

Public and Catholic District School Board Writing Partnerships

Technological Education

Course Profile Transportation Technology

Grade 12
College Preparation
TTJ4C

• *for teachers by teachers*

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

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Acknowledgments

This profile was a collaborative effort between the Simcoe County District School Board and the Institute for Catholic Education (ICE).

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Course Overview

Transportation Technology, TTJ4C, Grade 12, College Preparation

Policy Document: *The Ontario Curriculum, Grades 11 and 12, Technological Education, 2000.*

Prerequisite: Transportation Technology, Grade 11, College Preparation

Course Description

This course examines alternative modes of mass transit to enable students to develop the specialized knowledge and skills required to work with sophisticated land, air, or marine vehicles and transportation systems. Students solve problems related to vehicles and transportation systems, examine transportation-related issues such as energy conversion, power transfer, control systems, and environmental and societal impact, and investigate the educational requirements of career opportunities in the transportation sector.

How This Course Supports the Ontario Catholic School Graduate Expectations

Professionalism in a technical field is presented as opportunities to serve God both within the students' own community and globally. Through the examination of the choices that a student can make in a technological world, students develop their God-given potential and learn to make meaningful contributions to social justice issues such as protecting the environment, moral and ethical use of technology in the workplace, and striving to enhance the quality of life in our communities. Individual decision-making and collaborative efforts are explored as students develop knowledge and skills applicable in the critical analysis of transportation infrastructures, in light of the ethical stewardship of our environment and world communities. Students reflect on respect for the environment and wise use of resources, while acknowledging the diversity and interdependence of the world's various groups, people, and cultures. Applying the opportunity to improve the lives of others will be integral to success.

The social, economic, and environmental consequences and impact of the transportation sector on individuals and society are examined within the context of the Christian faith. This course also provides opportunities for critical reflection of these issues and responsibilities.

Course Notes

The units and activities in this course address the diversity of mass transit systems, vehicles, and infrastructures. Transportation issues are addressed in a global perspective regarding economic, environmental, and human needs issues. The activity-based delivery of course materials provides opportunities for students to develop individual and group learning skills. The students are provided with a number of opportunities to meet the expectations through the design and construction of models/systems to solve transportation problems.

The Technological Education policy document outlines the directions students would normally pursue and can give teachers guidance for course planning. Students should be made aware of the entrance requirements for College Engineering and Technology programs so that they take, for example, the required Mathematics, Chemistry, and Physics courses.

Special considerations are made in the course to incorporate specific health and safety guidelines such as the Workplace Hazardous Materials Information System (WHMIS). The teacher must note safety considerations and regulations from such organizations as the Industrial Accident Prevention Association (IAPA) and the Workplace Safety Insurance Bureau (WSIB) that impact the transportation industry and in turn, the technical classroom. Safe practices in the workshop must be addressed and reinforced throughout the course to ensure students learn and practise safe operating procedures in the classroom. (See Appendix A – Safety Passport)

The teacher must address security and safety issues on the Internet by implementing school and board policies on appropriate student use and access to Internet services.

Awareness of careers in transportation can be accomplished in a variety of ways, e.g., job shadowing, computer/Internet research, field trips, guest speakers, and introduction to cooperative education as both secondary and post-secondary program opportunities. Investigations into local transportation infrastructures help students connect classroom concepts.

Units: Titles and Time

Unit 1	Planning and Management of Mass Transit Systems	20 hours
* Unit 2	Sources of Energy and Power Transmission for Mass Transit Vehicles and Systems	30 hours
* Unit 3	Design Alternative Models of Mass-Transit Vehicles/Systems	60 hours

* These units are fully developed in this Course Profile.

Unit Overviews

Unit 1: Planning and Management of Mass Transit Systems

Time: 20 hours

Unit Description

Students examine various modes of mass transit in order to develop knowledge and skills required to work through activities in Units 2 and 3. Students research existing systems and vehicles used to move people and products through the identification of design issues, including energy use and methods of power generation, management and planning of mass transit systems. Students also analyse and compare various modes of transportation in terms of economic, environmental, and social impacts. Through their research and project work, students develop a greater understanding of issues related to infrastructure, from human needs, economics, and historical perspectives to mass transportation problems. Career opportunities in the transportation sector and their educational requirements are also investigated. Students also gain an appreciation of their duties to serve the community in the Catholic faith tradition.

Unit Overview Chart

Cluster	Learning Expectations	Assessment Categories	Focus
1.1	TFV.02, TF2.01, SPV.03, SP2.03, ICV.04, IC3.01, IC3.02, IC3.03 CGE2a, 2b, 2e	Knowledge/ Understanding Communication	Examine existing transportation systems and career opportunities in the transportation sector
1.2	TF2.01, SPV.03, SP2.06, SP2.04, SP2.05, SP3.01, SP3.02, SP3.04, SP4.01, IC2.03, IC2.04 CGE4a, 5b	Knowledge/ Understanding Thinking/Inquiry	Interpret organizational infrastructures and support systems within mass transportation Industries
1.3	SPV.03, SPV.04, SP2.07, ICV.01, ICV.03, IC1.02, IC1.03 CGE7b, 7h	Knowledge/ Understanding Thinking/Inquiry Communication Application	Review the social, economic and environmental impacts of existing systems

Unit 2: Sources of Energy and Power Transmission for Mass Transit Vehicles and Systems

Time: 30 hours

Unit Description

Students examine energy issues related to mass transportation, such as energy sources, conversion techniques, power transfer, and control systems. Many of the current propulsion systems for air, land, and marine mass transit vehicles use fossil fuels. Alternative energy sources and control systems are examined from the perspective of their social, environmental and economic impact. Students research energy systems and build a power generating system to test alternative power ideas. Through this unit, students learn to appreciate that we all have a duty as responsible citizens to protect and preserve the environment for future generations.

Unit Overview Chart

Cluster	Learning Expectations	Assessment Categories	Focus
2.1	TFV.03, TFV.04, TF3.01, TF3.02, TF3.04, TF3.05, SPV.03, IC1.02 CGE3b, 5c, 7i	Knowledge/ Understanding Communication	Research existing sources of energy and forms of conversion used in transportation
2.2	TFV.01, TF1.02, TF3.02, SPV.01, SPV.04, SP1.03, SP4.02, SP4.03, ICV.02, IC2.01 CGE3c, 4a, 5a, 5c	Knowledge/ Understanding Thinking/Inquiry Application	Investigate the generation of electrical power for transportation systems

Unit 3: Design Alternative Models of Mass-Transit Vehicles/Systems

Time: 60 hours

Unit Description

In this culminating activity, students solve problems using a design process that relates to the current and future needs of mass transportation. Models and prototypes of vehicles and systems are designed, constructed, and analysed to solve specific problems in mass transportation. In developing transportation vehicles/systems (or improving existing ones), students consider such parameters as finances, marketing, organizational structures/charts, fair pricing, environmental impact, service enterprises and production methods, as well as design parameters such as ergonomics, efficiency, aerodynamics, and mechanical engineering concepts. Students reflect and create meaningful solutions with an informed conscience in order to work towards the common good.

