Technology Education

Energy and Power Technology Module
Grade 9

Interim Edition

Newfoundland Labrador

Curriculum Guide
2009

Table of Contents

Acknowledgements v

Section I: Program Overview and Rationale 1
- Background 1
- Overview and Rationale 1
- Purpose of Curriculum Guide 2
- Context for Learning and Teaching 2
- Literacy Through Technology Education 3
- Meeting the Needs of All Learners 4
- Effective Assessment and Evaluation Practices 5

Section II: Curriculum Design and Components 7
- Program Components 7
  - Outcomes Structure 7
  - Curriculum Guide Structure 8
- Essential Graduation Learnings 9
- General Curriculum Outcomes 10
- Key Stage Curriculum Outcomes 11

Section III: Specific Curriculum Outcomes 15
- Overview 15
  - Unit 1 - Big Ideas 16
  - Unit 2 - Basic Skills 18
  - Unit 3 - Design Activity 19
- The 4-column layout 21
- Time Allocation 21
- Unit 1 - Big Ideas 23
  - Overview 23
    - Purpose 23
    - Profile 23
    - Implementation 24
  - Evaluation of the Big Ideas Unit 24
  - Outcomes and Strategies 25
    - Topic 1: Mass and Force 26
    - Topic 2: Work, Energy and Power 28

Topic 3: Sources, Forms, Conversion and Transmission of Energy 32
Topic 4: Sources of Energy for Electrical Generation 38
Topic 5: Career Connections.....48
Unit 2: Basic Skills 51
Overview.....51
Purpose.....51
Profile.....51
Implementation 52
Evaluation of the Basic Skills Unit.....52
Outcomes and Strategies.....53
Topic 1: Energy Conversion and Transmission 54
Topic 2: Measuring Energy and Energy Transmission 60
Topic 3: Schematics and Pictorials 70
Topic 4: Fabrication 76
Unit 3: Design Activity 81
Overview.....81
Purpose.....81
Profile.....82
Implementation 82
Organization and Management Issues 83
Planning for Design 83
Appropriate Problems 83
Student Design Teams.....84
Purpose of Student Design Teams 84
Student Design Teams vs. Professional Design Teams.....85
Effective Operation of Student Design Teams.....85
Key Issues for Managing Student Design Teams 86
Setting Up and Using Design Portfolios.....88
General Information on Design Portfolio Contents 88
Organizing the Design Portfolio 89
Maintaining the Design Portfolio.....89
Evaluation of the Design Activity Unit.....90

Outcomes and Strategies....91
Topic 1: The Design Team and The Design Portfolio....92
Topic 2: Identification of the Problem Situation (Step 1) 96
Topic 3: Development of the Design Brief (Step 2) 100
Topic 4: Investigation and Research (Step 3) 102
Topic 5: Identification of Possible Solutions (Step 4) 104
Topic 6: Selection of the Best Solution (Step 5)....106
Topic 7: Development of the Solution (Step 6) 108
Topic 8: Evaluation of the Solution (Step 7) 112
Topic 9: Presentation of the Report (Step 8)....114
Evaluation of Unit 3 - Design Activity (Summary)....116
Portfolios and Design Solution Collection 116
Portfolio Collection....116
Design Solution Collection....116
Evaluation of Design Activities 116
Purpose....116
Evaluation of the Design Process 117

Acknowledgements

The Department of Education of Newfoundland and Labrador gratefully acknowledges the contribution of the following members, of the provincial Technology Education Working Group:

Corey Downey
Itinerant Teacher, Fine Arts, Western School District

Don Dunphy
Itinerant Teacher, Technology Education Western School District

Tim Goodyear,
Technology Education Teacher,
Centre for Distance Learning and Innovation

Bruce King
Technology Education Teacher Elwood High School

Donna King
Technology Education Teacher Pasadena Academy

Eric Nippard
School Technology Integration Specialist
Centre for Distance Learning and Innovation

Frank Shapleigh
Communication and Connectivity Specialist
Centre for Distance Learning and Innovation

Gary Walsh
Technology Education Teacher, Tricentia Academy

John Barron
Program Development Sepcialist,
Skilled Trades and Technoloyg and Carreer Education Department of Education

Tony Hillier
Program Development Specialist,
Technology Education Department of Education, K-12

Section I

Program Overview and Rationale

Background

The Energy and Power Technology Module for Grade 9 is based, conceptually, philosophically and practically, on the Atlantic Canada Foundation for Technology Education Curriculum (2001). The teacher is directed to the Foundation document for specific information that forms the basis for this and other technology education curricula in the province of Newfoundland and Labrador.

The Energy and Power Module is the fourth of four modules to be delivered at the Intermediate level. It should be delivered to students who have completed the Grade 8 Control Technology Module, Grade 8 Production Technology Module and the Grade 7 Communications Technology Module. The delivery order of modules is: Grade 7 Communications Technology Module, Grade 8 Production and Control Technology Modules, and Grade 9 Energy & Power Modules.

Overview and Rationale

Technology education is defined by outcomes and characterized by courses and modular curriculum components. It encompasses all technological systems, processes, resources, and consequences. For practical purposes, technology education confines itself to representative samples of technological problems and systems. Historically, these have been in areas such as construction, manufacturing, communications, and power systems. This curriculum enables students to work across a much broader range of problems and technological systems, including communications, production, sensing-control, energy & power and management.

The focus of this curriculum is the development of students' technological literacy, capability, and responsibility (International Technology Education Association, 1996). Its primary strategy is to engage them in the design, development, management, and evaluation of technological systems as solutions to problems.

[Excerpted from the Foundation for the Atlantic Canada Technology Education Curriculum document (p. 1).]

Purpose of Curriculum Guide

The purpose of the curriculum guide is to provide the teacher with a clear picture of student expectations in the module. The guide outlines the specific curriculum outcomes, suggested learning and teaching strategies, suggested assessment and evaluation strategies and resources for the course.

The Grade 9 Energy and Power Module, like all intermediate technology education modules, consists of three units: big ideas, basic skills and design activity. Teachers are encouraged to carefully examine the student expectations outlined in the three units and plan lessons that accommodate the achievement of each of them.

Context for Learning and Teaching

Technology education curriculum in Atlantic Canada adheres to certain principles that guide decisions shaping the continuous improvement of learning and teaching. These principles guide the design and implementation of the curriculum and include:

- Authenticity
- Unity
- Constructivism
- Collaboration
- Autonomy
- Continuous Inquiry
- Continuous Improvement
- Continuous Learning

Teachers are encouraged to refer to the Foundation for the Atlantic Canada Technology Education Curriculum document (Contexts for Learning and Teaching section) for further elaboration.

Literacy Through Technology Education

Technological literacy encompasses a wide range of technological knowledge and skills. Students will be exposed to many facets of technology and will gain literacy through active participation in knowledge acquiring and skill developing activities presented throughout the implementation of the Grade 9 Energy and Power Module.

Taking ownership and responsibility for their own learning is a significant element in the growth of a student's technological capability. Doing so implies choice and opportunities to develop responsible habits of thought and action. Students need opportunities to

- identify, assess, and make decisions about their use of technological resources
- assess their technological literacy/capability in the context of specific situations
- develop personal action plans to acquire specific technical skills and capabilities
- safely use a wide variety of technological systems, tools, and other resources
- identify and address technological issues and situations important to them
- design, develop, and articulate technological solutions to a wide range of problems
- articulate ideas and take intellectual risks
- reflect on and evaluate their learning
- reflect on, evaluate, and express ideas and opinions on the relationship between technology and education and the role of technology education
- assess technology as a force for change in a variety of workplaces, jobs, occupations, and careers

[Excerpted from the *Foundation for the Atlantic Canada Technology Education Curriculum* document (p. 31).]

Meeting the Needs of All Learners

The society of Atlantic Canada, like all of Canada, is linguistically, racially, culturally, and socially diverse. Our society includes differences in race, ethnicity, gender, ability, values, lifestyles, and languages. Schools should foster the understanding of such diversity. The Foundation for the Atlantic Canada Technology Education Curriculum is designed to meet the needs, values, experiences and interests of all students.

In a learning community characterized by mutual trust, acceptance, and respect, student diversity is both recognized and valued. All students are entitled to have their personal experiences and their racial and ethnocultural heritage valued within an environment that upholds the rights of each student and requires students to respect the rights of others. Teachers have a critical role in creating a supportive learning environment that reflects the particular needs of all students. Educators should ensure that classroom practices and resources positively and accurately reflect diverse perspectives and reject prejudice attitudes and discriminatory behaviours.

To contribute to the achievement of equity and quality in education, curriculum must

- reflect students' abilities, needs, interests, and learning styles
- expect that all students will be successful regardless of gender, racial and ethnocultural background, socio-economic status, lifestyle, or ability
- enable students to value individual variation among mem bers of their classroom community

To enhance students' ability to appreciate diversity, instructional practices need to:

- foster a learning environment which is free from bias and unfair practices

- promote opportunities to develop positive self-images that will enable students to transcend stereotypes and develop as individuals
- promote communication and understanding among those who differ in attitude, knowledge, points of view, and dialect, as well as among those who are similar
- encourage and enable students to question their own assumptions, and imagine, understand, and appreciate realities other than their own
- promote the equitable sharing of resources, including teacher attention and support
- encourage students to examine and critique materials, resources, and experiences for bias and prejudice
- examine historical and current equity and bias issues
- promote opportunities in non-traditional careers and occupations
- encourage students to challenge prejudice and discrimination

Technology education curriculum outcomes provide a framework for a range of learning experiences for all students. Technology educators adapt learning contexts, including classroom organization, teaching strategies, time, and learning resources to provide support and challenge for all students, using curriculum outcomes in a flexible way to plan learning experiences appropriate to students' individual learning needs. Technology education provides opportunities for all students to develop confidence in themselves as learners and to experience learning success.

[Excerpted from the Foundation for the Atlantic Canada Technology Education Curriculum document (p. 28-29).]

Effective Assessment and Evaluation Practices

Assessment and evaluation are essential components of learning and teaching in technology education. Without effective assessment and evaluation it is impossible to know whether students have learned, whether teaching has been effective, or how best to address student learning needs. The quality of assessment and evaluation in the educational

process has a profound and well-established link to student performance. Research consistently shows that regular monitoring and feedback are essential to improved student learning. What is assessed and evaluated, how it is assessed and evaluated, and how results are communicated send clear messages to students and others about what is really valued, what is worth learning, how it should be learned, what elements of quality are considered most important, and how well students are expected to perform.

Teacher-developed assessments and evaluations have a wide variety of uses, such as

- providing feedback to improve student learning
- determining whether curriculum outcomes have been achieved
- certifying that students have achieved certain levels of performance
- setting goals for future student learning
- communicating with parents about their children's learning
- providing information to teachers on the effectiveness of their teaching, the program, and the learning environment
- meeting the needs of guidance and administrative personnel

[Excerpted from the *Foundation for the Atlantic Canada Technology Education Curriculum* document (p. 32).]

Section II

Curriculum Design and Components

Program Components

The Energy and Power Module is the fourth of four modules to be delivered at the Intermediate level. It is recommended students complete the Energy and Power Module after completing the Control Technology Module at the grade 8 level, as each module builds on knowledge and skills obtained in previous modules. The recommended delivery order of modules is: Grade 7 Communications, Grade 8 Production, Grade 8 Control, and Grade 9 Energy & Power Modules.

Outcomes Structure

Curriculum content and student activities are defined with respect to a structure of curriculum outcomes (Figure 1). The essential components of the outcomes structure are:

EGL's. Essential Graduation Learnings are statements describing the knowledge, skills, and attitudes expected of all students who graduate from high school.

GCO's. General Curriculum Outcomes are statements that identify what students are expected to know and be able to do upon completion of study in a curriculum area.

KSCO's. Key Stage Curriculum Outcomes provide additional detail for each of the GCO's. There are four Key Stages - Key Stage 1 (K-Grade 3), Key Stage 2 (Grades 4-6), Key Stage 3 (Grades 7-9), and Key Stage 4 (Grades 10-12). Key Stage
Curriculum Outcomes provide a means to quickly assess progress in a subject area at the end of a level of schooling.

SCO's. Specific Curriculum Outcomes are statements which describe knowledge, skills, and attitudes, in measurable terms, that students should possess upon completion of a grade level or course (e.g., Grade 9 Energy and Power Module).

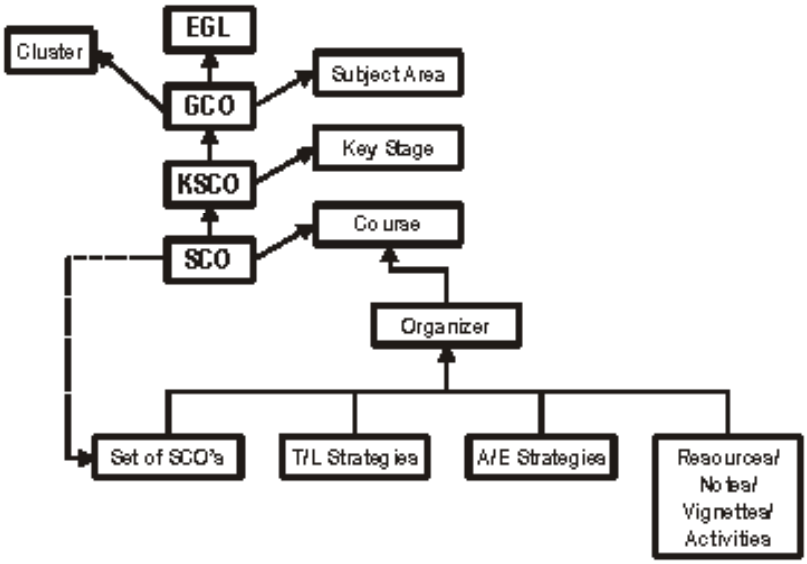

Figure 1

Curriculum Guide Structure

Curriculum Guides are developed for a course of study. This guide contains the SCO's for the course (Section III) and presents other information related to it. Content is presented in four columns that span across two pages. Each set of two pages has an Organizer stated at the top. An Organizer may be a topic or some other statement which is employed to create a discrete component of the course. The four columns of content include:

I Specific Curriculum Outcomes. The set is one or more SCO's from the course that will be addressed by the organizer. Each SCO also contains a listing of the KSCO's it directly relates to (the relative KSCO's are included in brackets). The KSCO would be those for the subject area the course fits.

