Electrotechnologies 11

Guide

NOVA SCOTIA
NOUVELLE-ÉCOSSE

2000

Website References

Website references contained within this document are provided solely as a convenience and do not constitute an endorsement by the Department of Education of the content, policies, or products of the referenced website. The department does not control the referenced websites and subsequent links, and is not responsible for the accuracy, legality, or content of those websites. Referenced website content may change without notice.

Regional Education Centres and educators are required under the Department's Public School Programs Network Access and Use Policy to preview and evaluate sites before recommending them for student use. If an outdated or inappropriate site is found, please report it to <curriculum@novascotia.ca>.

Electrotechnologies 11

Prepared by the Department of Education and Early Childhood Development

This is the most recent version of the current curriculum materials as used by teachers in Nova Scotia.

Electrotechnologies 11

Implementation Draft,

March 2000

Acknowledgments

The Nova Scotia Department of Education gratefully acknowledges the contribution of the Electrotechnologies 11 curriculum working group and other education partners to the development of this curriculum guide. Members of the working group include the following:

Preston Allen, J. L. Ilsley High School
Halifax Regional School Board

Fred Martell, Memorial High School
Cape Breton-Victoria Regional School Board

Mark Wilkes, Sir John A. Macdonald High School
Halifax Regional School Board

Paul Vickers, Sir John A. Macdonald High School
Halifax Regional School Board

Tim Vickers, Memorial High School
Cape Breton-Victoria Regional School Board

Contents

Introduction

Background

The Department of Education has made a commitment to provide a broad-based, quality education in the public school system and to expand the range of programming to better meet the needs of all students. The Department is working in collaboration with school boards and other partners in education, business, industry, the community, and government to develop a variety of new courses.

Electrotechnologies 11 is one of a group of innovative multidisciplinary course options that share certain characteristics.

New course options draw from and contribute to students' knowledge and skills in more than one discipline. Students synthesize and apply knowledge and skills acquired in other courses, including courses in English language arts, social studies, science, arts, mathematics, and technology.

New course options provide increased opportunities for senior high school students to

- earn the credits they require to attain a high school graduation diploma
- diversify their course options
- prepare for varied post-secondary destinations
- make connections among school, the community, and the workplace
- explore a range of career options

These courses offer students increased opportunities for hands-on experiences and for using technology within a variety of subject areas to expand and develop their learning and skills.

Electrotechnologies 11 focusses on helping students to gain an understanding of electro-mechanical systems. Students are motivated to learn by studying such systems in an activity-oriented environment.

Students enhance their problem-solving skills using observations, analysis, prediction, and verification. Electrotechnologies 11 provides opportunities for students to investigate and conceptualize real applications of technology and formulate conclusions as to how these application affect their personal and work lives.

An approach to teaching and learning that emphasizes open-ended problem-solving will help to prepare students for the challenges they will meet in the world outside the school. In the workplace, projects may not always be clearly defined, and standard methods and procedures may need to be modified and adapted to meet the unique requirements of a specific project. Experience with open-ended problem solving will give students practice in responding to challenges for which prescribed solutions do not already exist.

To enhance students' understanding of the foundation of the information-based society in which we live, Electrotechnologies 11 provides opportunities for students to reflect on scientific and technological investigations from a historical perspective. Such opportunities help students to make value judgments about the effects of technology in their personal and work lives.

Rationale

In our increasingly technological society, young people must be able to respond to rapidly changing social and economic conditions with confidence in their own abilities. They will be required to adapt to changes in their personal and professional lives more often and more quickly than past generations of graduates.

All students will have to make informed decisions about what they will do when they finish their secondary education. When they enter a highly competitive workforce, they must be able to face the challenges of an information-based society that is constantly changing.

To assist students in dealing with these issues, schools must consistently deliver high quality, cost-effective programs that students, parents, and the community find credible and relevant. It is becoming increasingly clear that the world of work places a strong emphasis on group endeavours in problem-solving situations, and the abilities of individuals will be combined in group efforts to solve increasingly complex problems.

Electrotechnologies 11 emphasizes a team approach to the solution of systems problems, preparing students for cooperative work environments.

Electrotechnologies 11 provides opportunities for students to investigate possible career paths into the technology industry and to develop knowledge and skills necessary to effective participation in the society of tomorrow. The course will help students to develop skills that can be applied in their personal and work-related lives now and in the future.

Electrotechnologies 11 also provides opportunities for students to strengthen and refine skills and knowledge learned in other areas of their high school program such as technology, physics, and mathematics.

Outcomes

Essential Graduation Learnings and Electrotechnologies 11

The Atlantic provinces worked together to identify the abilities and areas of knowledge that they considered essential for students graduating from high school. These are referred to as Essential Graduation Learnings. Details may be found in the document *Public School Programs*.

Some examples of learning in Electrotechnologies 11 that helps students move toward attainment of the essential graduation learnings are given below.

Essential Graduation Learnings	Electrotechnologies 11 Outcomes
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.	By the end of Electrotechnologies 11, students will be expected to • use writing and other ways of representing to explore, extend, and reflect on their experiences, investigations, and insights into various areas of electrotechnology • make effective choices of language and other ways of representing to express their interpretation of various technological problems
Citizenship Graduates will be able to assess social, cultural, economic and environmental interdependence in a local and global context.	By the end of Electrotechnologies 11, students will be expected to • display an understanding of the impact of technology on a global, national, and local scale • work co-operatively in group environments • display an understanding of the need for safety in work environments • appreciate the historical significance of various developments in technology
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.	By the end of Electrotechnologies 11, students will be expected to • demonstrate active listening and concern for the needs, rights, and feelings of others • present ideas, insights, and information to others through a range of communication mediums

Essential Graduation Learnings	Electrotechnologies 11 Outcomes
Personal Development Graduates will be able to continue to learn and to pursue an active, healthy lifestyle.	By the end of Electrotechnologies 11, students will be expected to • participate in career-related experiences that support their interest in technology and their development as lifelong learners • use writing and other ways of representing to explore, extend, and reflect on the basis for their feelings, values, and attitudes relating to careers in technology • ask discriminating questions to acquire, interpret, analyze, and evaluate ideas and information • research, in systematic ways, specific information to meet personal learning needs
Problem Solving Graduates will be able to use the strategies and processes needed to solve a wide variety of problems, including those requiring language, mathematical, and scientific concepts.	By the end of Electrotechnologies 11, students will be expected to • use graphical techniques to solve problems • use computer software to assist in problem solving • evaluate, formulate, and present informed solutions to technological problems and scenarios • use the Internet to assist in problem solving
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.	By the end of Electrotechnologies 11, students will be expected to • read and interpret electric schematic diagrams • use computer software to simulate electric circuits use computer software to produce graphs of mathematical data • use graphical techniques to solve problems • use the Internet as an aid in research • manipulate laboratory equipment • assemble electronic circuits • use electronic test equipment

Electrotechnologies 11 Outcomes

Module 1: Components and Concepts

Students will be expected to apply appropriate techniques, including component assembly procedures, to construct and analyze basic electronic circuits.

Module 2: Power Distribution and Conversion

Students will be expected to apply appropriate techniques, including component assembly procedures, to construct and test power distribution and conversion devices.

Module 3: Digital Technology

Students will be expected to identify, select, and apply integrated circuits to solve practical problems.

Module 4: Control Systems

Students will be expected to formulate, apply, and test the principles governing the forms and functions of control systems.

Module 5: Electrotechnologies Project

Students will work alone or in groups to extend, apply, or explore in depth, ideas, issues, or skills introduced in modules 1,2,3, and/or 4.

Specific Curriculum Outcomes

Module 1: Concepts and Components (Compulsory)

Students will be expected to apply appropriate techniques, including component assembly procedures, to construct and analyze basic electronic circuits.
Students will be expected to

- identify the variables involved in electronic circuits (current, voltage, and resistance)
- explain the relationship among variables involved in electronic circuits
- use a multimeter to measure the variables involved in electronic circuits
- arrange electronic components in series, parallel, and combination configurations
- predict the behaviour of electric circuits using their knowledge of the variables involved in electronic circuits
- solve problems involving series, parallel, and combination circuits
- demonstrate their ability to use industrially accepted fabrication techniques
- describe circuits using electronic symbols and conventions
- describe applications of series, parallel, and combination circuits
- identify appropriate construction methods to fabricate a circuit board

- lay out and construct a simple electronic circuit board using approved construction techniques
- use a PC board and accepted fabrication techniques to assemble a project

The following outcomes of Module 1 are addressed in all modules of Electrotechnologies 11.

- practise the appropriate health and safety procedures outlined in the *Nova Scotia Occupational Health and Safety Act*
- practise safety procedures applicable to chemical, electronic, and other equipment as appropriate
- use computer software to conduct investigations and solve problems
- use the Internet to search for and gather learning resource materials
- make connections among their learning, their own lives, and their communities

Module 2: Power Distribution and Conversion

Students will be expected to apply appropriate techniques, including component assembly procedures, to construct and test power distribution and conversion devices.

Students will be expected to

- explain the relationship between electricity and magnetism
- construct electromagnetic devices that illustrate the relationship between electricity and magnetism
- describe a range of electromagnetic applications in a range of settings
- describe various types of AC and DC power supplies
- construct a simple power supply
- demonstrate an understanding of the environmental impact of a range of power generation systems
- explain electromotive principles as applied to direct current (DC) and single phase alternating current (AC) motors
- explain the operational characteristics of AC motors
- practise the appropriate health and safety procedures outlined in the *Nova Scotia Occupational Health and Safety Act*
- use computer software to conduct investigations and solve problems
- use the Internet to search for and gather learning resource materials
- make connections among their learning, their own lives, and their communities

Module 3: Control Systems

Students will be expected to identify, select, and apply integrated circuits to solve practical problems.

Students will be expected to

- describe the binary numbering system
- relate the binary number system to electronic concepts
- describe basic logic gates
- construct basic logic gates
- verify basic logic gates using multimetres
- construct a simple logic circuit and explain its functions
- distinguish between analog and digital systems
- identify and describe the major components of a logic system such as a microcomputer system
- identify the major integrated circuit (IC) families and describe their unique functions
- identify and interface components with small-scale integration IC families
- identify components and construct a prototype of typical small-scale and complex logic networks using integrated circuits
- practise the appropriate health and safety procedures outlined in the *Nova Scotia Occupational Health and Safety Act*
- use computer software to conduct investigations and solve problems
- use the Internet to search for and gather learning resource materials
- make connections among their learning, their own lives, and their communities

Module 4: Control Systems

Students will be expected to formulate, apply, and test the principles governing the forms and functions of control systems.

Students will be expected to

- describe a variety of everyday problems that are solved by control systems
- identify how control systems are used in residential and commercial applications
- explain how basic process control systems function
- describe the operation of devices used for process control using standard terms
- construct basic process control circuits using passive devices
- distinguish between digital and analog systems
- construct basic control systems to process input information in order to achieve a desired result
- practise the appropriate health and safety procedures outlined in the *Nova Scotia Occupational Health and Safety Act*
- use computer software to conduct investigations and solve problems
- use the Internet to search for and gather learning resource materials
- make connections among their learning, their own lives, and their communities

Module 5: Electrotechnologies Project

Students will work alone or in groups to extend, apply, or explore in depth ideas, issues, or skills introduced in Modules 1,2,3 and/or 4.

Students will be expected to

- develop and refine a proposal for an inquiry or the development of a product or electronic device
- identify information needs, and locate evaluate resources
- identify and extend, refine and/or acquire required skills
- share research and reflections made by themselves and their peers
- make project decisions which demonstrate creativity, innovation, and a willingness to take risks
- set deadlines and develop a work plan to manage time and resources
- develop a plan for monitoring their progress and judging success
- contribute to the criteria used for evaluation
- gather, organize, and synthesize information and ideas
- use their knowledge and skills to conduct an inquiry or create a product or electronic device
- present the results of their investigation or product
- reflect on and assess their own learning and the learning of others
- practise the appropriate health and safety procedures outlined in the *Nova Scotia Occupational Health and Safety Act*
- use computer software to conduct investigations and solve problems
- make connections among their learning, their own lives, and their communities

Course Design and Components

Features of Electrotechnologies 11

Electrotechnologies 11 is characterized by the following features:

- a strong applied focus with an emphasis on integrating, applying, and reinforcing the knowledge, skills, and attitudes developed in other courses
- a strong connection to the essential graduation learnings
- a strong focus on refining career-planning skills to explore a range of pathways from school
- a strong connection to labour market opportunities with a focus on enhancing students' employability skills
- a strong connection to the community and workplace with a focus on using real-world community and workplace problems and situations as practical contexts for the application of knowledge and skills and for further learning
- a strong focus on hands-on learning experiences, including experiences with a range of technologies
- a flexible design framework based on learning modules

Key Concepts in Electrotechnologies

Structure	the essential physical or conceptual parts of a product, process, or system, including the way in which the parts are constructed or organized
Material	the substance or information from which the structure is made
Fabrication	the act or process of forming and assembling materials and structures
Mechanism	the parts of a structure that allow it to work or function
Power and Energy	the resource that enables a mechanism to perform work
Controls	the means by which a mechanism is activated and regulated
Systems	combinations of interrelated parts (structures and/or mechanisms) that make up a whole and that may be connected with other systems
Function	the use for which a product, process, or system is developed
Aesthetics	the aspects of a product, process, or system that make it pleasing to the human senses

Ergonomics

the aspects of a product, process, or system that allow people to use it efficiently with minimal waste of time or energy

Cross-Curricular Connections

Electrotechnologies 11 provides many connections to other technology education courses and to other subject areas in the high school curriculum:

English Language Arts

Students are expected to apply and refine language knowledge and skills in the preparation of reports, essays, summaries, discussions, and presentations. Teachers should encourage effective use of language and organization of ideas and information. Precise use of language in relation to the technical information is particularly important.

Mathematics

Mathematical skills, both algebraic and geometric, are basic tools in the analysis of data, as well as in the quantitative solution of problems in all modules of Electrotechnologies 11.

Sciences

Chemistry and physics are the primary connections to the sciences in Electrotechnologies 11. From their first experiments with wet cells through the design and construction of robotic systems, students discover and apply chemical and physical principles as they are needed. Throughout the course students investigate, analyze, predict, and test their own ideas.

Social Studies

A critical awareness of the development of science and technology concepts from a historical perspective is an important dimension of Electrotechnologies 11. An understanding of current trends in technology is difficult without awareness of the paths taken by our predecessors in reaching our present level of development. Students should have opportunities to examine the work done by notable contributors to technological theory.

Organization

Teachers and students may choose to organize the learning for Module 5 in any of the following ways:

- students may work alone
- students may work collaboratively with a partner or mentor
- students may work co-operatively in groups
- students may organize themselves into a design team, working collectively to explore an issue, solve a problem, or create a product in response to a need articulated by a school or community group
- students may undertake a shared or common project, working together in a class or group

Electrotechnologies 11 is designed to meet a range of learning needs. Students may earn one-half-credit by completing the compulsory module, Components and Concepts, and one other module, or they may earn a full credit by completing an additional three of the optional modules. Each module is twenty-five to thirty hours in length. The minimum time required for scheduling is 110 hours for a full credit and 55 hours for one-half credit.

Sequence of Modules

Modules may be organized in any of the following ways:

Module 1
Three of Modules 2, 3, 4, or 5

<table>
<tr><td colspan="3">Module 1</td></tr>
<tr><td>Module 2</td><td>Module 3</td><td>Module 4 or 5</td></tr>
</table>

<table>
<tr><td rowspan="3">Module 4</td><td>Module 1</td></tr>
<tr><td>Module 2</td></tr>
<tr><td>Module 3 or 5</td></tr>
</table>

How to Use the Four-Column Curriculum Matrix

The curriculum for this course has been organized into four columns for several reasons

- The organization illustrates how learning experiences flow from the outcomes.
- The relationship between outcomes and assessment strategies is immediately apparent.
- Related and interrelated outcomes can be grouped together.
- The range of strategies for teaching and learning associated with any specific outcome or outcomes can be scanned easily.
- The organization provides multiple ways of reading the document or of searching for specific information.

Outcomes	**Suggestions for Teaching and Learning**	**Suggestions for Assessment**	**Resources and Notes**

This column describes what students are expected to know, be able to do, and value by the end of this course. While the outcomes may be clustered, they are not necessarily sequential.

This column offers a range of strategies from which teachers and students may choose. Suggested learning experiences can be used in various combinations to help students achieve an outcome or outcomes. It is not necessary to use all of these suggestions, nor is it necessary for all students to engage in the same learning experience.

These suggestions may be used to assess students' success in achieving the outcomes; they are linked to the *Outcomes* column, rather than the *Suggestions for Teaching and Learning* column. The suggestions are only samples; for more information, read the section *Assessing and Evaluating Student Learning*.

This column contains a variety of information related to the items in the other columns, including suggested resources, elaborations on strategies, successes, cautions, and definitions.

MODULE 1: COMPONENTS AND CONCEPTS

Students examine a range of circuits and construct their own, both real and simulated through software, to establish an understanding of how electricity behaves and to develop skills in the use of technology commonly found in electronics laboratories and workplaces. The main focus of the teacher during this module is to help students understand that there is a clear, direct relationship among observable elements in electronic circuits. Some students may recognize that a relationship exists and be able to describe it, while others may be able to use mathematical methods to derive Ohm's Law.

Components and Concepts

Students will be expected to apply appropriate techniques, including component assembly procedures, to construct and analyze basic electronic circuits.

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • identify the variables involved in electronic circuits (current, voltage and resistance) • explain the relationship among variables involved in electronic circuits • use a multimeter to measure the variables involved in electronic circuits	Students can • examine actual electronic circuits and list components they are able to identify • Students should be encouraged to bring example circuits from home, for example, old battery-operated games, radios, or amplifiers. • work in groups, to share ideas and observations. (This activity will help the teacher determine the level of prior knowledge in the class, identify class experts, and make grouping decisions.) • work individually or in groups to construct a simple voltage divider circuit using breadboard circuit kits. The power sources could be – batteries or dry cells – DC power supplies – wet cells of their own construction (see Appendix C) using their own cell relates material studied in previous years to Electrotechnologies 11. • measure voltage, current, and resistance in simple circuits with a multimeter. The simplest case of one resistance and one power source can be used to introduce the topic of circuit variables (see Notes). Some students may also explore compound series/parallel circuits. • record their measurements in table format, or use computer interface to record data continuously, for example, – current versus voltage for constant resistance – current versus resistance for constant voltage – voltage versus resistance for constant current (This case presents a greater challenge for students and emphasizes the necessity of good experimental design.) • use electronic spreadsheets or other software to record data • graph the results of their measurements to search for and identify relationships among data • use graphing calculators or computer software to graph their data, for example, *Math Studyworks* Teachers can • identify students who may require extra support • identify students who may provide leadership in investigations and projects • demonstrate the use of Electronic Workbench to emulate electric circuits and coach students in its use. • encourage students who are familiar with software conventions and behaviour to provide assistance to less experienced students

Components and Concepts

Suggestion for Assessment

Students can

- keep daily journals and maintain portfolios throughout Electrotechnologies 11
- participate in group discussions and provide constructive criticism and suggestions to their peers
- work in groups, or as a class, to develop a graphic representation of data for classroom display
- summarize the results of their investigations in written or electronically generated reports
- develop a journal in which they can record questions and insights
- develop their own progress in consultation with the teacher
- summarize the results of their investigations in written or electronically generated reports
- develop a journal in which they can record questions and insights
- develop a portfolio and use it to evaluate their won progress in consultation with the teacher

Teachers can

- monitor students' group work and provide frequent feedback and suggestions as appropriate
- read student reports and offer specific suggestions and feedback to them for improvement
- monitor individual student work and provide feedback and suggestions on their performance in
  – following instructions where appropriate
  – organizing their work
  – analyzing and drawing conclusions from their investigations
  – operating computer software where appropriate
  – assembling simple electric circuits
  – using electric measurement devices such as multimeters, voltmeters, and ammeters.
- in observing students' construction of circuits, teachers can note students'
  – plan of action
  –quality of assembly
  – use of testing procedures
- provide models, outlines, and samples to assist students in developing journals and portfolios

Resources and Notes

Students may vary in their familiarity with the concepts of voltage, current, and resistance and the devices with which they are measured. Teachers should establish balanced work groups or design teams to include experienced and less experienced students.

The design team concept is an effective way to organize students. The design team is used in many workplaces and helps students make connections between their learning and careers in Electrotechnologies.

When people work in design teams, they contribute technical skills (doing the task, solving the problem, making the product), human skills (communicating and motivating people to work together), and conceptual skills (monitoring progress and group functioning, linking the work to that of other groups and to the overall project, dividing and delegating, judging success).

Design team organization also gives teachers an opportunity to assume supervisory roles that replicate the workplace and may have a dramatic effect on classroom dynamics and relationships.

Components and Concepts

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • arrange electronic components in series, parallel and combination configurations • predict the behaviour of electric circuits using their knowledge of the variables involved in electronic circuits • solve problems involving series, parallel, and combination circuits • demonstrate their ability to use industrially accepted fabrication techniques • describe circuits using electronic symbols and conventions • describe applications of series, parallel, and combination circuits	Students can • construct a range of series, parallel, and combination circuits using a variety of methods such as – commercial electronic breadboard packages (point-to-point and solderless) – components taken from discarded electronic devices such as old radios and games – soldered connections – nail and board sector and spring clip connections – wire wrapping if available • use multimeters to record the values of resistance, voltage and current in a range of series, parallel and combination circuits • use *Electronic Workbench* or another similar circuit emulation program to emulate the measurement of circuit variables • predict the results of changing circuit variables for a range of series, parallel and combination circuits. For example, if students examine a circuit with a 10V power supply and two resistors in series, measure the voltage drop across and current through each resistor, they should be able to predict what would happen if they changed the value of one of the resistors or added a resistor. Using trial and error and retesting their circuits with actual equipment could be a valuable strategy for some students. • use graphical methods to obtain solutions to a range of problems involving series, parallel and combination circuits • distinguish among a range of electronic components commonly used in circuits, such as – resistors – capacitors – transformers – transistors – integrated circuits (ICs) • describe a residential branch circuit in terms of series, parallel or combination circuits • construct a working model of a residential electric circuit Teachers can • provide instruction on soldering and other types of circuit construction as needed • introduce symbols for schematic diagrams as they are needed • encourage students to provide items for their investigations from outside resources • identify related opportunities for post-secondary education and training and for jobs, occupations, and careers • identify hobbies involving electronics, for example, amateur radio

Components and Concepts

Suggestion for Assessment

Students can

- provide constructive feedback to their peers in group situations
- draw schematic diagrams for circuits they construct and include them in their journals
- use *Electronic Workbench* or some other software capable of creating circuit diagrams to create graphics of electric circuits for inclusion in their reports and journals
- write solutions to a range of problems involving series, parallel, and combination circuits
- write reports that summarize their investigations
- identify and use appropriate cables and connectors to construct circuits
- demonstrate special knowledge of circuit construction techniques they may know, such as soldering or wire wrapping, for other students

Teachers can

- provide actual circuit boards and ask students to
  – identify individual components
  – identify series, parallel, and combination circuit structures
- accumulate a bank of discarded electronic devices and encourage students to bring examples of electronic circuits from outside the classroom to examine for construction technique, devices used, and power sources used
- use circuit problems to develop construction techniques by having students build circuits described in written problems

Resources and Notes

When analysing complex circuits, students should be encouraged to break the problems they encounter into simpler separate ones. The examination of combination circuits commonly involves breaking them down into separate series and parallel circuits. It may be valuable to have students record in their journals the steps for a range of such problems, drawing the intermediate circuits used to solve the complex circuit.

Some students may have difficulty with Cartesian graphical techniques to solve circuit problems and can achieve the outcomes in a different way, for example, experimenting to come to correct conclusions.

During their discussions of circuits, students should relate their investigations to the kind of work done in the electrical construction trades, electronic component, and computer industries as part of their future career investigations. The teacher may arrange for a person from industry to visit the class and describe his or her work. Some students might be interested in an assignment to interview such a person, or to investigate opportunities for job shadowing.

Components and Concepts

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • identify appropriate construction methods to fabricate a circuit board • lay out and construct a simple electronic circuit board using approved construction techniques • use a PC board and accepted fabrication techniques to assemble a project	Students can • use schematic symbols to represent electronic components • draw and modify schematic diagrams for a simple electronic circuit. • use *Electronic Workbench* to draw circuits they intend to build • match actual components to schematic symbols • make prototype circuits using a breadboard • create artwork layouts for printed circuit boards to construct actual circuits such as – amplifiers – radios – communications devices – power supplies – logic systems modules • describe the etch-resistance pen and photographic techniques to make printed circuit boards • use an etch-resistant pen or photographic technique to construct an actual printed circuit board and test their completed circuits with electronic instruments Teachers can • encourage students to conduct Internet searches to gather ideas for printed circuit board projects • students may choose to start with the Electrotechnologies 11 course support site at **http://www.ednet.ns.ca/educ/currwebs/electro** • encourage students to share ideas or work in teams to attempt large projects

Components and Concepts

Suggestion for Assessment

Students can

- keep accurate records of the procedures they follow in investigating and constructing printed circuits

Teachers can

- observe students work for
  – plan of action
  – quality of assembly
  – testing procedures
  – identifying appropriate connectors used in power, audio, and video circuits
  – fabricating cables and connectors

Resources and Notes

Simple circuits are found in project magazines such as *Scientific American* and *Popular Electronics*.