Unit Overview Chart

Cluster	Learning Expectations	Assessment Categories	Focus
3.1	TFV.01, TFV.02, TFV.04, TF1.01, TF1.02, TF2.01, TF2.02, TF2.03, TF3.01, TF3.02, TF3.03, TF3.04, TF3.05, SPV.01, SPV.02, SPV.03, SPV.04, SP1.02, SP2.01, SP2.02, SP3.03, SP4.02, ICV.01, ICV.02, IC1.01, IC1.02, IC2.01, IC2.02 CGE2a, 2b, 2e	Knowledge/Understanding Thinking/Inquiry Communications Application	Employ the design process and problem-solving activities to develop solutions and production plans for an alternative mass transit vehicle
3.2	TFV.01, TF1.02, SPV.01, SPV.02, SPV.04, SP1.01, SP1.03, SP3.03, SP4.02, SP4.03, ICV.02, IC1.01, IC1.02	Knowledge/Understanding Thinking/Inquiry Communication Application	Implement and modify production plans for a mass transit vehicle

Cluster	Learning Expectations	Assessment Categories	Focus
3.3	TFV.01, TFV.02, TFV.04, SPV.01, SPV.02, SPV.03, SPV.04, ICV.01, ICV.02, TF1.01, TF1.02, TF2.01, TF2.02, TF2.03, TF3.01, TF3.02, TF3.03, TF3.04, TF3.05, SP2.01, SP2.02, SP3.03, SP4.02, IC1.01, IC1.02, IC2.01 CGE4c, 4f	Knowledge/Understanding Thinking/Inquiry Communications Application	Test and evaluate vehicle Make modifications and enhancements to vehicle Reflection

Teaching/Learning Strategies

The study of transportation involves generating solutions to problems in transporting goods and people via air, space, land, and marine environments. This course requires a hands-on, project-based approach that incorporates individual and team efforts, a problem-solving process for generating ideas, and a variety of materials and tools to model, test and communicate solutions. Historical analysis and examination of local solutions and problems is critical to the development of students' appreciation of engineering and scientific concepts, as well as social and environmental issues.

In a transportation design project, the teacher provides students with a design brief that describes the problem to be solved, the constraints or criteria to be met in the solution and in many cases, possible paths to take to develop a viable solution. Activity initiation may take place with the whole classroom or with select groups.

It is important to provide students with the assessment criteria before initiating the project and to discuss the strategies for attaining their maximum potential. The teacher also discusses the production and maintenance of a portfolio as each activity is begun.

The teacher may provide students with a list of the course projects at the beginning of the course, or to introduce them in sequence. This lends itself to a variety of strategies for learning that is dependent on the project, the level of student understanding and experience, and the availability of local facilities and resources.

Possible teaching and learning strategies in a design project include:

- *Group collaboration:* students work in teams or with partners to accomplish specific tasks. Individuals with differing strengths, skills, and knowledge work together to solve problems. Group learning provides high levels of student engagement and interdependence. The teacher establishes a learning environment modelled after a service shop, engineering office, or race team prototype shop, depending on the project.
- *Individual effort:* students work independently to accomplish specific tasks or research topics of interest. This may include reporting or completing individual tasks related to a group project. Time management skills are addressed as both individual and group deadlines are clearly posted and adhered to.
- *Class discussion:* students actively participate by taking turns discussing relevant topics in the units of study. The teacher may direct discussions by posing initial questions, demonstrating specific procedures, or presenting a media topic related to the current activity. Student-to-student conferencing in groups should be done with outlined direction.
- *Theoretical study:* students learn concepts and theory in application through the study of appropriate texts and manuals. Theoretical concepts are taught through Socratic lessons provided by the teacher or invited guests, or through assignments that involve research and study into technical procedures that apply to the current activities.

It should be noted that important issues such as safety (WHMIS, Ontario Health and Safety Association [OHSA]) must be reinforced throughout the course. Following initial discussions and acceptable testing results, a safety passport (Appendix A) is assigned to each student. The teacher reintroduces specific related safety topics as required.

A key component of this course is that students be made aware of career opportunities in the field of transportation. Strategies such as inviting guest speakers, conducting field trips or industry visits, participating in community-based projects, encouraging and marketing job shadowing, and participation in co-op are highly recommended. Post-secondary studies and the procedures in applying to college programs should be highlighted to reflect the wide range of opportunities for students to explore.

Assessment & Evaluation of Student Achievement

Assessment and evaluation criteria must be clearly explained to students at the beginning of the course and at the onset of each activity. Performance assessment includes analysis of the completed task and of students' use of correct procedures and safe conduct. Knowledge acquisition can be assessed through testing, written reports and assignments, and formal student presentations. The teacher assesses individual progress through daily observation and self and peer assessment. Assessment of thinking/inquiry skills may take the form of testing for rationalization of design choices and evaluating the development of ideas into concrete products.

It is important that the teacher distributes assessment/evaluation tools to be used for activities, such as rubrics or checklists, at the beginning of each activity to guide students' development and to direct student efforts.

Seventy per cent of the grade is based on assessments and evaluations conducted throughout the course. Thirty per cent of the grade is based on a final evaluation in the form of an examination, performance, essay or other method of evaluation suitable to the course content and administered towards the end of the course.

It is important that the teacher provides multiple opportunities for students to demonstrate the expectations. The teacher must evaluate students individually, even when they are working within collaborative groups. Possible strategies include:

- individual deliverables, such as a research report or detailed work order;
- daily job or task sheets to be signed by students and the teacher. (**Note:** these sheets can be attached to end reports, clearly indicating the accomplishments of each group member.);
- individual conferencing (i.e., teacher-to-student discussions to assess development and to encourage or motivate);
- development of individual portfolios, skills profiles, log books or time cards.

Assessment Category	Assessment Strategies	Weight
Knowledge/Understanding	Written, Oral and Practical Tests Student/Teacher Conferencing Class Presentations Formal Projects Written Assignments Written Reports on Diagnostic Tasks	70%
Thinking/Inquiry	Sequenced Procedural Lists Written Reports on Diagnostic Tasks	
Communication	Report Writing Class Presentations Notebook	

Assessment Category	Assessment Strategies	Weight
Application	Safe Work Habits Products Skills Demonstration Design	
Final Assessment	Written Testing Problem-Solving and Design Tasks	30%

Accommodations

The teacher should consult individual student IEPs for specific direction on accommodation for individuals. Various accommodations may be made throughout the program as required. They include one-to-one teaching/conferencing, adaptation of handouts, small group learning, and peer tutoring. Activities are monitored and adapted to meet the needs of all learners by applying various accommodations, such as allowing increased time for activities and facilitating peer tutor assistance when possible.

Specific accommodations in the transportation activities include:

- additional assistance for physical tasks;
- additional language resources (especially for technical terms);
- templates or additional templates to assist in completing drawings or reports;
- peer tutoring or additional help in record-keeping, diagnosing, measuring, computing, or fabricating tasks;
- examples of completed assignments;
- one-on-one assistance in sequencing tasks.

Resources

Various resources are used throughout the course, including research software, CAD programs, transportation textbooks, websites, instructional videos, and community industry experts. Special tools may be required for fabricating parts and welding. Other resources, such as a teacher-developed worksheet of procedures and observations, are to be completed by students at predetermined points in the activity.