II **Suggested Teaching and Learning Strategies**. Suggested Teaching/Learning Strategies are recommendations for implementing the curriculum. This section could include Organization and Prepara tion and Sample Student Projects and Activities sections.

III **Suggested Assessment and Evaluation Strategies.** Suggested Assessment and Evaluation Strategies are recommendations for determining student achieve ment. Suggestions are provided to assist the teacher with the evaluation and assessment of student activity.

IV **Resources.** This column provides additional information that may be of help to the teacher in lesson planning. Refer ences to teacher and student texts, appendix material, and other resources will be included here.

The appendices in this guide provide additional material and resource support to the teacher. Concepts, strategies, and resources identified in the guide are elaborated upon in the appendices.

Essential Graduation Learnings

Essential Graduation Learnings

Essential Graduation Learnings are documented in the Outcomes section of the Foundation for the Atlantic Canada Technology Education Curriculum (2001) document. The Essential Graduation Learnings for (EGL's) are:

- **Aesthetic Expression**. Graduates will be able to respond with critical awareness to various forms of the arts and be able to express themselves through the arts.
- **Citizenship**. Graduates will be able to assess social, cultural, economic, and environmental interdependence in a local and global context.
- **Communication.** Graduates will be able to use the listening, viewing, speaking, reading, and writing modes of language(s), and mathematical and scientific concepts and symbols, to think, learn, and communicate effectively.
- **Personal Development.** Graduates will be able to continue to learn and to pursue an active, healthy lifestyle.
- **Problem Solving.** Graduates will be able to use the strategies and processes needed to solve a wide variety

of problems, including those requiring language, and mathematical and scientific concepts.

- **Technological Competence**. Graduates will be able to use a variety of technologies, demonstrate an understanding of technological applications, and apply appropriate technologies for solving problems.
- **Spiritual and Moral Development.** Graduates will be able to demonstrate understanding and appreciation for the place of belief systems in shaping the development of moral values and ethical conduct

Reference to the Foundation for the Atlantic Canada Technology Education Curriculum (2001) document is encouraged.

General Curriculum Outcomes (GCO's)

General Curriculum Outcomes

Technology Education curriculum in the Atlantic Provinces is defined in terms of five General Curriculum Outcomes (GCO's). These define the intent and focus of the Technology Education Program and apply from Kindergarten to Grade 12. They are:

- **GCO 1**: Technological Problem Solving. Students will be expected to design, develop, evaluate, and articulate technological solutions.
- **GCO 2:** Technological Systems. Students will be expected to evaluate and manage technological systems.
- **GCO 3**: History and Evolution of Technology. Students will be expected to demonstrate an understanding of the history and evolution of technology, and of its social and cultural implications.
- **GCO 4**: Technology and Careers. Students will be expected to demonstrate an understanding of current and

evolving careers and of the influence of technology on the nature of work.

- **GCO 5:** Technological Responsibility. Students will be expected to demonstrate an understanding of the consequences of their technological choices.

Key Stage Curriculum Outcomes (KSCO's)

Key Stage Curriculum Outcomes

The Key Stage Curriculum Outcomes for Technology Education are listed in the Outcomes section of the *Foundation for the Atlantic Canada Technology Education Curriculum (2001)* document. Key Stage Curriculum Outcomes (KSCO's) expand the intent of the GCO's and summarize what is expected of students during each of the four Key Stages. The Grade 8 Control Technology Module adheres to the KSCO's at the Key Stage 3 level (Grades 7-9).

Key Stage 3 Curriculum Outcomes listed are organized according to each of the five General Curriculum Outcomes (GCO's) for the Atlantic Canada Technology Education Curriculum.

GCO 1
Technological Problem Solving

By the end of grade 9, students will have achieved the outcomes for entry to grade 6 (Key Stage 1 and Key Stage 2) and will also be expected to:

1.301 articulate problems that may be solved through technological means

- examine problem situations
- construct simple design briefs that include the problem statement and conditions affecting the solution

1.302 conduct design studies to identify a technological solution to a problem

- investigate related solutions
- document a range of options to solve the problem
- determine and justify the best option
- create a plan of action that includes technical sketches

1.303 develop (prototype, fabricate, make) technological solutions to problems

- identify appropriate tools and resources
- employ safe practices and resource conservation
- develop the solution with redesign as neces sary to ensure the design brief is satisfied
- document all activities and decisions

1.304 critically evaluate technological solutions and report their findings

- use established and their own criteria to evaluate the effectiveness of both their own and others' technological solutions
- assess solution components and incorporate the required changes during the design activity
- document and report their changes, the rationale for change, and conclusions

1.305 communicate ideas and information about technological solutions through appropriate technical means

- create more sophisticated orthographic and isometric views
- create alternate representations, such as computer animations and physical models

GCO 2
Technological Systems

2.301 operate, monitor, and adjust a representative range of technological systems

2.302 manage a representative range of technological systems

2.303 employ programming logic and control systems to sense, switch, and regulate events and processes

2.304 classify technological systems, using one or more schema, and determine their operational components

and parameters (e.g., schema include general makeup, underlying principles and purposes, and sub-systems)

2.305 diagnose and repair malfunctioning systems

3.301 examine the historical evolution of technologies and predict future developments

GCO 3
History and Evolution of Technology

3.302 investigate ways that science activities depend on technology and that inventions in technology depend on science

3.303 examine technological literacy and capability in modern society and their effects on citizenship and education

3.304 evaluate the effects of rapid change in technological systems on people in their schools and communities

3.305 account for effects of cultural diversity on technological solutions

- examine the effects of culture on traditional products, and vice versa
- explore how products are designed differently for different markets
- apply their understanding of cultural preferences when developing technological solutions

GCO 4
Technology and Careers

4.301 examine the technologies of specific careers and workplaces, including the organizational structures of work environments and the effects of newer technologies.

4.302 examine the roles of design and invention in business growth and economic development

4.303 develop strategies to assess their technological literacy/capability and plan for continuous personal growth, using external criteria

GCO 5
Technological Responsibility

5.301 demonstrate an understanding of the nature and purpose of legal and ethical rules and principles

5.302 develop personal rules of conduct that ensure healthy and safe practices

5.303 develop and demonstrate risk-management strategies for a variety of technological activities

Section III

Specific Curriculum Outcomes

Overview

The Specific Curriculum Outcomes (SCO's) for the Grade 9 Energy and Power Technology Module are derived from Key Stage 3 (Grade 7-9) Key Stage Curriculum Outcomes (KSCO's). The SCO's are organized into three units:

- Unit 1 - Big Ideas
- Unit 2 - Basic Skills
- Unit 3 - Design Activity

Outcomes in each unit are listed within Unit topics.

Unit 1 - Big Ideas

- Topic 1: Mass and Force
- Topic 2: Work Energy and Power
- Topic 3: Sources Forms Conversion and Transmission of Energy
- Topic 4: Sources of Energy for Electrical Generation
- Topic 5: Career Connections

Unit 2 - Basic Skills

- Topic 1: Energy Conversion and Transmission
- Topic 2: Measuring Energy and Energy Transmission
- Topic 3: Schematics and Pictorials
- Topic 4: Fabrication

Unit 3 - Design Activity

- Topic 1: The Design Team and The Design Portfolio
- Topic 2: Identification of the Problem Situation (Step 1)
- Topic 3: Development of the Design Brief (Step 2)

- Topic 4: Investigation and Research (Step 3)
- Topic 5: Identification of Possible Solutions (Step 4)
- Topic 6: Selection of the Best Solution (Step 5)
- Topic 7: Development of the Solution (Step 6)
- Topic 8: Evaluation of the Solution (Step 7)
- Topic 9: Presentation of the Report (Step 8)

Each topic has one or more SCO's associated with it. Suggested Teaching/Learning Strategies and Assessment/ Evaluation Strategies for each topic are designed to provide introductory material for the teacher and guide lesson preparation.

Intermediate Technology Education Modules are sequential and successive modules that build upon knowledge and skills achieved in previously completed modules. It is recommended that students complete the modules in sequential order, thus students would enrol in the Grade 9 Energy and Power Module upon completion of the Grade 8 Control Technology Module , the Grade 8 Production Technology Module and the Grade 7 Communications Technology Module. Some the of the SCOs from previous modules will be repeated in Energy and Power.

Specific Curriculum Outcomes

All of the Specific Curriculum Outcomes (SCO's) for the Grade 9 Energy and Power Module are listed. The Key Stage Curriculum Outcome(s) (KSCO's) that the SCO relates to is included in the brackets at the end of each SCO statement. Refer to the Key Stage Curriculum Outcomes section in Section II of this curriculum guide.

Unit 1 - Big Ideas

Unit 1 has eighteen (18) Specific Curriculum Outcomes. Students will be expected to:

1.01 define the term mass and state the unit of measurement for mass. [2.304, 3.301]

1.02 define the term force and state the unit of measurement for force (weight). [2.304, 3.301, 3.302]

1.03 explain the historical context for the unit measurement of force. [2.304, 3.301, 3.302]

1.04 define the term work and state the unit of measurement for work. [2.304, 3.301, 3.302]

1.05 define the term energy and state the unit of measurement for energy. [2.304, 3.302]

1.06 define kinetic energy and explore sources of kinetic energy. [2.304,3.301]

1.07 define potential energy and explore sources of potential energy. [3.302]

1.08 define the term power and state the unit of measurement for power. [03.302]

1.09 define the term electrical potential difference and state the unit of measurement for electrical potential difference. [2.304, 3.302]

1.10 define the term electrical current and state the unit of measurement of electrical current. [2.304, 3.302]

1.11 identify and describe the major forms and sources of energy. [2.303, 3.301, 3.303]

1.12 identify how energy can be converted from one form to another. [2.304, 3.302]

1.13 investigate and report on sources that can be used to produce electricity. [02.303, 03.301, 03.303, 05.301, 05.302, 05.303]

1.14 identify how electrical energy is distributed from the source to the consumer.. [02.303, 03.301]

1.15 discuss legal, ethical, and environmental consequences related to the generation, conversion, transmission and consumption of energy for individuals and society. [3.301, 3.301 5.301]

1.16 examine new technologies that are evolving for more efficient conversion, transmission, and consumption of electrical energy. [01.305, 02.304, 03.301,03.302, 03.304]

1.17 develop personal rules of conduct for dealing with energy conservation. [0.302]

1.18 examine and consider career trends and professions in energy and power related industries. [04.301, 04.303]

Unit 2 - Basic Skills

Unit 2 has fifteen (15) Specific Curriculum Outcomes. Students will be expected to:

2.01 measure the mass of an object. [2.304]

2.02 measure the forces acting on a mass. [2.304]

2.03 calculate the work done on a mass. [2.304]

2.04 calculate the amount of energy used by an electrical device.[2.301, 2.304]

2.05 calculate the energy input, output, and efficiency of a system. [2.304]

2.06 calculate the power used by a system. [02.304]

2.07 demonstrate ways that energy can be transmitted from one location to another or from one system to another by a number of mechanisms. [2.301, 2.304]

2.08 demonstrate the conversion of energy from one form to another using a variety of simple systems. [02.301, 2.304]

2.09 identify basic symbol sets that are employed in schematic drawings. [1.305]

2.10 read and interpret a simple schematic diagram. [1.305]

2.11 relate a schematic drawing to a pictorial drawing. [1.305]

2.12 create simple schematic drawings. [1.502, 1.305]

2.13 create orthographic projections and isometric drawings to represent system components. [1.305]

2.14 employ safe practices when fabricating systems and components. [5.302]

2.15 employ shaping, forming, combining and finishing techniques to fabricate components for generating electricity. [1.303]

Unit 3 - Design Activity

Unit 3 has nineteen (19) Specific Curriculum Outcomes.

Students will be expected to:

3.01 work cooperatively and collaboratively in design teams.

3.02 maintain a complete design portfolio of the design process and design activity.

3.03 investigate problem situations to determine opportunities to develop systems for energy conversion and transmission. [1.301,1.305]

3.04 identify specific problems for the design and development of an energy efficient system. [1.301, 1.304, 2.301]

3.05 select a specific problem for design and development of an energy efficient system and communicate it clearly in the form of a design brief. [1.304, 2.304]

3.06 investigate problems similar to the electrical energy conversion and transmission problem selected and assess their solutions. [1.302, 1.304, 5.301, 5.303]

3.07 identify technological resources available to resolve the design brief. [1.302, 3.305]

3.08 engage in idea generating strategies to identify a range of alternative solutions to solve the electrical energy conversion and transmission problem. [1.302]

3.09 develop criteria for assessing electrical energy conversion and transmission solution options. [1.302,3.303, 5.303]

3.10 using established criteria, examine the electrical energy conversion and transmission solution options and select the most appropriate. [1.302]

3.11 identify specific tools/machines and resources that are required to effectively develop the electrical energy conversion and transmission solution. [1.303, 4.303]

3.12 determine new skills that will need to be acquired to effectively develop the electrical energy conversion and transmission solution. [1.303, 4.303]

3.13 create a plan of action that will guide the implementation of the electrical energy conversion and transmission solution. [1.302]

3.14 using safe practices, develop the electrical energy conversion and transmission solution, redesigning as necessary. [5.302, 5.303, 1.303, 1.305]

3.15 establish criteria for evaluating the electrical energy conversion and transmission solution. [1.304]

3.16 evaluate the electrical energy conversion and transmission solution, based on established criteria. [1.304]

3.17 develop a presentation plan that is based on information recorded in the design portfolio. [1.305]

3.18 develop a presentation that uses appropriate presentation tools and strategies, demonstrates how the design model was implemented, and identifies the implications of the electrical energy conversion and transmission solution. [1.305, 3.305]

3.19 present the design portfolio, the design solution and the design activity report to the class. [1.305]

The 4-column layout in the curriculum guide spans across two pages and presents the necessary information to the teacher to deliver a particular course topic to the student. The 4-column layout consists of

The 4-column Layout

I **Specific Curriculum Outcomes**. This is one or more of the SCO's from the course that will be addressed by the organizer. Each SCO also contains a listing of the KSCO's it directly relates (the relative KSCO's are included in brackets). The KSCO would be those for the subject area the course fits.