Throughout Electrotechnologies 11, there are outcomes which students can achieve by doing a project. The outcome dealing with printed circuit boards is a good example.

Some students may be satisfied with understanding the construction methods for printed circuit boards while others may wish to create them as an extended project.

A framework for assessing workshop and laboratory investigations is found in Appendix L.

Components and Concepts

Outcomes	Suggestions for Teaching and Learning
Students will be expected to • practise the appropriate health and safety procedures outlined in the *Nova Scotia Occupational Health and Safety Act* • practise safety procedures applicable to chemical, electronic, and other equipment as appropriate	Students can • maintain a section of their journals to record safe laboratory procedures as the need arises; for example, when handling integrated circuits, they should be aware of the need to observe antistatic procedures by grounding themselves first using static mats and grounding straps to discharge any static electricity they might be carrying • describe hazards associated with voltage (including capacitor discharge), currents, grounded systems, floating systems, and isolated systems • demonstrate appropriate procedures when using solder and associated chemicals Teachers can • assist students in understanding the need for safe practices in all aspects of Electrotechnologies 11 by providing a good example through their own use of safe practices • provide students with manufacturers' recommendations for handling semiconductor materials • prepare students for written examinations similar to those they may encounter in industry or work experience; for example, teachers may obtain safety tests from local industries or use WHMIS materials as a basis for teaching

Components and Concepts

Suggestions for Assessment

Students can

- maintain lists of safety procedures used in their laboratory investigations in their daily journals
- specify in writing safety procedures which must be used in laboratory exercises, material handling, and equipment handling as directed by their teachers

Teachers can

- administer written tests which they prepare based on industry guidelines
- monitor students' journals regularly to ensure that safety is considered in all their work
- provide feedback and suggestions to students about safety requirements as needed

Resources and Notes

The health and safety outcomes specified in this section have applicability throughout the entire Electrotechnologies 11 course and are referred to in several places.

For information about the Occupations Health and Safety Act, see Appendix M.

National Semiconductor has an Internet site for teachers.

Flinn Scientific offers several school safety pages on their Internet site. It is recommended that teachers visit this site. They suggest safety contracts with students as a means to promote awareness of safety procedures in the laboratory.

Components and Concepts

Outcomes	Suggestions for Teaching and Learning
Students will be expected to • use computer software to conduct investigations and solve problems • use the Internet to search for and gather learning resource materials	Students can • identify software with which they might be familiar to maintain records and journals; for example, some students may use software at home that is not available in school • use computer software to emulate electronic circuits, for example, *Electronic Workbench*. See Appendix A for more information on it. • use *Math Studyworks* to aid in plotting graphs for reports and projects • use computer software to track time use and plan projects; for example, students might want to use *Microsoft Project* to plan the execution of a project • use database software such as *Microsoft Access* or spreadsheet software such as *Microsoft Excel* to organize information for projects and reports • use graphics, drawing, or CAD programs to prepare illustrations for reports and projects. There are many shareware programs for this purpose. • search the Internet for information relating to Electrotechnology 11 • share information with other students across the province through the Web site provided to support Electrotechnologies 11 Teachers can • help students maintain their focus on the curriculum outcomes when working with computer software, rather than spending a disproportionate amount of time learning to use the software • provide guidance to students in selection of resource sites • identify and provide support to students whose computer skills may need development or reinforcement. Such students may occasionally be paired with others more versed in computer software operation or may work through a software tutorial together. • ensure that all students have equitable access to computer resources • help students to initiate a joint project using the Internet to work with another school or several schools

Components and Concepts

Suggestions for Assessment

Students can

- include in their journals records of software used and the purposes for which it was used
- include lists of information which they may have saved in database software in report and project submissions
- critique the use of software by other students in their research during seminars and small group discussions to provide feedback to them and to share ideas
- select an appropriate software tool for a specific application

Teachers can

- monitor student journals regularly to ensure that any software use is appropriate to the task at hand
- participate in discussions and offer feedback and suggestions concerning appropriate and effective software use
- ask students to undertake a guided Internet search such as the WebQuest described in Appendix N"

Resources and Notes

Microsoft Office, listed in *Authorized Learning Resources*, can import and export files from most commonly used word processors, spreadsheets, and databases.

Math Studyworks also includes an encyclopedia section with information on many disciplines including Electrotechnologies.

A planning tool called *Inspiration* is listed in *Authorized Learning Resources*. The company producing it makes other resources available at their Web site.

The Internet is a valuable tool for students in the search for information. A list of links is available in Appendix B. More links are available on the Electrotechnologies 11 website at **http://www.ednet.ns.cs/educ/currwebs/electro**

Teachers should consider various options to monitor Web use so that they can assure that student computer use is appropriate.

Components and Concepts

Outcomes	Suggestions for Teaching and Learning
Students will be expected to • make connections with their own lives and community	Students can • invite parents or acquaintances who may have experience in areas they are studying to visit the school to share experience with other students • provide materials and information from their own homes for use in projects and experiments • choose projects that make use of expertise in community businesses or that provide a service or product to local businesses or community groups. For example, students might – design a security system or sound system – provide a wiring plan for a building renovation or addition – analyze and develop schematic drawings of existing electronic installations It is important that students undertake such project work with a qualified professional and that issues of warranty or liability are adequately addressed. Teachers can • identify local resources and encourage students to relate their project work to them • encourage students to provide materials for laboratory work from outside the school. For example, students may have access to a source of used computer equipment which could be of value throughout the course. • be receptive to visits from parents or others in the community who have information and experience to share about electrotechnologies. For example, parents who work in aerospace, manufacturing, or communications industries may be willing to share information on advanced control systems with students.

Components and Concepts

Suggestions for Assessment

Teachers can

- encourage students to include community references in their written work by providing potential sources, and organizing field trips
- work with co-op education teachers or co-ordinators to arrange job shadow and other short-term placement opportunities
- ask students to write in their journals about specific career-related topics, for example
  - what I have learned in this course that will help me in the workplace
  - how my skills and interests could lead me to a career in electrotechnologies
  - planning a career path based on the Conference Board of Canada's *Employability Skills Profile*

Resources and Notes

A number of career related documents are available at the Conference Board of Canada's Web site.

MODULE 2:

POWER DISTRIBUTION AND CONVERSION

Students will develop skills in working with electronic components to construct devices for power distribution and conversion. By enquiring into the form and function of such devices, they will develop knowledge based on real world devices and will extend that knowledge to develop a greater understanding of the behaviour of electricity and of magnetism and of the relationship between them.

Power Distribution and Conversion

Students will be expected to apply appropriate techniques, including component assembly procedures, to construct and test power distribution and conversion devices.

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • explain the relationship between electricity and magnetism • construct electromagnetic devices that illustrate the relationship between electricity and magnetism • describe a range of electromagnetic applications in a range of settings	Students can • demonstrate that a magnet moving in the vicinity of a stationary wire will cause a current to flow in the wire, and similarly demonstrate that a wire moving in the vicinity of a stationary magnet causes a current to flow in the wire • demonstrate that a wire carrying an electric current creates a magnetic field in its vicinity • construct electromagnets from readily available materials, for example, nails and hookup wire • participate in small group discussions to examine the results of their inquiries and suggest ways in which they are related to the real world. • examine electronic equipment for the presence of electromagnetic devices and list them; for example, students could, with help from a qualified board or school employee, examine devices in the school heating system, the school bell system and computers • construct electromagnetic devices to perform simple tasks • work in a design team to construct an electromagnetic device needed to solve a problem Teachers can • encourage students to relate simple electromagnetic experiments to everyday life by considering the applications of their observations to electrical power generation and motors. • provide video demonstrations of electromagnetic phenomena which are available from a variety of scientific suppliers • encourage students to visit websites which provide electromagnetic demonstrations, for example, the Exploratorium or the Ontario Science Centre (See Appendix B)

Power Distribution and Conversion

Suggestion for Assessment

Students can

- create graphics of a range of electromagnetic devices found on the home or school environment
- present the results of their design team investigations of electromagnetic devices to their peers
- produce video demonstrations of their work with electromagnetism to demonstrate the effects of magnetic fields on conductors
- present written or electronic reports of Internet investigations in class. Some students may wish to use presentation software to display their results
- students who have indicated an interest in post-secondary education in sciences or technology may wish to investigate the historical development of electromagnetic theory by Oerstedt, Faraday, or Maxwell

Teachers can

- suggest variations on student presentations and suggest refinements or other ways to demonstrate electromagnetic phenomena. For example, if a student is using bar magnets to demonstrate an effect, the teacher could ask the student to predict how the observed effect would vary if the student used a horseshoe magnet.
- suggest refinements in student demonstrations which result in further discovery. For example, if a student concludes that moving a conductor in a magnetic field produces a current, the teacher may suggest that the student examine the effect produced by moving the conductor at different speeds.
- monitor the use of computer software to ensure its use is appropriate to the task
- provide feedback and coaching

Resources and Notes

For magnet and wire demonstrations, Alnico bar magnets and common hookup wire would be sufficient.

Students can also bring magnets from home or use magnets removed from old disk drives or microwave ovens. Currents can be measured with ammeters or galvanometers which are available in most schools.

Examples of the application of electromagnets in the home are in doorbells, actuators for security systems and electric power meters

Electromagnetic devices include, for example,

- –buzzers or doorbells
- –magnetic toys such as cranes
- –simple motors (See Appendix E)
- –simple generators

The focus in these outcomes is to show a close relationship between electricity and magnetism and that they interact in real world devices. Some students may want to quantify their investigations by observing the three-dimensional nature of the relationship between electricity and magnetism in the Left Hand Rules.

Power Distribution and Conversion

Outcomes	Suggestions for Teaching and Learning
Students will be expected to • describe various types of AC and DC power supplies	Students can • gather examples of power supplies from home or throughout the school and record their results in lists • identify and describe how energy is converted into electricity in the following situations –wet/dry cell (simple cells can be constructed using common materials - Appendix C) –photovoltaic cell, for example solar heating systems thermocouple –generator/alternator, for example a bicycle generator or an emergency power generation system. Students can examine how computer power backup systems work. –piezoelectric crystal, for example, butane lighters or barbecue ignition devices • list a range of functions of power supplies, for example –step up voltage –step down voltage –supply variable voltage –change AC to DC current –isolate circuits • list reasons why commercial electrical power is distributed as alternating current • observe the operation of power supplies of various types using *Electronic Workbench* Teachers can • arrange a field trip to an electric power generation facility and ask the students to • provide written reports on devices they observe on their trip • prepare a list of questions before the visit for themselves and for power generation facility staff • prepare a sketch of a typical power generation facility beforehand and revise it after the field trip • research a list of careers common to the power generation industry and plan to interview someone in at least one occupation

Power Distribution and Conversion

Suggestions for Assessment

Students can

- demonstrate power supplies they have gathered in classroom presentations and prepare a worksheet for the class to guide them through the demonstration with prompts for comment and analysis
- construct, analyze, and evaluate various single-phase rectifier systems such as
  –half-wave rectifier circuit
  –two-diode rectifier circuit
  –bridge rectifier circuit
- classify power supplies they have collected as alternating or direct current power supplies
- create block diagrams of a typical DC power supplies
- create block diagrams of typical filtered AC power supplies

Resources and Notes

Power Distribution and Conversion

Outcomes	Suggestion for Teaching and Learning
Students can • construct a simple power supply • demonstrate an understanding of the environmental impact of a range of power generation systems	Students can • construct, analyze, and evaluate various single-phrase rectifier systems such as –half-wave rectifier circuit –two-diode rectifier circuit –bridge rectifier circuit • research issues related to electrical generation, transmission and distribution systems, for example • cost efficiencies • environmental impact of fossil fuel, hydro electric and nuclear power plants • conventional (fossil fuel) versus non-conventional (tidal, solar, wind) sources • report on issues related to energy efficiency and conservation • explore the risks and benefits of a range of energy generation sources such as tidal, wind, solar, hydro, and coal Teachers can • arrange a field trip to an electric power generation facility and ask the students to • prepare a list of questions before the visit for themselves and for power generation facility staff • prepare a sketch of a typical power generation facility beforehand and revise it after the field trip • research a list of careers common to the power generation industry and plan to interview someone in at least one occupation • provide written reports on devices they observe on their trip • arrange job shadows or other short-term placements at a power generation facility or with an electrical contractor for students who show an interest in such work as a career • invite guest speakers from the power generation industry to discuss their work

Power Distribution and Conversion

Suggestion for Assessment

Students can

- participate in classroom competitions or presentations which demonstrate a range of power supplies built by students. Design teams could prepare questionnaires for their peers to analyze their work and suggest improvements or modifications
- stage a mock trial of a power generation company accused of polluting the environment. Such a trial could enable the students to examine environmental pollution critically
- create a standby power supply for school computer systems
- prepare charts comparing efficiency of design, power output and effectiveness of presentation for power supply projects constructed by individuals or groups of students
- prepare presentations using computer software showing information gathered from field trips or work experience they may have been involved in
- measure power output of electric generators with multimeters
- draw diagrams representing the stages in production of electrical power in conventional and nuclear power plants

Teachers can

- select members of design teams according to interests they indicate. Teachers may wish to include students of varying interests in each team to try to simulate real world design teams. For instance, some students may be interested in construction techniques and others in data analysis. The teacher should ensure that, during a presentation, all team members participate and are familiar with the results generated by the entire team.
- collect all student built generators and showcase them during a school open house, inviting comments and suggestions from visitors to the school

Resources and Notes

The construction of a power supply is a suitable topic for project work. Some or all of the outcomes in this module may be accomplished by following strategies outlined in Module 5. The construction of a power supply may be part of a project which spans the entire course.

Students should be encouraged to examine all aspects of power generation as possible career choices.

The increasing importance of alternative methods of power generation and conservation in general is an important topic for students. They should be encouraged to pursue their active interests in alternative energy.

Alternative energy generation schemes could form the basis of a research project during which students could meet other outcomes of *Electrotechnologies 11*. For example, a project to build a wind power generator could be used to meet the first four outcomes of this module. Teachers should be prepared to monitor such projects regularly to ensure that students do indeed meet the required outcomes.

Students could research and report on an environmental catastrophe related to power generation such as Three-Mile Island or Chernobyl.

Power Distribution and Conversion

Outcomes	Suggestions for Teaching and Learning
Students will be expected to • explain electromotive principles as applied to direct current (DC) and single-phase alternating current (AC) motors • explain the operational characteristics of AC motors	Students can • list applications of electric motors in their own homes and classify them by type (AC or DC) • explain how electric motors are used to convert electrical energy into mechanical energy • demonstrate that an electromagnet in the vicinity of another electromagnet experiences a force • explain how this demonstration illustrates the motor principle that two magnetic fields can be made to interact to produce motion • use the Right Hand Rule to relate magnetic field direction to direction of rotation of a motor • identify DC electric motors as to whether they are permanent magnet or electromagnet motors and compare the two motor types • construct a DC motor from common materials Teachers can • provide sample motor kits available from science and technology suppliers to assist students with the construction of their own motors • run a competition among individual students or design teams to create DC electric motors • arrange a field trip to a motor repair shop

Power Distribution and Conversion

Suggestion for Assessment

Students can

- create graphics to illustrate the component parts of DC and AC motors with annotations to describe their workings
- use their knowledge of electromagnetism to write a report explaining how a DC electric motor works
- create a technology fair project to generate electric power efficiently
- draw diagrams to show how a current-carrying conductor in a magnetic field experiences a force perpendicular to the direction of the field
- explain why and how the speed of a DC motor is easily controlled (Speed is proportional to the voltage applied to the armature)
- draw a block diagram of a DC electric motor to illustrate the Right Hand Rule for motors showing:
  –field coils
  –armature
  –bearings
- draw a block diagram of a universal motor and explain why it can operate using either DC or AC current
- draw block diagrams of single-phase AC motors and explain that an AC motor works by creating a rotating magnetic field in the stator winding
- define the terms induction and synchronous as applied to AC motors
- explain how motors are rated according to the work they can do
- define and use the term torque as applied to electric motors

Teachers can

- invite colleagues or parents to competitions for which individual students or design teams have built electric motors. It might be useful to supply visitors with a comment sheet so the students could benefit from outside input and make modifications and adjustments to improve their projects
- challenge students to examine faulty or burned out motors to see if they can determine the cause of the failure (refer to the table on page 324 of *Essentials of Electronics* or a similar text for assistance in classifying problems)

Resources and Notes

The project work in this module offers many opportunities for students to enhance their portfolios. Photographs or videos can be used to document the process; anecdotal comments or summaries from comment sheets can demonstrate the response of students and community if a competition or exhibition is staged.

MODULE 3: DIGITAL TECHNOLOGY

Students develop an understanding of the range of applications for solid state electronics, and of the career options associated with digital technology. Students apply their understanding to develop a model to describe the behaviour of logic gates and circuits and to account for the structures and behaviours of logic circuits.

Digital Technology

Students will be expected to identify, select, and apply integrated circuits to solve practical problems.

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • describe the binary numbering system • relate the binary number system to electronic concepts	Students can • discuss the origin of 'binary', noting that it means 'two', and therefore is associated with the number 2. Most students will have encountered binary number representations, most likely when dealing with computers, and will have seen sequences of digits containing only the digits '0' and '1' • gather articles or illustrations containing binary numbers in text or graphics. Electronics or computer magazines with binary sequences displayed in an article or on the cover are common • undertake Internet searches for sites which deal with the binary number system • summarize the results of their searches or create graphics to illustrate information they have gathered • discuss electric circuits and components with which they are familiar to examine them for properties that could be described using two mutually exclusive states, such as 'ON' and 'OFF' for switches and relays, or 'TRUE' and 'FALSE', to indicate whether or not current flows from a junction point in a circuit • use their knowledge of electric circuits and their everyday experience to list reasons why the binary number system is the most practical system to use in electronic applications • construct a simple binary counter using LEDs and switches to generate a table of binary numbers and decimal equivalents for the numbers 0 to 64 • work in design teams to adapt the printer port on an older computer (i286 or i386) to be used as a control port for lights, motors and other small devices • use multimeters to measure output voltage and adjust time intervals, for instance, building delays into an operation. They could set a time delay to turn off electric lights or construct a simple running counter. This activity introduces students to the concept of computer control of other systems • participate in discussions on basic theory of number systems to explore how the common decimal system is an expansion in powers of ten and the binary system in powers of two

Digital Technology

Suggestion for Assessment

Students can work in groups to organize a classroom of school display for with these suggestions:

- state that the binary number system uses only the digits zero and one
- explain the weighting of the positions of digits in the binary number system by comparing it to the decimal system. In the decimal system the position weights are 1, 10, 100, 1000 and so on and in the binary number system they are 1, 2, 4, 8, 16, 32, 64 and so on. Students should be able to explain that the binary number system is based on powers of two (see Notes)
- develop a table in which to record the decimal values of binary numbers displayed on an LED binary counter and vice-versa
- calculate the binary representations of decimal numbers

Teachers can

- arrange competitions with other high schools to produce devices that illustrate the construction and use of devices based on simple logic gates
- ask students to emulate logic gates they have drawn using *Electronic Workbench*
- for students who have chosen to extend their knowledge to other number systems, the teacher could arrange class presentations for them to demonstrate their investigations

Resources and Notes

See Appendix B and the notes for this outcome

One suggested reference is Gordon McComb, *Robot Builders Bonanza*, Tab Books, a Division of McGraw Hill., p 276

See Appendix I for a discussion of number systems. The appendix contains an interesting experiment which allows students to relate binary numbers to the sorting process and provides a conceptual link to possible applications of binary numbers to computers.

Some students who have difficulty with mathematics may need help to achieve this outcome. The focus, however, should be to lead realization that binary numbers are a natural way to represent electronic phenomena, not to ask them to develop a facility with binary mathematics

Some websites have been developed which deal with number systems and contain valuable sources of information which students could use to expand their knowledge. One such site is the I Love Binaries, Primes and Factors page at Earthlink.

Students wishing to examine in more detail how number systems are related to computers and other logic systems can explore octal and hexadecimal numbers.

Examples are available in any introductory text dealing with computer operation.

Digital Technology

Outcomes	Suggestions for Teaching and Learning
Students will be expected to • describe the binary numbering system • relate the binary number system to electronic concepts • describe basic logic gates • construct basic logic gates • verify basic logic gates using multimeters • construct a simple logic circuit and explain its functions	Teachers can • participate in discussions on basic theory of number systems to explore how the common decimal system is an expansion in powers of ten and the binary system in powers of two • use video presentations to illustrate logic gates. They are available from many scientific suppliers. ((Have we identified some for the Media Library)) • encourage students with an interest in computer programming to develop simple computer programs to illustrate logic gates. Example programs are available in many electronic hobbyist magazines. • enrichment topics in a discussion of logic gates could include combinatorial logic including the commutative laws, associative laws and distributive laws. Some students may be able to write Boolean expressions for the basic logic gates. • approach electrical contractors as a source for donations of used or surplus three-way switches • encourage students with an interest in computer logic and number systems to extend their inquiry to octal, hexadecimal and BCD numbers Students can • discuss a range of applications for simple logic gates, for example –car door light switches (opening either car door causes the interior light to illuminate) –three-way switches in homes which allow someone to control a light from switches at the top or bottom of a stairway • use *Electronic Workbench* to emulate basic logic circuits and record their results in a chart which shows a diagram of the logic gate, a schematic representation of it and measurements of voltage across the output terminals for each of the gates. Students could also include truth tables for each gate using their knowledge of binary numbers from the previous outcome

Digital Technology

Suggestions for Assessment	Resources and Notes
Students can • use computer graphics software, prepare graphics to illustrate gate circuits and display them as an HTML page on a website • construct a model of a residential three-way switch system using two switches to control a single light source	The *Math Studyworks* (Appendix D) has a section dealing with logic gates. Other information is available on their website (available from within the program)

- construct a set of devices for a team game which has a button in front of all players with a light which illuminates when the first player to press his button has his light illuminate while all the other players lights are blocked out. Several game shows have used this configuration (e.g., Reach for the Top or Jeopardy).
- construct truth tables for the basic logic gates
- prepare graphics for display in the classroom to illustrate the basic types of gate circuits
- construct block diagrams of the standard logic gates
  –AND gate
  –NOT gate
  –OR gate
  –NAND gate
  –NOR gate
  and combine them to represent an XOR gate
- construct electric circuits which represent the basic logic gates using switches, a lamp and a power source and write reports to summarize their work (Reference: *Essentials of Electronics*, 524-555) Students should include diagrams of their apparatus and schematic representations of the gates they build in their reports

- build and measure outputs for a complex logic circuit from simple gates which could include one or more of
  –adder circuit
  –parallel subtracter
  –comparator
  –seven segment LED display
  –binary to decimal decoder

- write a report or create a graphical representation that describes the basic logic gates as decision-making devices. Students should include diagrams, measurements of output, schematic diagrams, and a written description of the operation of the circuit in their reports. All these circuits can be constructed from inexpensive or readily available materials.
- search the Internet for school sites with projects on logic systems

An interesting website for teachers is the Contemporary Logic Design site, available at

An excellent site with tutorials on many aspects of solid-state electronics is found at Circuit Central

As well as tutorials on many topics dealing with digital electronics, there are many example circuits available which can form the basis of projects. It is recommended that teachers and students visit this site. It has a mailing list which will inform subscribers of updates to the site on a regular basis.

A link to a website with simulations of electronic devices can be found on the Electrotechnologies 11 website.