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

Print

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Toboldt, W., L. Johnson, and W. Gauthier. *Automotive Encyclopedia*. Toronto: Irwin Publishing, 2000. ISBN 1-56637-7137

Wohlens, T. *Applying AutoCad 2000: A Step by Step Approach*. Whitby, ON: McGraw Hill Ryerson, 2000.

Wright, R.T. *Technology*. Toronto: Irwin Publishing, 2000.

Magazines

Komacek, S. "Transportation Technology Education." *Foundations of Technology Education*. 44 (10) (1995): 345-368

Videos

Several videos are available from The Learning Tree Mechanic – (<http://www.autovideo2000.com>), or Thompson/Delmar Learning (AutoEd.com: – <http://www.autoed.com/>)

Videos on the design process and projects such as washing machines, bicycles, toys, and mobile homes are available from Classroom Video, 107 1500 Hartley Avenue, Coquitlam, BC V3K 7A1

Understanding Auto Technology and Repair Video Series. USA: Delmar, 2000.

Websites

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

Air Quality Program - Pollution Probe – <http://www.pollutionprobe.org/air/index.htm>

Pollution Probe is a Canadian environmental organization that deals with issues such as air quality

Alternative Fuels Data Center – <http://www.afdc.doe.gov/>

A one-stop shop for all your alternative fuel and vehicle information needs

American Public Transportation Association – <http://www.apta.com/>

An international organization representing the transit industry

Bad Designs – www.baddesigns.com

A scrapbook of illustrated examples of things that are hard to use because they do not follow human factors principles

BP-Educational Services – <http://www.bpes.com>

Educational resources and information

Canada Transportation Development Centre – <http://www.tc.gc.ca/tdc/>

The Transportation Development Centre (TDC) is Transport Canada's research organization

Carleton University School of Industrial Design – www.id.carleton.ca

School of Industrial Design

C.A.R.S. (Canadian Automotive Repair and Service) Council – <http://www.cars-council.ca/>

Addresses the human resource training and development needs of the Canadian automotive repair and service industry

Catholic Conservation Centre – <http://conservation.catholic.org>

A collection of writings and documentation about ecology and environmental justice

Communications Canada Fact Sheets: Transportation in Canada

– http://www.communication.gc.ca/facts/trans_e.html

Facts on Canada

CSA International – www.csa.ca

The Canadian Standards Association is a not-for-profit membership-based association

History of Technology – www.englilb.cornell.edu/ice/lists/historytechnology/historytechnology.html

History of Technology Resources Available on the Internet

How Stuff Works – <http://www.howstuffworks.com/>

A website containing descriptions of how various technical devices function

How Things Work – www.howthingswork.com

A description of how various technologies work

Industry Canada – http://strategis.ic.gc.ca/sc_indps/sectors/engdoc/tran_hpg.html
A description of various transportation sectors in the Canadian economy

Inner Auto – <http://www.innerauto.com/>
An exploration of inner functions of the automobile

International Directory of Design – www.penrose-press.com/IDD/search.html
A wide variety of resources on Design

Online Ethics Centre for Engineering and Science – <http://onlineethics.org>
Resources for understanding and addressing ethically significant problems in engineering

Ontario Power Generation Info Center – <http://www.opg.com/info/learning.asp>
OPG's Info Centre is intended to help you understand our business and the technology behind our business

Popular Mechanics – <http://www.popularmechanics.com>
A variety of articles from Popular Mechanics magazine

Popular Science – <http://www.popsci.com/popsci/>
A variety of articles from Popular Science magazine

Presentations.Com – <http://www.presentations.com/>
Provides several links on strategies for a good presentation and information on software applications

Society of Automotive Engineers – <http://www.sae.org/about/index.htm>
The Society of Automotive Engineers is your one-stop resource for technical information

Tech Streets – www.techstreet.com
Standards and information (ASTM, CSA, ISO, etc.)

The Subway Page – <http://www.reed.edu/~reyn/transport.html>
Links to World Subway and Other Transportation Information Resources

Transportation Research: The University of Leeds – <http://www1.leeds.ac.uk/~yimling>
External WWW sites related to transportation and environment

Transport Canada – <http://www.tc.gc.ca>
Information about Transport Canada and related links

Vocabulary definitions – <http://whatis.techtarget.com/>
Definitions for thousands of the most current IT-related words

Wired Magazine – www.wired.com
Trends and future directions in technology

Wondrously Advantageous Ventures in Education – www.millenniumwave.com
Resources for teaching design

Software

Computerized Repair Manuals

Design Software (i.e. AutoCad LT)

Microsoft Encarta Encyclopaedia. CD-ROM. Microsoft #X03-52495

Presentation software such as Corel Presentation or Microsoft Power Point

Wohlens, T. *Applying AutoCad: A Step by Step Approach* for AutoCad Release 14. Windows Package.

Whitby, ON: McGraw Hill Ryerson, 1998. ISBN 0-02-667638-9

Associations

PEO (Professional Engineers Ontario), 25 Sheppard Ave. West, Suite 1000 Toronto, Ontario, Canada
– www.peo.on.ca

OACETT (Ontario Association of Certified Engineering Technicians and Technologists), 285 McLeod Street, Ottawa, Ontario, Canada

OSS Considerations

College preparation courses are designed to equip students with the knowledge and skills they need to meet the entrance requirements for College programs. The range of courses offered and the content of these courses allow students to prepare for most College programs and related careers. Teaching and learning emphasizes concrete applications of the theoretical material covered in the course and also emphasizes the development of critical-thinking and problem-solving skills. All College preparation courses are based on rigorous provincial curriculum expectations and emphasize the development of both independent research skills and independent learning skills. Courses also require students to demonstrate that they have developed these skills.

Transportation Technology, Grade 12, College Preparation can be used as an additional compulsory credit (one credit from Science [Grade 11 or Grade 12] or Technological Education [Grade 9 –12]) or as an optional credit. This course is designed to provide students with a broad educational base that prepares them for their studies in Cooperative Education and/or post-secondary education, and to instil in them the need for life-long learning in the workforce.

Students are involved in practical and theoretical aspects of transportation technology. The curriculum provides opportunities for students to undertake hands-on practical activities as well as to conduct research and analysis. There is a wide range of teaching/learning strategies and accommodations to meet the needs of all students. Anti-discrimination education, equity/social justice issues, career goals/cooperative education, conflict resolution/violence prevention, and community partnerships may be addressed in the day-to-day progression of the course. All of these support Ontario Secondary School Policies.

Career exploration throughout all units is made available to students with specific reference to *Choices into Action: Guidance and Career Education Program Policy for Elementary and Secondary Schools, 1999*.

Appendix A

Safety Passport

This is a sample of a generic safety passport that may be adopted for use in a number of technology classrooms. The purpose of the safety passport is to ensure that students are fully aware of all safety features on each piece of equipment in the technical facility prior to using it independently. This process may be adapted to suit the needs of the teacher and students.