II **Suggested Teaching** and Learning Strategies. Suggested teaching/Learning Strategies are recommendations for implementing the curriculum. This section could include Organization and Preparation and Sample Student Projects and Activities sections.

III **Suggested Assessment and Evaluation Strategies**. Suggested Assessment and Evaluation Strategies are recommendations for determining student achievement. Suggestions are provided to assist the teacher with the evaluation and assessment of student activity.

IV **Resources**. This column provides additional information that may be of help to the teacher in lesson planning. references to teacher and student texts, appendix material, and other resources will be included here.

The teacher is encouraged to expand and elaborate upon the information presented in columns II, III and IV, as the information provided in those columns is meant to be suggestions.

Time Allocation

The Grade 9 Energy and Power Module is designed to be completed in a minimum of twenty-six (26) hours of class time as a stand-alone module. Although the module requires students to construct physical objects, it does so by implementing a design and problem solving methodology. There are many opportunities to connect to other subject areas, either through one or more stages of the problem

solving process, or through the very nature of the problem being solved.

Unit 1

Big Ideas

Overview

Purpose

The purpose of the Big Ideas section is to provide students with an introduction to the ideas, terminology and concepts covered in the module. In this section, students will develop knowledge of the following topics:

- Topic 1: Mass and Force
- Topic 2: Work Energy and Power
- Topic 3: Sources, Forms, Conversion and Transmission of Energy
- Topic 4: Sources of Energy for Electrical Generation
- Topic 5: Career Connections

Profile

This unit introduces the basic concepts of energy and power as an activity that employs a broad range of tools and methodologies. Specific tools and methods will be introduced as examples. In particular, students will be introduced to basic principles of physics and will have the opportunity to explore the technology of electrical energy generation. This unit contains connections to other subjects, and will include non-class activities, such as homework. .

Implementation

This section should be completed in not more than 8 hours of class time. Consideration should be given to integrating parts of this section with Unit 2: Basic Skills and Unit 3: Design Activity.

Evaluation of the Big Ideas Unit

The Big Ideas section is intended to introduce ideas, terminology and concepts related to energy and power technology. Evaluation will focus primarily on student's understanding of this information.

Although activities and evaluation suggestions are offered with each topic, it is not intended that significant detail be covered, or that students engage in any great depth of treatment. Much of the content will actually be learned while engaging in the activities of Unit 2: Basic Skills and Unit 3: Design Activity.

The Big Ideas unit should account for 20% of the evaluation for the Energy and Power Technology Module.

Outcomes and Strategies

Topic 1: Mass and Force

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.01 define the term mass and state the unit of measurement for mass.[2.304, 3.301]

1.02 define the term force and state the unit of measurement for force (weight). [2.304, 3.301, 3.302]

1.03 explain the historical context for the unit measurement of force. [2.304, 3.301, 3.302]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is for students to understand the concepts of mass and force and their historical context.

Points to Emphasize

- Mass and force are related. Mass is a measure of the amount of matter in an object. It is a fundamental measurement and is measured in kilograms. Force is another fundamental concept. It is the measurement of influences that change the direction of an object. It is measured in Newtons and may be explained through Newton's Second Law. The most dominant of the forces is gravity.
- Two objects with the same mass will weigh differently depending on the measure of gravitational force on that object. For example, if an object has a mass of 1kg on earth, it would have a mass of 1kg on the moon, even though it would weigh less. The force of gravity on the moon is less than on earth; therefore the object will weigh less on the moon.
- Most of the units of measurement in Physics are named after researchers who contributed heavily to that field. For example, Newton's First and Second Laws.

For the Student

- Students could view a presentation prepared by the teacher that reviews the units of mass and force and where these units originated (historical background).
- Students could view demonstrations to illustrate differences between mass and force using objects readily available around the home or school.
- Students could role play to demonstrate the concepts. The class could be divided into teams and each student would take on the behavior of a unit of mass and force.
- Students could develop a timeline for the historical context for the unit of measurement of force.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Audio editing - create a song incorporating the terms: mass, force and the historical context for the unit of measurement of force
- Flipbook – create a flipbook that would illustrate the following concepts: mass, force, kinetic energy, potential energy, and power. For example, you could use a ping pong ball, pool ball, or puck, etc to illustrate each concept.

Digital Portfolio

- Add mass and force to your dictionary of terms with appropriate definitions including the units of measure for each.

Pencil and Paper

- Define the terms mass and force and state the unit of measurement for each.
- Explain the historical context for the unit measurement of force.

Resources

Windows to the Universe: What is Mass

http://www.windows.ucar.edu/tour/link=/glossary/mass.html

Technology Interactions pp. 392 - 401

CDLI Resource: Intermediate Energy and Power.

http://www.cdli.ca/courses/ep/predesign/t03.htm

Topic 2: Work, Energy and Power

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.04 define the term work and state the unit of measurement for work. [2.304, 3.301, 3.302]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is for students to understand the concepts of work and acquire some understanding of the unit of measurement of work

Points to Emphasize

In order to do work, a force has to be applied to a mass and the mass has to be moved in the direction of the force over a distance. Work is not done on the mass if the mass doesn't move or if the force applied to the mass is in the opposite direction to its motion. Work is measured in Joules (a Joule is a Newton-metre).

For the Student

Have the students view simple demonstrations and determine which does work on the mass?

- Pushing against wall
- Tossing a wad of paper across room
- Lifting a book from the floor to a table
- Moving the book from the table to a floor

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Use audio editing software create a song incorporating the term work and its unit of measure.
- flipbook – create a flipbook that would illustrate the following concepts: mass, force, kinetic energy, potential energy, and power. For example you could use a ping pong ball, pool ball, puck, etc to illustrate each concept.

Digital Portfolio

- Add the term work to your dictionary of terms with the appropriate definition including the unit of measure.

Pencil and Paper

- Define the term work and state the unit of measurement for work.

Resources

Technology Interactions pp. 392 - 401

Topic 2: Work, Energy and Power

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.05 define the term energy and state the unit of measurement for energy. [2.304, 3.302]

1.06 define kinetic energy and explore sources of kinetic energy. [03.301]

1.07 define potential energy and explore sources of potential energy.

1.08 define the term power and state the unit of measurement for power. [03.301]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is to provide students with an opportunity to explore energy and power in general and more specifically, to help them understand these concepts from a real world perspective.

Points to Emphasize

- Energy is the ability to do work. For example, a plane uses energy to carry passengers. When electricity turns a motor, the motor is using energy. When water is changed into steam it uses energy. Since energy is the ability to do work, it is also measured in Joules.
- Kinetic energy is energy of a mass in motion whereas potential energy is stored energy. An example of kinetic energy would be a loaded oil tanker coming up Placentia Bay. This vessel would need miles to stop simply because it has a tremendous amount of kinetic energy. Examples of potential energy would be sunlight, coal, oil being pumped out of Hibernia , water in a dam above a power plant, etc.
- Power is the amount of energy expended in a unit of time or the amount of work done in a unit of time. The unit of power is the Watt which is a Joule per second. For example, people shovelling a mound of dirt by hand may take all day whereas a loader can come in and do that in a few minutes. The loader does the same amount of work in a shorter period of time and therefore has more power.

For the Student

- Using appropriate sources, students can define work, energy, power, kinetic energy and potential energy.
- Students can identify examples of each of the above definitions Students can investigate where the term horse power came from
- The units Joule and Watt are named after historical figures. Investigate why?

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- use audio editing software create a song incorporating the terms: energy, kinetic energy, potential including the units of measure and sources for each.
- flipbook - create a flipbook that would illustrate the following concepts: mass, force, kinetic energy, potential energy, power . For example you could use a ping pong ball, pool ball, puck, etc to illustrate each concept.

Digital Portfolio

- Add energy, kinetic energy, potential energy and power to your dictionary of terms with appropriate definitions including the units of measure for each.

Pencil and Paper

- Define the terms energy, kinetic energy, potential energy and power and state the unit of measurement for each.

Resources

Technology Interactions pp. 392 - 401

The Physics Classroom
Lesson 1: Basic Terminology and Concepts

http://www.physicsclassroom.com/Class/energy/U5L1a.html

Topic 3: Sources, Forms, Conversion and Transmission of Energy

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.09 define the term electrical potential difference and state the unit of measurement for electrical potential difference. [2.304, 3.302]

1.10 define the term electrical current and state the unit of measurement of electrical current. [2.304, 3.302]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is to have students explore the concepts of electrical potential difference and electrical current.

Points to Emphasize

- Energy consumed by an electrical device is measured differently than mechanical energy. Energy consumed by an electrical device is a product of the voltage, current and the length of time that the device is on. Electrical power is the product of the voltage multiplied by the current being consumed by an electrical device.
- The Volt is the unit of measure of electrical potential difference. An electric potential difference must exist for current to flow in an electric circuit
- The symbol for current is I. Current is the measure of electrons flowing through a conductor (wire). The unit of measure of current is the ampere or amp.

For the Student

Break the students into small groups and have them discuss the volt and the amp. This discussion should include defining these terms, their units of measure and real world examples of their application.

Teachers could set up a role play in the classroom where some students could represent electrons and neutrons, while other students could act as positive and negative terminals on a power source. The electrical potential difference and current could be demonstrated by moving students around the classroom.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Use audio editing software create a song incorporating the term electrical potential difference including the unit of measure.

Flipbook

- Create a flipbook that would illustrate the following concepts: mass, force, kinetic energy, potential energy, power. For example you could use a ping pong ball, pool ball, puck, etc to illustrate each concept.

Digital Portfolio

- Add electrical potential to your dictionary of terms with appropriate definitions including the units of measure for each.

Resources

Technology Interactions pp. 292 - 299

Design and Problem Solving in Technology pp. 168-170

Bill's Electronics Reference Library

Electricity - Table of Contents

http://www.reprise.com/host/electricity/default.asp

Topic 3: Sources, Forms, Conversion and Transmission of Energy

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.11 identify and describe the major forms and sources of energy. [02.303, 03.301, 03.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to introduce students to the many forms energy can take and the major sources that provide the energy.

Points to Emphasize

- Forms of energy - mechanical (wind, water), thermal (geothermal, solar) chemical (biomass, fossil fuels, bioluminescence, food), electromagnetic (electricity), and nuclear (radiant, light, heat)
- Sources of energy - chemical (sugar, gasoline, batteries), mechanical (rolling stone, windmill, running water, water waves, sound), electromagnetic (lightning, microwaves, light), thermal (geothermal, solar), nuclear (fusion, fission)

For the Student

- Have a discussion with the class. Have students disprove that all the earths energy comes from a star. The sun is a star and it can be argued that many forms of energy on earth originated from the sun. Other forms of energy such as geothermal energy originated from the earths beginnings as a product of a celestial event; Therefore, it can be debated that the earths energy came from a star.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Create an animation that demonstrates how one of the major forms and sources of energy works.
- Journal
- Respond to the statement "that all energy that we use comes from a star."

Digital Portfolio

- Which of the forms of energy would be most environmentally friendly? Include evidence to support your choice.

Pencil and Paper

- Identify and describe the major forms and sources of energy. Provide examples of each.

Resources

Energy Information Administration Energy Kids Page:

http://www.eia.doe.gov/kids/energyfacts/index.html

Topic 3: Sources, Forms, Conversion and Transmission of Energy

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.12 identify how energy can be converted from one form to another. [02.303, 03.301, 03.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to get students to understand how energy can be converted from one form to another. It is another common principle of physics that students need to understand as they move closer to their alternative energy design projects.

Points to emphasize

There are many ways that energy can be converted from one form to another.

- Turn a flashlight on - chemical to electrical to light.
- Plant growing - solar to chemical energy.
- Pouring water into a pan - potential to kinetic energy - add a turbine to produce electrical energy.
- Rubbing two sticks together to start a fire - mechanical energy
- Using a magnifying glass to ignite a piece of paper - light to heat energy.

For the Student

- Have the students observe a demonstration of various energy conversions and identify and discuss the types of conversions
- Have students visit a number of stations where energy conversions are taking place. Students will observe the energy changes and document their findings.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Create an animation that demonstrates how energy can be converted from one form to another.

Journal

- List the items that you use in a day that convert from one form of energy to another. For example, an mp3 player converts chemical energy to electrical energy to acoustic (sound) energy.

Digital Portfolio

- Which of the forms of energy conversion would be most environmentally friendly? Include evidence to support your choice.

Pencil and Paper

- Draw and label a diagram that demonstrates how energy can be converted from one form to another.