110100 100010,000100,000
$10^0 10^1 10^2 10^3$ $10^4 10^5$
Decimal System

12481632
$20^0 2^1 2^2 2^3 2^4 2^5$
Binary System

Digital Technology

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • distinguish between analog and digital systems • identify and describe the major components of a logic system such as a microcomputer system	Students can • participate in group discussions which examine a range of applications in electronics of analog systems and present the results of their investigations in class seminars. For example, the students could consider: –audio speakers –amplification –alternating current –video recorders The focus should be on phenomena which are continuously variable. • research a range of applications in electronics of digital systems, for example –switching circuits –computer memory –computer CPUs –programmable controllers The focus is on discrete phenomena. • Examine a microcomputer motherboard and identify the major logic components –random access memory (RAM) –read only memory (ROM) –central processing unit (CPU) –registers –input/output (I/O) ports Teachers can • collect discarded computer equipment from local businesses • encourage students to visit the websites of manufacturers of digital recording equipment

Digital Technology

Suggestion for Assessment

Students can

- present the results of their research in a variety of ways including
  –preparation of web pages to display the results
  –taped video presentations
  –charts and tables
  –seminars
  –presentation software
- describe in writing how digital technology can be made to emulate analog phenomena; for example, they might describe the recording and playback of audio CDs and compare the sound produced to the sound which was recorded
- draw block diagrams to represent the major components of a microcomputer system
- undertake a class project on the history of sound recording from Edison to the present, describing the transition from purely analog to digital technology
- describe in writing how digital technology can be made to emulate analog phenomena; for example, they might describe the recording and playback of audio CDs and compare the sound produced to the sound which was recorded
- draw block diagrams to represent the major components of a microcomputer system
- undertake a class project on the history of sound recording from Edison to the present, describing the transition from purely analog to digital technology

Teachers can

- display a range of computer components in the classroom and ask the students to identify them in writing and describe their use

Resources and Notes

There are many topics which a student could investigate that demonstrate the application of digital technology to analog phenomena
–sound recording
–video recording
–digital photography
–radio astronomy
–map making
–weather satellites

All these could stimulate students to create a meaningful project to demonstrate the value and application of digital techniques in everyday life. Most students are so used to digital technology that they take it for granted. It is important for them to discover and describe the approximations made when using digital methods to describe reality.

Digital Technology

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • identify the major integrated circuit (IC) families and describe their unique functions • identify and interface components with small scale integration IC families • identify components and construct a prototype of typical small scale and complex logic networks using integrated circuits	Students can • research manufacturing processes for solid state electronic devices and describe them in reports as single chips of silicon with entire circuits built upon them using atomic structures to emulate large scale electronic circuits. They can visualize integrated circuits as ordinary circuits on a molecular scale. • create diagrams to represent a diode as single PN (Positive-Negative) junction, formed by introducing negatively charged impurities into a layer of positively charged silicon ions, thereby restricting current flow through it to a single direction. From their diagrams students could conclude that the main purpose of diodes is to provide rectification. They can further generalize their diagrams in order visualize a transistor as a pair of PN junctions and visualize one of them use to control current flow through the other. • collect a selection integrated circuits (ICs) from a range of sources and prepare charts to illustrate their unique functions, for example –TTL –CMOS –DTL –RTL –MOS Teachers can • help students to demonstrate that diodes can be used as current flow control devices. For example, they could construct a full wave bridge circuit to show that current will always pass through a resistor in the same direction no matter what polarity the input may be. • provide the students with inexpensive transistors, for example, 2N2222 or 2N3906, 2N3904, and worksheets to demonstrate the use of transistors as switching devices. By inserting a lamp across the output and a variable resistor, controlled by temperature or light in the input, students can demonstrate that small input currents can effectively control large output currents.

Digital Technology

Suggestion for Assessment

Students can

- examine a range of ICs or classify them as monolithic and hybrid integrated circuits
- write reports to describe the use of integrated circuits in terms of their
  –size
  –cost
  –reliability
- prepare graphics to describe the various packaging formats for ICs
  –round
  –square
  –dual in-line
- explain in writing why integrated circuits operate at low voltages and currents
- using only 7400 series integrated circuits, construct actual circuits to simulate all the types of logic gates discussed in outcomes covered previously in this module:
  –AND gate
  –NOT gate
  –OR gate
  –NAND gate
  –NOR gate
- solve a digital problem and build a digital system for a solution (two or three inputs for a single output). For example, create a circuit using two input gates to make a three input gate
- examine a selection of ICs provided by the teacher and classify them as either analog or digital. Digital ICs contain switching circuitry whereas analogue ICs contain amplifying circuitry. Students can emulate a variety if ICs using *Electronic Workbench* to observe the waveforms across the output ports to determine the type of IC they are observing. They can further classify analog devices as Operational Amplifiers by locating them in a master reference text. They should examine a range of ICs large enough to include
  –voltage amplifiers
  –voltage comparators
  –linear power amplifiers
  –timers
- participate in group discussions to examine a range of integrated circuits and draw annotated diagrams showing the pinouts and function of any IC using IC master reference texts available from manufacturers or listed in the course resource list

Resources and Notes

Major manufacturers of solid-state devices maintain specification catalogues on their websites (Appendix B)

Many websites for example, NASA, JPL, deal with the history of technology in electronics.

Students may wish to investigate methods of production of IC devices. INTEL has valuable resources dealing with their particular strength, computer CPUs and memory.

If students show interest in the actual operation of transistors, for example, it may be worthwhile for them to examine the operation of a triode vacuum tube, if one can be found. The first transistors emulated the operation of triodes.

7400 series ICs are relatively inexpensive. Students could examine a range of integrated circuits from that family draw pinout diagrams by examining them and comparing them with published data from master reference texts, and label input and output ports and power connections.

Examples of circuits will be available on the Electrotechnologies 11 website.

MODULE 4: CONTROL SYSTEMS

Students investigate residential and industrial applications of control systems, determine the principles and processes which explain their function, and apply their knowledge in designing and constructing systems which solve real problems in built environments.

Control Systems

Students will be expected to formulate and apply the principles governing the forms and functions of control systems.

Outcomes	**Suggestion for Teaching and Learning**
Students will be expected to • describe a variety of everyday problems which are solved by control systems • identify how control systems are used in residential and commercial applications	Students can • research a range of applications for controls systems within their own homes. Their investigations may include doorbells, refrigerators, furnaces, fuel quantity measuring systems and other household or automotive devices. Students could draw block diagrams representing the major components of the control systems and write a note describing their workings in their journals. • participate in small group discussions aimed at describing the steps in the design of a simple control system. As the work in this module progresses, students could be aware of possible project topics which they might use to meet some of the outcomes dealing with control systems. • summarize processes used in industry which use control systems in their operation by a range of industries. • record voltage, resistance and current readings at various points in circuits which represent simple control systems, for example, door bells and buzzers and summarize their measurements in a lab report • examine various control systems directly using multimeters to measure changes in applied voltage and current and summarize their measurements in tables. Students should be aware that changing voltage and/or current in such systems can produce variable results. The variance should be described as the purpose of the control system. Teachers can • show a video which illustrates the operation of common devices using control systems, for example, refrigerators, heating and cooling systems, security systems, military target control systems, traffic control, pinball games, player pianos. Garage door openers, elevators, battery charging systems.

Control Systems

Suggestion for Assessment

Students can

- construct a model to demonstrate that electrical control systems operate by varying voltage and current to produce desired results
- visit a local home security company or appliance repair firm and create a video to illustrate their trip. Students could prepare questionnaires for company staff before the trip so that they could produce the video in the form of a documentary. They could design questions about the use and operation of control systems in the products the firm uses, sells or repairs. Some firms may allow the students to use demonstration models on their premises from which they can record data with their multimeters or other equipment. An activity such as this could be extended to encompass a project which would meet all the outcomes of this module.
- use software, for example, *Electronic Workbench*, to emulate and display operational circuit diagrams for control systems they have examined in class
- devise a plan to measure circuit variables in a range of control systems and use their measurements as a basis for describing their operation

Teachers can

- arrange for the school custodian to take the class on a tour of the school heating system. The students could prepare charts and questions in advance to ensure they find the answers to questions which are relevant to meet the outcomes for this module.
- ask students to identify possible uses of gate circuits (See Module 3) to operate control systems they examine
- respond to students' journal entries, responding to level of detail, accuracy, and evidence that the student has applied principles learned in previous modules in their explanations

Resources and Notes

Many educational sites on the Internet contain graphics suitable for inclusion in student projects (see Appendix B). Be sure to avoid copyright infringement when using graphics from the Internet or any other source.

Many electronic component manufacturers will provide free educational materials to teachers. Students can organize a letter-writing campaign soliciting materials.

Students could ask their teachers to arrange trips to local industries or draw information from corporate websites. Students share research information with other schools in different areas of the province by communicating through the Electrotechnologies 11 website (See Appendix B)

See the discussion of Design Teams in module 1 for more suggestions

See a discussion of the use of computer software in Module 1 and Appendix A

Control Systems

Outcomes	Suggestions for Teaching and Learning
Students will be expected to • explain how basic process control systems function • describe the operation of devices used for process control using standard terms • construct basic process control circuits using passive devices • distinguish between digital and analog systems	Students can examine a range of control systems to identify their components and describe the behaviours of a range of components used in control systems such as the following: • rectifiers (construct a rectifier circuit and examine the output on an oscilloscope or emulate it with *Electronic Workbench*) • silicon controlled rectifier (SCR)(build a simple colour organ and observe the changes in light intensity, or build a light dimmer circuit and observe the changes in light intensity) • transistors (build a simple amplifier or switching circuit to determine when a door or window is opened and measure the input current and compare it to the output current to show that a small input current produce a large change in output current) • triode, alternating current (TRIAC)(construct an AC motor speed control or light dimmer circuit and observe changes in speed and light intensity and observes changing in phase of the output waveform relative to the timing pulse which activates the TRIAC) • diode, alternating current (DIAC)(usually used in conjunction with TRIACS as trigger devices) • field effect transistor (FET)(construct a high input impedance amplifier circuits) • metal-oxide semiconductor field effect transistor (MOSFET) • timers (555 ICs)(construct a series of circuits including monostable and bistable and astable oscillators in time delay and pulse circuits) • OP amps (741 ICS) (construct circuits with a 741 ICS including a basic CD or current amplifier, a comparator or differentiators) • solid-state relays (construct devices to demonstrate that current can be switched without any moving parts, e.g., light control) • other special devices such as Hall effect devices (magnetic field detectors), condenser microphones Teachers can • provide working examples of as many types of control systems as possible

Control Systems

Suggestions for Assessment

Students can

- prepare tables to display the schematic symbol of a device, its name and operating features
- prepare wall charts with drawings or photographs of components which describe their application and use in control systems
- work co-operatively with groups of students in other schools over the Internet to share information gathered from firms and companies in other areas which may not be readily available in their own. For example, schools in an agricultural area could exchange the results of their trip to an agribusiness with schools who have visited a power generation facility. The partnership could begin in the planning stage with classes negotiating questions that both groups would like to have answered. The results could be extended to the creation of a webpage or mutually accessible forum in the Electrotechnologies website (see Appendix B for the URL). In some cases it make be possible to share experiences with schools in other countries through Internet contact.

Teachers can

- provide the students with functional diagrams of a range of systems to include
  –home heating control
  –sump pumps
  –lighting control
  –alarm systems
  –remote controls for TV and stereo systems
  –ask the students to identify the key components (input, process, output and feedback). For example, the student could analyze a sump pump as follows
  –input is water level sensor
  –process is activation of the motor on the pump
  –output is the water flowing out to the drain
  –feedback is the dropping of the float sensor and the pump turning off

Resources and Notes

When dealing with control systems, some teachers feel that they may never have enough resources to adequately address the outcomes of Electrotechnologies 11. However, the analogies drawn from Computer Aided Instruction (CAI) programs like *Electronic Workbench* can now provide learning experiences equal to real hands-on experimentation in many cases.

Students can use Electronic Workbench to examine a broad range of control systems and their components.

The *Math Studyworks* website maintains a series of forums designed to link schools. It is also possible to leave messages there requesting co-operation among schools and creating new forums.

Control Systems

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • describe the operation of devices used for process control using standard terms • construct basic process control circuits using passive devices • distinguish between digital and analog systems	Students can • examine a range of control systems and describe their operation using terms such as the following –precision –standard –calibration –accuracy –sensor –transducers –distortion –transients –sampling –interrupt –frequency Teachers can • facilitate the design process by providing function block circuits that may easily be connected using common terminals, For example, teachers could create –power supply blocks –timer blocks –amplifier blocks –buffer blocks –output and input devices to match the other block circuits • provide a collection of materials which students may adapt as input sensors, for example –clothes pins and washers as trip switches –conductive foam for pressure switches –lenses for focussing light –cables and wires with suitable connectors

Control Systems

Suggestion for Assessment

Students can

- identify and describe analog and sensor components used in process control for a range of control systems provided by the teacher including the following
  –thermistor
  –pressure sensor
  –photoelectric transducers
  –hall effect probes
  –opto couplers
  –bar code readers
  –light controlled resistors
  –light emitting diode (LED)
  –photo diode
  –photo transistor
  –proximity switches

Resources and Notes

Unilab and other suppliers provide modularized kits which contain block circuits, but they may be created locally with little expense of time and resources. Instead of purchasing kits, students could develop projects to construct modular blocks

Teachers and students might invite local company representatives to visit their classroom as guest speakers on control systems.

Field trips to local firms would provide students with opportunities to see control equipment in use.

Industry representatives could also be invited to talk to students about entry requirements and employment opportunities in related occupations.

Control Systems

Outcomes	Suggestions for Teaching and Learning
Students will be expected to • construct basic control systems to process input information in order to achieve a desired result	Students can work individually or in design teams to construct basic process control systems to illustrate energy conversion using passive and active devices, including the following • heat control circuits using thermistors to monitor temperature change or control the operation of a fan • conductive foam pressure sensor to activate a device when pressure is applied to it, for example a device to indicate when a car arrives at a gas pump at a service station • a device which will follow the sun using photo resistors and OPAMPs • rain detectors using a pressure sensor to determine when water appears in a container • fish finder using a thermistor to measure water temperature • a touch switch using a 555 IC • a device to turn on a dock light when a flashlight is shone on it • design a float switch to turn on a water pump when water level reaches a predetermined level • use a series of reed switches and a magnet to design a wind direction indicator • use photovoltaic cell to build a light meter for photography Students can work in design teams to construct a basic process control system using passive devices, such as the following • thermistor • pressure sensor • proximity switch • light control resistor • float switch • reed switch • photo cell Students can design laboratory experiments to t4est process control circuit(s) using factors such as voltage, current, continuity, opens, shorts, and use of multimeters.

Control Systems

Suggestions for Assessment

- Students can display their devices using a variety of methods, including

a showcase in science fair format
use presentation software to illustrate their selection of components
seminars

- Presentations should include schematics, block diagrams, justification for component selection, description of components, description of the electrical processes involved, and a discussion of limitations and suggestions for improvements they could make. They should also include a strategy for testing and verifying the operation of their process control circuit(s) using factors such as voltage, current, continuity, opens, and shorts

- Students can design or simulate a prototype mini control circuits for a specific application, for example
  –temperature control circuits
  –light control circuits
  –fluid level control circuits

Teams can present their work in a variety of ways including the following
preparation of webpages to display the results
- taped video presentations
- charts and tables
- seminars
- presentation software

Students can present the results of their laboratory experiments in lab reports which include
- diagrams
- schematics
- description of control system and its operation
- tables of measurements recorded
- conclusions drawn from these measurements

Resources and Notes

If suitable components are not available for bread boarding circuits, students can emulate all devices with *Electronic Workbench* (Appendix A).

Ideas for student projects can be found in many electronic magazines. *Radio Shack* produces a series of small *Engineers Mini Notebooks* which contain a wide variety of circuit examples as well as pinouts and specifications for inexpensive ICs.

Texts which contain project ideas include the following
Fred Blechman, *Simple Low Cost Electronic Projects*, Technology Publishing
Jones and Flynn, *Mobile Robots*, A.K. Peters
Gordon McComb, *Robot Builders Bonanza*, TAB Books, a division of McGraw Hill

Students learning can be enhanced by field trips to museums or companies that feature or design control systems.

Students could follow up such field trips with a journal entry or could develop reports in a variety of formats for presentation.

Control Systems

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • construct basic control systems to process input information in order to achieve a desired result	Students can dissemble and analyze control systems salvaged from equipment such as the following • discarded computer disk drives • washing machine timers • electric typewriters • dot matrix printers • electromechanical games like pinball machines or hockey games • salvaged weather balloon transmitters • photocopiers • garage door openers Teachers can devise a series of scenarios for students or design teams to undertake in a round robin competition to apply their problem solving skills in basic control systems. The instruction should include an object with a description of the desired objective or device to be constructed, materials to be used, limitations if any, and an evaluation criterion which will be applied. Example scenarios could include • the rapid pace of computer development has produced a great resource in form of unused or obsolete computer systems. Recycle an old system to serve as the controller for a robot arm including the computer program to do the manipulation. • design a device to climb up an inclined length of wire powered continuously and completely using only a 9 V battery. • many buildings, commercial, industrial, institutional and private are not easily accessible to persons confined to wheelchairs. Design a system to open doors and hold them open for use by such people. • design a device to climb to the top of a 30 or 40 degree incline and guard the 300mm square top against other climbing devices. Teachers can • provide salvage equipment containing control systems which students can disassemble and analyze

Control Systems

Suggestion for Assessment

- Students can create a table to illustrate the function and applications of various semiconductor components by prototyping mini control circuits in a range of applications, including
  –rectifiers
  –SCR
  –transistors
  –uni-junction transistor
  –TRIAC
  –DIAC
  –FET
  –JFET
  –MOSFET
  –timers (e.g., 555s)
  –operational amplifiers
  –solid-state relays

Teachers can

- assist students in developing projects to achieve the outcomes of this section. Topics can be taken from several texts available which present circuitry to be used in small electronic projects
- provide salvage equipment containing control systems which students can disassemble and analyze

Resources and Notes

Tutorials on many aspects of solid-state electronics maybe found at Circuit Central

As well as tutorials on many topics dealing with digital electronics, there are many example circuits available which can form the basic of projects. It is recommended that teachers and students visit this site. It has a mailing list which will inform subscribers of updates to the site on a regular basis.

Intel has a series of video tapes, *Journey Inside the Computer*, which are **free** to qualified teachers.

More sites are available on the Electrotechnologies 11 website.

MODULE 5: PROJECT

This module offers teachers and students considerable flexibility in developing learning experiences which meet the needs of individuals, and which give students practical experience in working with others in settings which resemble the workplace.

Project

Students may choose to work alone or in groups to extend, apply, or explore in depth ideas, issues or skills introduced in modules 1, 2, 3 and/or 4.

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • develop and refine a proposal for an inquiry or the development of a product or electronic device • identify information needs, locate and evaluate resources • identify and extend, refine and/or acquire required skills • share research and reflections made by themselves and their peers • make project decisions which demonstrate creativity, innovation, and a willingness to take risks	Students can • develop and present written proposals for projects they want to undertake. • generate lists of websites and other information sources they have investigated and include assessments of the value to their projects of the information from these sources • negotiate with the teacher to agree upon a list of skills to be acquired during project work. For example, it might be necessary to learn some HTML programming to present a report for the web. It might be necessary for a student to learn how to use a piece of computer software like *Electronic Workbench* in order to demonstrate an electronic principle. Another student might need to learn about a type of gate circuit not covered in the Digital Technology module in order to build a control system • participate in discussions with their peers and make suggestions for improvement. Students may discover strategies which may be useful in their own projects. • if a project is being done by a team then students should work with others to encourage peers, suggest and assess solutions, and resolve research tasks Teachers can • help students find a project focus • provide topics lists (See Appendix F) • identify high school student websites which display or report on related projects • work with students to ensure that their suggestions from projects are within the scope of Electrotechnologies 11; for example, a student might suggest a project involving Internet website construction as a presentation tool and devote most of his/her effort to learning HTML programming instead of to the electronics outcomes of Electrotechnologies 11.

Project

Suggestion for Assessment

Some students may suggest projects that exceed their ability to complete. Teachers should suggest ways to help the student design a project for which they have a fair chance of success. However, students must also be given the chance to undertake projects which lead to mixed results. Such risk-taking on the part of students should not go unrewarded. Students learn valuable lessons in the process of problem solving. Teachers must, therefore, monitor students' progress carefully during project work so that assessments support the learning process as well as the results.

Students can

- work with the teacher to develop criteria to be used in the evaluation of their projects
- maintain a journal or portfolio throughout the development of their projects. They could record agreements made with the teacher about goals they would reach at several stages in the development of their projects in order that the teacher can monitor their progress and provide timely feedback
- participate in discussions about the projects of other students and provide comments and suggestions for their improvement
- critique electrotechnology project designs of their own creation and/or those offered by peers using criteria which focus on a growing understanding of the relationship between the products, humans, and design
- students should select or develop criteria which can be used to evaluate their projects according to their individual strengths and weaknesses

Teachers can

- provide students with a rubric to use as a basis for negotiating expectations for project work (An example of such a rubric is included in Appendix L
- monitor student progress and provide feedback at regular intervals
- prepare assessment materials for students who need to acquire skills not directly associated with Electrotechnologies 11. For instance, if a student has had to learn some HTML programming, the teacher may ask the student to build a simple Web page as a demonstration of his/her competence

Resources and Notes

Project work is a critical component of Electrotechnologies 11. Project work may be undertaken as a separate unit in its own time block, if the project is substantial enough to require 25-30 hours of instructional time, or project work may be integrated with the other units of Electrotechnologies 11 as either a continuing project or a series of smaller projects.

Project work provides an opportunity for students to investigate topics of particular interest while working toward achievement of curriculum outcomes in the context of particular modules or to apply and extend their learning from those modules.

Project topics should be engaging for the students and should afford opportunities for independent research as well as group investigations. Teachers and students should be aware of the Internet Access and Use Policy. While the Internet provides access to a wealth of information, it also facilitates plagiarism. The help students avoid this temptation, teachers can
encourage topics with unique and original features
require students to maintain daily journals of their work
monitor students' progress on a regular basis

Project

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • set deadlines and develop a work plan to manage time and resources • develop a plan for monitoring their progress and judging success and contribute to the criteria used for evaluation	Students can • learn to use a project management tool such as *Microsoft Project* to create a plan for completion of their projects. As with any software, teachers should help them to realize that operating software is in most cases a tool to accomplish specific goals and should not become so important to the student that it hinders the achievement of project goals • present the teacher with a written plan for completing project showing time lines, tools to be used and presentation materials under consideration Teachers can • work co-operatively with design teams or individuals to develop a plan that represents an appropriate challenge for that team or individual • make project management software available to students if possible • encourage students to visit websites which deal specifically with time management

Project

Suggestion for Assessment

Students can

- establish a production schedule
- include calendars in their journals to track their progress
- if using project management software, include printed copies of the current schedule in their journals

Teachers can

- conduct regular production meetings with teams or individuals
- monitor student progress and success in meeting their time lines by examining their journals frequently
- provide constructive feedback and suggestions to students who may be falling behind in their schedules. In some cases the project goals may have to be modified as the project proceeds. The ability of students to deal with necessary changes could form part of the teacher's evaluation.

Resources and Notes

Many project management software programs are available ranging in value from shareware to very expensive program suites designed for corporate use. Teachers should be reasonably familiar with the software in order to give students appropriate support.

Here are some examples

Microsoft Project
Time Wizard from AC Software
Captor

Teachers could also use spreadsheet programs to track time use, for example, *Microsoft Excel*.

Project

Outcomes	Suggestions for Teaching and Learning
Students will be expected to • gather, organize, and synthesize information and ideas • use their knowledge and skills to conduct an inquiry or create a product or electronic device	Students can • keep journals to record their progress, identify their learning needs and monitor deadlines • comment on the work of other students during seminars arranged by the teacher to provide useful feedback • collate the information they collect in an organized manner. For example, they may use a software database program such as *Microsoft Access* to maintain their information. Possible data columns for the purpose might be –date –source –information –applicability –binary information such as images • follow appropriate safety practices Teachers can • monitor the use of software to ensure that it is used to support the students' project investigations only, and not become so time consuming as to interfere with students' achieving their goals

Project

Suggestions for Assessment

Students can

- keep written or electronic records of information they have gathered or products and devices they are building
- discuss their progress with the teacher on a regular basis

Teachers can

- read student journals or software records regularly and offer feedback
- assess students' use of resources and suggest alternatives
- monitor students' use of safe laboratory practices for those involved in construction of electronic devices
- model constructive response and specific feedback
- define roles in design teams and clarify responsibilities as appropriate
- facilitate peer assessment sessions
- conduct regular seminars so that students can benefit from reviewing the work of others
- encourage students to participate in peer assessment
- assist students' in making appropriate use of their peers' feedback and suggestions

Resources and Notes

With the wealth of tools available to students for project work, teachers must monitor work closely to ensure that time on task is effective. Internet searches and the use of software can become ends in themselves distracting students from the focus of their project work.