The general process is as follows:

1. When a new piece of equipment (e.g., lathe) is introduced, the teacher demonstrates techniques for the safe operation of the machine and the required personal protective procedures and equipment (e.g., wearing proper eye protection and protective clothing, securing loose hair, removing jewellery, etc.). Students record the date of the safety demonstration on the safety passport (see sample below). Students take notes of the demonstration and record the information in a notebook along with the signed passport slip. If a student is absent on the day of a safety demonstration, a makeup opportunity must be provided.
2. Each student must complete a written (or verbal) test on the safe operation of the machine tool, outlining all safety features that must be observed. Students must record the written tests in a notebook. These individual machine tests are designed to complement any general facility safety rules. When the test is completed satisfactorily students record the date in the “tested” column and the teacher initials this as complete. Next, students must demonstrate to the teacher a thorough knowledge of the safety rules for the equipment, and demonstrate competency on the equipment. Once the teacher has observed the required safe set-up and operation of the equipment, the teacher signs off that portion of the safety passport.
3. The teacher signs the final column of students’ safety passport once students have completed steps 1, 2 and 3. Students are now able to use that piece of equipment.
4. Students must be able to provide the teacher with their signed passport for that equipment each time they wish to use it. A summary document of all the various permissions may be created by students and signed by the teacher (as permissions are earned). These summary safety passports may be protected with page protectors or laminated for protection.

Sample Equipment Safety Passport

Student Name: _____							
Equipment: _____							
See notebook for the note on safe set-up and operation of the equipment.							
Attended Teacher Safety Instruction and Demonstration (and note recorded)		Passed Written or Verbal Testing		Demonstrated Safe Set-up and Operation of Equipment to the Teacher		Granted Permission to Use Equipment by the Teacher	
Date of Lesson	Teacher Initial	Date Tested	Teacher Initial	Date of Demo	Teacher Initial	Date	Teacher Initial

Coded Expectations, Transportation Technology, Grade 12, College Preparation, TTJ4C

Theory and Foundation

Overall Expectations

- TFV.01** · apply the design process to develop solutions, products, processes, or services in response to challenges or problems related to vehicles or vehicle systems;
- TFV.02** · identify different forms of mass transit and explain how they interrelate with each other;
- TFV.03** · analyse and describe the kinds and costs of different forms of energy conversion used in the transportation of people and goods using land, air, and marine vehicles;
- TFV.04** · research sources of energy and power transmission that could be used to fuel vehicles and transportation systems in the future.

Specific Expectations

The Design Process

- TF1.01** – explain how human needs or wants related to transportation can be met through a new or improved vehicle or vehicle system;
- TF1.02** – apply the following steps of the design process to solve a variety of transportation technology challenges or problems:
- identify what has to be accomplished (the problem);
 - gather and record information, and establish a plan of procedures;
 - brainstorm a list of as many solutions as possible;
 - identify the resources required for each suggested solution, and compare each solution to the design criteria, refining and modifying it as required;
 - evaluate the solutions (e.g., by testing, modelling, and documenting results) and choose the best one;
 - produce presentation and working drawings, sketches, graphics, mathematical and physical models, or a prototype of the best solution;
 - evaluate the prototype and determine the resources, including computer applications, required to produce it;
 - communicate the solution, using one or more of the following: final drawings, graphs, charts, sketches, technical reports, electronic presentations, flow charts, mock-ups, models, prototypes, and so on;
 - obtain feedback on the final solution and repeat the design process if necessary to refine or improve the solution.

Transportation Systems

- TF2.01** – evaluate and compare the efficiency, capacity, and convenience of a variety of different mass-transit systems;
- TF2.02** – describe the need for coordination among the different forms of mass transit;
- TF2.03** – identify the infrastructure requirements of an efficient mass-transit system.

Energy and Energy Conversion

- TF3.01** – describe a variety of energy sources and investigate the availability of future energy sources;
- TF3.02** – analyse the requirements of converting various types of energy into power in terms of such things as the equipment required, efficiency, and costs;

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- TF3.03** – describe the different forms of energy required to power mass-transit systems after analysing their power output, accessibility, abundance, environmental impact, cost, and conversion efficiency;
- TF3.04** – explain the by-products produced by the conversion of a variety of energy sources;
- TF3.05** – analyse and describe the power requirements of different vehicles and the energy source of each and its transmission method.

Skills and Processes

Overall Expectations

- SPV.01** · apply effective work practices and procedures as part of a team when developing models of mass-transit systems;
- SPV.02** · develop and operate models of effective mass-transit systems;
- SPV.03** · communicate effectively regarding the transportation sector using a variety of means;
- SPV.04** · use mathematical and language skills effectively and apply technological and scientific principles to solve vehicle and mass-transit challenges.

Specific Expectations

Organizational Skills

- SP1.01** – design a mass-transit enterprise incorporating the five major areas of activity: research and development, production, marketing, industrial relations, and financial affairs;
- SP1.02** – function effectively in a model of a mass-transit organization in one or more areas of activity;
- SP1.03** – simulate the execution of the four typical functions of management: planning (setting goals and a course of action), organizing (structuring the job into manageable tasks), directing (assigning tasks and supervising their completion), and controlling (comparing results against the outlined plan).

Applied Work Practices and Procedures

- SP2.01** – select the most appropriate type of mass-transit system for a particular need;
- SP2.02** – effectively model mass-transit systems using a variety of means including software programs or scale models;
- SP2.03** – determine cost, quality of service, and capacity considerations in existing forms of public transport;
- SP2.04** – develop appropriate models for establishing a fair pricing structure for a mass-transit system;
- SP2.05** – simulate the effective management and marketing of a model mass-transit system;
- SP2.06** – quantify the financial cost of environmental impacts and carry out an accurate risk analysis;
- SP2.07** – analyse the demand for services at different times of the day on a mass-transit system to establish the services required.

Communication Skills

- SP3.01** – develop an accurate line organization chart of a model mass-transit enterprise in a school transportation facility;
- SP3.02** – develop an appropriate flow chart for the major areas of activity in their model mass-transit enterprise;
- SP3.03** – generate product specifications for their mass-transit model using engineering drawings, sketches, and reports;
- SP3.04** – present effective proposals related to the establishment of a transportation-related enterprise.

Interdisciplinary Skills

- SP4.01** – apply mathematical skills in spreadsheet analysis to make calculations to close tolerances and to control inventory, costs, and quality;
- SP4.02** – use appropriate language in flow charts, operation and inspection charts, job descriptions, lists of tooling requirements, formal presentations, and bills of material;
- SP4.03** – apply the technological systems approach to solving a transportation challenge, taking each of the following into consideration: inputs – all the resources needed to accomplish the goals of the system (e.g., people, knowledge, materials, energy, finance, capital); process – the scheme of purposeful actions and practices that make up the technical aspects of the system; outputs – the goal or ends to which the inputs and processes are applied; and feedback – the mechanisms that provide preferred direction for the system.

Impact and Consequences

Overall Expectations

- ICV.01** · explain the social, economic, and environmental consequences and impact of the transportation sector on individuals, society, and the environment;
- ICV.02** · effectively evaluate and implement safe work practices when performing transportation-related tasks;
- ICV.03** · identify the role of health and safety legislation in transportation technology programs in schools and in the transportation sector;
- ICV.04** · describe the postsecondary and career opportunities available in the transportation sector on graduation from a college program.

Specific Expectations

Impacts

- IC1.01** – identify potential harmful consequences of specific mass-transit activities for the individual and for society, and formulate alternatives to minimize these consequences;
- IC1.02** – describe possible negative impacts of transportation activities on the environment and identify a variety of materials, processes, and waste-management methods to minimize them;
- IC1.03** – explain the economic impact of the transportation sector on the local community, the province, and the nation.