Resources

Energy Quest: Energy Story

http://www.energyquest.ca.gov/story/index.html#table

Topic 4: Sources of Energy for Electrical Generation

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.13 investigate and report on sources that can be used to produce electricity. [02.303, 03.301, 03.303, 05.301, 05.302, 05.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to give students the opportunity to explore the sources of electrical energy production.

Points to Emphasize

Electricity can be produced in a number of ways:

- Turbines in nuclear plants
- Hydroelectric stations
- Fossil fuels
- Solar panels/collectors
- Windmills
- Batteries
- Hydrogen cells

For the Student

Select an example (local if possible) of an electricity source and explain the system that produces the electricity. This can take the form of a slideshow presentation, poster, word processing document or a web page.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Bring an item to class and explain how it is used to produce electricity. For example: a solar power flashlight, solar garden light, etc., or an image of the item.

Journal

- List and give an example of the sources of electricity that are used in your house each day.

Digital Portfolio

- Collect and organize images and information on the various sources that can be used to produce electricity

Pencil and Paper

- List and define sources that can be used to produce electricity.

Resources

Energy Quest

Chapter 8: Fossil Fuels - Coal, Oil and Natural Gas

http://www.energyquest.ca.gov/story/chapter08.html

Energy Quest

Chapter 6: Turbines, Generators and Powerplants

http://www.energyquest.ca.gov/story/chapter06.html

Topic 4: Sources of Energy for Electrical Generation

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.14 identify how electrical energy is distributed from the source to the consumer. [02.303, 03.301]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students identify how electrical energy may be transferred from one place to another. Specifically, how energy is moved from the source of generation to the consumer.

Points to emphasize

Electricity is normally carried in overhead wires with very high voltages between communities. The reason for this is to reduce energy loss (the higher the voltage the less energy loss over long distance). Voltage is reduced at substations in or near each community for distribution to consumers and is further reduced near the consumer's premises.

For the Student

Students can do an Internet search for "Newfoundland and Labrador Hydro" and investigate some examples of transmission lines in the province and make a brief report in their portfolio.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Create an animation that shows how electrical energy is distributed from the source to the consumer
- Create a 3D model that shows how electricity is stepped down from the time that it leaves the source until it reaches the consumer (220 000v – 240v).

Journal

- List the components that are used to transport the electricity from the source to the consumer.
- Digital Portfolio
- Collect and organize images and information on how electrical energy is distributed from the source to the consumer.

Pencil and Paper

Trace the journey of potential energy from its source to the consumer. Be sure to outline the voltage at each step.

Resources

Energy Quest - Chapter 7:Electricity Transmission Story

http://www.energyquest.ca.gov/story/chapter07.html

Topic 4: Sources of Energy for Electrical Generation

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.15 discuss legal, ethical, and environmental consequences related to the generation, conversion, transmission and consumption of energy for individuals and society. [05.301]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to make students aware of a variety of legal, ethical, and environmental issues related to the generation, conversion and transmission of energy.

Points to Emphasize:

- This issue relates to individual homes as well as on a global scale. Some examples are: disposing of batteries, global warming, inefficient incandescent light bulbs.
- Every kind of generation, conversion, and transmission has some legal, ethical, and environmental issue related to it.

Even alternative energy sources can have negative environmental effects.

- Wind farms in western Canada are affecting: wildlife (rare species of bats, birds), humans (low frequency noise damage), and aesthetics. Ice buildup on blades during winter months can fly off and cause property damage or injury. Communities can be displaced and natural vegetation can be destroyed.
- Hydroelectric reservoirs cause rotting vegetation which produces significant amounts of green house gases. In some cases the destruction of sacred native lands have caused disputes with native cultures (Three Gorges Dam, China, James Bay Project, Quebec).
- Geothermal energy can cause noise pollution, dissolved solids in steam quickly erode pipes, natural steams contain many green house gases, not easily transported.

For the Student

Assigned case study with an in-class discussion. Alternatively, students could be divided into teams. Each team could be given a legal or ethical scenario with a real world application. Each team could be tasked with preparing a statement for or against the issue provided in the scenario

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Role play – debate the environmental impact of: hydroelectricity (Bay D'Espoir, Smallwood Reservoir, Three Gorges Dam, etc); wind farms (Ramea); nuclear; solar, etc.

Journal

- Write a letter to the editor of a local newspaper from the perspective of a cabin owner in Come By Chance who has to abandon his cabin and hunting areas due the construction of a new oil refinery.
- Complete the following statement: "I do not agree with building hydro electric transmission lines through a national park area because..."

Digital Portfolio

- Document with images the environmental, ethical and legal impact of energy creation, conversion, transmission and consumption.

Pencil and Paper

- List some of the environmental, ethical and legal impacts of energy creation, conversion, transmission and consumption.

Resources

The Pembina Institute: Sources of Renewable Energy
http://re.pembina.org/sources

Energy Quest Chapter 8: Fossil Fuels - Coal, Oil and Natural Gas
http://www.energyquest.ca.gov/story/chapter08.html

Video Resource
Energy Quest: EQ Cinema

You've Got the Power - Energy facts produced by the California Energy Commission. Duration 00:11:50
http://www.energyquest.ca.gov/movieroom/index.html

Topic 4: Sources of Energy for Electrical Generation

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.16 examine new technologies that are evolving for more efficient conversion, transmission, and consumption of electrical energy [01.305, 02.304, 03.301,03.302, 03.304]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to give students the opportunity to explore new or evolving technologies for the more efficient conversion, transmission, and consumption of electrical energy.

Points to emphasize

All new technologies are aimed at more efficient use or conservation of electrical energy. For example:

- Transmission issues and the re-emergence of interest in DC power
- Consumption issues and hybrid vehicles
- Miniaturizing of electronic circuitry
- Quantum computers
- The introduction of fluorescent and LED technologies
- Conversion advances with photovoltaic solar cells, wind, small hydro, and biomass technologies

For the Student

Working in small groups, students take on the role of advocates for one of the emerging technologies and develop a promotional product for their choice.

Suggested Assessment and Evaluation Strategies

Journal

- List five alternate heating methods for your home and give advantages and disadvantages of each.
- List five alternate energy sources for your vehicle and give advantages and disadvantages of each.

Digital Portfolio

- Record the use of new forms of energy such as the newer BMW power plant next to landfill to use the methane gas that is created. Another example would be the use of manure in underground tanks and as it breaks down methane gas is created and is then used a power source.
- Research and record new home heating devices such as in floor heating, geothermal, solar, hot water radiation, wood, etc.

Resources

The Pembina Institute: Sources of Renewable Energy
http://re.pembina.org/sources

David Suzuki Foundation: Nature Challenge Newsletter
http://www.davidsuzuki.org/WOL/Challenge/Newsletter/Four.asp

How Stuff Works
http://auto.howstuffworks.com/electric-car.htm

Toyota Hybrid Synergy Drive
http://www.hybridsynergydrive.com/en/top.html

Topic 4: Sources of Energy for Electrical Generation

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.17 develop personal rules of conduct for dealing with energy conservation. [05.302]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to get students to become sensitive to their impact on the environment and their role in conservation. Teachers should use current issues to provide an authentic context for this outcome.

Points to emphasize

- Any activity used should enable students to realize that each decision they make with regard to energy use has consequences locally, regionally and/or globally.
- This has potential to be used as a cross-curricular topic. It can be used in social studies, science (science and technology fair project) and mathematics (data manipulation).

For the Student

Students could keep a log for a 24 hour period documenting their personal energy consumption. They should be prepared to discuss and share their data in class.

Short activity - Environmental Footprint (See resources column).

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Develop a webpage outlining some things that people can do in their everyday lives to conserve energy
- Use an audio editor to create a Public Service Announcement on energy conservation.

Journal

- Record some basic personal guidelines dealing with energy conservation.

Digital Portfolio

- Research and record some personal guidelines for dealing with energy conservation that people are currently following.

Pencil and Paper

- Record five strategies that your family should follow to conserve energy.
- Create a poster that illustrates principles of energy conservation.

Resources

Earthday Network: Ecological Footprint Quiz
www.myfootprint.org

The Pembrina Institute: Benefits of Renewable Energy
http://re.pembina.org/benefits

Topic 5: Careers Connections

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

1.18 examine and consider career trends and professions in energy and power related industries. [04.301, 04.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to make students aware of career opportunities associated with energy and power industries. Teachers should try to use current information to provide an authentic context for this outcome.

Points to emphasize

Research should include careers in both existing and emerging technologies.

For the Student

Students can research an occupation using guidelines provided by the teacher. Students will be expected to do a brief presentation on their selected occupation. One or two presentations could be done at the beginning of a number of classes. This would infuse the career component throughout the course.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Interview an individual who works in an energy and power related industry and create a career profile of that individual.

Journal

- Select a career in energy and power related industry and explain how your personal attributes would make this an appropriate career choice for you.

Digital Portfolio

- Research and record at least one career in the area of energy and power related industries including a job description, required level of education, job prospects and salary.

Pencil and Paper

- Write a research essay on a career of your choice including a job description, required level of education, job prospects and salary.

Resources

Science Master:

JumpStart - Physical Science-Careers in Renewable Energy

http://www.sciencemaster.com/jump/physical/careers_energy.php

Unit 2

Basic Skills

Overview

Purpose

The purpose of the basic skills section is to provide students with an introduction to the basic tools and techniques to be employed throughout the remainder of the module's implementation. Students will develop basic skills related to:

- The calculation of mass, force, work and energy in a system
- Discovering the amount of energy being used by an electrical device
- Calculate the energy output and input in a system
- Explore ways that energy can be generated and moved efficiently
- Creating and interpreting schematic, orthographic and isometric drawings.

Topic 1: Energy Conversion and Transmission
Topic 2: Measuring Energy and Energy Transmission
Topic 3: Schematics and Pictorials
Topic 4: Fabrication

Profile

Students will be involved with:

- The interpretation and development of simple schematics and pictorials associated with systems that produce electricity.

- The use of basic measuring tools for measuring work energy and power.
- The use of basic tools and production techniques to develop systems that produce electricity.
- Identification of components for systems that produce electricity.
- The development of systematic troubleshooting techniques that are associated with developing systems that produce electricity.
- Participation in individual and design team activities.
- Application of healthy and safe attitudes and procedures related to the development of systems that produce electricity.

Implementation

This section should be completed in not more than 8 hours maximum class time. Consideration should be given to integrating parts of this section with Unit 1: Big Ideas and Unit 3: Design Activity.

.

Evaluation of the Basic Skills

Evaluation of Basic Skills

Unit 2 is intended to introduce tools and basic tool skills related to energy and power technology. Evaluation will focus primarily on students' understanding of the tools and procedures and, to some extent, on the development of basic skills.The Basic Skills unit should account for 20% of the evaluation for the Energy and Power Module.

Outcomes and Strategies

Topic 1: Energy Conversion and Transmission

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.01 measure the mass of an object. [02.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students measure the mass of an object.

Points to Emphasize

- The mass of an object can be determined using an equal arm balance.
- The mass of an object remains constant no matter what planet you are on. Mass and weight are not the same: mass is a measure of the quantity of material in a physical object whereas weight is the measure of gravity acting on a physical object. The amount of gravity changes depending on the size of a given planet. While an object will have the same mass on two different sized planets, its weight will vary between them because of the change in gravitational force.
- Students should have an understanding of the principles behind how the equal arm balance works.

For the Student

Activity - measure the mass of an object using an equal arm balance.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Divide class into groups. Select one group of students to collaborate and explain to the class how an equal arm balance works.
- Given several objects and an equal arm balance, measure the mass of the objects.

Portfolio

- Record the results of the measurement in your portfolio.

Journal

- Briefly outline the principles behind the equal arm balance.

Resources

Equal arm balance and masses.

Topic 1: Energy Conversion and Transmission

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.02 measure the forces acting on a mass. [02.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students measure the forces acting on a mass.

Points to Emphasize

Force can be measured using a spring scale calibrated in Newtons.

For the Student

Activity - measure the weight of an object using a spring scale.

Activity - measure the force required to pull an object across a level surface.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Select another of the groups created earlier and have students collaborate and explain to the class how the mass of an object and the force required to lift the object or drag it across a surface are related.
- Given several objects and a spring scale measure the force required to lift the objects and measure the force required to drag the objects a certain distance.

Portfolio

- Have students record the results in their portfolios.

Journal

- Briefly outline how the mass of an object and the force required to lift the object or drag it across a surface are related.

Resources

Spring scale graduated in Newtons and a mass

Technology Interactions (Harmsand Swernofsky) pp. 393 - 394

Topic 1: Energy Conversion and Transmission

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.03 calculate the work done on a mass.[02.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students understand the relationships required to calculate the work done when moving a mass.

Points to Emphasize

- The mathematical relationship is: work is the product of force and istance (Eg. w=f×d).
- The mass has to move for work to be done on the object.
- The mass has to move in the direction of the applied force.
- Weight is equivalent to force of gravity.
- The spring scale should be parallel to the surface when pulling the object across the table.

For the Student

Activity - Determine the weight of a mass and the force needed to lift it. Then calculate the work done when the mass is lifted through a distance.

Activity - Determine the work done in pulling an object across a horizontal surface.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Using the formula w=f×d, calculate the work done on each of the previous objects using the force measured and the distance the object moved.
- Create a winch using a motor, string and thread spool, lift an object (measure weight (force)) a known distance and calculate the work done moving the object that distance.
- Create a flipbook animation using the formula and the relative sizes of the symbols w, f & d to show the relationship between work, force and distance. i.e. How the work changes when the force is increased or the distance is increased.

Pencil and Paper

- Have students complete a worksheet using proper formula to calculate work done moving a mass over a distance.

Resources

Spring scale graduated in Newtons and a weight

Authorized Digital Resources

Topic 2: Measuring Energy and Energy Transmission

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.04 calculate the amount of energy used by an electrical device. [02.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students understand how to calculate the energy used by an electrical device.