Project

Outcomes	Suggestion for Teaching and Learning
Students will be expected to • present the results of their investigation or product • reflect on and assess their own learning and the learning of others	Students can present their projects in one of several ways, for example • written presentations • class oral or multimedia presentations • demonstration or showcase, for example a science fair or museum exhibit • dramatization; for example, a group of students could present a drama illustrating the stages in the development of the micro chip. It could be interesting for them to relate the work of people at Bell Labs and other research institutions to their own lives through drama. Students might also want to examine the environmental impact of a scientific development by staging a mock trial of a company that develops a product which endangers the environment or impinges a copyright. • media presentations using presentation software such as *Microsoft Powerpoint, Avid Cinema, or Hyperstudio* Teachers can • invite other staff members or members of the community to observe presentations and evaluate them according to questionnaires generated by the teacher and the students • encourage students to relate their project work to local resources so their work will have meaning in their personal lives

Project

Suggestion for Assessment

Students can

- contribute insight and constructive feedback to peers and apply the response and comments of peers and teachers to their own development
- discuss aspects of their project according to specific criteria
- in presentations, and assess the effectiveness of the techniques they use to engage the audience
- elaborate critically the selection of materials, presentation format, and organization of their own presentations and those peers

Teachers can

- revisit with students the criteria negotiated for evaluation of their projects
- read and respond to reports generated by students
- ask students to identify, and consider the role played by the principles of electrotechnology in their projects
- examine student journals, looking for coherent and detailed notes of their growth towards new knowledge and proficiency in choosing and using electronic tools and devices
- monitor student use of relevant terminology to clearly articulate and defend project decisions
- assess and provide feedback on student successes at critiquing peer projects fairly and meaningfully
- assess the materials selected by students to share and defend decisions with an audience of peers (REPHRASE)
- evaluate the quality of organization in project presentations, looking for clarity and the capacity of the presentation to inform and hold an audience's attention.
- assess presentation techniques, determining student decisions to select the most appropriate vehicle through which to present their project accomplishments
- observe, and when possible participate in, presentations to determine the overall effectiveness of the presentation and project success

Resources and Notes

Teachers should encourage students to go further with their project work than originally planned if they find information which may help them in career planning. For example, if students are doing a project on nuclear accelerators, the chances of making that currently relevant are small, but they may be interested in it in postsecondary studies in the field.

Contexts for Learning and Teaching

Principles of Learning

The public school program is based on principles of learning that teachers and administrators should use as the basis of the experiences they plan for their students. These principles include the following:

1. **Learning is a process of actively constructing knowledge.**

   Therefore, teachers and administrators have a responsibility to

   - create environments and plan experiences that foster inquiry, questioning, predicting, exploring, collecting, educational play, and communicating
   - engage learners in experiences that encourage their personal construction of knowledge, for example, hands-on, minds-on science and math; drama; creative movement; artistic representation; writing and talking to learn
   - provide learners with experiences that actively involve them and are personally meaningful

2. **Students construct knowledge and make it meaningful in terms of their prior knowledge and experiences.**

   Therefore, teachers and administrators have a responsibility to

   - find out what students already know and can do
   - create learning environments and plan experiences that build on learners' prior knowledge
   - ensure that learners are able to see themselves reflected in the learning materials used in the school
   - recognize, value, and use the great diversity of experiences and information students bring to school
   - provide learning opportunities that respect and support students' racial, cultural, and social identity
   - ensure that students are invited or challenged to build on prior knowledge, integrating new understandings with existing understandings

3. **Learning is enhanced when it takes place in a social and collaborative environment.**

   Therefore, teachers and administrators have a responsibility to

   - ensure that talk, group work, and collaborative ventures are central to class activities

- see that learners have frequent opportunities to learn from and with others
- structure opportunities for learners to engage in diverse social interactions with peers and adults
- help students to see themselves as members of a community of learners

4. **Students need to continue to view learning as an integrated whole.**

   Therefore, teachers and administrators have a responsibility to

   - plan opportunities to help students make connections across the curriculum and with the world outside and structure activities that require students to reflect on those connections
   - invite students to apply strategies from across the curriculum to solve problems in real situations

5. **Learners must see themselves as capable and successful.**

   Therefore, teachers and administrators have a responsibility to

   - provide activities, resources, and challenges that are developmentally appropriate to the learner
   - communicate high expectations for achievement to all students
   - encourage risk-taking in learning
   - ensure that all students experience genuine success on a regular basis
   - value experimentation and treat approximation as signs of growth
   - provide frequent opportunities for students to reflect on and describe what they know and can do
   - provide learning experiences and resources that reflect the diversity of the local and global community
   - provide learning opportunities that develop self-esteem

6. **Learners have different ways of knowing and representing knowledge.**

   Therefore, teachers and administrators have a responsibility to

   - recognize each learner's preferred ways of constructing meaning and provide opportunities for exploring alternative ways
   - plan a wide variety of open-ended experiences and assessment strategies
   - recognize, acknowledge, and build on students' diverse ways of knowing and representing their knowledge

- structure frequent opportunities for students to use various art forms—music, drama, visual arts, dance, movement, crafts—as a means of exploring, formulating, and expressing ideas

7. **Reflection is an integral part of learning.**

   Therefore, teachers and administrators have a responsibility to

   - challenge their beliefs and practices based on continuous reflection
   - reflect on their own learning processes and experiences
   - encourage students to reflect on their learning processes and experiences
   - encourage students to acknowledge and articulate their learnings
   - help students use their reflections to understand themselves as learners, make connections with other learnings, and proceed with learning

A Variety of Learning Styles and Needs

Learners have many ways of learning, knowing, understanding, and creating meaning. Research into links between learning styles and preferences and the physiology and function of the brain has provided educators with a number of helpful concepts of and models for learning. Howard Gardner, for example, identifies eight broad frames of mind or intelligences: linguistic, logical/mathematical, visual/spatial, body/kinesthetic, musical, interpersonal, intra personal, and naturalistic. Gardner believes that each learner has a unique combination of strengths and weaknesses in these eight areas, but that the intelligences can be more fully developed through diverse learning experiences. Other researchers and education psychologists use different models to describe and organize learning preferences.

Students' ability to learn is also influenced by individual preferences and needs within a range of environmental factors, including light, temperature, sound levels, nutrition, proximity to others, opportunities to move around, and time of day.

How students receive and process information and the ways they interact with peers and their environment, in specific contexts, are both indicators and shapers of their preferred learning styles. Most learners have a preferred learning style, depending on the situation and the type and form of information the student is dealing with, just as most teachers have a preferred teaching style, depending on the context. By reflecting on their own styles and preferences as learners and as teachers in various contexts, teachers can

- build on their own teaching-style strengths

- develop awareness of and expertise in a number of learning and teaching styles and preferences
- identify differences in student learning styles and preferences
- organize learning experiences to accommodate the range of ways in which students learn, especially for whom the range of ways of learning is limited

Learning experiences and resources that engage students' multiple ways of understanding allow them to become aware of and reflect on their learning processes and preferences. To enhance their opportunities for success, students need

- a variety of learning experiences to accommodate their diverse learning styles and preferences
- opportunities to reflect on their preferences and the preferences of others to understand how they learn best and that others may learn differently
- opportunities to explore, apply, and experiment with learning styles other than those they prefer, in learning contexts that encourage risk taking
- opportunities to return to preferred learning styles at critical stages in their learning
- opportunities to reflect on other factors that affect their learning, for example, environmental, emotional, sociological, cultural, and physical factors
- a time line appropriate for their individual learning needs within which to complete their work

The Senior High School Learning Environment

Creating Community

To establish the supportive environment which characterizes a community of learners, teachers need to demonstrate a valuing of all learners, illustrating how diversity enhances the learning experiences of all students, for example, by emphasizing courtesy in the classroom through greeting students by name, thanking them for answers, and inviting, rather than demanding participation. Students could also be encouraged to share interests, experiences, and expertise with one another.

Students must know one another in order to take learning risks, make good decisions about their learning, and build peer partnerships for tutoring, sharing, cooperative learning, and other collaborative learning experiences. Through mini-lessons, workshops, and small-group dynamic activities during initial classes, knowledge is shared about individual learning styles, interpersonal skills, and team building.

The teacher should act as a facilitator, attending to both active and passive students during group activities, modelling ways of drawing everyone into the activity as well as ways of respecting and valuing each person's contribution, and identifying learners' strengths and needs for future conferences on an individual basis.

Having established community within the classroom, the teacher and students together can make decisions about learning activities. Whether students are working as a whole class, in small groups, in triads, in pairs, or individually, teachers should

- encourage comments from all students during whole class discussion, demonstrating confidence in and respect for their ideas
- guide students to direct questions evenly to members of the group
- encourage students to discover and work from the prior knowledge in their own social, racial or cultural experiences
- encourage questions, probing but never assuming prior knowledge
- select partners or encourage students to select different partners for specific purposes
- help students establish a comfort zone in small groups where they will be willing to contribute to the learning experience
- observe students during group work, identifying strengths and needs, and conference with individuals to help them develop new roles and strategies
- include options for students to work alone for specific and clearly defined purposes

Engaging All Students

A supportive environment is important for all learners and is especially important in encouraging disengaged or underachieving learners.

Electrotechnologies 11 provides new opportunities to engage students who lack confidence in themselves as learners, who have a potential that has not been realized, or whose learning has been interrupted, for example refugees. These students may need substantial support in gaining essential knowledge and skills and in interacting with others.

Students need to engage fully in learning experiences that

- are perceived as authentic and worthwhile
- build on their prior knowledge
- allow them to construct meaning in their own way, at their own pace
- link learning to understanding and affirming their own experiences
- encourage them to experience ownership and control of their learning
- feature frequent feedback and encouragement

- include opportunities for teachers and others to request and receive clarification and elaboration
- are not threatening or intimidating
- focus on successes rather than failures
- are organized into clear, structured segments

It is important that teachers design learning experiences that provide a balance between challenge and success, and between support and autonomy.

All students benefit from a variety of grouping arrangements that allow optimum opportunities for meaningful teacher-student and student-student interaction. An effective instructional design provides a balance of the following grouping strategies:

- large-group or whole-class learning
- teacher-directed small-group learning
- small-group-directed learning
- co-operative learning groups
- one-to-one teacher-student learning
- independent learning
- partnered learning
- peer or cross-age tutoring
- mentoring

Health and Safety

Activities in shop, laboratory, or workplace settings should include an element of safety education. Teachers should plan learning experiences with a specific safety focus, and also embed safe practices in classroom procedures and routines in order that students may acquire

- a strong orientation toward both personal and group safety
- an awareness of potential safety hazards at school and in the workplace
- a knowledge of safety procedures and safe work habits
- a knowledge of emergency procedures
- the ability to design and maintain safe work areas

Learning Beyond the Classroom

Electrotechnologies 11 offers many opportunities for students to extend learning beyond the classroom. Alternative settings provide students with opportunities to connect their learning to tangible, practical purposes, their future education and career plans, and the world beyond the high school setting.

Teachers may choose to organize learning experiences which include workplace settings for some or all students. Learning experiences may include

- practices and procedures to encourage students to use technology properly and with care
- activities with mentors
- classroom visits from workplace experts
- field trips to local business, industry, and community sites
- a focus on career exploration through job shadowing
- work placements which extend and reinforce learning
- entrepreneurship-related projects
- community and service learning projects
- use of Internet listservs, newsgroup, bulletin board, and on-line conversations

It is important that administrators and teachers work to establish mutually beneficial relationships with businesses, organization, and industries in the community. Class or group field trips are an effective way to initiate the contact. In organizing field trips teachers should

- visit the facility beforehand to identify potential safety issues, establish a relationship with personnel, and clarify the purposes of the trip
- work with students to articulate clear expectations for learning during the field trip experience
- schedule field trips to complement preceding and subsequent classroom learning experiences
- ensure that the field trip complies with their Board's guidelines and policies
- establish class practices and procedures that promote positive and ongoing community relationships

Meeting the Needs of All Students

Learners require inclusive classrooms, where a wide variety of learning experiences ensure that all students have equitable opportunities to reach their potential.

In designing learning experiences, teachers must accommodate the learning needs of individuals, and consider the abilities, experiences, interests, and values which they bring to the classroom.

In recognizing and valuing the diversity of students, teachers should consider ways to

- create a climate and design learning experiences to affirm the dignity and worth of all learners in the classroom community
- give consideration to the social and economic situations of all learners
- model the use of inclusive language, attitudes, and actions supportive of all learners
- acknowledge racial and cultural uniqueness

- adapt classroom organization, teaching strategies, assessment practices, time, and learning resources to address learners' needs and build on their strengths
- provide opportunities for learners to work in a variety of contexts, including mixed-ability groupings
- identify and utilize strategies and resources that respond to the range of students' learning styles and preferences
- build on students' individual levels of knowledge, skills, and attitudes
- design learning and assessment tasks that draw on learners' strengths
- use students' strengths and abilities to motivate and support their learning
- provide opportunities for students to make choices that will broaden their access to a range of learning experiences
- acknowledge the accomplishment of learning tasks, especially those that learners believed were too challenging for them

In a supportive learning environment, all students receive equitable access to resources, including the teacher's time and attention, technology, learning assistance, a range of roles in group activities, and choices of learning experiences when options are available.

All students are disadvantaged when oral, written, and visual language creates, reflects, and reinforces stereotyping. Teachers promote social, cultural, racial, and gender equity when they provide opportunities for students to critically examine the texts, contexts, and environments associated with Electrotechnologies 11 in the classroom, in the community, and in the media. Teachers should look for opportunities to

- promote critical thinking
- recognize knowledge as socially constructed
- model gender-fair language and respectful listening in all their interactions with students
- articulate high expectations for all students
- provide equal opportunity for input and response from all students
- encourage all students to assume leadership roles
- ensure that all students have a broad range of choice in learning and assessment tasks
- encourage students to avoid making decisions about roles and language choices based on stereotyping
- include the experiences and perceptions of all students in all aspects of their learning
- recognize the contributions of men and women of all social, cultural, linguistic, and racial backgrounds to all disciplines throughout history

Social and cultural diversity in student populations expands and enriches the learning experiences of all students. Students can learn much from the backgrounds, experiences, and perspectives of their classmates. In a community of learners, participants explore the diversity of their own and others' customs, histories, values, beliefs, languages, and ways of seeing and making sense of the world.

When learning experiences are structured to allow for a range of perspectives, students from varied social and cultural backgrounds realize that their ways of seeing and knowing are not the only ones possible. They can come to examine more carefully the complexity of ideas and issues arising from the differences in their perspectives and understand how cultural and social diversity enrich their lives and their culture.

The curriculum outcomes designed for Electrotechnologies 11 provide a framework for a range of learning experiences for all students.

Teachers must adapt learning contexts, including environment, strategies for learning and strategies for assessment, to provide support and challenge for all students, using curriculum outcomes to plan learning experiences appropriate to students' individual learning needs. When these changes are not sufficient for a student to meet designated outcomes, an individual program plan is required. For more detailed information, see *Special Education Policy Manual (1996)*, Policy 2.6.

A range of learning experiences, teaching and learning strategies, resources, and environments provide expanded opportunities for all learners to experience success as they work toward the achievement of designated outcomes` Many of the learning experiences suggested in this guide provide access for a wide range of learners, simultaneously emphasizing both group support and individual activity. Similarly, the suggestions for a variety of assessment practices provide multiple ways for students to demonstrate their achievements.

In order to provide a range of learning experiences to challenge all students, teachers may adapt learning contexts to stimulate and extend learning. Teachers should consider ways that students can extend their knowledge base, thinking processes, learning strategies, self-awareness, and insights. Some learners can benefit from opportunities to negotiate their own challenges, design their own learning experiences, set their own schedules, and work individually or with learning partners.

Some students' learning needs may be met by opportunities for them to focus on learning contexts which emphasize experimentation, inquiry, and critical and personal perspectives; in these contexts, teachers should work with students to identify and obtain access to appropriate resources.

The Role of Technology

Vision for the Integration of Information Technologies

The Nova Scotia Department of Education has articulated five components to the learning outcomes framework for the integration of IT within curriculum programs:

1. **Basic Operations and Concepts**
   concepts and skills associated with the safe, efficient operation of a range of information technologies

2. **Productivity Tools and Software**
   the efficient selection and use of IT to perform tasks such as

   - the exploration of ideas
   - data collection
   - data manipulation, including the discovery of patterns and relationships
   - problem solving
   - the representation of learning

3. **Communications Technology**
   the use of specific, interactive technologies which support collaboration and sharing through communication

4. **Research, Problem Solving, and Decision Making**
   the organization, reasoning, and evaluation by which students rationalize their use of IT

5. **Social, Ethical, and Human Issues**
   that understanding associated with the use of IT which encourages in students a commitment to pursue personal and social good, particularly to build and improve their learning environments and to foster stronger relationships with their peers and others who support their learning

Integrating Information and Communication Technologies within the Classroom

As information technologies shift the ways in which society accesses, communicates, and transfers information and ideas, they inevitably change the ways in which students learn.

Students must be prepared to deal with an information and communications environment characterized by continuous, rapid change, an exponential growth of information, and expanding opportunities to interact and interconnect with others in a global context.

Because technologies are constantly and rapidly evolving, it is important that teachers make careful decisions about applications, always in relation to the extent to which technology applications help students to achieve the curriculum outcomes.

Technology can support learning for the following specific purposes.

Inquiry

Theory Building: Students can develop ideas, plan projects; track the results of growth in their understanding, develop dynamic, detailed outlines; and develop models to test their understanding using software and hardware for modelling, simulation, representation, integration, and planning.

Data Access: Students can search for and access documents, multimedia events, simulations, and conversations through hypertext/hypermedia software; digital, CD-ROM, and Internet libraries, and databases.

Data Collection: Students can create, obtain, and organize information in a range of forms, using sensing, scanning, image and sound recording and editing technology, databases, spreadsheets, survey software, and Internet search software.

Communication

Media Communication: Students can create, edit, and publish, present, or post documents, presentations, multi-media events, Web pages, simulations, models, and interactive learning programs, using word processing, publishing, presentation, Web page development, and hypertext software.

Interaction/Collaboration: Students can share information, ideas, interests, concerns, and questions with others through e-mail; Internet audio, video, and print conferences; information servers; Internet news groups and listservs; and student-created hypertext environments.

Teaching and Learning: Students can acquire, refine and communicate ideas, information, and skills using tutoring systems and software, instructional simulations, drill and practice software, and telementoring systems.

Expression

Students can shape the creative expression of their ideas, feelings, insights, and understandings using graphic software, music making, composing, editing and synthesizing technology; interactive video and hyper media, animation software; multimedia composing technology; sound and light control systems and software; and video and audio recording and editing technology.

The Role of Technology in Electrotechnologies 11

Electrotechnologies 11 uses technology to illustrate how the world around us may be adapted to human needs by

- creating electronic and electro-mechanical devices for our use
- managing and assisting human production processes
- using or controlling aspects of our natural environment

Students need to understand the connections among these areas and how they interact with one another and with society as a whole.

The study of electronic and electro-mechanical devices requires students to design and build a variety of devices using different types of tools and equipment and a wide range of materials. They also study the uses made of various devices and their effects on society and the environment.

Students analyze and learn about a range of human production processes and undertake projects that require them to design, develop, and use examples of such processes. In doing so, they take account of the impact of the processes on individuals, the environment, and society as a whole.

Students analyze and learn about different environmental systems and the technologies that enable us to use or modify those systems to suit our own purposes. They also examine the impact of technology on the natural environment. They learn about both the beneficial and the harmful effects and the short-term and long-term consequences of various types of technological intervention.

Assessing and Evaluating Student Learning

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 judgements or decisions based upon the information gathered.

The Principles of Assessment and Evaluation articulated in the document *Public School Programs* should be used as the basis of assessment and evaluation, policies, procedures, and practices.

Using a Variety of Assessment Strategies

When teachers make decisions about what learning to assess and evaluate, how to assess and evaluate, and how to communicate the results, they send clear messages to students and others about what learning they value; for example, teachers can communicate that they value risk taking or lateral thinking by including these elements in determining marks.

Assessment involves the use of a variety of methods to gather information about a wide range of student learning and to develop a valid and reliable snapshot of what students know and are able to do that is clear, comprehensive, and balanced. The assessment process provides information about each student's progress toward achievement of learning outcomes that teachers can use to assign marks, to initiate conversations with students, or to make decisions in planning subsequent learning experiences.

Teachers align assessment and evaluation practices with student-centred learning practices when they

- design assessment and evaluation tasks that help students make judgements about their own learning and performance
- provide assessment and evaluation tasks that allow for a variety of learning styles and preferences
- individualize assessment and evaluation tasks to accommodate specific learning needs
- work with students to describe and clarify what will be assessed and evaluated and how it will be assessed and evaluated
- provide students with regular, specific, frequent, and consistent feedback on their learning

Assessment activities, tasks, and strategies include, for example,

- anecdotal records
- artifacts
- audiotapes
- certifications
- checklists
- conferences
- demonstrations
- dramatizations
- exhibitions
- interviews (structured or informal)
- inventories
- investigations
- learning logs or journals
- media products
- observations (structured or informal)
- peer assessments
- performance tasks
- portfolios
- presentations
- projects
- questioning
- questionnaires
- quizzes, tests, examinations
- rating scales
- reports
- reviews of performance
- self-assessments
- sorting scales (rubrics)
- surveys
- videotapes
- work samples
- written assignments

Involving Students in the Assessment Process

When students are aware of the outcomes they are responsible for and the criteria by which their work will be assessed or evaluated, they can make informed decisions about the most effective ways to demonstrate they know, are able to do, and value.

It is important that students participate actively in the assessment and evaluation of their learning, developing their own criteria and learning to judge a range of qualities in their work. Students should have access to models in the form of scoring criteria, rubrics, and work samples.

As lifelong learners, students assess their own progress, rather than relying on external measures, for example marks, to tell them how well they are doing. Students who are empowered to assess their own progress are more likely to perceive their learning as its own reward. Rather than asking What does the teacher want? students need to ask questions such as What have I learned? What can I do now that I couldn't do before? What do I need to learn next?

Effective assessment practices provide opportunities for students to

- reflect on their progress toward achievement of learning outcomes
- assess and evaluate their learning
- set goals for future learning

Diverse Learning Styles and Needs

Teachers should develop assessment practices which affirm and accommodate students' cultural and linguistic diversity. Teachers should consider patterns of social interaction, diverse learning styles, and the multiple ways oral, written, and visual language are used in different cultures for a range of purposes. Student performance takes place not only in a learning context, but in a social and cultural context as well.

Assessment practices must be fair, equitable, and without bias, providing a range of opportunities for students to demonstrate their learning.

Teachers should be flexible in evaluating the learning success of students, and seek diverse ways for students to demonstrate their personal best. In inclusive classrooms, students with special needs have opportunities to demonstrate their learning in their own way, using media which accommodate their needs, and at their own pace.

Portfolios

A major feature of assessment and evaluation in Electrotechnologies 11 is the use of portfolios. A portfolio is a purposeful selection of a student's work that tells the story of the student's efforts, progress, and achievement.

Portfolios engage students in the assessment process and allow them to participate in the evaluation of their learning. Portfolios are most effective when they provide opportunities for students to reflect on and make decisions about their learning. The students and teacher should collaborate to make decisions about the contents of the portfolio and to develop the criteria for evaluating the portfolio. Portfolios should include

- the guidelines for selection
- the criteria for judging merit
- evidence of student reflection

Portfolio assessment is especially helpful for the student who needs significant support. Teachers should place notes and work samples from informal assessment in the portfolio and use the portfolio to collaborate with the student in identifying strengths and needs, selecting learning experiences, and selecting work that best reflects the student's progress toward achievement of learning outcomes.

It is important that students share their portfolios with other students so that all students may see exemplars that represent a range of strategies for expression and levels of complexity in ideas and understanding.

Outlines and other evidence of planning, along with multiple revisions, allow students to examine their progress and demonstrate achievement to teachers, parents, and others.

Students should be encouraged to develop a portfolio which demonstrates their achievements in a context beyond a particular course, including letters, certificates, and photographs, for example, as well as written documents. A career portfolio can be very helpful when students need to demonstrate their achievements to potential employers or admission offices of post-secondary institutions.

Tests and Examinations

Traditional tests and examinations are not, by themselves, adequate to assess student learning. The format of tests and examinations can be revised and adapted to reflect key aspects of the curriculum. Some teachers, for example, have designed tests and examinations based on collaborative or small-group learning, projects, or portfolio learning. Creating opportunities for students to collaborate on a test or examination is an effective practice in the interactive classroom, when assessing learning of a higher order than recall of information, for example, learning that requires synthesis, analysis, or evaluation.

In learning activities that involve responding to a text or solving a problem, for example, students might work collaboratively to clarify and define the task, and then work either collaboratively or individually to develop an answer. Students might be given a range of questions, issues, or problems, and work collaboratively to clarify their understanding of the assignments and plan responses in preparation for the examination for which only one of the questions, issues, or problems will be assigned. The initial list of questions, issues, or problems can be developed by the teacher, negotiated by the teacher with students, or developed by students and screened by the teacher.

Process-based tests and examinations allow students demonstrate knowledge and skills and apply strategies at multiple stages in learning processes, for example, in creating texts; responding to texts or issues; solving problems; or gathering, evaluating, and synthesizing information.

Traditional tests and examinations may present a number of problems in scheduling and resource allocation. Process-based tests and examinations may be undertaken in steps during several class periods over a number of days. Students have opportunities to revise, reflect on, and extend their knowledge and understanding. Teachers have opportunities to develop comprehensive assessments, to monitor and evaluate learning at multiple points in a process, and to use time flexibly.

Certification and Credentialling

In Electrotechnologies 11, students will need to prepare to demonstrate their learning through entrance tests and examinations, or to obtain or upgrade a certification. Replicating this type of assessment in the classroom can help students prepare for the conditions and assessment formats they may encounter in workplace and post-secondary situations.