Safety and Legislation

- IC2.01** – identify safe work practices and recommend the safest and most appropriate method for a particular operation;
- IC2.02** – develop and conduct effective safety audits and inspections of the school transportation facility and implement a plan to address any deficiencies;
- IC2.03** – develop an effective emergency action plan for the school transportation facility;
- IC2.04** – describe the Occupational Health and Safety Act (OHSA) and identify its implications for the school transportation facility and the transportation sector workplace;
- IC2.05** – analyse and describe the issues related to transportation technology addressed in the Workplace Hazardous Materials Information System (WHMIS).

Education, Training, and Career Opportunities

- IC3.01** – describe career opportunities in the transportation sector following postsecondary training (e.g., management, marketing, finance, production, quality control, engineering);
- IC3.02** – identify postsecondary programs associated with the transportation sector and evaluate the appropriateness of the programs to their career plans;
- IC3.03** – assess their strengths and limitations in preparation for careers in the transportation sector.

Ontario Catholic School Graduate Expectations

The graduate is expected to be:

A Discerning Believer Formed in the Catholic Faith Community who

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

An Effective Communicator who

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

A Reflective and Creative Thinker who

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

A Self-Directed, Responsible, Life Long Learner who

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

A Collaborative Contributor who

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

A Caring Family Member who

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

A Responsible Citizen who

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

Unit 2: Sources of Energy and Power Transmission for Mass Transit Vehicles and Systems

Time: 30 hours

Unit Description

Students examine energy issues related to mass transportation, such as energy sources, conversion techniques, power transfer, and control systems. Many of the current propulsion systems for air, land, and marine mass transit and vehicles use fossil fuels. Alternative energy sources and control systems are examined from the perspective of their social, environmental, and economic impact. Students research energy systems, then build a power generating system to test alternative power ideas. Through this unit, students learn to appreciate that as responsible citizens, we all have a duty to protect and preserve the environment for future generations.

Unit Synopsis Chart

Activity	Time	Learning Expectations	Assessment Categories	Focus
2.1 Energy in Transportation	7.5 hours	TFV.03, TFV.04, TF3.01, TF3.02, TF3.04, TF3.05, SPV.03, IC1.02 CGE3b, CGE5c, CGE7i	Knowledge/Understanding Communication Application	Research existing sources of energy and forms of conversion used in transportation
2.2 Building an Operating Energy System for Transportation	22.5 hours	TFV.01, TF1.02, TF3.02, SPV.01, SPV.04, SP1.03, SP4.02, SP4.03, ICV.02, IC2.01 CGE3c, CGE4a, CGE5a, CGE5c	Thinking/Inquiry Application	Build a test electrical generation system

Activity 1: Energy in Transportation

Time: 7.5 hours

Description

Students research and analyse existing forms of energy sources, its distribution systems, and forms of conversion as it relates to transportation technology. Students investigate ideas regarding environmentally friendly methods of generating electricity in transportation systems. It is in humankind's best interest to learn to properly manage energy resources and continue to develop alternatives for the good of all people, especially those in need, at present and in the future.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE3b - creates, adapts, and evaluates new ideas in light of the common good;

CGE5c - develops one's God-given potential and makes a meaningful contribution to society;

CGE7i - respects the environment and uses resources wisely.

Strand(s): Theory and Foundation, Skills and Processes

Overall Expectations

TFV.03 - analyse and describe the kinds of and costs of different forms of energy conversion used in transportation of people and goods using land, air, and marine vehicles;

TFV.04 - research sources of energy and power transmission that could be used to fuel vehicles and transportation systems in the future;

SPV.03 - communicate effectively regarding the transportation sector using a variety of means.

Specific Expectations

TF3.01 - describe a variety of energy sources and investigate the availability of future energy sources;

TF3.02 - analyse the requirements of converting various types of energy into power in terms of such things as the equipment required, efficiency, and costs;

TF3.04 - explain the by-products produced by the conversion of a variety of energy sources;

TF3.05 - analyse and describe the power requirements of different vehicles and the energy source of each and its transmission method;

IC1.02 - describe possible negative impacts of transportation activities on the environment and identify a variety of materials, processes, and waste-management methods to minimize them.

Prior Knowledge & Skills

Students should have basic computer knowledge and library and Internet research skills developed in the prerequisite course, Transportation Technology, Grade 11, College Preparation.

Planning Notes

This research activity requires access to a library and computers with Internet connections. The teacher should also arrange for videos prior to initiating the activity (see Resources).

Please note that the teacher should feel free to change the number of questions posed to students in Appendix 2.1.1 – Energy and Vehicles of Mass Transportation. Students should have the challenge of investigating several energy sources and their respective economic and ecological impacts.

Teaching/Learning Strategies

1. The teacher leads a discussion regarding different types of energy conversion. Students list different types of energy conversions, e.g., internal combustion engine converts potential energy into kinetic and heat energy, a battery is a device that stores chemical energy and converts it into electrical energy, a windmill can convert wind energy into kinetic or electrical energy. The discussion then focuses on how these forms of energy are applied in transportation systems (urban subway systems rely heavily on electrical energy, rail systems rely heavily on internal combustion processes) and in vehicles (mass transit vehicles may rely on different energy conversion processes than personal vehicles).
2. The teacher chooses two or three energy generators related to transportation, then has students list positive and negative values associated with each generator. The teacher asks students to consider the environmental impact of each conversion process, and to consider what it means to have “stewardship” as members of the Catholic community. The teacher also asks students to define and give examples of exhaustible, inexhaustible, and renewable energy sources.
3. The teacher may elect to show a video on energy sources and environmental impact (see Resources). The teacher may also facilitate discussions by having each student at the beginning record two questions or statements of a general nature relating to issues of energy use in land, air, and marine transportation systems. One example of such a query may state, “Why are trains in North America diesel electric and not pure electric as found in Europe?” The introductory lesson should take approximately 75 min.
4. Students are assigned research tasks and are given a question sheet to fill out responses (Appendix 2.1.1). Students are given approximately five hours to complete the questions. The answers may take a variety of forms and be the result of discussion, Internet, periodical, text research, or application of prior knowledge.
5. The teacher uses the last 75 minutes of the activity to review the questions on the activity sheet and to provide directions and meanings. To conclude, the teacher initiates a discussion about using human power to generate electricity, which leads to the next activity.

Assessment & Evaluation of Student Achievement

Completed questions sheets (Appendix 2.1.1) are assessed on quality and clarity of responses, indication of level of effort and achievement, and evidence of depth of research. Assessment and evaluation may also include an oral presentation by students to the class and/or the teacher.

Accommodations

The teacher may provide those students having difficulties with the research aspect of the activity with additional materials and an increased level of support. Conversely, students with more advanced capabilities may be given leadership roles to assist other students or to help organize a presentation event.