Points to Emphasize

- The mathematical relationship is: voltage = current × time.
- Potential difference (V) or voltage is measured in volts, Current (I) is measured in amps and time (t) is measured in seconds.

For the Student

Activity - Use a multimeter to measure the current and the voltage being used by a small motor over a given time. Given the three measurements calculate the energy used.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Use a multimeter to measure the current and the voltage being used by a small motor over a given time. Given the formula energy = voltage × current × time calculate the energy used by the motor.
- Use the energy meter provided in the resources to measure the energy used by the same motor for the same time period. 3.6 megajoules = 1 kilowatt-hour.

Digital Portfolio

- Using online energy calculators such as those listed here; check the efficiency of appliances in your home.

  http://tristate.apogee.net/lite/lecoeuc.asp

  http://www.energywise.govt.nz/calculator/

  http://takechargenl.ca/HowsYourHouse/Default.aspx

Journal

- Compare the calculated energy used to the energy used according to the energy meter.

Pencil and Paper

- Have the student bring the energy meter home to plug in a large common household appliance, such as a television, microwave, and record the energy consumption. If data is available, compare the rated energy consumption to the actual use.

Resources

Virtual Labs - Electricity/ Light Units - 2 CDs and teacher's guide pp. 83

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 169-17

Digital Multimeter

Energy Meter

Small DC motor

Topic 2: Measuring Energy and Energy Transmission

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.05 calculate the energy input, output, and efficiency of a system. [02.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students understand that systems that use energy to do work are not 100% efficient. That is, some of the work input is turned into undesired forms of energy such as heat and sound instead of useful work.

Points to emphasize

- Mechanical friction and its electrical analog resistance is the cause of inefficiencies in most systems designed to do work.
- The efficiency of a system is mathematically determined by the ratio of work output to work input expressed as a percent (Eg. (work output ÷ work input) × 100%).

For the Student

Activity - use the given work input and the calculated work output in 2.03 to calculate the efficiency of that system.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Given the work input and your calculated output for the activity in 2.03 and the formula efficiency = (work output ÷ work input) × 100%, calculate efficiency of the winch.

Digital Portfolio

- Research the efficiency of selected machines and create a report on that particular machine.

Paper and Pencil

- Sketch and label the parts of the winch in operation including the input and output.
- Calculate efficiency and record your results in a table.

Resources

Digital Multimeter

Small DC motor

Authorized Digital Resources

Topic 2: Measuring Energy and Energy Transmission

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.06 calculate the power used by a system. [02.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students understand the relationship between work done and the time it takes to do that work.

Points to emphasize

- Power is the measurement of how fast work is done.
- Power is the work divided by time (work in joules, time in seconds, power in watts).
- Machines can do work faster than humans.

For the Student

Determine the power of a motor when it is used to lift a weight a certain distance in a measured time. Students can use a geared motor, mass, string, and stop watch. See activity A06 from the Grade 8 control module resource.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Select another group from the class and have them collaborate to research how to measure time, present their findings and demonstrate how to accurately measure time.
- Using a geared motor, mass, string and stop watch use the formula power = work ÷ time, determine the power developed by the motor in 2.05

Resources

Activity A06 Grade 8 Control Module.

Geared motor, mass and a string

Authorized Digital Resources

Topic 2: Measuring Energy and Energy Transmission

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.07 demonstrate ways that energy can be transmitted from one location to another or from one system to another by a number of mechanisms. [02.301, 02.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students demonstrate an understanding of how energy can be transferred from one location to another.

Points to emphasize

- Energy transfer can be pure energy transfer (light, electricity, water waves) or the transfer of potential energy sources (oil in a tanker or pipeline, uranium in a railcar).
- Energy transfer requires energy consumption.
- Simple demonstrations can be used to clarify the concept such as: battery and light, flashlight shining on a solar cell motor or small voltmeter.
- Examples: transmission lines, tankers, gas or oil pipelines, microwaves, from sun to earth, rubber band, wind transferring energy to water to create waves (transfer of mechanical energy), magnet picking up a paper clip, etc.

For the Student

- The student will configure a circuit to transport electrical energy to a load such as a motor, lamp, or LED.
- The student can use a solar cell to capture the electromagnetic energy from the sun or a light bulb and use it to power a load.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Have small groups of students research a way that energy can be transferred from one location to another and deliver a multimedia presentation (ex. Microsoft PowerPoint slideshow) to the class.
- Have students use the Virtual Labs Electricity resource to create a virtual demonstration of a circuit containing a battery or other energy source, a load and a switch, including a multimeter.
- In small groups write a poem (ex. Shakespearian sonnet) or song (ex. rap) depicting the transfer of energy using appropriate terminology. Recite the poem or sing the song to the class.
- Create a game where materials labeled as stored (potential) energy are moved from one place to another. Ex. A relay race using medicine balls or a package of D-Cell batteries would demonstrate that it requires energy to move stored energy.

Journal

- Have students explain how the game demonstrates the use of energy to move energy.

Resources

Virtual Labs - Electricity/Light Units - 2 CDs and teacher's guide

Authorized Digital Resources

Topic 2: Measuring Energy and Energy Transmission

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.08 demonstrate the conversion of energy from one form to another using a variety of simple systems. [02.301, 02.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is have the student demonstrate their understanding of ways to convert energy from one form to another.

Points to Emphasize

- Many technological devices are designed to convert energy from one form to a form suitable for a given purpose.
- Some examples are:
    - ♦ Solar cell attached to a rechargeable battery pack (solar to electrical to chemical)
    - ♦ Wind-up LED flashlight
    - ♦ Pulling back on a bowstring (work pulling back on the bowstring, stored potential energy of the string, releasing of the string to give the arrow kinetic energy)

For the Student

Teacher could set up a series of activity stations using the demonstrations listed above. Students could be required to describe the energy conversion process for each system.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Have small groups of students select a form of energy conversion such as different sizes of rubber bands shooting paper balls, solar cells charging rechargeable batteries, wind up LED flashlights, hand held windmills, springs in the click top of a ballpoint pens, etc. Research their selected energy conversion and demonstrate the technology to the class explaining how the energy is converted. *Note: students must wear safety glasses where appropriate.

Paper and Pencil

- Have students visit a series stations in the classroom where energy conversion is demonstrated and complete a worksheet on the energy conversion at each station. *Note: the teacher can create the stations or have students form groups to create the stations (each group would visit all other groups' stations)

Resources

Materials kit to be distributed to each pilot school

Authorized Digital Resources

Topic 3: Schematics and Pictorials

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.09 identify basic symbol sets that are employed in schematic drawings. [01.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to introduce students to the idea of representing circuits in a simplified way using symbols.

Points to Emphasize

- Schematic drawings are a form of shorthand.
- Rather than drawing each item in a pictorial way, each item is represented by a symbol.

For the Student

Identify basic symbol sets that are employed in energy and power related schematic drawings for electricity and electronics. This should include the symbols for a cell, battery, lamp, LED, resistor (load), switch, ammeter, voltmeter, and variable resistor. Teachers could use an identification game or matching activity to help students become familiar with the schematic symbols.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Have groups of students create their own board game in which students need to identify and understand the basic electronics circuit symbols to create and play the game.

Pencil and Paper

- Teachers create a matching activity to help students become familiar with the schematic symbols, their names and the actual components.

Resources

Seattle Robotics Society

Really Basic Electronics

http://www.seattlerobotics.org/guide/electronics.html

Virtual Labs - Electricity/Light Units - 2 CDs and teacher's guide

Design and Technology (Garratt) pp. 110-127

Topic 3: Schematics and Pictorials

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.10 read and interpret a simple schematic diagram. [01.305]

2.11 relate a schematic drawing to a pictorial drawing. [01.305]

2.12 create simple schematic drawings. [01.502, 01.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is to have students interpret simple schematic diagrams. This includes relating simple schematic diagrams to corresponding pictorial drawings and creating simple schematic diagrams based on a circuit description.

Points to Emphasize

- Once you learn the basic symbol sets you can read any schematic drawing.
- Each pictorial object has a corresponding schematic symbol.
- Try not to get too complicated. Simple circuits with a source, a load and a control are sufficient.
- Students should be aware of the basic symbols (ie. battery, lamp, motor, resistor, led, switch). Optional symbols could include: the inductor, capacitor, and transistor.

For the Student

- Given a schematic diagram, identify the basic symbols.
- Given a pictorial drawing, use the standard symbols to create a schematic drawing.
- Given a description of a circuit, use the standard symbols to create a simple schematic drawing.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Given a set of schematic symbols and a pictorial drawing, have students create the appropriate schematic diagram by hand and/or using Virtual Labs Electricity.
- Have students create a poster of a schematic circuit with an explanation of the components in the circuit and their functions.
- Have groups of students extend their board game to include schematic diagrams which include the basic symbols. Reference 2.09.

Pencil and Paper

- Teachers create a series of schematic diagrams and their equivalent pictorial drawings. Students match the schematic diagram to the pictorial drawing.

Resources

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 80-81 pp. 171-176

Authorized Digital Resources

Topic 3: Schematics and Pictorials

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.13 create orthographic projections and isometric drawings to represent system components [01.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students create technical drawings. These technical drawings can be drafted using pencil, ruler and paper.

Points to Emphasize

- Present the students with a collection of physical objects such as simple wooden blocks and the objects' corresponding isometric and orthographic representations (i.e. the technical drawings).
- Review the alphabet of lines.
- Briefly review the steps in the drawing process.

For the Student

Activity - have students do some simple drawings of a variety of precut wooden shapes. Have students do a number of both isometric and orthographic drawings.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Have students select a shape and create a presentation demonstrating to the class how to create an isometric or orthographic drawing of the selected shape.
- Have students work in pairs. Each student creates a model using modeling clay, wooden blocks, etc. and their partner creates an isometric and orthographic drawing of the model.
- Given an isometric or orthographic drawing and modeling clay or manipulative, have students construct the shape depicted in the drawing.

Pencil and Paper

- Given a set of pre-cut wooden shapes, have students do both isometric and orthographic drawings of the shape.
- Have students match simple wooden blocks to their isometric or orthographic drawings.

Resources

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 53-74

Authorized Digital Resources

Topic 4: Fabrication

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.14 employ safe practices when fabricating systems and components. [05.302]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to introduce students to the safety issues related to fabrication facilities and processes.

Points to emphasize

- Review general safety rules for the fabrication facilities, stressing the reason these rules are in place.
- Review the safety rules for the fabrication equipment.
- Students need to be reminded to wear/use appropriate safety equipment **at all times** when in the fabrication area.

For the Student

- Be aware of, and use, all the safety rules and procedures in fabricating parts.
- Complete safety checks and/or a safety test
- Identify potential hazards in the fabrication facilities.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Observation checklist for safety in the fabrication lab:

	Rarely				Always
- Wears appropriate PPE	1	2	3	4	5
- Removes / secures loose clothing, jewelry, & hair	1	2	3	4	5
- Observes General rules of fabrication lab	1	2	3	4	5
- Makes certain work surface is clear of debris	1	2	3	4	5
- Exhibits safe and courteous behavior in the fabrication lab	1	2	3	4	5
- Works collaboratively with peers	1	2	3	4	5
- Follows instructions	1	2	3	4	5
- Asks permission to use power tools	1	2	3	4	5
- Uses power tools with care using proper safe operation techniques	1	2	3	4	5
- Observes proper margin of safety	1	2	3	4	5
- Makes certain machine has come to full stop	1	2	3	4	5
- Returns tool & accessories to proper location	1	2	3	4	5
- Cleans up equipment and work area	1	2	3	4	5
- Returns all adjustments to original state	1	2	3	4	5

Pencil and Paper

- Have students complete and pass (100%) safety test on all power tools and general safety rules.

Journal

- Interview a fabrication/skilled trades professional regarding the importance of safety on the job and which PPE they require to do their job.

Field Trip

- Arrange for students to visit a work site and have the supervisor explain what safety procedures and PPE is required for working in that site.

Guest Speaker

- Have a fabrication/skilled trades professional, Workplace Health and Safety office or School OH&S Committee visit the class to do a presentation on safety in the workplace.

Resources

Design and Technology (Garratt) pp 15-16

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al) pp.43-60

PTI Power Tool Institute Inc. http://www.powertoolinstitute.com/safety.html

Topic 4: Fabrication

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to:

2.15 employ shaping, forming, combining and finishing techniques to fabricate prototypes [01.303]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students become familiar with common techniques used in the fabrication of prototypes.

Points to emphasize

- Fabrication techniques require students to understand each of the elements of the process.
- For different projects and different materials, different techniques will be required.
- Forming and Shaping - the use of heat and steam to form and shape wood, metals, or plastics.
- Combining - using nails, screws, staples, glue, bond materials and soldering, among other things to combine (hold together) wood, metals or plastics.
- Conditioning and Finishing - the use of sandpaper, buffing compound, paint, etc. to condition and finish wood, metals, or plastics.

For the Student

- Activity - students could work through a one or two day short project that takes them through a simple project. Because of time constraints, it would be useful for students to fabricate something that can be applied to the final design project. For example if a wind turbine project is proposed for the final fabrication project, students can construct blades under this outcome. If a solar project is proposed give students solar cells and have them build a platform for the cell. The platform can tilt to face the sun.

Suggested Assessment and Evaluation Strategies

Presentation/Performance

- Have students fabricate a project using appropriate materials and properly employing appropriate shaping, forming, combining and finishing techniques. *Note: students must adhere to safety protocols.

Journal

- Create a photo essay outlining the fabrication process and explaining why the material choices and fabrication processes are appropriate to this particular project.