To make this kind of assessment an effective learning experience, teachers should define a specific context and purpose, for example, the operation of a device, the identification of materials labels, or the demonstration of a technique or procedure.

Effective Assessment and Evaluation Practices

Effective assessment improves the quality of learning and teaching. It can help students to become more reflective and to have control of their own learning, and it can help teachers to monitor and focus their instructional programs.

Assessment and evaluation of student learning should accommodate the complexity of learning and reflect the complexity of the curriculum. Evaluation should be based on the full range of learning outcomes towards which students have been working during the reporting period, be proportionate to the learning experiences related to each outcome, and focus on patterns of achievement as well as specific achievement.

In reflecting on the effectiveness of their assessment program, teachers should consider the extent to which their practices

- are fair in terms of the student's background or circumstances
- are integrated with learning
- provide opportunities for authentic learning
- focus on what students can do rather than on what they cannot do
- provide students with relevant, supportive feedback that helps them to shape their learning

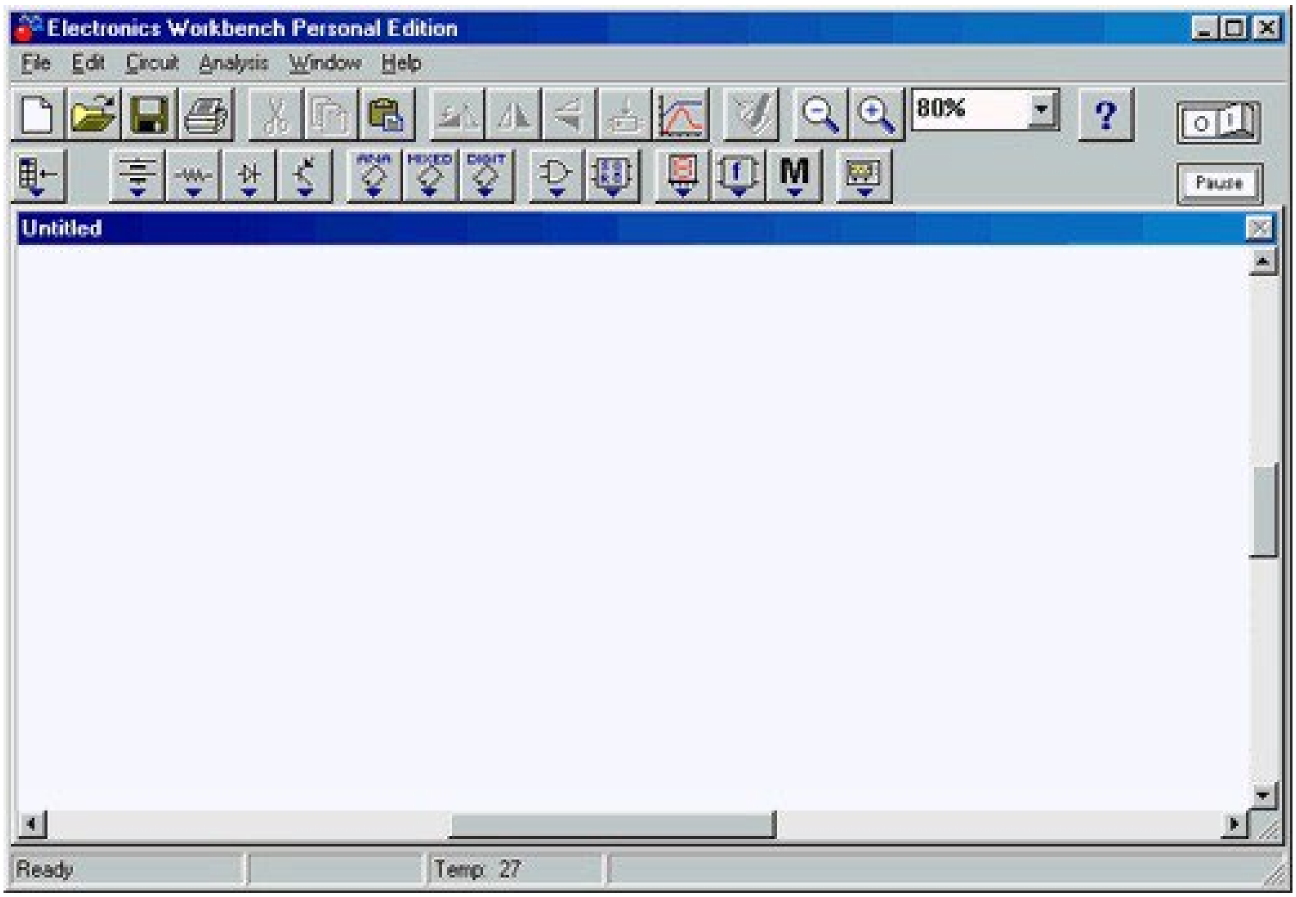
- describe students' progress toward learning outcomes
- help them to make decisions about revising, supporting, or extending learning experiences
- support learning risk taking
- provide specific information about the processes and strategies students are using
- provide students with diverse and multiple opportunities to demonstrate their achievement
- provide evidence of achievement in which students can take pride
- acknowledge attitudes and values as significant learning outcomes
- encourage students to reflect on their learning and to articulate personal learning plans
- help them to make decisions about teaching strategies, learning experiences and environments, student grouping, and resources
- accommodate multiple responses and a range of tasks and resources
- include students in developing, interpreting and reporting on assessment

APPENDICES

Appendix A: Using Electronic Workbench

Electronic Workbench is a very sophisticated but versatile program. It can be used in educational situations ranging from elementary school through the research level.

There are many facets to Electronic Workbench. Teachers of Electrotechnologies 11 should become familiar with its operation before allowing students to work with it. While there is some useful documentation with the program, most of it goes far beyond the needs of grade 11 students. With that in mind, the program is an excellent source of material for enrichment work.

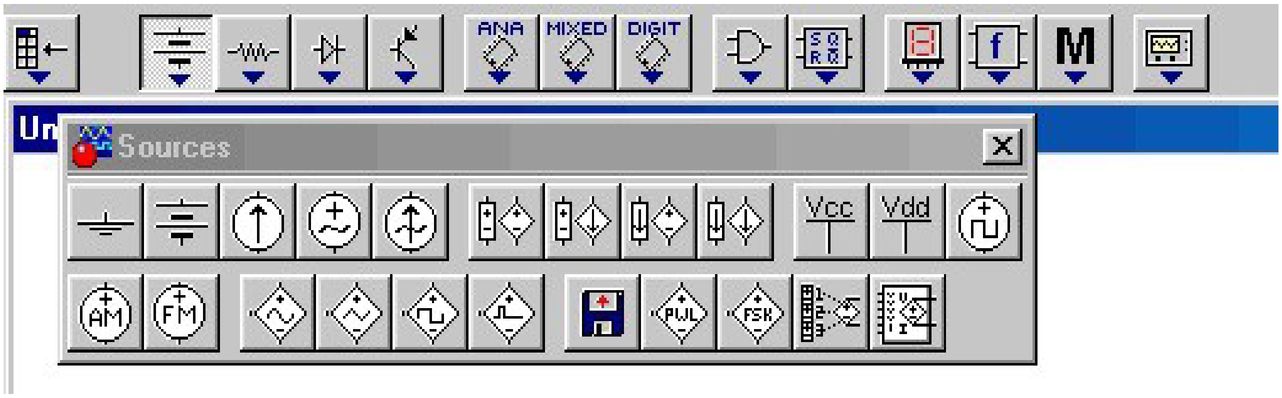


The EWB main screen is a bit formidable at first. To construct simple circuits one must use the items in the lower toolbar.

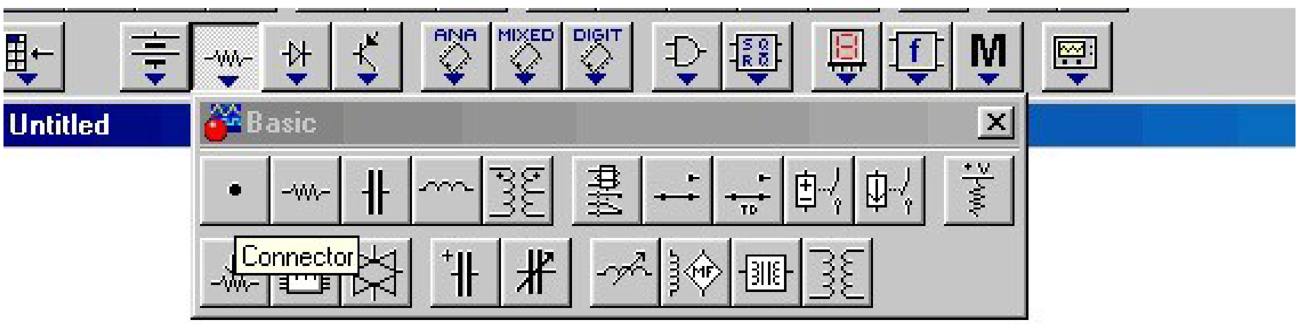
Each of the buttons brings up another toolbar containing various electronic components which may be dragged into the drawing area in the main widow, in this case, the window labeled "Untitled".

In Electrotechnologies 11 most students will be able to complete compulsory tasks using very few of the tool palettes. In most cases they will not be required to use all tools within specific palettes. The User=s Guide does not illustrate all the Parts Bin components. It is assumed that users will have the program at hand to try things out. Therefore the following are the parts bin palettes which will be of most use to Grade 11 students:

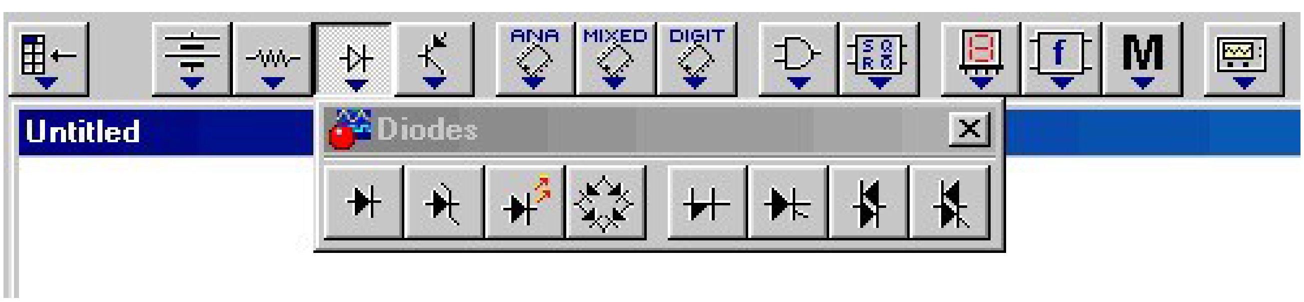
Sources



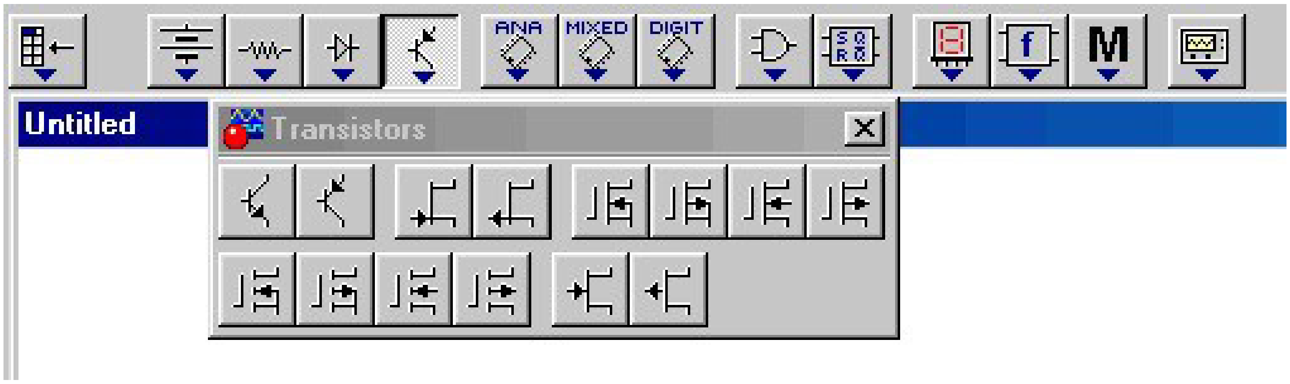
Basic Components



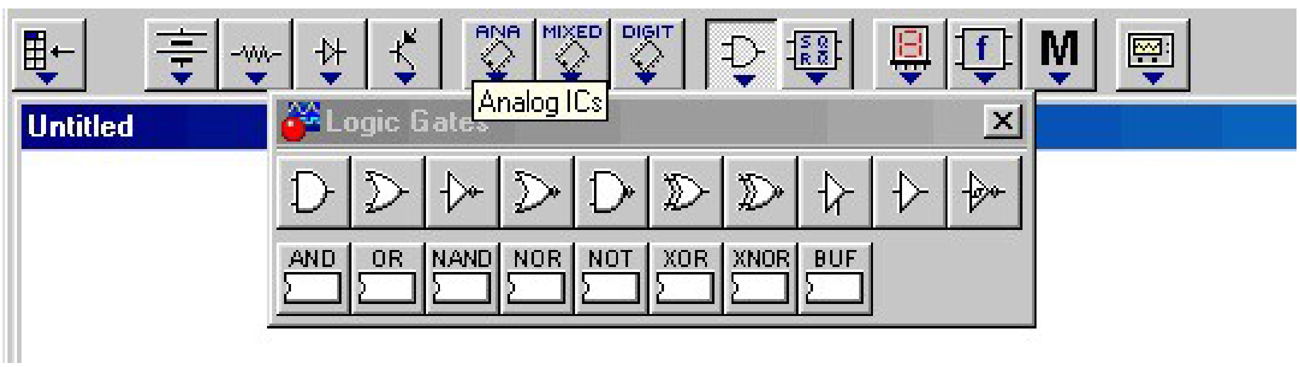
Diodes



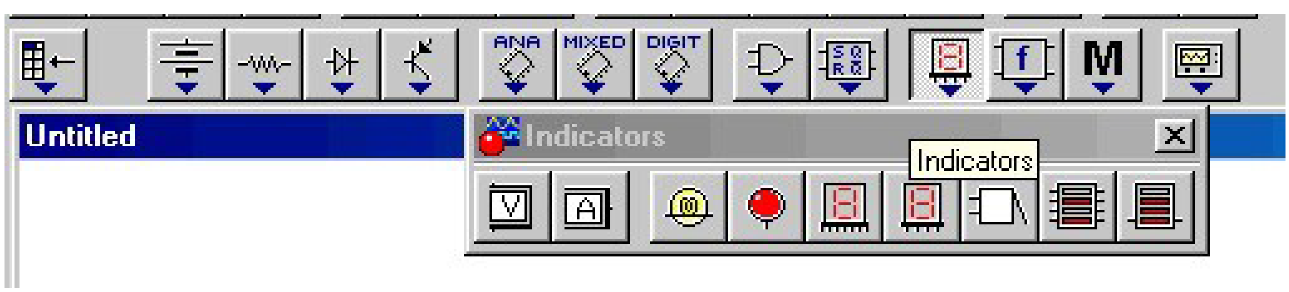
Transistors



Logic Gates



Indicators



Miscellaneous Components

Instruments

One of the palettes can be opened at a time. The circuit is drawn by dragging a selected component or components into the drawing area. When the mouse cursor is place on a free end of a component, a black dot appears. You may drag this dot to any other component on the drawing area. EWB then completes the connection by drawing in wires automatically in a geometric fashion. EWB is not a CAD program. Most of the work of creating actual diagrams is carried out behind the scenes. EWB itself arranges wires in a neat rectangular fashion so the user need not be concerned about creating neat diagrams.

Very few sample circuits are contained with the EWB software. Those that are provided are rather too advanced for grade 11 students, at least at first. It is best if teachers provide some simple examples themselves to get students started. It is estimated that from a cold start, a teacher should be able to produce a working diagram of a DC power source, a resistance, and a multimeter in about an hour.

Circuits may be turned on and off with the power switch at the top right hand corner of the EWB screen.

A Sample Lab with Electronic Workbench

This example describes the steps used to create a very simple circuit using EWB.

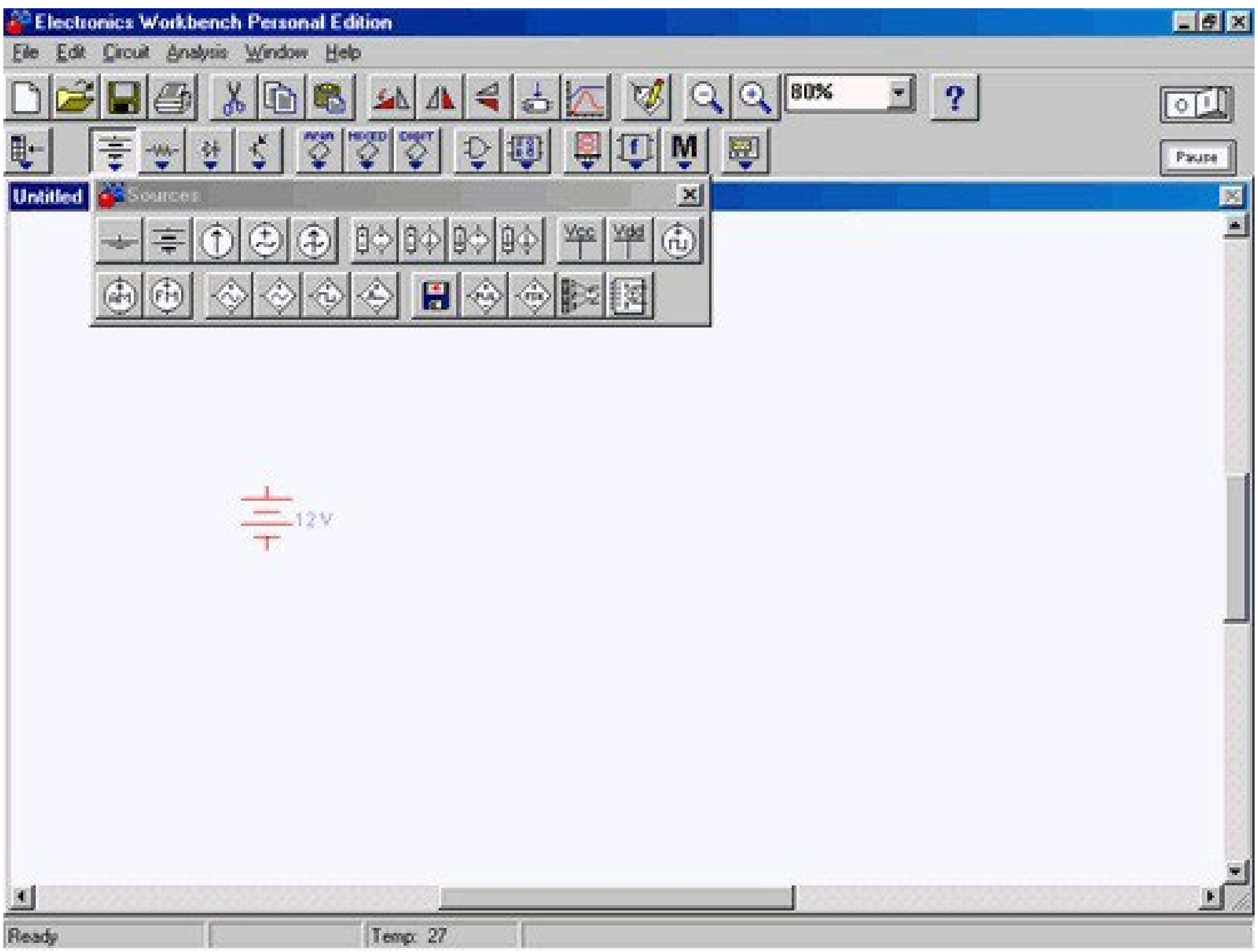
Purpose to emulate measurement of voltage and current in a simple circuit using Electronics Workbench

Tools Electronics Workbench running on a PC.

Method

- Start Electronics Workbench.
- Click on the sources palette to open it.
- Drag a battery onto the work surface by holding thee left mouse button and pulling the battery onto the work surface. Drop it there by releasing the left mouse button.
- Close the sources palette by clicking the "X" in the top right corner of it.

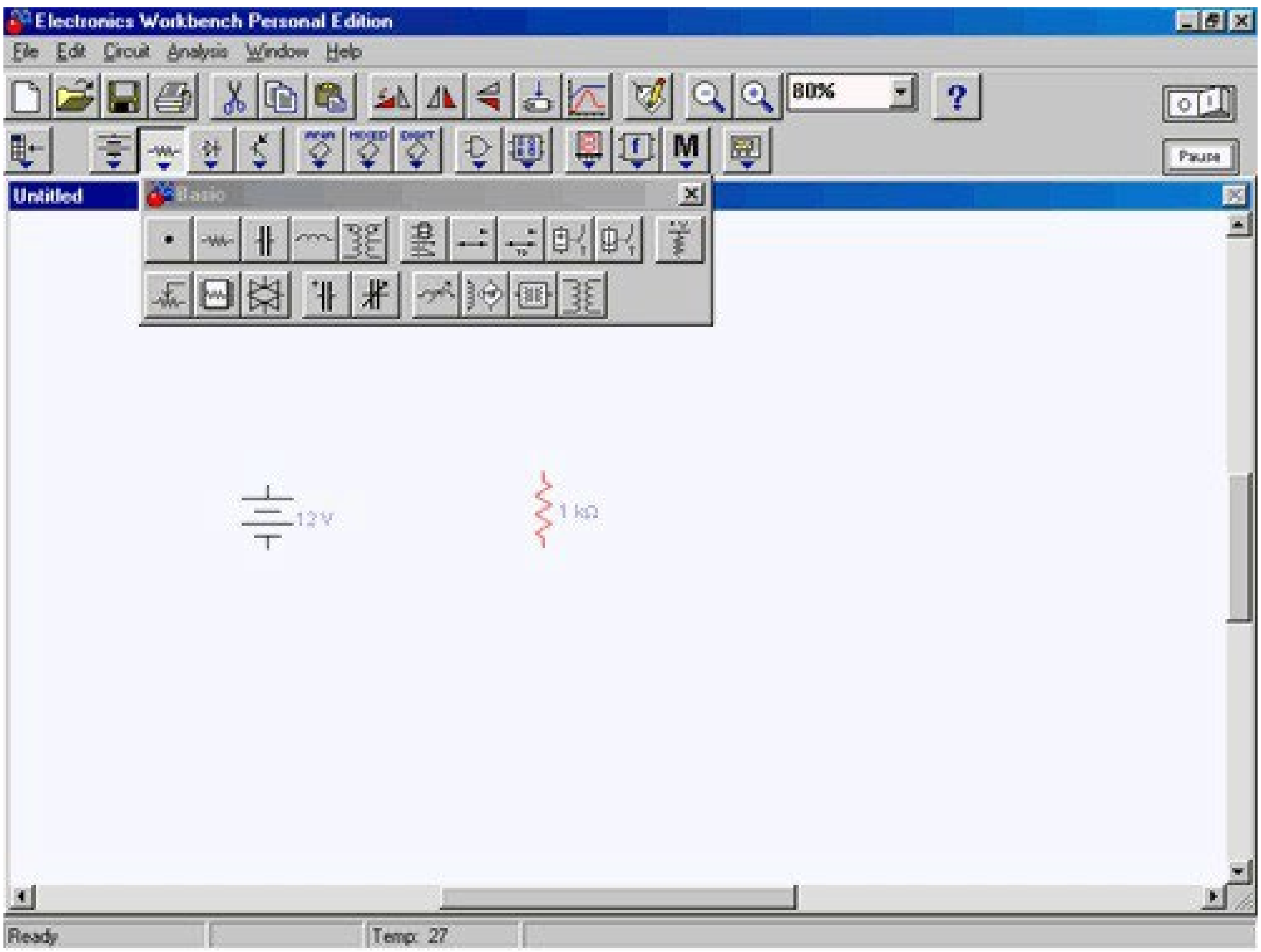
Your screen should look like this:



To proceed:

- Click on the Basic Pallette to open it.
- Drag and drop a resistor onto the work surface. It will be horizontally displayed. Right click on the resistor to open its context menu.
- Select "Rotate" to align the resistor vertically.
- Close the Basic Palette.