Resources

Non-print Materials

“Energy choices.” (video recording)/MediCinema, Ltd. and Cinar Films, 1994. Toronto, Ontario, MediCinema. ISBN: 1896415067-125-00

“Renewable Energy”(video recording)/BP - Educational Services

– <http://www.bpes.com/resources/secondary/renewable.asp>

Websites

Guided Tour on Wind Energy – <http://www.windpower.dk/tour/index.htm>

A guided tour on wind energy

High Speed Maglev – <http://www.maglevpa.com/>

The Pennsylvania mag lev project website

MontanaGreenPower – <http://www.montanagreenpower.com/index.html>

Your Guide to Renewable Energy in Montana

US Department of Energy: Energy Efficiency and Renewable Energy Network
– <http://www.eren.doe.gov/EE/transportation.html>

A variety of information on energy sources and systems

Alternative Fuels Data Center – <http://www.afdc.doe.gov/>

The Alternative Fuels Data Center is a one-stop shop for all your alternative fuel and vehicle information needs.

Communications Canada – http://www.communication.gc.ca/facts/trans_e.html

Communications Canada Fact Sheets: Transportation in Canada

Canada Transportation Development Centre – <http://www.tc.gc.ca/tdc/>

The Transportation Development Centre (TDC) is Transport Canada's research organization

Ontario Power Generation Info Centre – <http://www.opg.com/info/learning.asp>

OPG's Info Centre is intended to help you understand our business and the technology behind our business

BP-Educational Services – <http://www.bpes.com>

Educational resources and information

About Shell - New Energy – <http://www.shell.com>

Shell.com - linking you to our businesses, activities and news worldwide

Online Learning Environment by Ed Schmidt – <http://www.geocities.com/Baja/8205/robotenter.htm>

Google Web Directory – <http://directory.google.com/Top/Science/Technology/Transportation/>

A variety of websites located using Google search engine

Popular Mechanics – <http://www.popularmechanics.com>

A variety of articles from Popular Mechanics magazine

Appendix 2.1.1

Energy and Vehicles of Mass Transportation

Student Name: _____

Please read all the instructions carefully and research the selected questions thoroughly. The goal of this exercise is to give you an awareness of the current issues in energy production and conservation.

Energy can be classified into three categories:

1. *Inexhaustible*: This is energy that will always be available. Examples include solar, wind, and geothermal.
2. *Exhaustible*: This is energy that cannot be replaced once it is all used up. Examples include fossil fuels and nuclear energy.
3. *Renewable*: This is energy that can be used indefinitely if it is properly managed. Examples include wood and plants.

Some sources of energy include the following: Wind, Water, Solar, Geothermal, Fossil Fuel, Nuclear, Chemical, Bioconversion, Electrical, and Wood Burning. Many of these energy sources have been used by humankind at one time or another to power various means of transportation. Some energy sources are extremely difficult to collect or harvest, and because of the high cost, not feasible for mass transportation. In your research you will discover facts about these topics that may be historical or future predictions and development. Use some judgment to formulate a balanced perspective for this information in your answers.

Let's have a look at how some of these energy sources are used to power mass transportation vehicles. Please research the following questions and provide answers using the most informative and succinct response; short answer, fundamental statement, diagram, etc.

Electrical Power

- 1a. What is electricity and how is electricity created from water?
- 1b. Name the other sources of energy that can be used to create electricity.
2. Name vehicles of mass transportation that are powered solely by electricity.
3. How is electricity distributed?
4. How is electricity created in an automobile or in a mag-lev train?
5. How does a diesel electric engine in a train work?

Fossil Fuel Power

6. How is crude oil transformed into gasoline?
7. What is diesel fuel?
8. How is oil extracted from the ground?
9. What is diesel fuel?

Wind Power

10. How does a wind turbine work?
11. Is it possible to power a pure electric train through electrical energy generated by a windmill?
12. How much does a wind turbine cost?

Appendix 2.1.1 (Continued)

Energy Comparisons

13. Describe the differences between energy sources in air, marine, and land vehicles.
14. What are the benefits of human powered transportation and what are the shortcomings?
15. What are the waste products of the different energy sources, and describe the disposal of waste products?
16. Based on your research, what do you feel will be the method of generating energy in vehicles 10 years from now? 25 years from now?
17. Why is the car considered a big polluter on this planet?
18. How does a magnetic levitation train work?

Energy in Our World

19. How much does it cost to fill up a 747 Jumbo with jet engine fuel?
20. What is jet engine fuel?
21. Read a study about the pollution problems of traveling by airplane and summarize it.
22. Where are wind turbines placed?
23. How is nuclear energy produced?
24. Name vehicles of mass transportation that are powered by nuclear energy.
25. What does Canada do with nuclear waste?

Some Possible Solutions

26. Would it be possible to produce electricity by pedalling on a bicycle?
27. What kinds of things could be powered by a bicycle?
28. Would it be possible to electrically power a mass transit vehicle such as a pedestrian walkway or a city bus through pedal power?

Activity 2: Building an Operating Energy System for Transportation

Time: 22.5 hours

Description

Building upon the research undertaken in Activity 1, students build a simple power system to generate and store electricity. This system is designed as a test model for activities developed in the next unit. This project is intended to demonstrate both the technological and human challenges in harnessing the energy to move people, products, and things. The activity is intended as a means for putting faith into practice, as humans are involved as developers and operators in harnessing God's resources.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE3c - thinks reflectively and creatively to evaluate situations and solve problems;

CGE4a - demonstrates a confident and positive sense of self and respect for the dignity and welfare of others;

CGE5a - works effectively as an interdependent team member;

CGE5c - develops one's God-given potential and makes a meaningful contribution to society.

Strand(s): Theory and Foundation, Skills and Processes, Impact and Consequences

Overall Expectations

TFV.01 - apply the design process to develop solutions, products, processes, or services in response to challenges or problems related to vehicles or vehicle systems;

SPV.01 - apply effective work practices and procedures as part of a team when developing models of mass-transit systems;

SPV.04 - use mathematical and language skills effectively and apply technological and scientific principles to solve vehicle and mass-transit challenges;

ICV.02 - effectively evaluate and implement safe work practices when performing transportation-related tasks.

Specific Expectations

TF1.02 - apply the following steps of the design process to solve a variety of transportation technology challenges or problems:

- identify what has to be accomplished (the problem);
- gather and record information, and establish a plan of procedures;
- brainstorm a list of as many solutions as possible;
- identify the resources required for each suggested solution and compare each solution to the design criteria, refining, and modifying it as required;
- evaluate the solutions (e.g., by testing, modeling, and documenting results) and choose the best one;
- produce presentation and working drawings, sketches, graphics, mathematical and physical models, or a prototype of the best solution;
- evaluate the prototype and determine the resources, including computer applications, required to produce it;
- communicate the solution, using one or more of the following: final drawings, graphs, charts, sketches, technical reports, electronic presentations, flow charts, mock-ups, models, prototypes, and so on;
- obtain feedback on the final solution and repeat the design process if necessary to refine or improve the solution;

TF3.02 - analyse the requirements of converting various types of energy into power in terms of such things as the equipment required, efficiency, and costs;

SP1.03 - simulate the execution of the four typical functions of management: planning (setting goals and a course of action), organizing (structuring the job into manageable tasks), directing (assigning tasks and supervising their completion), and controlling (comparing results against the outlined plan);

SP4.02 - use appropriate language in flow charts, operation and inspection charts, job descriptions, lists of tooling requirements, formal presentations, and bills of material;

SP4.03 - apply the technological systems approach to solving a transportation challenge, taking each of the following into consideration: inputs – all the resources needed to accomplish the goals of the system (e.g., people, knowledge, materials, energy, finance, capital); process – the scheme of purposeful actions and practices that make up the technical aspects of the system; outputs – the goal or ends to which the inputs and processes are applied; and feedback – the mechanisms that provide preferred direction for the system;

IC2.01 - identify safe work practices and recommend the safest and most appropriate method for a particular operation.