Pencil and Paper

- Have students create a flowchart outlining their plan for fabrication of their particular project. *Note: This is a good precursor to the design process and students could accomplish this through hand drawn or computer generated flowcharts using software such as Microsoft Word, Microsoft Visio or Inspiration Ltd. Inspiration.

Resources

Design and Technology (Garratt) pp. 256-272

Authorized Digital Resources

Unit 3

Design Activity

Overview

Purpose

The purpose of the Design Activity unit is to provide students with experience designing and fabricating an alternative energy conversion and transmission system. Students will develop capability with the design process for developing technical solutions by employing the fundamental processes associated with energy and power technology.

Topics include:

- Topic 1: The Design Team and The Design Portfolio
- Topic 2: Identification of the Problem Situation (Step 1)
- Topic 3: Development of the Design Brief (Step 2)
- Topic 4: Investigation and Research (Step 3)
- Topic 5: Identification of Possible Solutions (Step 4)
- Topic 6: Selection of the Best Solution (Step 5)
- Topic 7: Development of the Solution (Step 6)
- Topic 8: Evaluation of the Solution (Step 7)
- Topic 9: Presentation of the Report (Step 8)

Note: The Grade 9 Energy and Power Module's Unit 3 Design Activity is based on the structure and content of the other three Intermediate Technology Education Modules' Unit 3 Design Activities. The Intermediate Technology Education curricula will employ similar strategies throughout the entire program delivery.

Profile

The Design Activity constitutes the major activity of the Grade 9 Energy and Power Module.

Typical activities/processes include:

- Usage and maintenance of design portfolios
- Application of the design process to the development and fabrication of a electrical conversion and transmission system
- Identification of useful problems, and problems which students are capable of solving
- Identification of resources, including tools and materials
- Investigation and research of possible solutions to energy and power technology design problems
- Identification of possible solutions to energy and power technology design problems
- Selection of the most appropriate solution to an identified energy and power technology problem
- Development of the solution through the construction of the energy and power technology system
- Evaluation and/or testing of the energy and power technology system, and the solution
- Presentation of a report on the design problem, the process, and the solution
- Relationship building to other subject areas
- Participation in design teams

Implementation

This unit should be completed in not less than 10 hours minimum class time. This may be expanded depending on the delivery style of Units 1 and 2. Additional time may be used if the minimum 26 hours for the module are expanded, possibly through integration with other subject areas.

This design activity may be related directly to an activity or problem in another discipline.

This is primarily a design team activity, but it is reasonable to expect individual students to maintain a design portfolio, or be

Organization and Management Issues

responsible for specific parts of the design team portfolio and product development/production processes.

Planning for Design

Planning for design in the Grade 9 Energy and Power Module needs to address the following:

- Student exposure to problem situations and sample design briefs with flexibility to accommodate the actual needs of the student.
- Student access to space that can accommodate a wide range of production activities, including fabrication and testing areas.
- Student access to tools and materials appropriate to the problems that students will be solving.
- Distribution of clear instruction concerning the design process/procedure guidelines for students.
- Distribution and explanation of appropriate evaluation criteria to the students - course and design activity.
- Distribution of design portfolio guidelines and management strategies to students.
- Development of a plan for students to manage the design process.
- Development of design team organization and maintenance strategies for students.
- Development of a clear timeline for students, specifying completion dates for each phase of the process.

Appropriate Problems

One of the most difficult tasks for the teacher is determining what is an appropriate problem for students to solve. Students can attempt to solve many of the problems that professional designers attempt. However, a grade 9 student cannot be expected to develop a solution with the same level of
sophistication as a professional designer or even a student enrolled in a senior high technology education course. As an example, the student and professional designer can each attempt to solve a problem for a common client but the

solutions will differ in their complexity. The main difference between each of those solutions is determined by the expectations for the solution.

A number of factors may be manipulated to affect solution expectations to design problems, including:

- **Statement of the Design Brief** - A design brief is used to focus the efforts of the design team. It states the problem, limits that are on the solution, and what the solution must do. It can be worded to make the process very open (e.g., any solution is possible), or narrow (e.g., solutions must come from a narrow range of possibilities).
- **Statement of Design Work Evaluation** - Inform students so they understand how they are being evaluated - what will they get marks for and what will cost them marks. Help them understand that they are building capability with technological problem solving, and that they are being graded on this more than the actual product. Many students are accustomed to being graded on a product (e.g., essay, report, test) and may find it difficult to adjust to this type of evaluation methodology.
- **Complexity of the Problem** - Restrict the problem to very simple ones. Don't confuse a general problem situation (e.g., there is a need to communicate directly to all students about events in the school) with a specific problem (e.g., the intercom is intrusive and interrupts classes). Pick a very specific problem, keep the solution simple, and ensure that there are resources to develop the chosen solution. In the case of the energy and power design activity, students should be challenged to solve alternative energy problems and experience the authentic real world challenge of producing sustainable energy. It is up to the teacher's discretion to judge the complexity of the problem to be solved; however, students should have to draw on the skills developed in Unit 2 to solve the problem.

Student Design Teams

Purpose of Student Design Teams

Student design teams:

- emulate standard practices from industry

- develop team skills
- develop better solutions to real world problems
- build on strengths of individual students
- increase chances of success for individuals

Student Design Teams vs. Professional Design Teams

There is a substantially different expectation with students-as-designers and professional designers. There are high expectations on professionals in terms of skills, strategies, knowledge and the quality of their solutions. Students are learning a methodology, while at the same time acquiring basic technical skills and know-how. They are building capability in the academic, social and technological arenas. Professionals are presumed to have advanced capabilities.

Students are evaluated differently as well. The purpose of evaluation is to determine their knowledge, technical skill, and level of design capability.

Effective Operation of Student Design Teams

Some key points regarding student design teams. They require:

- collaboration and cooperation among members
- sharing of ideas among members
- each student to do his/her part
- each student to assume leadership in an area of expertise or interest when called upon to do so
- each student is to allow another to be leader when necessary
- willingness of each student to compromise on some issues

Key Issues for Managing Student Design Activities

Teachers must:

- **ensure that the problem is well understood by the students.** This is the purpose of the design brief. The design brief should state the problem clearly, state any special conditions related to solving it, state what the solution should accomplish, and what the students are expected to do (what they are accountable for).
- **ensure that students understand team versus individual work.** There will be individual work required of students and that individual work will be part of the overall design team work.
- **ensure that students maintain a design portfolio.** The design portfolio must have a record of things done, including drafts and developmental work; a record of decisions made and the reasons for making them. The design portfolio normally uses the steps of the design process as its main headings.
- **ensure that students understand the Design Process.** The major steps of the design process serve to help students focus on tasks that need to be done. Although the steps are presented below as a linear sequence, in practice students may move back and forth through the steps.
    - *Identification of the Problem Situation*. Specifies the problem that requires a solution.
    - *Development of the Design Brief*. The Design Brief sets the task and conditions.
    - *Investigation and Research.* This step forces students to find information about similar problems and resources available.
    - *Identification of Possible Solutions.* Identifying solutions is a brainstorming activity to determine the possible ways of solving a specific design problem. Note that this step does not deal with any aspects of developing the solution. This step provides students with an opportunity to develop a lot of ideas very quickly.

- ♦ *Selection of the Best Solution.* Picking the best solution means just that - evaluate the solution ideas formed in the previous step and pick the "best" one.
- ♦ *Development of the Solution.* This step and the *Modelling and Prototyping* step account for the most work in the Design Process. During this step the details of the solution are defined and preparation is made for the completion of the next step.
- ♦ *Modelling and Prototyping.* The chosen solution is created, built, made, etc.
- ♦ *Solution Testing and Evaluation.* Testing and evaluating the solution is a trial to see if the solution actually solves the design problem identified. The process may occur throughout other steps in the design process to determine if individual parts or subsystems of the solution work.
- ♦ *Solution Redesign and Improvement.* It has been said that the redesigning and improving of a solution can continue forever. During this step students should act upon some of the findings from the previous *Testing and Evaluation* phase.

- **ensure that the reporting procedure is clearly outlined and understood.** Reporting is a means for students (as part of design teams) to share the results of their design problem solving activity with other students in the class. It also provides a means of closure for the Control Technology Module as the process of student reporting will provide a review of the material covered during the Module. The design team should present a report to the class.
- **ensure that the importance of the solution development is addressed.** A solution must be developed. No solution means that the design activity was not successful.

Setting Up and Using Design Portfolios

- **ensure that the evaluation outline for the module includes the three design components.** The components are the design portfolio, the design solution, and the design report. The purpose of the design portfolio is to document what actually happened, and, as such, it offers clues as to how students thought through the process.

General Information on Design Portfolio Contents

Portfolios are often used to keep records of the students' best work. This is not the purpose of design portfolios in technology education courses.

The design portfolio is essentially a diary of the progress of the design activity. It contains all relevant information, especially trial and error information. It is used to illustrate the thinking and planning processes that students engage in while developing a technological solution to a problem. Evaluation of the process is often indirect, in that the evidence comes from the design portfolio. The evaluation of the design portfolio is of major importance.

The Design Portfolio should contain the following items:

- A copy of the design brief
- An entry for each class activity and time the student worked on the project. Each entry should note the following:
    - ♦ things done
    - ♦ things that worked
    - ♦ things that did not work
    - ♦ record of discussions related to the design activity
    - ♦ decisions made
    - ♦ reasons for the decisions
    - ♦ originals and/or copies of sketches, notes, and other materials developed as part of the process.
    - ♦ images of devices, or actual physical components, that were part of the transitory development

process including things that did not work, along with information on what this led to.

- ♦ information obtained from research and investigation.
- ♦ Any other pertinent information.

Organizing the Design Portfolio

Design portfolios use the design process steps as its major headings. Information needs to be recorded at each step of the process. Headings normally would be:

- Identification of the Design Problem
- Design Brief
- Investigation and Research
- Solution Ideas (Alternate Solutions/Options)
- Solution Choice
- Development of the Solution
- Modelling and Prototyping
- Testing and Evaluation of the Solution
- Redesigning and Improving
- Report Presentation (The presentation would include the entire design portfolio but there can be a section devoted to the actual presentation material within the context of the design portfolio)

Most of the content of the design portfolio would be related to the development of the solution.

Maintaining the Design Portfolio

Students can employ two methods to maintain their design portfolios:

- **Electronic**. An electronic design portfolio could be developed around a template that contains the headings and appropriate instructions that outline the type and amount of information required of the student. This method would be greatly enhanced if students have access

to a scanner and a digital camera. The scanner would be used to add all paperwork and sketches to the design portfolio and the digital camera could be used to record other kinds of activities. If the electronic portfolio is web-based students will have the opportunity to link content and provide a much more interactive product to their audience.

- **File Folder.** A paper (hard copy) design portfolio could be maintained in a file folder. All documentation, sketches, and pertinent information would be added to the file. A written record of events and file contents would be maintained.

The electronic design portfolio, especially a web-based one, will provide the students with a direct interaction with the more contemporary communications technology tools available to them.

Evaluation of the Design Activity Unit

Unit 3 accounts for the largest time allotment of all three units in the Control Technology Module. It therefore, should account for the largest percentage of the Module's evaluation, a total value of 60%.

Evaluation of Unit 3 should be based on the following:

Design Process (observation during each step)	10%
Design Portfolio	40%
Solution	30%
Report	20%
Total	100%

Outcomes and Strategies

Topic 1: The Design Team and The Design Portfolio

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.01 work cooperatively and collaboratively in design teams [1.301, 1.302, 1.303, 1.304, 1.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students form design teams which will work together cooperatively.

Points to Emphasize

- Effective collaboration is an essential labor market skill.
- Design teams are most effective in groups of two or three. Teams of four students should be avoided if resources permit.
- It is important that the teacher review the characteristics of a good team member and principles of good group collaboration.

For the Student

- Establishment of design team structure, determination of roles and responsibilities, and development of an initial plan of action.
- It is your responsibility as a member of the team to:
  - ♦ share responsibilities
  - ♦ share ideas
  - ♦ participate
  - ♦ assume leadership in the area of expertise/interest when called upon to do so
  - ♦ allow others to take the lead when necessary
  - ♦ compromise on some issues
  - ♦ show respect for the opinions of other group members

Suggested Assessment and Evaluation Strategies

Teachers should determine students' ability to:

- share responsibilities
- share ideas
- participate
- assume leadership in the area of expertise/interest when called upon to do so
- allow others to take the lead when necessary
- compromise on some issues

Evaluation of outcomes *3.01* and *3.02* will become a major component of Unit 3's evaluation.

Resources

Technology Interactions (Harms and Swernofsky) pp. 30-45.

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al) pp. 65-66.

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 48-90; Appendix B: pp. 339-343

Design and Problem Solving in Technology - Instructor's Guide (Hutchinson, Karsnitz) pp. 21-25; 73-85; 92-114.

Topic 1: The Design Team and The Design Portfolio

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.02 maintain a complete design portfolio of the design process and design activity. [1.301, 1.302, 1.303, 1.304, 1.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have each design team document this process in the form of a portfolio.

Points to Emphasize

The design portfolio is an essential component of the design process. It will make up most of the content of the final team presentation at the end of the project. It should contain:

- an introductory page.
- adesign team page.
- a daily log page
- the design process steps as major heading
- a prototype evaluation page

Because of time restraints teachers may wish to provide a design portfolio template. The portfolio can be electronic using a variety of applications (website, presentation or word-processing

- Maintenance of the design portfolio throughout the completion of the Design Activity must be a priority with students.
- Development of a format for individual design portfolios and determination of individual roles for the group design portfolios. If the design portfolios are digital in nature (recommended) skill development/competency with the tools/software may be required.