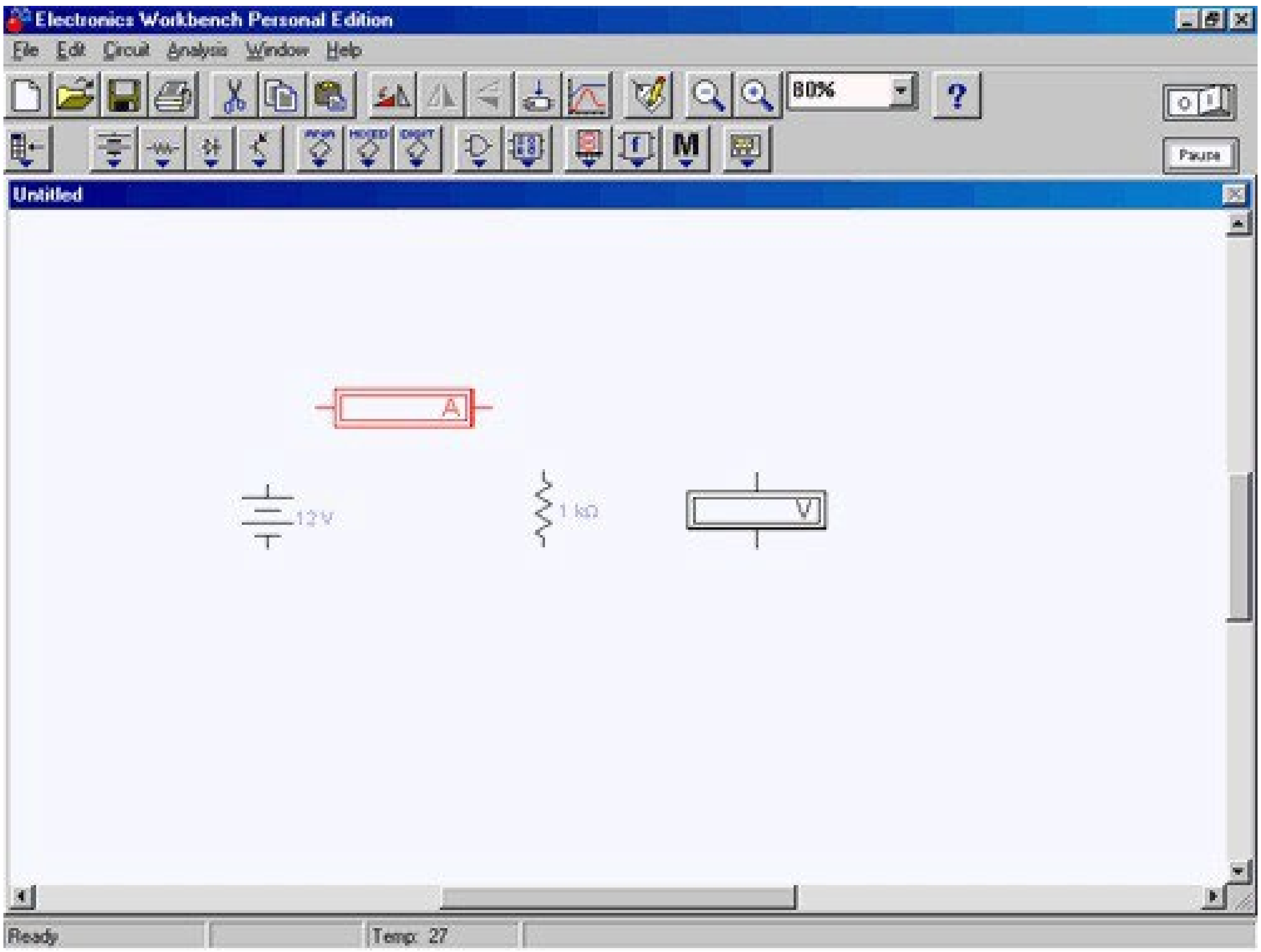
Your screen should now look like this:



To proceed:

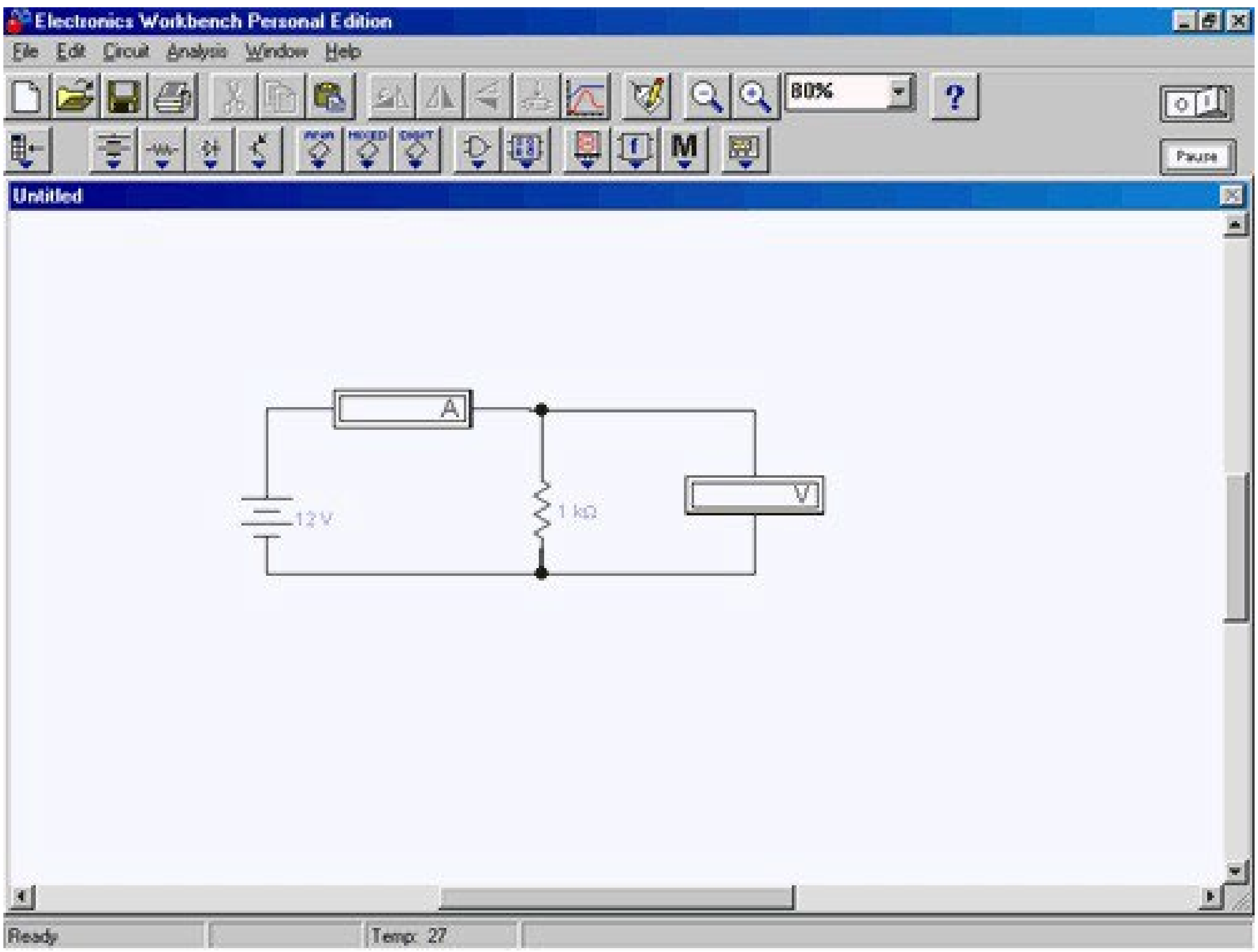
- Click on the Indicators Palette to open it.
- Drag and Drop a Voltmeter ([V]} to the right of the resistor.
- Drag and Drop an Ammeter above and between the battery and the resistor.
- Close the Indicators Palette.

Your screen should now look like this:



To proceed:

- Move the mouse pointer to the top lead of the battery. A small black dot should appear.
- Holding down the left mouse button, drag that dot to the left lead of the ammeter.
- Drop the line when a black dot appears at the end of the ammeter lead.
- Do the same for the voltmeter.
- Join the right hand lead of the ammeter to the wire on the top of the resistor.
- Join the bottom voltmeter lead to the bottom lead of the resistor.

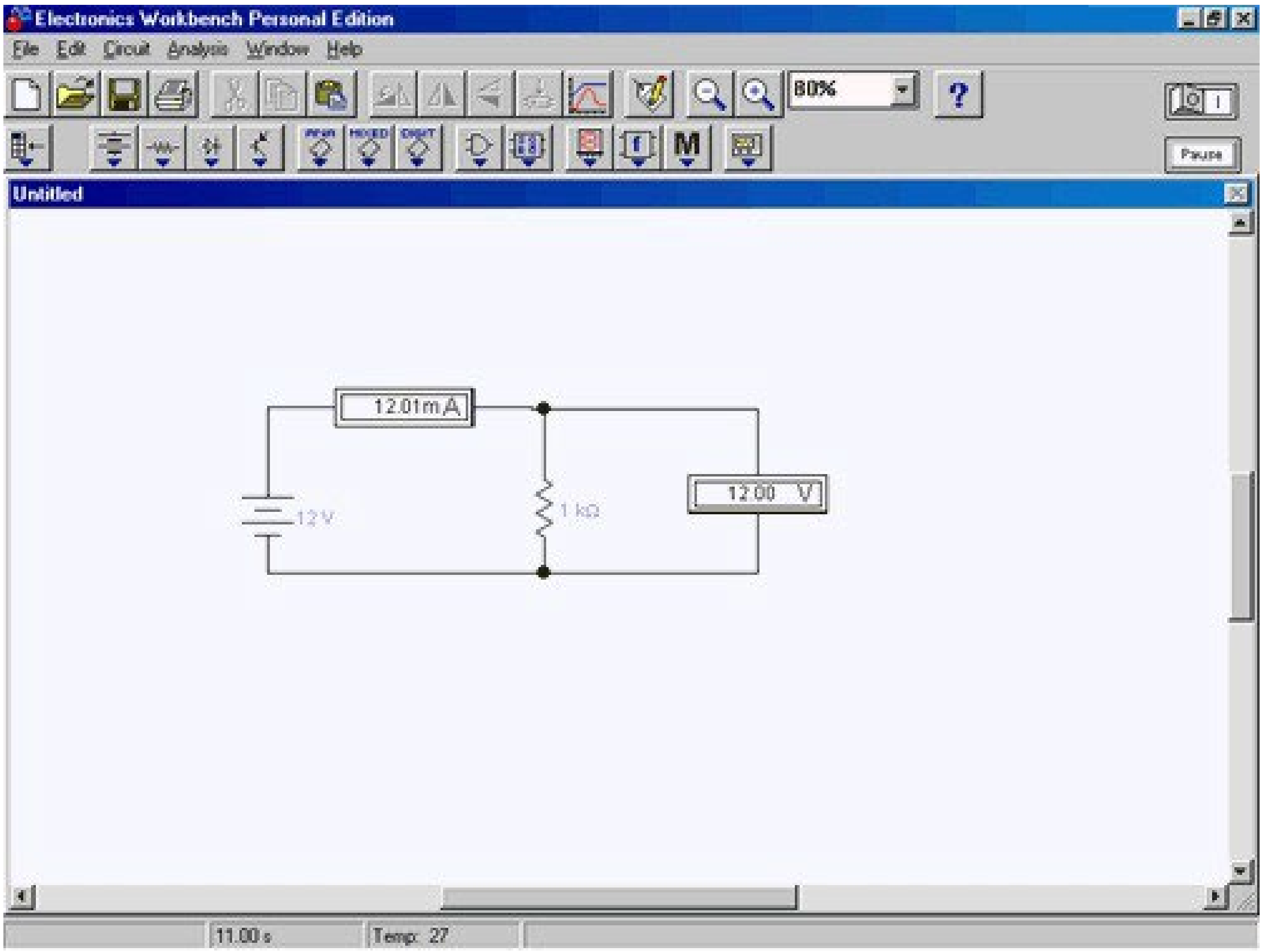


Your screen should now look something like this:

The lead positions may be adjusted by dragging them until the diagram is the way you want it.

To proceed:

- Turn on the circuit by pressing the toggle switch at the top right of the screen down using a mouse click
- Allow time for EWB to perform necessary calculations before displaying the readings in the Ammeter and Voltmeter.



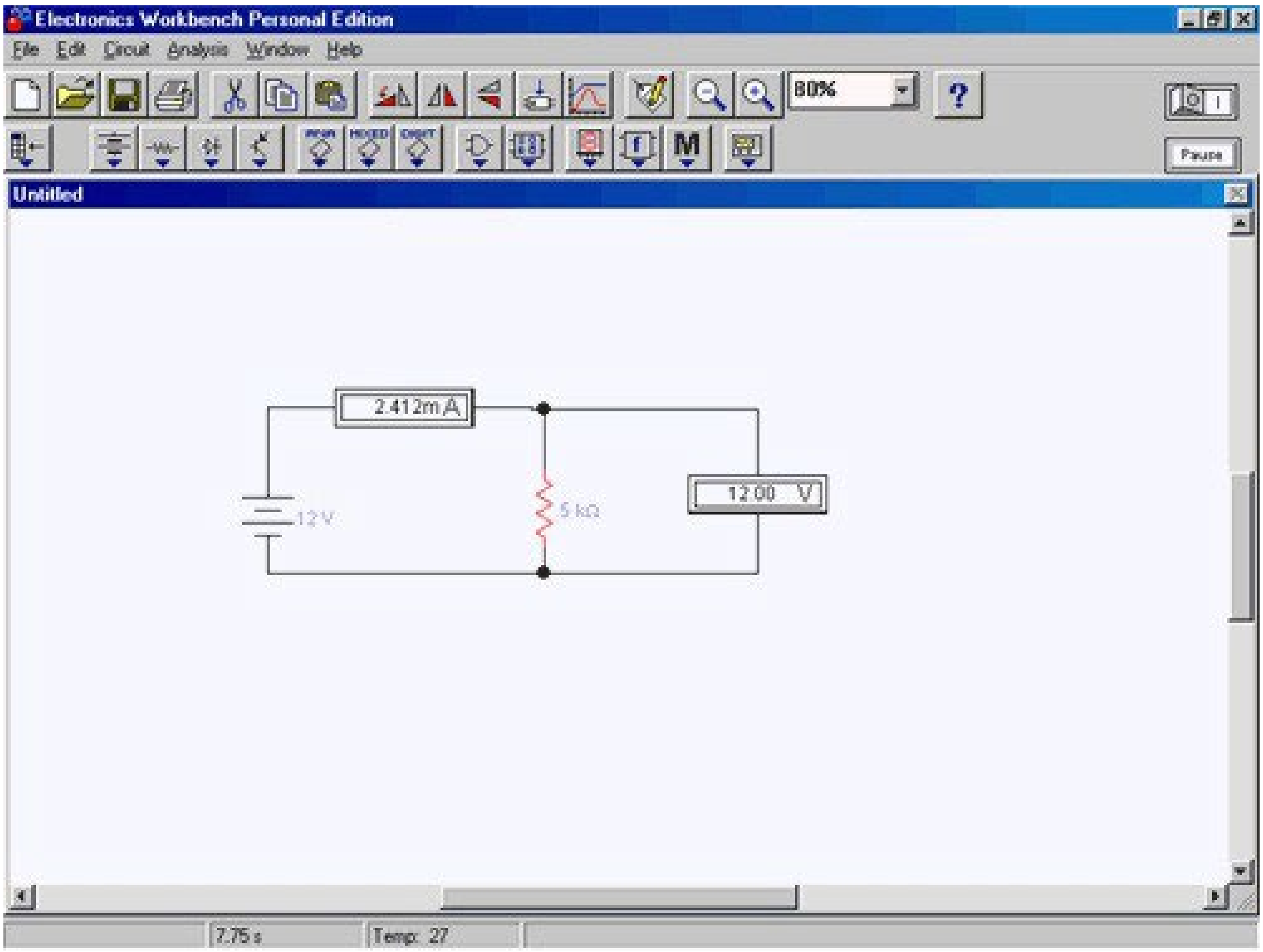
Your screen should now look like this:

Notice that the currents and voltages will be rounded off. EWB uses floating point mathematics which is very much like using logarithms to do calculations.

To proceed:

- Click on the resistor with the RIGHT mouse button to open a context menu.
- Select "Component Properties" from that menu by clicking on it with the left mouse button.
- In the box showing the properties, change the resistance to 5
- Turn the circuit back on with the toggle switch. You will have to do this every time you make a change to a component property.

Your screen should now look like this:

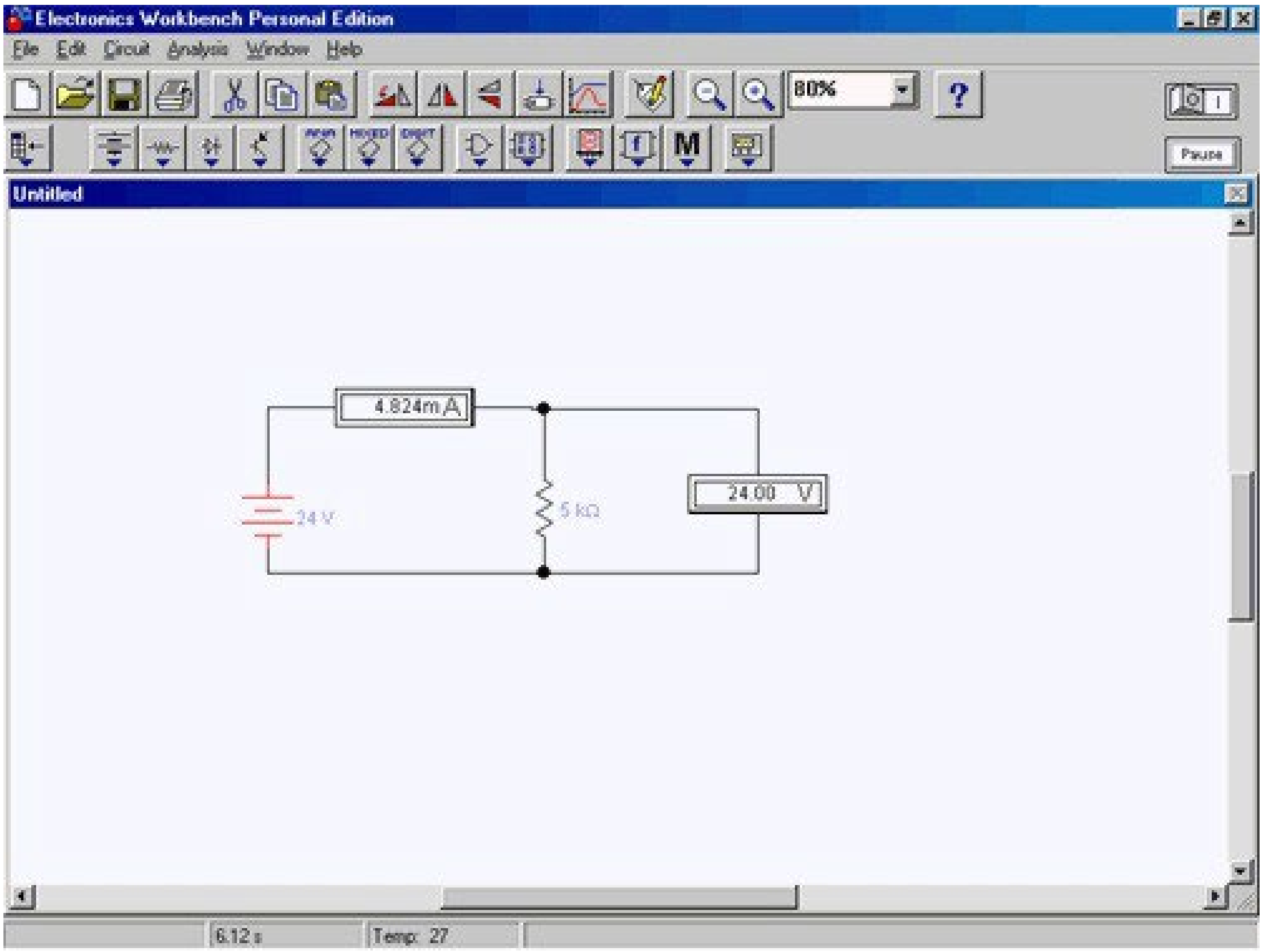


Notice that the current changes.
Change the resistance several times keeping a written record for the current and voltage.

To proceed:

Right click on the battery and change its voltage to 24.
Turn on the circuit.

Your screen should now look something like this:



Now record several values of current and resistance, leaving the resistance the same and changing the voltage.

Analysis

- Draw graphs of current against voltage for a varying resistance and constant voltage.
- Draw graphs of current against voltage for a varying voltage and a constant resistance
- What are the shapes of your graphs?
- Draw graphs of voltage against resistance for a varying resistance and a constant voltage.
- How does the shape of your graph differ from the previous ones.
- Calculate the slope of your graphs.
- Write down your conclusions about how voltage, current and resistance are related.
- Suggest ways you could use to verify your conclusions and test them with Electronics Workbench.

Appendix B: Using the Internet

The Internet can be a valuable resource for information searches on topics not readily available in the classroom. It is most valuable used to extend concepts learned in the classroom. It is important that teachers ensure that all students have equal access to Internet resources.

The links listed here may not all be operational due to the fluid nature of the Internet. An on-line site for *Electrotechnologies 11* containing support for this course and current links to technology related sites may be found at http://www.ednet.ns.ca/educ/currwebs/electro

Teachers can approach the *Electrotechnologies 11* webmaster for aid in creating dedicated forums in which discussions can be carried on among classes in other schools. An example might be the case where students in schools from different parts of the province want to share information gathered during field trips to businesses in their local areas with other schools.

General Links for All Modules

Website	Comment
Math Studyworks Collaboratory	Internet extensions for Math Studyworks. Using an external browser is faster than using the Web connection in the Math Studyworks program.
San Francisco Exploratorium	Very useful general scientific site
Ontario Science Centre	Very useful general scientific site
The Discovery Channel	Features some on-line versions of technology programs
Critical Velocity	Independently maintained science site. Contains archives of articles useful in the ET course and also the beginnings of a list of schematic symbols with images describing. the actual components.
Carnegie Science Academy	society that encourages high school students to take an interest in science.
Edison	Digital magazine about Science & Technology. Scientists and experts answer Kids' questions
The Evidence Database at Berkeley	Famous database of archived articles covering all branches of scientific thought.

Module 1: Components and Concepts

Website	Comment
Lawrence Livermore National Laboratory	High energy electrostatic devices
van de Graaf Linear Accelerator Facility	Advanced site showing uses of electrostatic devices. A research site.
Electrostatic Applications	Contains a section for Projects and Teaching
Electrostatics articles	Devoted to popular articles dealing with electrostatics such as the Hindenberg disaster.

Module 2: Power Distribution and Conversion

Website	Comment
Auburn University Oersted Page	Demonstration of apparatus used in the Oersted Effect
Oersted	Part of a comprehensive site dealing with the development of electrical technology
AAPT page devoted to recipients of the Oersted medal for science teaching	Teachers' page

Module 3: Digital Technology

Website	Comment
The Programmable ASIC company	A list of paper on control circuit chips
Siemens	A large manufacturer of electronic components and circuit boards
IEEE	History of computing
IEEE	Design and test of computers
ASCII	An ASCII chart in various number systems
Another ASCII site	Very useful site for educators. Winner of several awards

Module 4: Robotics

Website	Comment
Automation Tooling Systems	One of the largest Canadian robotics companies
http://www.androidworld.com/ Android World	A site devoted to anthropomorphic robots
Cool Robot of the Week	A NASA site that features robotics sites
Robot Science and Technology On-Line magazine	Magazine for educators, students, hobbyists, and enthusiasts
White Noise BEAM Robotics	A very interesting private site that specializes in the construction of robots using simple materials

Appendix C: Using Common Materials to Construct and Use Electric Wet Cells for Testing Circuits

Rationale

Common fruits and vegetables may be used to derive most of the circuit concepts detailed in Module 1 as well as showing the nature of wet cells. However, since this is a technology course, students should be exposed to real industrial quality devices as well.

The Nature of Wet Cells

Wet cells are nothing more than a container filled with an electrolyte into which are immersed electrodes of differing metals. Since fruits are acidic in nature we assume that they can be used as the container filled with the electrolyte.

Naturally, the best fruits and vegetables to use are the most acidic, but the investigation should not be limited to them. It is just as important to get so called “bad” results as it is to get good ones. Therefore, one might want to consider using lemons, oranges, apples, melons, or potatoes. Citrus fruits will give the best results, but others will also give valuable results.

Any small strips of metal such as pieces cut from cans, nails, screws, and so on can be used as electrodes.

Getting Organized

As is the case with any small-group learning experience, organization is of the utmost importance. The teacher should lead the groups in developing strategies that will result in worthwhile results. It is probably best to limit group size to four or five students.

Have the students accept responsibilities to build wet cells from predetermined fruits and electrodes in order to provide a range of results.

Developing Testing Strategies

Most students will readily accept the fact that the way to test a wet cell is to see if it produces “electrical power”. Teachers must guide them at this early stage to find variables which will give useful results. Measuring voltage and current flow with a multimeter will give quantitative results that can be used in calculations later, but it is also a fair test of a wet cell to see if it will, for instance, illuminate a flashlight bulb or an LED. Qualitative results are as important as quantitative ones in developing concepts.