Prior Knowledge & Skills

This activity extends the skills and knowledge of design and fabrication work introduced in the prerequisite, Transportation Technology, Grade 11, College Preparation. Students should have basic measuring, fabricating, and component fitting skills, as well as general safe and productive work habits in a technical setting. The teacher should review and reinforce safe work habits throughout the activity.

Planning Notes

This activity involves the design and fabrication of a human powered stationary test vehicle. The design process is one of “prototyping,” where the design is scratch built and immediately tested. The following items are required:

- method of obtaining energy (i.e., a foot crank - old bicycles, or small engine);
- method of converting mechanical energy to electrical (i.e., car generator, alternators);
- method of storing energy (i.e., car battery and associated electrical devices);
- method of measuring electricity output (multi-meter, gauges or protocol to measure rpm);
- a load to consume the energy (i.e., 12V car motor);
- fabrication tools (i.e., torches, MIG or stick welder, drills, grinders, saws);
- a reasonable stock of spec. steel (angle, tubing and flat) and fasteners.

The basic test vehicle construction may be approached as a small group or full class endeavour. The project may be scheduled concurrently with other projects to allow for material acquisition and equipment scheduling. This provides variety and planned time to develop the project to its full potential.

Opportunities in partnering or showcasing this project for your students and school or board may exist in the community. Local government, engineering firms, Ontario Power Generation, energy/conservation associations or societies should be contacted. Board field trip policies must be followed.

For student portfolios, plan to provide some recognition of the project suitable for inclusion, such as a certificate, article or project précis.

This activity involves a variety of tasks that require students to keep track of their daily accomplishments for assessment and evaluation purposes. See Appendix 2.2.8 for a sample student task log.

Teaching/Learning Strategies

1. Students are introduced to the activity through a brief description of the project and an outline of the team member's roles and responsibilities (Appendix 2.2.1). The project assessment and evaluation sheet and daily task log are also given (Appendices 2.2.2 and 2.2.8).
2. The values of working with others to accomplish goals and of making meaningful contributions to society are highlighted at the start and reinforced throughout the activity.
3. The concept of a project "critical path" is discussed (see Appendix 2.2.3), the "parts bin" is stocked, and the format for requesting additional materials and components is addressed. A basic platform package (4' × 8' sheet) is provided.
4. The definitions on the Engineering Principle Guide (Appendix 2.2.4) are fully discussed by the whole class and the terms are applied to the descriptions and specifications for the alternator/generator, storage, and measuring devices.
5. The lab's safety document is reviewed specific to the tools and equipment to be used in this project. Students demonstrate safe and competent use of tools and equipment.
6. Students are selected to adopt the roles of the eight-member team (can be in a rotating fashion) to complete the project (see Appendix 2.2.1). It is noted that these are leadership "signing" responsibilities only, that all team members are to work cooperatively with whatever task is at hand. The student responsible signs off any completed task on the project log noting his/her team member function at that time. The lead students must address deficiencies in design or fabrication in a timely fashion, or request and log teacher intervention.
7. The test plans and vehicle(s) are constructed and tested. Revisions to the design are made as needed.
8. Students conduct tests to record electricity generated.
9. As an option, visitors and media are invited.
10. Individual students record results of tests and their own daily logs in a final report or presentation, outlining:
 - the process used to develop the vehicle;
 - the individual student's management role in the project (job description) and daily tasks accomplished (from daily log sheets);
 - results of engineering tests that the team conducted (using graphs or charts), considerations of materials used (and costs), and tools used in accomplishing project;
 - the safety issues observed and the selection process to decide on fabrication techniques;
 - suggestions for improvements or for further work.

(These reports or presentations are used as a basis for assessment and evaluation.)

(See Appendices 2.2.5 through 2.2.8.)

Assessment & Evaluation of Student Achievement

Students are assessed and evaluated on their individual effort and completion of tasks assigned. Their final reports, posters, or presentations are used to evaluate their knowledge of mathematical and scientific principles, their knowledge of the rapid prototyping process, their individual contribution to the team project, and safety issues in fabrication and testing (See Appendix 2.2.2).

Accommodations

The teacher or peer mentor gives students, uncomfortable with management tasks, extra help.

Students with physical disabilities should be given alternative fabrication tasks or extra help from the teacher and/or peer helpers.

For enrichment, students can be given more responsibilities in project management tasks.

Resources

Print

Soman and Swernofsky. *Experience Technology*. Illinois: Glencoe MacMillan/McGraw-Hill, 1993.

Haller and Thompson. *Technology: Today & Tomorrow*. Illinois: Glencoe MacMillan/McGraw-Hill, 1993.

Oberg, et al. *Machinery's Handbook*, 26th ed. New York: Industrial Press, 2001.

(Information at – <http://www.industrialpress.com/mh.htm>)

Internet

Scotty's WAVE – <http://www.millenniumwave.com>

(Wondrously Advantageous Ventures in Education) teaching design

How Things Work – <http://www.howthingswork.com>

A source of information on how various technologies work

International Human Powered Vehicle Association (IHPVA) – <http://www.ihpva.org/>

Promotes improvement, innovation and creativity in the use of human power, especially in the design and development of human-powered vehicles

Exploratorium: Science of cycling: Human Power

– <http://www.exploratorium.edu/cycling/humanpower1.html>

This site investigates the bicycle as a tremendously efficient means of transportation

Appendix 2.2.1

Project Brief: The Energy Generator for Transportation

Challenge

Using a rapid-prototyping design and fabrication methodology and a supplied parts bin, fabricate an electrical power generation, storage and load device. Within the project, recognize and record specific activities you are involved in as particular roles within a design and technologist team.

Team Project Deliverables

- Project Layout - an executed design of an operable generator and load
- Power Plant Components – a project specific set of components
- Engineering Specifications - Materials Report covering all materials used
- Data Record – test results from constructed electrical power generation storage and load device.