For the Student

Design portfolios are essential to the design process. They are like diaries and need to be constantly maintained to have meaning. They should track all ideas, decisions, actions and activities. Pages may contain but are not limited to:

- photographs of members working on the various aspects of the project
- any sketches/documents related to the topic
- short videos of prototype development and testing
- notes, questions related to research and group decisions

Suggested Assessment and Evaluation Strategies

Teachers should determine students' ability to:

- document information in the design portfolio
- provide evidence of their reflection on design decisions
- populate the design portfolio with appropriate information
- demonstrate an understanding of the necessity for including information related to the various steps of the design process in the design portfolio

Both outcomes 3.01 and 3.02 will be assessed and evaluated on a continuous basis throughout the *Unit 3 Design Activity*.

Resources

Technology Interactions (Harms and Swernofsky) pp. 30-45.

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al) pp. 65-66.

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 48-90; Appendix B: pp. 339-343

Design and Problem Solving in Technology - Instructor's Guide (Hutchinson, Karsnitz) pp. 21-25; 73-85; 92-114.

Design and Technology (Garratt) pp. 6-19.

Topic 2: Identification of the Problem Situation

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.03 investigate problem situations to determine opportunities to develop systems for energy conversion and transmission. [1.301, 1.302, 1.303, 1.304, 1.305]

3.04 identify specific problems for the design and development of an energy efficient system. [1.301, 1.302, 1.303, 1.304, 1.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this stage of design is to identify and select suitable opportunities to engage in the design of efficient systems for energy conversion and transmission from alternative energy sources.

Points to Emphasize

In this design activity students will be developing prototypes that convert energy such as wind power into electrical energy and transmitting the electrical energy to some sort of a load (i.e. LED or motors). There are two parts to this section of the process. They are:

- identifying opportunities from which you will select a suitable project
- from those identified, select a suitable design project

It is important for the teacher to gauge the time allotment and skill level in the class when deciding on the complexity of design projects. The extent to which students are going to be left to identify their own problem situations depends on the particular class. Although it may not be realistic to require students to identify their own problem situations, it is not the intent of the design activity to give students everything they need to develop a solution from a given set of plans. Design teams should be given the time to question and problem solve as part of the design activity. For example the teacher can provide a list of design problems from which students can choose a problem that interests them. Even within this example every opportunity should be taken to have students troubleshoot, question and solve problems.

For the Student

Students should recognize that traditional energy sources and systems have a substantial impact on the earth's environment. To combat these issues we need to find alternative energy solutions which are sustainable in the long term and have far

Continued on Page 78

Suggested Assessment and Evaluation Strategies

Teachers should determine students' ability to:

- identify various energy conversion and transmission problems and associated specific problem situations
- determine students' ability to effectively communicate their understanding of specific energy conversion and transmission problem situations to others in the class

If students do identify specific problems teachers could assess the students on the basis of clarity of the problem statement. Students may have developed the knowledge and skill required to identify their own design problem situations due to their involvement in prior technology education modules.

Criteria for Assessment

Teachers should assess and evaluate the students' understanding of the material by using criteria such as:

- accuracy of information
- range and scope of information
- understanding of the material
- communication style/skills
- quality of report and other materials
- level of language and indication of technological literacy
- group and individual dynamics
- accountability of individuals within the group

Resources

Technology Interactions (Harms and Swernofsky) pp 30-34.

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al) pp. 65-66.

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 19-20; 29-42.

Design and Problem Solving in Technology - Instructor's Guide (Hutchinson, Karsnitz) pp. 17-20; 103-109.

Topic 2: Identification of the Problem Situation

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.03 investigate problem situations to determine opportunities to develop systems for energy conversion and transmission. [1.301, 1.302, 1.303, 1.304, 1.305]

3.04 identify specific problems for the design and development of an energy efficient system. [1.301, 1.302, 1.303, 1.304, 1.305]

Suggested Teaching and Learning Strategies

less impact on the planet. Students need to discuss what it means to convert a source of energy to create energy and the importance of conversion and transmission of electrical energy as efficiently as possible.

Through class and team discussions students now need to identify opportunities from which you will select a suitable project.

Suggested Assessment and Evaluation Strategies

Teachers should determine students' ability to:

- identify various energy conversion and transmission problems and associated specific problem situations
- Determine students' ability to effectively communicate their understanding of specific energy conversion and transmission problem situations to others in the class

If students do identify specific problems teachers could assess the students on the basis of clarity of the problem statement. Students may have developed the knowledge and skill required to identify their own design problem situations due to their involvement in prior technology education modules.

Criteria for Assessment

Teachers should assess and evaluate the students' understanding of the material by using criteria such as:

- accuracy of information
- range and scope of information
- understanding of the material
- communication style/skills
- quality of report and other materials
- level of language and indication of technological literacy
- group and individual dynamics
- accountability of individuals within the group

Resources

Technology Interactions (Harms and Swernofsky) pp 30-34.

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al) pp. 65-66.

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 19-20; 29-42.

Design and Problem Solving in Technology - Instructor's Guide (Hutchinson, Karsnitz) pp. 17-20; 103-109.

Topic 3: Development of the Design Brief

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.05 select a specific problem for design and development of an energy efficient system and communicate it clearly in the form of a design brief. [1.301, 1.302, 1.303, 1.304, 1.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to get the student design teams to select a specific problem and to communicate it clearly in the form of a design brief. The design brief is used in business as a binding contract between client and designer. In this case, the design brief will define the nature and scope of the design activity, and will be determined by the design team in collaboration with the teacher.

Points to Emphasize:

The Design Brief should contain the following components:

- description of the problem situation
- statement of a specific problem
- criteria (conditions and limitations) affecting the solution
- expectations for the solution
- information about the tasks the designers are expected to do or deliver

For the Student

- Identify and clearly state electrical energy problem.
- Specify conditions and criteria that determine the design and development of a solution to the problem.
- Generate a design brief for this problem.

Suggested Assessment and Evaluation Strategies

Teachers should determine students' ability to:

- understand the process of developing a design brief
- assess students' ability to work as part of a design team that displays cooperative and collaborative behaviour

Criteria for Assessment

Teachers should assess and evaluate the students' understanding of the material by using criteria such as:

- accuracy of information
- range and scope of information
- understanding of the material
- communication style/skills
- quality of report and other materials
- level of language and indication of technological literacy
- group and individual dynamics
- accountability of individuals within the group

Resources

Technology Interactions (Harms and Swernofsky) pp. 34-35.

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al) pp. 65-66.

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 20-22; 29-46.

Design and Problem Solving in Technology - Instructor's Guide (Hutchinson, Karsnitz) pp. 17-20; 74; 94; 103-109.

Design and Technology (Garratt) p. 10.

Topic 4: Investigation and Research

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.06 investigate problems similar to the electrical energy conversion and transmission problem selected and assess their solutions [1.302, 1.304, 5.301, 5.303]

3.07 identify technological resources available to resolve the design brief [1.302, 3.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is to investigate similar problems to the ones students have chosen to solve and identify technological resources available to solve the problems.

Points to Emphasize

- Reference Materials may include books, magazines, catalogs (showing ready-made products), CD-ROM's, or the Internet.
- Students will need to be made aware of the two components of this step. They are:
  - ♦ research of similar problems and related solutions
  - ♦ identification of available resources to solve their own design problem
- Strict timelines will have to be applied to keep this step of the design activity from becoming too extensive.
- Teachers could ensure student design team members understand the importance of the information they gather.
- Teachers could demonstrate how the information obtained needs to be documented in the design portfolio. An initial review of the student design portfolios could be completed at this point in the design process to ensure students are properly maintaining them. The design portfolios should be assessed early to allow students opportunity to correct any procedural issues.

For the Student

Students must complete the following tasks

- design teams meet and assess the design task
- design project responsibilities are distributed equitably among design team members
- design team members conduct research as required
- research acquired is recorded in the design portfolio
- resources required to complete the project are identified

Suggested Assessment and Evaluation Strategies

How students respond to the issues stated below is an indicator of their understanding of the specific problem to be solved, the technological resources required, and the possible methods for solving the problem based upon investigation and research.

Teachers could determine students' ability to:

- stay on task and complete the step on time
- generate quality information about similar problems
- relate problem information to the students selected problem.
- research the available resources
- provide quality information related to the resources retrieved by the students

Criteria for Assessment

Components that need to be evaluated include:

- research by the student of similar problems and their solutions. This may not include a great deal of detail at this level.
- identification by the student of resources to solve the identified problem. Much of the information may be provided by the teacher.

Design portfolio review should also be done to ensure that students are having success in properly recording and organizing the appropriate information.

Resources

Technology Interactions (Harms and Swernofsky) pp 34-35; 98-113.

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al) pp. 65-66; 73-74.

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 22; 91-109.

Design and Problem Solving in Technology - Instructor's Guide (Hutchinson, Karsnitz) pp. 26-32; 75; 95.

Design and Technology (Garratt) pp. 11-12.

Topic 5: Identification of Possible Solutions

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.08 engage in idea generating strategies to identify a range of alternative solutions to solve the electrical energy conversion and transmission problem. [1.302]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students generate ideas for the possible solution of their team's problem.

Points to Emphasize

- Typically, this step can be accomplished by a brainstorming exercise. It may be useful to ask students to think about solutions in advance and share their ideas with other design team members.
- Teachers could ensure that all students have an opportunity to express their ideas - all ideas should be given equal weight.
- Students could record every idea in their portfolio in the appropriate section.
- They could try for a minimum of 6-8 different ideas, not just variations on the same idea. Variations on the same idea could be listed but not included in the 6-8 count.
- Teachers should encourage students to resist the urge to qualify or judge the ideas as they identify them.
- The brainstorming activity should be student led within their design team.
- This should be a 20-25 minute exercise.
- Note that this activity is not focused on how a solution might or might not get developed, and may result in lots of nonsensical ideas.
- Often times, even the most frivolous ideas may lead to a useful solution if it is used to spark other ideas.

For the Student

Complete a brainstorming exercise to identify means of solving the problem. One student can be the recorder and write all ideas in the portfolio. Another can moderate the activity and ensure that all ideas are treated equally, and that all students have an opportunity for input. Complete a preliminary analysis of the results of the brainstorming activity and categorize the possible solutions.

Suggested Assessment and Evaluation Strategies

This is an idea generating activity. Evaluation needs to focus on quantity of ideas generated by the student, the level of divergent thinking exhibited, and on the willingness of the student to be innovative. Evaluation may be formative, occurring during the process of students identifying the possible solutions, and summative, evaluating the ideas after they are identified by the students.

Teachers should determine students' ability to:

- participate in the idea generating activities. Observation techniques, coupled with a checklist can be used to identify quantity of interventions. This could be used formatively to encourage participation and/or to help students moderate how they participate.
- record the ideas and observations generated buy reviewing student portfolios.

Criteria for Assessment

Teachers should assess and evaluate the students' understanding of the material by using criteria such as:

- accuracy of information
- range and scope of information
- understanding of the material
- communication style/skills
- quality of report and other materials
- level of language and indication of technological literacy
- group and individual dynamics
- accountability of individuals within the group

Resources

Technology Interactions (Harms and Swernofsky) pp. 35-36.

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al) pp. 65-66.

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 22-24; 205-232.

Design and Problem Solving in Technology - Instructor's Guide (Hutchinson, Karsnitz) pp. 54-56; 76; 96.

Design and Technology (Garratt) p. 13.

Topic 6: Selection of the Best Solution

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.09 develop criteria for assessing electrical energy conversion and transmission solutions [1.302,3.303, 5.303]

3.10 using established criteria, examine the electrical energy conversion and transmission solutions and select the most appropriate [1.302]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is for students to learn the importance of creating a systematic approach to the evaluation of potential solutions to a design problem.

Points to Emphasize

- Teachers should prepare a sample evaluation of one solution idea (if time permits this can involve the entire class).
- A solution evaluation checklist should be required of each design team.
- Evaluation of solutions should be treated as a team activity. Each member of the group should have input into the evaluation of each solution. This should lead to the selection of the "best" solution by the design team.
- Teachers should ensure that students understand the importance of selecting the best solution at this stage of the design process.
- Students should be able to justify their decision.

For the Student

Students must develop a method to effectively evaluate the possible design solutions, including:

- development of a criteria-based rating scale
- completion of an accurate evaluation of each possible solution based on the criteria-based rating scale
- determination of the "best" solution, based upon the results produced by the criteria-based rating scale
- team members should insure accurate recording of this selection process in the design portfolio

Suggested Assessment and Evaluation Strategies

Selection of a solution is a deductive, analytical activity that provides a variety of assessment approaches to the teacher. Students will assess each idea against a set of pre-determined criteria and sometimes, the teacher will supply the criteria to the students. However, some students may wish to create their own set of criteria and should be encouraged to do so. Evaluation has to reflect how well students:

- use objective criteria to assess solution options
- use an appropriate rationale for selecting a solution option
- document the solution selection process in the design portfolio

Teachers should determine students' ability to:

- complete a criteria-based rating scale.
- provide quality rationale for selecting the solution
- provide accurate documentation and organize material produced during the design solution selection stage

Criteria for Assessment

Teachers should assess and evaluate the students' understanding of the material by using criteria such as:

- accuracy of information
- range and scope of information
- understanding of the material
- communication style/skills
- quality of report and other materials
- level of language and indication of technological literacy
- group and individual dynamics
- accountability of individuals within the group

Resources

Technology Interactions (Harms and Swernofsky) p. 36.

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al) pp. 65-66.

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 24-25; 232-235.

Design and Problem Solving in Technology - Instructor's Guide (Hutchinson, Karsnitz) pp. 54-56; 77; 97.

Design and Technology (Garratt) p. 13.