The students themselves may come to the realization that better and more useful results could be generated if the class were to pool their results to get a wider range of data. The goal should be to have them come up with some kind of chart to complete, such as the following:

Fruit	Electrodes	Voltage	Current	Comments
lemon	Iron Copper	???	???	does it illuminate a flashlight bulb
lemon	Aluminum Copper	???	???	(as above)
lemon	Iron Aluminum	???	???	
orange	Iron Copper			
orange	Aluminum Copper			
potato	and so on			

It is easy to see that quite a large amount of data can be generated. Displaying the results can best be done by having each group prepare charts of their results then enter them in a consolidated class chart.

Questions to be Answered

- Which fruits and vegetables make the best wet cells? Why
- Which electrodes work the best?
- Is there a combination of metals which give better results than others?
- Do all fruits of the same type give the same results? Why?
- What could you do to a "bad" fruit to make it work better?

Extensions

Once students see that wet cells are nothing special and that valuable results and data can be obtained from ordinary materials they could go on to investigate further:

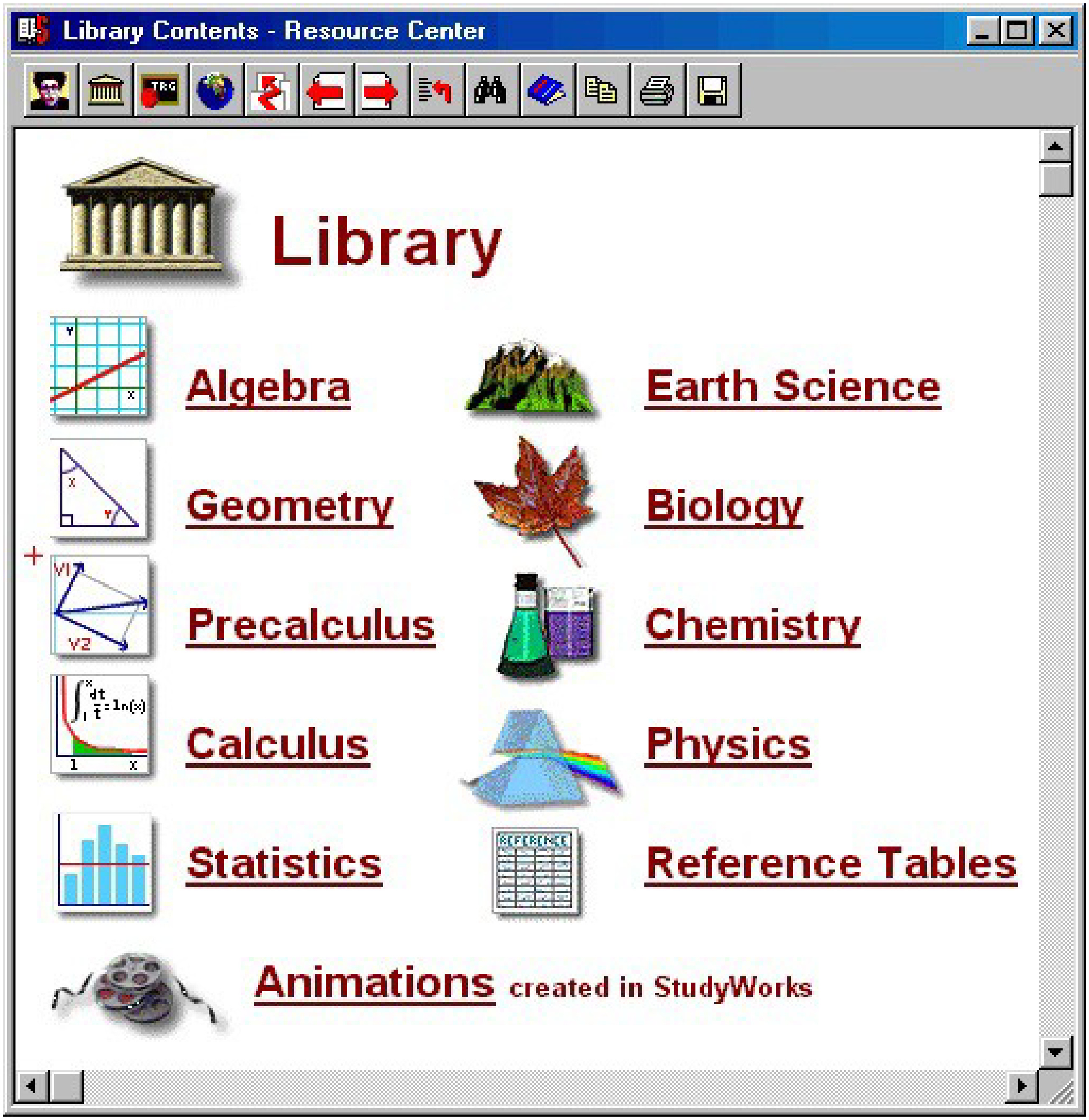
- connect various fruit cells in series
- determine whether or not the voltage produced by each is additive

While students may not have been exposed to the idea of series and parallel circuits, they could easily make the connection if they can show in the laboratory that a lemon plus an orange can actually give a predictable result. In other words, if a lemon produces 0.3V and an orange 0.2V, does the combination give 0.5V. This works fairly well; however, care must be taken to accumulate the result quickly because fruit cells tend to have a very short shelf life.

As stated in the rationale, the entire requirement for this course with respect to series and parallel circuits could be met with their fruit cells, but students will tire of this quickly and it is better to get on with using real cells as quickly as possible.

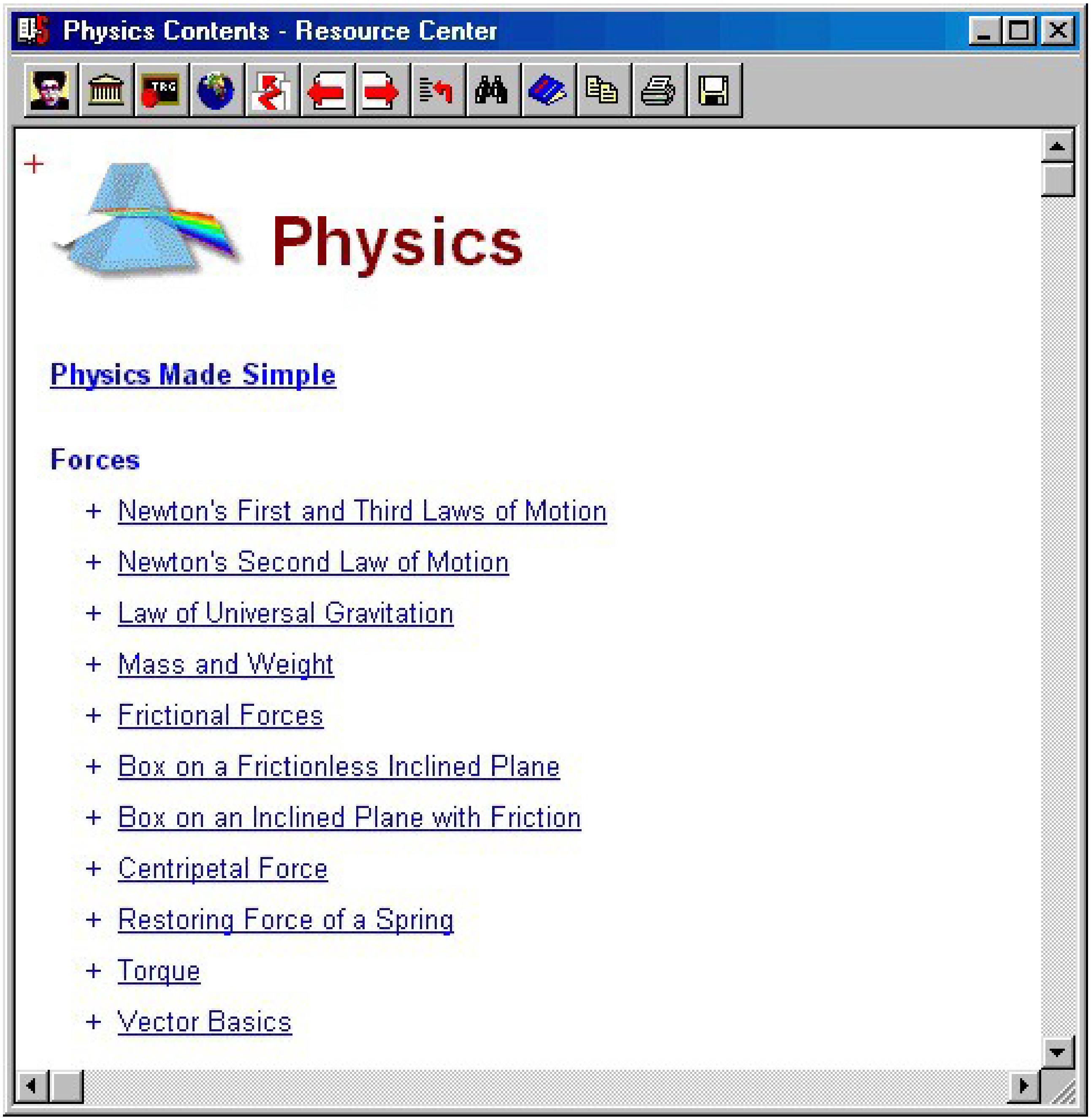
Appendix D: Using the Math Studyworks

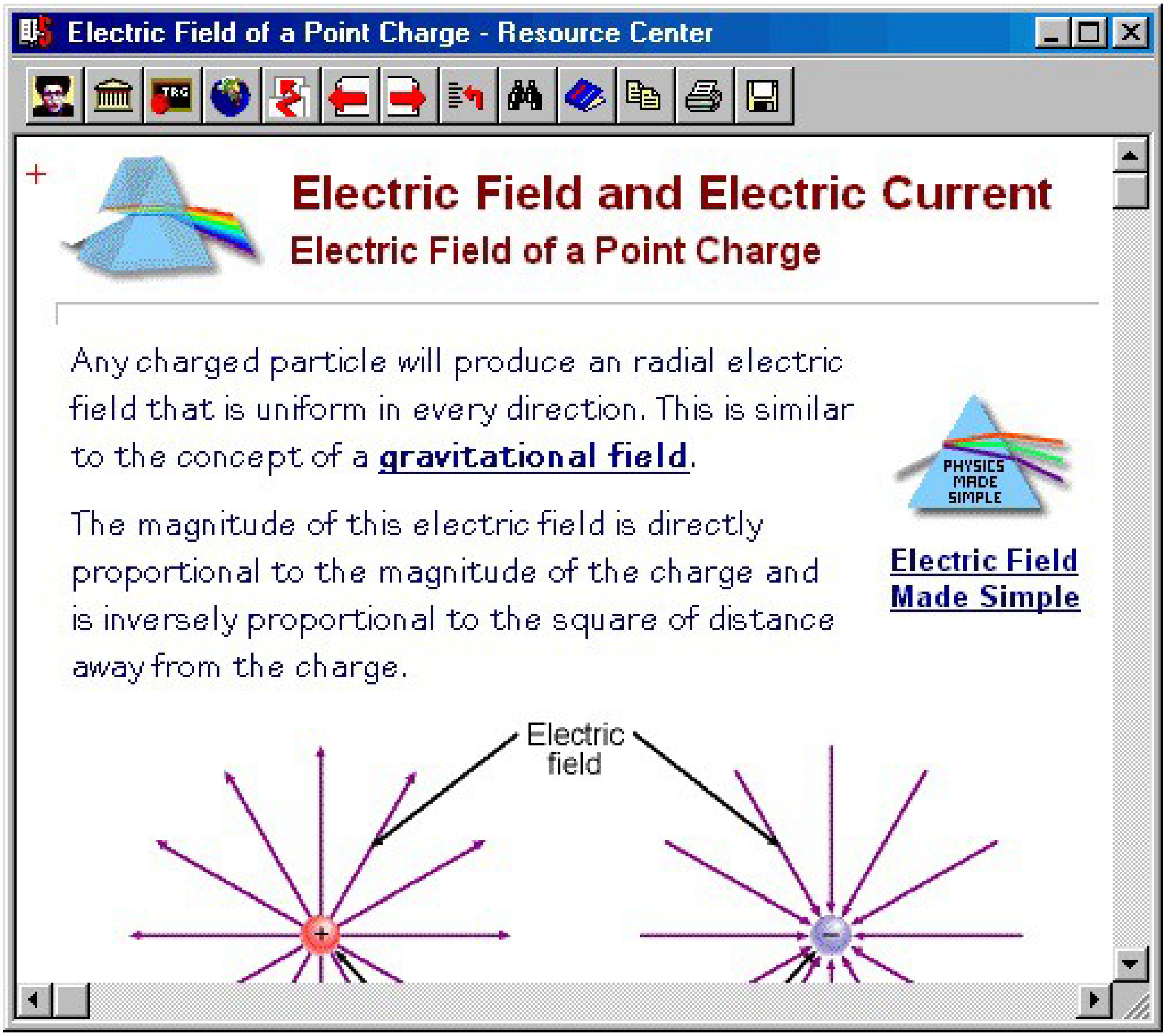
When you start Math Studyworks, the Control Center opens.



It is very useful to familiarize yourself with all its options. A very valuable tool is the library.

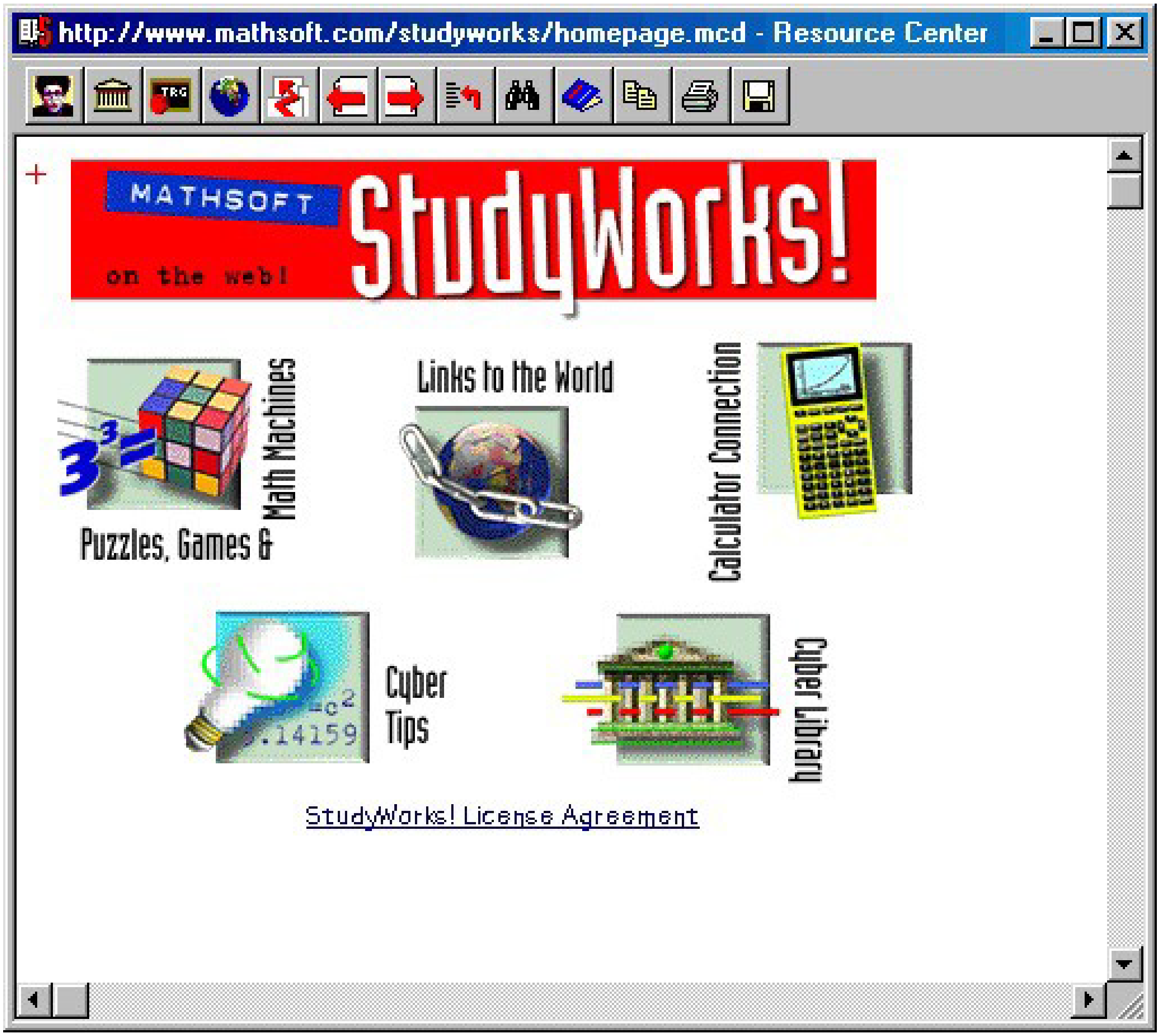
The section dealing with physics has many items of use for electrotechnologies:





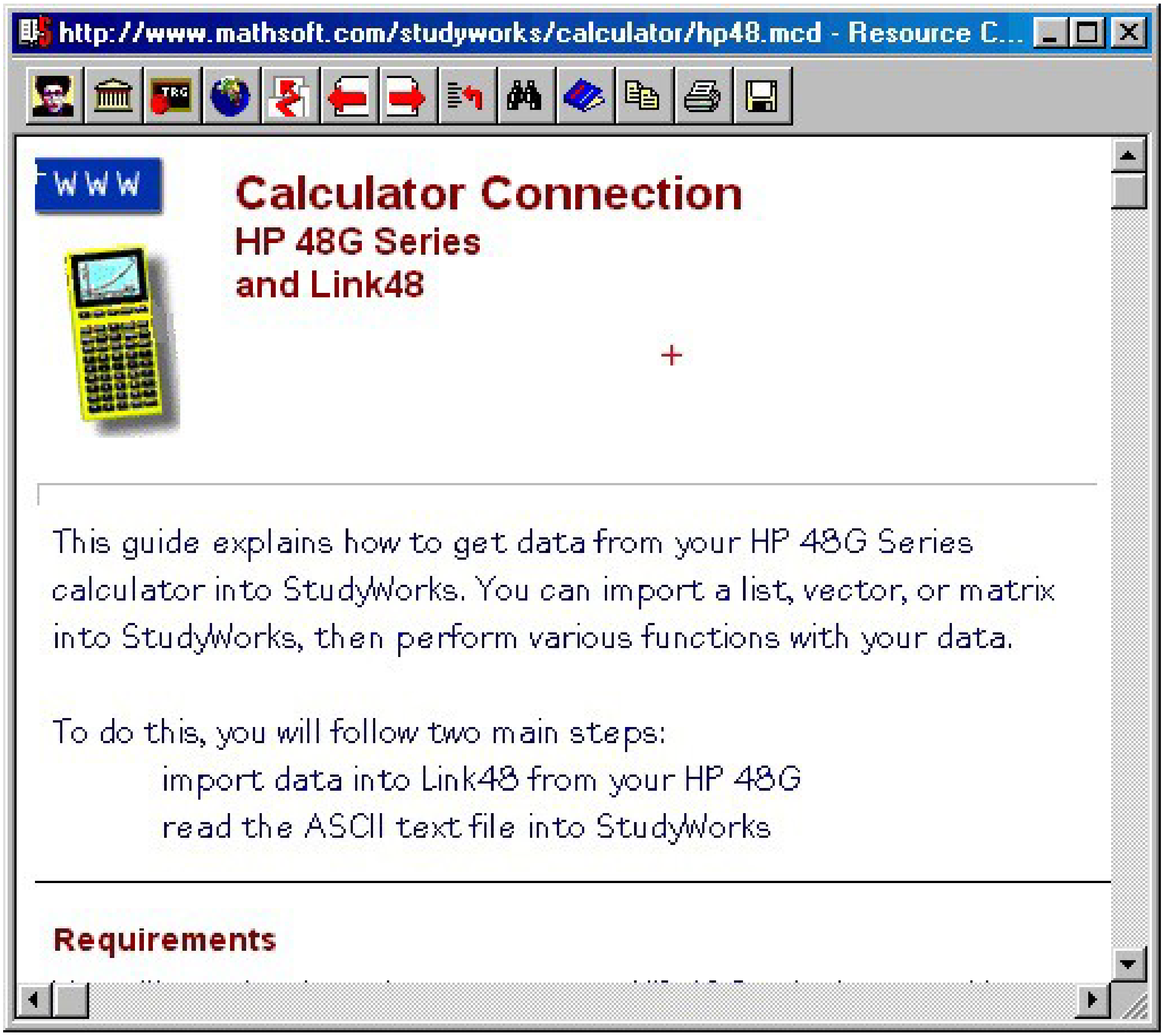
Here is an example of the electric field of a point charge:

The Weblink requires a connection to the Internet and is a browser to the Math Studylinks site. The browser

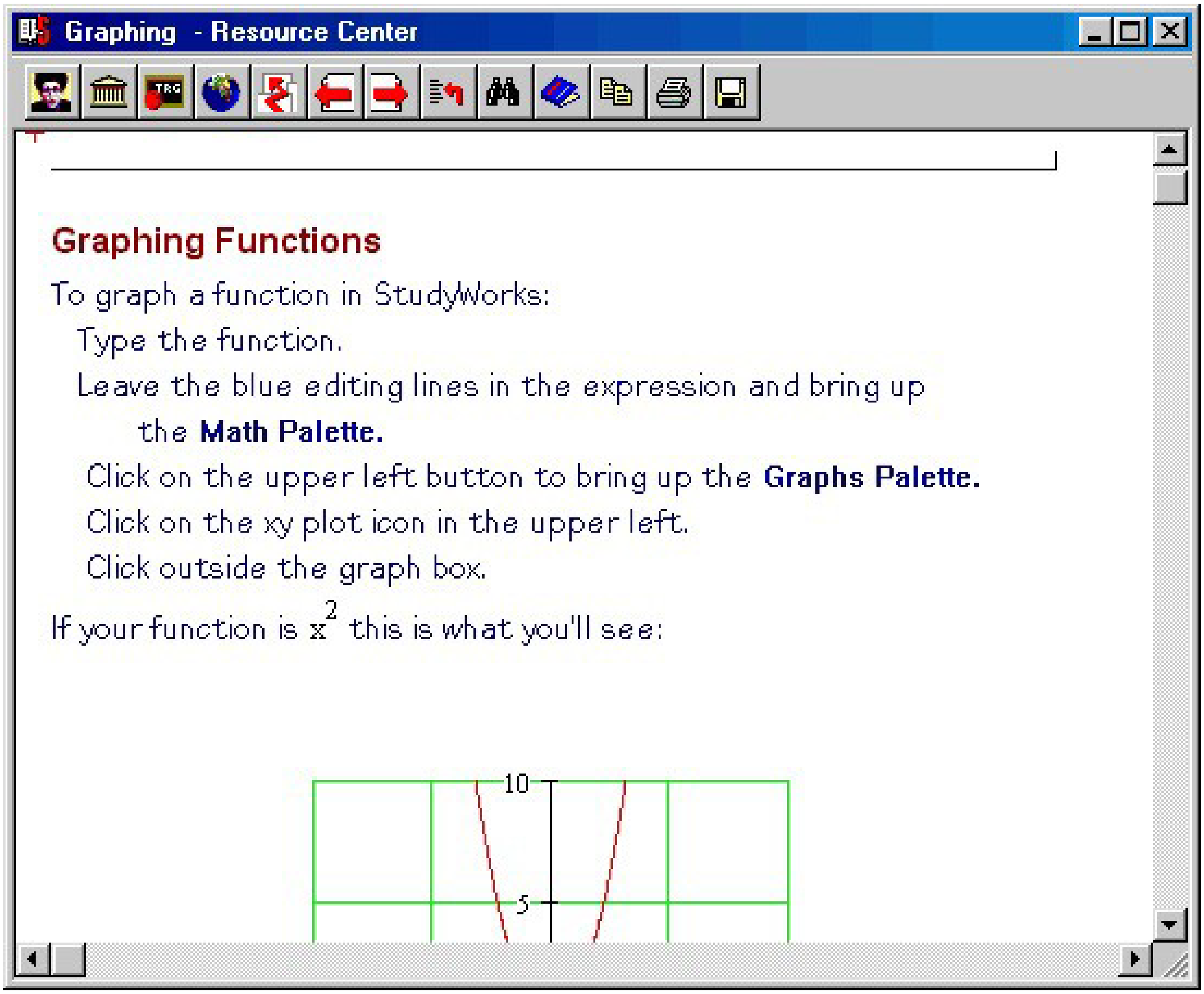


and file format are proprietary, so viewing the site with an ordinary browser will not yield the same results as the program itself. Here is the opening screen at the site:

It is recommended that the teacher to browse through all the sections to see what they hold.



The Calculator Connection includes instructions on how to use various models of calculators:



Math Studyworks has a complete on-line guide to using all its various features. For example:

Math Studyworks is, more than anything, a mathematical word-processor. It allows you to type in equations, edit them, graph them, and even read data files from the disk.