Topic 7: Development of the Solution

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.11 identify specific tools/machines and resources that are required to effectively develop the electrical energy conversion and transmission solution. [1.303, 4.303]

3.12 determine new skills that will need to be acquired to effectively develop the electrical energy conversion and transmission solution. [1.303, 4.303]

3.13 create a plan of action that will guide the implementation of the electrical energy conversion and transmission solution. [1.302]

3.14 using safe practices, develop the electrical energy conversion and transmission solution, redesigning as necessary. [5.302, 5.303, 1.303, 1.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is for students to develop the solution to the chosen problem including identifying tools and machinery, skills required, developing an action plan and following proper safety practices.

Points to Emphasize

- This is the Solution Development Stage of the design process.
- This step is the most time consuming step of the design process. Preparation must include:
  - ♦ identification and preparation of appropriate work spaces for the design teams
  - ♦ collection of resources, including consumable items, for the design activities
  - ♦ development of a strategy to keep work progressing smoothly, especially with limited tools and workstations
  - ♦ development of a strategy that ensures design work is shared equitably among the design team membership.
  - ♦ encouragement to design teams that testing of ideas before committing to full development of a design is of critical importance. Most students would want to 'just do it'. Often this causes more delays than taking the time to test.
  - ♦ recognition of when to rethink an idea or method and make critical decisions
  - ♦ ensure that students understand and are following the safety rules covered in unit 2
- Teachers should ensure that design portfolios are maintained.
- They should have students keep all materials, tests, trials, and sketches organized and recorded in the design portfolio. If something is to be discarded, students should provide a picture of it to include. If a digital camera is available, students should be encouraged to take lots of

Continued on Page 90

Suggested Assessment and Evaluation Strategies

This activity is the single largest component of the design activity in terms of time and actual student workload. It will have a planning component, a trial and error component, a fabrication component, and it will require that students know when to rethink an idea or method and make critical decisions. This is the point in the design process where the solution gets produced. Evaluation will consider how students engage in the process, including their ability to synthesize information and reach reasonable conclusions. Evidence of technical skill may also be considered as a component of the evaluation.

This step of the design process will require development of effective design team group skills including work sharing, responsibility sharing, collaboration, cooperation and planning.

Teachers should determine students' ability to:

- work as an individual and as a member of a team.
- discard ideas that are not working and move in a new direction.
- development technical skills related to processes, tools and techniques.
- take responsibility for their work.
- learn new methods and techniques.
- follow good documentation procedures.
- use the design brief as a reference during the entire design process.
- use of information discovered during investigation/research to guide work.
- design portfolio review will need to be done periodically during the entire step. Teachers should look for evidence of critical decision-making, daily entries, sketches, pictures of work in progress, and all other design activity-related work by the student.

Continued on Page 91

Resources

Topic 7: Development of the Solution

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.11 identify specific tools/machines and resources that are required to effectively develop the electrical energy conversion and transmission solution. [1.303, 4.303]

3.12 determine new skills that will need to be acquired to effectively develop the electrical energy conversion and transmission solution. [1.303, 4.303]

3.13 create a plan of action that will guide the implementation of the electrical energy conversion and transmission solution. [1.302]

3.14 using safe practices, develop the electrical energy conversion and transmission solution, redesigning as necessary. [5.302, 5.303, 1.303, 1.305]

Suggested Teaching and Learning Strategies

Continued from page 88

pictures or video of themselves in action, and of the project at various stages of completion.
- Each design team must finish the product during this phase. Modeling and prototyping of the solution are required.
- Periodic inspection and assessment of the student's solution and design portfolio development will need to be done.

For the Student

At this stage students should have:
- developed a fully functional prototype of the design solution
- followed all appropriate safety precautions for the tools and processes used
- documented all aspects of the design solution development in the design portfolio. All steps of the design process, including tests of ideas, things that worked and things that did not work, all sketches and plans, all problems that arose and had to be solved, and new tools/skills that had to be learned must be included.
- equally shared responsibility for documentation among the design team membership

Suggested Assessment and Evaluation Strategies

Continued from page 89

Criteria for Assessment

Teachers should assess and evaluate the students' understanding of the material by using criteria such as:

- accuracy of information
- range and scope of information
- understanding of the material
- communication style/skills
- quality of report and other materials
- level of language and indication of technological literacy
- group and individual dynamics
- accountability of individuals within the group

Resources

Technology Interactions (Harms and Swernofsky) pp. 39-40; 136-179.

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al) pp. 43-62; 77-80.

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 26-27; 237-279; 292-319.

Design and Problem Solving in Technology - Instructor's Guide (Hutchinson, Karsnitz) pp. 57-60; 64-66; 78; 98-99.

Design and Technology (Garratt) pp. 14-17; 256-272.

Topic 8: Evaluation of the Solution

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.15 establish criteria for evaluating the electrical energy conversion and transmission solution [1.304]

3.16 evaluate the electrical energy conversion and transmission solution, based on established criteria [1.304]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is to evaluate the solution to the design problem using criteria established by the design team.

Points to Emphasize

- Evaluating the solution depends on the problem and the solution. In some instances, this simply means determining if the solution meets the conditions stipulated in the design brief. Evaluation of the solution will require analysis and a reasoned judgment by the students. Evaluation will include referencing the criteria used to select the solution option, including all recorded responses that have been recorded in the design portfolio.
- Evaluating the solution could also mean using the solution (the product) for its intended purpose and determining if it actually works. This would apply if the prototype was a full scale working model.
- Teachers could provide samples of evaluation criteria and allow students to choose the best qualities of each sample and then design their own evaluation criteria.
-

For the Student

Design teams will evaluate their solution by applying appropriate criteria to assess it, and/or by testing it under actual working conditions. Design team members will record the results and the decisions made in their design portfolios.

Suggested Assessment and Evaluation Strategies

This activity requires that students evaluate their own solution using a set of predetermined criteria, or criteria they develop or establish themselves. Evaluation of their work will assess how well they employed the process and understood the criteria. Evaluation objectivity should be emphasized and students must understand that the solution must be evaluated based on specific criteria and not influenced by personal biases toward the design.

Teachers should determine students' ability to:

- use objective criteria to evaluate the solution
- articulate a sound rationale for decision-making processes employed throughout the solution development stage
- make observations/predictions that lead to the improvement of the design solution

Criteria for Assessment

Teachers should assess and evaluate the students' understanding of the material by using criteria such as:

- accuracy of information
- range and scope of information
- understanding of the material
- communication style/skills
- quality of report and other materials
- level of language and indication of technological literacy
- group and individual dynamics
- accountability of individuals within the group

Resources

Technology Interactions (Harms and Swernofsky) pp. 40-41.

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al)

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 28; 280-291.

Design and Problem Solving in Technology - Instructor's Guide (Hutchinson, Karsnitz) pp. 61-63; 79-80; 85; 100-101.

Design and Technology (Garratt) pp. 17; 19.

Topic 9: Presentation of the Report

Specific Curriculum Outcomes

Grade 9 Energy and Power Module

Students will be expected to

3.17 develop a presentation plan that is based on information recorded in the design portfolio [1.305]

3.18 develop a presentation that uses appropriate presentation tools and strategies, demonstrates how the design model was implemented, and identifies the implications of the electrical energy conversion and transmission solution [1.305, 3.305]

3.19 present the design portfolio, the design solution and the design activity report to the class [1.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is to have students develop a presentation using appropriate tools and strategies which demonstrates their understanding and use of the design process in the solution of the design problem.

Points to Emphasize

- This may be a difficult thing for many students to do. Teachers should ensure that everyone is attentive to and respectful of others.
- Teachers should ensure that the necessary equipment and space are available and ready.
- Teachers should ensure that all members of the design team participate in the presentation.

For the Student

- Presentation of the design team report. When presenting the report students should use appropriate language and terminology. The report should include:
    - ♦ a summary of the design brief
    - ♦ a summary of how the design process enabled the design team to achieve the solution, including successes and challenges encountered and an explanation of how the challenges were resolved
    - ♦ a demonstration/exhibition of the solution
    - ♦ an evaluation of the solution, including evidence of any improvements made to the design based on the evaluation
    - ♦ the presentation structure should be based on the structure of the design team's design portfolio. The portfolio will contain evidence of all aspects of the design activity and will prove to be both informative and comprehensive. If the design portfolio is in electronic form (e.g., web site or slide show) the presentation of it will be easier to deliver.
    - ♦ evidence of shared responsibility among the design

Suggested Assessment and Evaluation Strategies

The design report is the student's opportunity to summarize and present information on the design brief, the solution, and specific reasons why the problem was solved in the manner it was. Evaluation should consider how well students understand the design process as related to the design activity, how well the design report is presented, and how well the solution addresses the design problem stated in the design brief. Some consideration should also be given to the technical quality, workability, fit and finish of the solution.

Teachers should determine students' ability to:

- use the design process main headings within the context of the design portfolio
- provide a comprehensive coverage of work accomplished at each step of the design process
- synthesize and summarize the material presented
- use props, such as trials that failed, things that were tested and included, and visuals
- use technical language and terminology
- share responsibilities among design team members
- understand the problem and its solution as depicted in the design report
- understand of the design process

Evaluation can address individual student work as well as full design team work.

Resources

Technology Interactions (Harms and Swernofsky) pp. 66-83; 98-113.

Technology Interactions (Teacher's Resource Guide) (Harms, Swernofsky et al) pp. 69-70; 73-74.

Design and Problem Solving in Technology (Hutchinson, Karsnitz) pp. 48-90.

Design and Problem Solving in Technology - Instructor's Guide (Hutchinson, Karsnitz) pp. 21-25; 73-85.

Design and Technology (Garratt) pp. 18-19.

Evaluation of Unit 3 - Design Activity (Summary)

Portfolios and Design Solution Collection

Portfolio Collection

Portfolios should be collected just prior to, or just after, the design report has been presented to the class.

Design Solution Collection

Student solutions should be collected at the conclusion of the design team's presentation. Where possible, solutions can be displayed for a period of time to elicit feedback from other students. It may be an idea to showcase solutions as examples for future course use.

Evaluation of Design Activities

Purpose

Evaluation of design is cumulative and occurs at each stage of the design process. Evaluation of students' design activities at the intermediate level has several purposes:

- it is used to determine how well students understand and employ design as a technological problem solving process
- it is used to assess the students' design capability. Design capability is defined as the ability to develop useful technological solutions to problems
- it is used to assess the students' ability to engage in divergent thinking and to develop effective solutions to identified problems. Effective design tends to not just solve the problem but to provide an elegant solution. Elegance is considered to be simple, uses minimal resources and energy, may be novel, is not always obvious, is reliable, is cost effective, and is of high quality.
- it is used to determine how well the solution addresses the problem as stated in the design brief

Evaluation of the Design Process

To be effective, evaluation of the design process has to address each stage and specific issues at each stage. There are three primary pieces of evidence which can be used to assess students' capability with the process - the design portfolio, the design solution, and the in-class report. The report may have oral, written, resource material or presentation components. Additional evidence may be gathered from observation and interaction with students. Evaluation needs to address each stage of the process:

Step 1 - Identification of the Problem Situation

In the Grade 9 Energy and Power Module, the *Problem Situation* step may be completed for the students, depending on how the module is managed, or this may be identified by the students. Students will have gained experience identifying *Problem Situation* through their completion of the Grade 7 Communications Technology Module; the Grade 8 Production Technology Module and the Grade 8 Control Technology Module. If the *Problem Situation* is provided to the students it would not be included in the overall evaluation of the student's design work.

Step 2 - Development of the Design Brief

The Design Brief may be provided to the students in whole or in part. However, students may have the necessary skills and knowledge at the Grade 9 level to develop their own design briefs. If the design brief is to be evaluated in its entirety, the following components are required:

- short description of problem situation
- statement of a specific problem
- criteria (conditions and limitations) affecting the solution
- expectations for the solution
- what the designers are expected to do or deliver

Step 3 - Demonstration of Investigation and Research

This step has 2 components and each requires evaluation:

- research into similar problems and their solutions. This will be a very simple element with not a lot of detail.

- resources to solve this problem. This element will have little detail. Much of the information may be provided by the teacher

Step 4 - Identification of Possible Solutions

This is an idea generating activity. Evaluation needs to focus on quantity of ideas, on divergent thinking, and on student willingness to be innovative and spontaneous. Evaluation may be done during or after the process.

Step 5 - Selection of the Best Solution

This is a more deductive, analytical activity. Students will assess each idea against a set of pre-determined criteria. Typically, the teacher will supply the criteria for this class. Some students may wish to create their own criteria. Evaluation has to reflect how well students can perform the task.

Step 6 - Development of the Solution

This activity will have a planning component, a trial and error component, and will require that students know when to discard an idea or method and when to move forward. This is the point in the design process where the solution gets constructed - the product gets made. Modelling and Prototyping are components of this step. Evaluation will have to consider how students engage in the process, including their ability to synthesize information and reach reasonable conclusions. Evidence of technical skill may also be used as an evaluation component.

Step 7 - Evaluation of the Solution

This activity requires that students evaluate their own solution using a set of pre-determined criteria. Evaluation of their work will assess how well they employed the process and understood the criteria. Evaluation objectivity should be emphasized and students must understand that the solution must be evaluated based on specific criteria and not influenced by personal biases toward the design.

Step 8 - Presentation of the Report

The report is the student's opportunity to summarize and present information on the design brief, the solution, and

reasons for making particular choices. Evaluation should consider how well students synthesize the material and how well they present it to the class.

The Design Portfolio

Evaluation of the Design Portfolio should consider:

- completeness of items
- level of detail
- conciseness
- evidence of decisions and reasons for the inclusion of authentic information, like sketches, drawings, photos, video, etc.
- inclusion of components that failed
- organization according to design process headings

The Solution

Evaluation has to consider how well the solution addresses the problem. Some consideration should also be given to the solution's technical quality, workability, fit and finish.