Appendix E: Building DC Motors from Common Materials

A kit can be made up of things gathered from around the school. In most cases these items will be readily available:

- one piece of wood 10 cm by 10 cm (from industrial arts wood shop or scraps from a lumberyard) on which to mount the motor
- five paper clips for bearings
- 3 finishing nails 10 cm long for the spindle and field coils
- a one inch cork for the field coil
- a piece of paper foil to construct the commutator (the commutator can simply be extensions of the armature coil)
- a piece of very thin cardboard or heavy paper to insulate the commutator from the spindle
- one or two metres of thin varnished wire for connections and to wrap coils
- a dozen heavy thumb tacks to mount the items on the wood base
- a diagram to show how the wiring is connected in the final motor

Teachers and students may with to organize a competition, perhaps at lunch time or after school, where students present their motors. The teachers and students could judge the motors as to construction and operation, in much the same way as science fair projects are judged.

Once the students have completed their individual projects and are familiar with the basic concepts of the operation of DC motors, another project could be assigned to small groups in which the students actually design and construct a motor themselves and go through the same kind of demonstration process; this could be a very good introduction to the design process.

If sufficient interest is shown, there is no reason why individual students should not be encouraged to build low voltage AC motors. They may need guidance in the construction of commutators for such motors.

Appendix F: Choosing Electrotechnologies Projects

EDnet maintains a website for the Electrotechnologies 11 course. It is a clearinghouse for ideas shared among teachers and students in all aspects of the course. Its address is

Links to the websites mentioned here can be found on the Electrotechnologies 11 website.

The following suggestions may be valuable for students who need help in deciding on a project topic:

- Design and manufacture an electronic device to meet a specified need, for example:
  - a telephone amplifier for the hearing impaired
  - an automatic tracking system for the school=s astronomical telescope
  - an intercom system to be used at home to monitor nurseries
  - a timer to control an automatic watering system for a greenhouse

- Design and create an Internet website to explain an electronic principle to other students. The site could outline and describe the work of a person who made significant contributions to the development of some aspect of electronics or technology. Michael Faraday, for example, was known for being one of the greatest teachers of his time as well as for advancing electromagnetic theory. Another possibility is to outline the work done in one of the present-day electronic research facilities such as Bell Laboratories of Northern Electric

- Present the work of a famous Nova Scotian or Maritimer who advanced human understanding in Electrotechnologies. Most students are aware that Baddeck was the home of Alexander Graham Bell for many years. It was during his residency there that he let his creativity loose to explore many topics in addition to his most famous, the telephone. The Bell museum is a very good source of project material. It may be reached through the Internet. The Nova Scotia Museum is a good starting point for project ideas in many areas. Parks Canada also maintains a list of historic sites, for instance Signal Hill in Newfoundland, the site of the first transatlantic radio transmission.

  Alexander Graham Bell Museum
  Nova Scotia Museum
  Signal Hill

- Present an analysis of design and marketing for electronic devices created by local entrepreneurs in their own communities. Students may be aware of possibilities near where they live, but teachers should be prepared to help them search for information. Chambers of Commerce are good starting points for a search.

- As part of a design team, participate in a robotics competition. An annual competition is held throughout the Maritime provinces. Information is available from the Association of Science Teachers.

- Other websites that are useful sources of ideas for technology fair projects include the following:

  PEI Science Fairs
  Canada Wide Science Fair 1999
  Canada Wide Science Fair 2000
  School Science Fairs

Many other websites world wide maintain science fair information. An Internet search will identify many of them which will lead you to others.

- Design and construct a radio-controlled model such as an airplane or boat

  Many hobby supply companies have interesting sites, for example,

  AGR Hobbies
  Remote Controlled Flying Saucer
  RC Aerowatch EMag

- Design and build a technology fair project to create an electronic device. (See the Internet links above for ideas).
- Design and build an binary adder using simple gate circuits.
- Design and build a series of small control devices to illustrate gate circuits.
- Design and build a radio.
- Design and build a stereo amplifier.
- Analyze and explain the operation of several types of atomic particle accelerators.

  Helpful websites include the following:

  Fermilab
  Stanford Linear Accelerator
  CERN

- Obtain an amateur radio license and present guideline for doing so to other students.

  Canadian Amateur Radio on the Internet

- Construct a working computer from discarded parts. Old computers are often available at little or no cost. One of the best places to look for information is the buy and sell news groups on the Internet.

- Design and construct a video monitoring system to prevent theft in schools. Local security companies would no doubt be willing to help in a project of this sort.

- Work with Nova Scotia's Technology Recycling Program

Appendix G: Project Rubric

This simple tool provides an example for teachers and students to use in defining project expectations, negotiating a mark, and monitoring progress. Not all of these elements will be useful for all projects.

	Does not yet meet expectations: 1 Point	Meets expectations: 2 Points	Exceeds expectations: 3 Points	Self Evaluation	Teacher Evaluation
Topic/Content	includes some essential information/elements and few details	includes essential information/elements with enough elaboration to give audience an understanding of the topic	covers topic completely and in depth. encourages audience to reflect or enquire further		
Analysis/ Discussion/ Development	information/ideas presented without questioning or analysis	information/ideas selected, analysed, and evaluated	information /ideas selected and combined clearly and comprehensively		
Product/ Solution/ Inquiry	has limited effectiveness or is not effective	is effective	results are elegant, sophisticated, or comprehensive		
Specific Requirements	includes ___ or less____ *(to be filled in by teacher and student)*	includes at least _______	includes at least ___ or more_____		
Format	includes several inappropriate, incorrect, or ineffective elements	elements are generally used effectively, appropriately, and correctly	elements are used to enhance, clarify, and emphasize		
Group Work	works with others, but has difficulty sharing decisions and responsibilities with others	works well with others, takes part in decisions, and contributes fair share to group	works well with others, assumes a clear role and related responsibilities, motivates other to do their best		
Presentation Skills	some difficulty communicating ideas	communicates ideas with adequate preparation, and some enthusiasm	communicates ideas with enthusiasm, clarity, and control		
			Total Points		

Appendix H: Key Concepts in the Design Process

The following is taken from the Ontario Ministry of Education website. The entire document is available online.

The design process described below has five stages. Sections in italic in parentheses indicate the instructions for each stage that could be addressed to the student(s) designing the product or providing the service.

1. Developing a Focus

The students identify the problem or challenge and begin keeping a record of the design process (a technological report or design brief). Initially, students should use the design brief to outline the broad aims of the project and describe in a general way what needs to be done to achieve those aims. As work progresses on the project, students may periodically revise the initial broad plan to reflect what is actually happening. (Meet with your client or the group for whom your product or service is being developed. Discuss the project with them to determine what you must accomplish and to establish goals for completing the product or delivering the service.)

2. Developing a Framework

The students identify various possible solutions and the resources required to achieve them; they determine whether the various resources are available and record their findings in the design brief. During this stage they may discover that they need to redefine the problem or challenge. (Identify various ways in which the possible solutions could be achieved. Evaluate each of these alternatives in terms of quality, cost, durability, expectations, etc. As at any other stage in the process, you may need to redefine what you want to accomplish.)

3. Choosing the Best Solution

The students consider such factors as what materials, tools, and resources are available, the amount of time needed to carry out different procedures, and any relevant ergonomic and aesthetic requirements. If necessary, they construct and evaluate a model. Based on the results of these activities, they choose the solution that seems best. They record the reasons for choosing a particular solution in the design brief. (Draw up a technical report that sets out for your client the recommendations or best alternatives. Develop a draft plan of action, which may include preliminary drawings.)

4. Implementing a Plan

The students try out different ways of achieving the best solution and construct the product, process, or system. For physical products, they make a full-sized prototype using production-type materials, tools, and equipment. As they assess every aspect of the construction phase, they may make changes to the production plan. They may even modify the original conception of the product to reflect ideas that emerge during construction or to solve problems they did not think of when they began the process. The students record any and all such changes in the design brief. (Develop a final plan, including final working drawings and a prototype for the approval of your client. Make the product, or provide the service, to your client's specifications.)

5. Reflecting on the Process and the Product

The students evaluate the process used and the end result in light of their own expectations and the reactions of peers and the client. As a result of their evaluation, they may decide to modify the production process, the product, or even the original definition of the problem or challenge. Also at this stage they complete the design brief or technological report and communicate their results. (As a group, evaluate the final product or service, including your client's reaction to it. Redesign and make changes to the process or product that will be incorporated when filling subsequent orders. Prepare reports and marketing strategies. Outline quality-control procedures that should be used for further products or services).

The steps or techniques used in solving a problem are known as the problem-solving process. In technological studies, this process is often called "the design process". At the beginning of a design process the student analyzes a given set of conditions in order to identify a problem, challenge, or need. The student then works through a number of identifiable stages in order to arrive at a solution.

A design process includes all the stages in the development of a product or process. Designing is not necessarily a linear activity, however, but may require the student to reformulate or restate the problem, or revise the plan for solving it, or both. Although the process may have distinct stages, those stages will not necessarily be followed in a rigid sequence. For example, students must evaluate (reflect on) their work at each stage of the process. As they do so, they may discover that they need to return to an earlier stage to make modifications; or they may decide to complete a particular step sooner than was originally planned.

The projects that students develop and work on must be closely monitored by the teacher to ensure that students acquire the knowledge, skills, and values that have been identified as the learning outcomes for the course. Before approving a student's project, the teacher must analyze it carefully to determine whether it will promote the necessary learning. Teacher and students must collaborate to ensure that safety issues have been taken into account and that the required resources, learning aids, tools, equipment, and materials are identified and obtained for each project.

Students should be aware that they are required to participate in their own evaluation. When they find themselves in the world of work, they will often be called upon to make judgements about their own work before it is seen by others, and in some cases the only quality control will be in the hands of the original designer.

A project must not necessarily be successful in order for it to achieve a valid educational result. Risk taking and imagination on the part of students is a valuable indicator of learning, if the lessons taken from it are understood.

Appendix I: Facts about Number Systems

The word binary actually means "two" which makes sense since it expresses two states, (ON/OFF, TRUE/FALSE, etc.). Components recognize "ON" as 1 and "OFF" as 0. In this way computers can make decisions. For example, by grouping sets of 1s and 0s together, computers can recognize letters and symbols known as ASCII (letters and numbers).

Computers and Binary Numbers

Without Binary the modern day computer would cease to exist. Everything entered into a computer is converted into binary. If you type in the letter "B" it is converted to the Binary "01000010" by your keyboard which sends the information to the CPU (Central Processing Unit). Binary is somewhat like Morse code it is sent to the CPU in a series of electronic pulses. High voltage pulses are considered 1's and low voltage pulses are considered 0s.

A single 1 or 0 is one bit. There are eight bits in a byte (That is why each letter consists of eight ones or zeros). This means that one 1.44 Meg disk holds over 1 million letters or characters (which means that it holds over 8 million 1s and 0s in total!).

CD-ROMs are based on Binary (whether or not a hole (Micropit) is present on the CD-ROM (the laser picks this up))

- John Atanasoff was the first person to think of using Binary with computers.
- Electronic circuits use Binary in logic decisions (True/False etc.)
- Binary was a counting system long before computer as we know them were even thought of.

How Computers Recognize Letters and Numbers (Ascii)

Here is the conversion chart from Binary to Ascii:

A	01000001	S	01010011	k	01101011
B	01000010	T	01010100	l	01101100
C	01000011	U	01010101	m	01101101
D	01000100	V	01010110	n	01101110
E	01000101	W	01010111	o	01101111
F	01000110	X	01011000	p	01110000
G	01000111	Y	01011001	q	01110001
H	01001000	Z	01011010	r	01110010
I	01001001	a	01100001	s	01110011
J	01001010	b	01100010	t	01110100
K	01001011	c	01100011	u	01110101
L	01001100	d	01100100	v	01110110
M	01001101	e	01100101	w	01110111
N	01001110	f	01100110	x	01111000
O	01001111	g	01100111	y	01111001
P	01010000	h	01101000	z	01111010
Q	01010001	i	01101001		
R	01010010	j	01101010		

Period 00101110
Comma 00101100
Space 00100000

Numbers

0 00110000
1 00110001
2 00110010
3 00110011
4 00110100
5 00110101
6 00110110
7 00110111
8 00111000
9 00111001

Other Miscellaneous Characters

! 00100001
" 00100010
00100011
$ 00100100 (Money counts even in binary!)
% 00100101
& 00100110
' 00100111
(00101000
) 00101001
* 00101010
+ 00101011
, 00101100
/ 00101111
- 00101101
: 00111010
; 00111011

< 00111100
= 00111101
> 00111110
? 00111111
@ 01000000
[01011011
\ 01011100
] 01011101
^ 01011110
_ 01011111
{ 01111011
| 01111100
~ 01111110
' 01100000

Appendix J: Sample Rubric for Workshop and Laboratory Procedures and Health and Safety Practices

Rating	Criteria
	Resource The student • prepares self for task • organizes and works in an orderly manner • identifies appropriate tools and resources
	Lab Routines The student • follows established routines • recognizes and avoids unsafe acts and conditions • demonstrates responsibility for housekeeping • is aware of first aid and emergency practices • uses time effectively
	Tools and Equipment The student • identifies appropriate tools and equipment • uses tools and equipment in a safe manner • uses personal protective equipment • stores tools, materials, and equipment as instructed

Rating Scale	
4	The student exceeds defined outcomes, makes plans, and solves problems effectively and creatively in a self-directed manner. Tools, materials and/or processes are selected and used efficiently, effectively, and with confidence. Quality, particularly details and finishes, and productivity are consistent and exceed expectations. Leads others to contribute to team goals.
3	The student meets defined outcomes, makes plans, and solves problems in a self-directed manner. Tools, materials, and/or processes are selected and used efficiently and effectively. Quality and productivity are consistent. Works co-operatively and contributes ideas and suggestions that enhance team effort.
2	The student meets defined outcomes, makes plans, and solves problems with limited assistance. Tools, materials, and/or processes are selected and used appropriately. Quality and productivity are reasonable consistent. Works co-operatively to achieve team goals.
1	The student meets defined outcomes, and, with guidance, follows a guided plan of action. The student makes appropriate use of a limited range of tools, materials, and/or processes. Quality and productivity are reasonable consistent. Works co-operatively.
0	The student has not completed defined outcomes. The student does not make appropriate use of tools, materials, and/or processes are used inappropriately.

Reflections/Comments

Appendix K: Sample Rubric for an Electricity/Electronics Investigation

Rating	Criteria
	The Student Fundamentals states the function of system/circuit explains the operation of system/circuit explains electrical/electronics concepts involved
	Planning and Preparation uses schematics, manuals, resources creates/uses block diagram(s), flow chart(s) identifies and locates components creates/uses a circuit layout identifies system(s), sub system(s), component(s) states component value, characteristics identifies component placement applies computer simulation of circuit installs and configures software
	Constructing/Prototyping constructs electrical/electronic prototype installs materials/components cabling for given application uses correct tools, equipment, and procedures applies correct connecting techniques
	Evaluation/Testing shows how system operates within given parameters analyzes basic electrical circuit uses correct voltage source uses multimeter (analog and digital) uses voltmeter/ammeter/ohmmeter uses an oscilloscope is able to interpret results
	Problem Solving identifies system/sub system problem area research steps to solve problem follows flow chart is able to correct problem performs routine maintenance

Rating Scale	
4	The student exceeds defined outcomes, makes plans, and solves problems effectively and creatively in a self-directed manner. Tools, materials and/or processes are selected and used efficiently, effectively, and with confidence. Quality, particularly details and finishes, and productivity are consistent and exceed expectations. Leads others to contribute to team goals.
3	The student meets defined outcomes, makes plans, and solves problems in a self-directed manner. Tools, materials, and/or processes are selected and used efficiently and effectively. Quality and productivity are consistent. Works co-operatively and contributes ideas and suggestions that enhance team effort.
2	The student meets defined outcomes, makes plans, and solves problems with limited assistance. Tools, materials, and/or processes are selected and used appropriately. Quality and productivity are reasonable consistent. Works co-operatively to achieve team goals.
1	The student meets defined outcomes, and, with guidance, follows a guided plan of action. The student makes appropriate use of a limited range of tools, materials, and/or processes. Quality and productivity are reasonable consistent. Works co-operatively.
0	The student has not completed defined outcomes. The student does not make appropriate use of tools, materials, and/or processes are used inappropriately.

Reflections/Comments:

Appendix L: Sample Framework for Assessing Workshop or Laboratory Investigations

	Meets minimum expectations	Meets expectations	Exceeds expectations
Management	The student prepares self for task organizes and works in an orderly manner carries out instructions accurately uses time effectively	The student prepares self for task organizes and works in an orderly manner interprets and carries out instructions accurately plans and uses time effectively adheres to routine procedures	The student prepares self for task organizes self and works in an orderly manner interprets and carries out instructions accurately plans and uses time effectively in alogical sequence displays leadership in adhering to routine procedures attempts to solve problems prior to requesting help
Teamwork	co-operates with group members shares work appropriately among group members	co-operates with group members shares work appropriately among group members negotiates solutions to problems	co-operates with group members shares work appropriately among group members negotiates with sensitivity solutions to problems displays effective communication skills
Use of Equipment and Materials	selects and uses appropriate equipment/materials follows safe procedures/techniques weighs and measures accurately returns clean equipment/materials to storage areas	selects and uses appropriate equipment/materials models safe procedures/techniques weighs and measures accurately practises proper sanitation procedures minimizes waste of materials advises of potential hazards and necessary repairs	selects and uses appropriate equipment/materials models safe procedures/techniques weighs and measures accurately practises proper sanitation procedures minimizes waste of materials anticipates potential hazards and emergency response
Investigative Techniques	gathers and applies information from at least one source makes predictions that can be tested sets up and conducts experiments to test a prediction distinguishes between manipulated/responding variables obtains results that can be used to determine if some aspect of the prediction is accurate summarizes important experimental outcomes	gathers and applies information from at least one source makes predictions that can be tested plans, sets up and conducts experiments to test a prediction identifies and explains manipulated/responding variables obtains accurate results that confirm/reject the prediction summarizes and applies experimental outcomes	uses relevant information to explain observations makes predictions that can be tested plans, sets up, and conducts experiments to test a prediction analyzes relationships among manipulated/responding variables obtains accurate results that confirm/reject prediction and answer related questions summarizes, applies, and evaluates experimental outcomes

Appendix M: Occupational Health and Safety Act

Internal Responsibility System

The foundation of this Act is the Internal Responsibility system which is based on the principle that employers, contractors, constructors, employees and self-employed persons at a workplace, and the owner of a workplace, a supplier of goods or provider of an occupational health or safety service to a workplace or an architect or professional engineer, all of whom can affect the health and safety of persons at the workplace, share the responsibility for the health and safety of persons at the workplace;

Required instruction in principles

The curricula of
(a) a trade school or home study course within the meaning of the *Trade Schools Regulation Act*;
(b) a program of instruction within the meaning of the *Community Colleges Act*; and
(c) any other educational institution or class of educational institution designated pursuant to the regulations,
shall include instruction in the principles of occupational health and safety contained in this Act. 1996, c. 7, s.
The Act clearly stipulates that both employers and employees share responsibility for safety, therefore it is in a teacher's best interest to make himself aware of the further provisions of the Act.

A sample rubric for workshop and laboratory health and safety practice is found in Appendix J.

The entire Act is available for viewing on the Internet at

http://www.gov.ns.ca/legi/legc/statutes/
occph&s1.htm

(d) provision for the preparation of written work procedures required to implement safe and healthy work practices.

(e) a hazard identification system that includes
- (i) evaluation of the workplace to identify potential hazards,
- (ii) procedures and schedules for regular inspections,
- (iii) procedures for ensuring the reporting of hazards and the accountability of persons responsible for the correction of hazards, and
- (iv) identification of the circumstances where hazards must be reported by the employer to the committee or representative, if any, and the procedures for doing so;

As well, the attention of teachers is drawn to the following sections for further reading:

Section 58
Restriction on use of chemicals
Where a biological, chemical or physical agent or a combination of such agents is used...

Section 59
Duty of employer to prepare list of chemicals

59 (1) Subject to Section 61, unless the employer has received from the Director specific written direction to the contrary and the direction has not been revoked by the Director, the employer shall prepare a list of all chemical substances regularly used.

Appendix N: WebQuest

A WebQuest is an Internet-based inquiry or problem-solving learning experience in which students, usually working in groups, have access to a range of on-line and other resources. Students gather information and ideas to build a scaffold of understanding leading to insights or solutions that they can share with others.

introduction	use background information to articulate an engaging topic, issue, or question
task	define the scope and limits of the task
plan	identify steps, develop a graphic organizer, guiding questions, and assessment
resources	make a list of Internet, text*, and human resources
process	analyze, evaluate, and synthesize ideas; organize, refine, and present results
conclusion	summarize, reflect on, and extend learning

*text describes any language event, whether oral written, or visual

WebQuest Links	
A WebQuest about WebQuests	http://edweb.sdsu.edu/courses/edtec596/webquestwebquest.html
Building Blocks of a WebQuest	http://edweb.sdsu.edu/people/bdodge/webquest/buildingblocks.html
Matrix of Example WebQuests	http://www.esc20.net/techserv/projects/webquests.html
Examples of WebQuests	http://edweb.sdsu.edu/people/bdodge/Professional.html
Introduction to WebQuests	http://www.esc20.net/techserv/webquest/default.html
WebQuest In-service	http://www.nde.state.ne.us/SS/webqinfo.html
Thoughts About WebQuests	http://edweb.sdsu.edu/courses/edtec596/about_webquests.html
The WebQuest Page	http://edweb.sdsu.edu/webquest/webquest.html
Triton Summer Symposium	http://edweb.sdsu.edu/people/bdodge/Professional.html
WebQuest Index (MISD)	http://www.macomb.k12.mi.us/wq/webqindx.htm
WebQuests Created by Teachers	http://www.plainfield.k12.in.us/hschool/webquest.htm
WebQuests for Learning	http://edweb.sdsu.edu/edfirst/courses/webquest.html
WebQuests in Our Future	http://www.capecod.net/schrockguide/webquest/wqsl1.htm
Teaching with the Web	http://www.thacher.pvt.k12.ca.us/weaving/ExampleWebQuests.html

Appendix O: Suggested Learning Resources

Description	Potential Supplier	Quantity
Software		
*ELECTRONICS WORKBENCH	Interactive Image Technologies Ltd 111 Peter St Suite 801 Toronto Ont M5V 2H1 (on Authorized Learning Resources List)	4:C
CIRCUITS FOR USE WITH ELECTRONIC WORKBENCH	(on Authorized Learning Resources List)	4:C
Equipment and Materials		
DC POWER SUPPLY (12 VOLT)	RAE Industries 11 Morris Dr, Suite 103 Dartmouth NS B3B 1M2	4:C
COPPER MAGNETIC WIRE (MOTOR)	WYCCO 2 Park Ave Lower Sackville NS B4C 4A3	6kg coil
TECHNICAL SET to demonstrate simple machines	LEGO Mindstorm http:/www.legomindstorms.com	1
PROTOBOARD (#10)	WYCCO 2 Park Ave Lower Sackville NS B4C 4A3	4:C
CRIMPLING/CUTTING TOOL		4:C
CRIMP TERMINALS, SLOTTED	assorted	
STUDENT PULL SPRING SCALE		4:C
METER STICKS		12:C
LEVER KNIFE EDGE CLAMP		4:C
HOOK WEIGHTS		4:C

Description	Potential Supplier	Quantity
STOP WATCHES, ELECTRONIC		
DIGITAL MULTIMETER (GENERAL USE)	RAE Industries 11 Morris Dr, Suite 103 Dartmouth NS B3B 1M2	4:C
WELLER #8200 Pk CSA SOLDERING GUNS	RAE Industries 11 Morris Dr, Suite 103 Dartmouth NS B3B 1M2	2:C
ROLLS RESIN CORE SOLDER (wire) 1LB	RAE Industries 11 Morris Dr, Suite 103 Dartmouth NS B3B 1M2	2:C
ASSORTED PLIERS	RAE Industries 11 Morris Dr, Suite 103 Dartmouth NS B3B 1M2	1:C
SCREWDRIVER SETS (Robinson/Phillips/Slot) 25 pc set #57-3547-8	Canadian Tire 24 Forest Hills Parkway Dartmouth NS B2W 6E4	2:C
DRILL 3/8" 3.5 AMP	Canadian Tire 24 Forest Hills Parkway Dartmouth NS B2W 6E4	2
SET DRILL BITS (1/16-1/2), 29 pc #54-3619-4	Canadian Tire 24 Forest Hills Parkway Dartmouth NS B2W 6E4	2
TEACHER RESOURCES		
*ESSENTIAL OF ELECTRONICS INSTRUCTOR 'S RESOURCE GUIDE, 2nd Ed	IT Nelson (Delmar) (on Authorized Learning Resources List)	1
*ESSENTIAL OF ELECTRONICS A SURVEY- STUDENT BASIC 2nd Ed	IT Nelson (Delmar) (on Authorized Learning Resources List)	1