Individual Project Deliverables

- Team role account – Project Development Timeline and Check-off (Appendix 2.2.3 – Critical Path)
- Daily Task Log – (Appendix 2.2.8) and description of role in generator development

Parts Bin

- Bicycle cranks, drive chain and gear assembly or suitable small engine, drive wheel/gear
- Assorted angle, rod and tube steel or uni-strut material
- 12v Drive motor
- Copper Conductor (assorted gauges)
- Storage Batteries (automotive, marine or purpose-specific type)
- Grip tape or paint
- Automotive Alternator with suitable drive coupler
- Storage box or bin(s)
- Drums and belt for conveyor drive or wheels for cart
- Multi-meter or voltmeter, ammeter or charge indicator lamp
- Fasteners, assorted wood, plastic, and metals
- Platform (4' × 8' sheet material)

Team Member Roles and Responsibilities

Project Manager	Finance, Time Control, Personnel Control, Procedures and Operation Consultant
Design Engineer	Platform Layout, Component Selection, Specification Development
Materials Engineer	Selection and Report on Materials, Production Consultation, Prototype Components
Production Engineer	Assembly and Modifications
Operating Engineer	Operation and Maintenance Procedures
Maintenance Mechanic	Post-Prototype Components, Manufacturing and Repair (wood and plastics fixtures)
Welder	Fabrication (metal fixtures) and Assembly of Components
Electrician	Wiring, Instrumentation, and Controls

Appendix 2.2.2

Test Vehicle Fabrication Rubric

Criteria	Level 1 (50-59%)	Level 2 (60-69%)	Level 3 (70-79%)	Level 4 (80-100%)
Knowledge/ Understanding - knowledge of scientific technical and mathematical concepts TF3.02, SPV.04, SP4.02	- uses math, technical and scientific terms and principles in limited fashion when describing project	- adequately uses math, technical and scientific terms and principles in describing project	- effectively uses math, technical and scientific terms and principles in describing project	- high degree of effective use of math, technical and scientific terms, and principles in describing project
Application - application of design procedures, contribution to solving challenges TFV.01, TF1.02, SP4.03 CGE3c, CGE5c - contributes effectively as a team member SPV.01, SP1.03 CGE4a, CGE5a - uses procedures, tools, and equipment safely ICV.02, IC2.01	- individual contribution demonstrates limited participation in prototyping procedures, problem solving - participation in team efforts and assigned tasks is limited - uses procedures, equipment, and technology safely and correctly only with supervision	- individual contribution demonstrates some participation in prototyping procedures, problem solving - adequately participates in team efforts and assigned tasks - uses procedures, equipment, and technology safely and correctly with some supervision	- individual contribution demonstrates active and thorough participation in prototyping procedures, problem solving - actively participates in team efforts and assigned tasks - uses procedures, equipment, and technology safely and correctly	- individual contribution demonstrates thoroughly researched and creative participation in prototyping procedures, problem solving - highly effective participation in team efforts and assigned tasks - demonstrates and promotes the safe and correct use of procedures, equipment, and technology

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

Appendix 2.2.3

Critical Path (sample)

Student: _____

Class: _____

Allotted	Actual	Project Stage	Clock	Role and Contribution
0.5	0.5	Team briefing, initial design brainstorming, role review, team building	0.5	
1.0	2.0	Set Critical Path, locate resources, develop engineering report templates (materials report and operating manual)	3.5	
1.5	2.0	Specifications development, complete Engineering Guide	5.5	
1.5	2.0	Materials and Components sourcing, Materials Report implemented	7.5	
2.5	4.0	Project Design development and approval, fabrication list	11.5	
6.0	6.0	Fabrication, Materials Report entries	17.5	
1.0	2.0	Installation	19.5	
1.0	2.0	Testing	21.5	
0.5	1.0	Maintenance	22.5	
1.0	1.0	Peak Performance testing, Operational Standards developed	23.5*	
2.0	2.0	Applying Load	25.5*	
1.0	1.0	Testing	26.5*	
1.0	1.0	Maintenance	27.5*	
1.0	1.0	Demonstration, Operational Standards finalized	28.5*	
1.0	1.5	De-Commissioning or Re-fitting, Materials Report finalized	30.0*	

* denotes additional time

Role Key:

Project Manager (PM)

Design Engineer (DE)

Materials Engineer (ME)

Production Engineer (PE)

Operating Engineer (OE)

Welder (WE)

Industrial Maintenance Mechanic (IMM)

Electrician (ELC)

Appendix 2.2.4

Engineering Principle Guide

Working Definitions

Source Voltage	P.E. (potential energy) for load (storage battery)
Ohms	unit of measure for identifying resistance of load/circuit ($E=I/R$)
Resistance	as found in conductors, under charged or damaged cells, loads
Amperage	quantity of current flow, found in generation and load
Voltage Regulation	method of creating efficient and sufficient current in a charging circuit
Operating R.P.M.	required turning speed for magnetic field current generation
Charging Voltage	operating charge required to contribute to overload storage
Surface Charge	an increased voltage, lower current initial charge caused by chemical behaviour in battery
Gear Reduction	output speed lesser than input
Multiplying Gearset	output speed greater than input
Mechanical Advantage	manipulation of power, speed or torque by mechanical means (gearsets, levers, etc.)
Battery Reserve	non-charging operating power in a battery
Motor Efficiency	temperature determined optimum for load
Belt Tension	required drag on a belt to maintain drive grip
Thermal Load	by-product generated by motor operation (inefficiency)

Appendix 2.2.5

Engineering Principle Guide: Required Specifications and Components

Storage Battery(ies)

1. Voltage Range:
2. CCA (if applicable):
3. AmpHour Rating:
4. Recommended Charging Rate:
5. Specific Gravity Indexed to Charge:

Inputting Device/Generating Device

1. Input RPM/Output RPM:
2. Minimum Charging RPM:
3. Voltage Range:
4. Maximum Output:
5. Field Voltage (Regulator Range):
6. Drive Belt Tension:

Switches and Meters

1. Voltage Range:
2. Amperage Range:
3. Resistance:
4. Polarity:

Load Motor

1. Min. Voltage Required:
2. Current Draw:
3. Output RPM:
4. Approximate Load Designed Rating:
5. Approximate Gearing to Achieve Load Rating:

Safety and Maintenance Items

1. Fire Extinguisher-Type/Application:
2. Hand/Eye/Ear Protection:
3. Moving Parts Guides:
4. Ground Shields and Straps:
5. Platform Markings and Grips:

Appendix 2.2.6

Engineering Principle Guide: Materials Report Entry Guide (sample)

Material	Component	Manufacture/Process Applications/Engineering Strengths	Recycle/ End-use	Commercial Specs (cost/unit format)
Exterior Grade Plywood	Base	Wood Resources Industry Product/ Cut-Shape-Bend-Fasten-Adhere Inexpensive-Lightweight-Millable with Common Tools- Paintable/Strength Data Available	- due to glues used in manufacturing, end-use only in small quantities - recyclable by chipping and reclaiming for other composites	- standard and Metric sizings over all dimensions - graded by strength, water resistance and fire rating - sample unit cost in project <\$40 per 4' x 8' @ 1/4"

Unit 3: Design Alternative Models of Mass Transit Vehicles/Systems

Time: 60 hours

Unit Description

In this culminating activity, students solve problems that relate to the current and future needs of mass transportation using a design process. Models and prototypes of vehicles and systems are designed, constructed, and analysed to solve specific problems in mass transportation. In developing transportation vehicles/systems (or improving existing ones), students consider parameters such as finances, marketing, organizational structures/charts, fair pricing, environmental impact, service enterprises and production methods, as well as design parameters such as ergonomics, efficiency, aerodynamics and mechanical engineering concepts.

Unit Synopsis Chart

Activity	Time	Learning Expectations	Assessment Categories	Tasks
3.1 Design an Urban Transit Vehicle/System	10 hours	TFV.01, TFV.02, TFV.04, TF1.01, TF1.02, TF2.01, TF2.02, TF2.03, TF3.01, TF3.02, TF3.03, TF3.04, TF3.05, SPV.01, SPV.02, SPV.03, SPV.04, SP1.02, SP2.01, SP2.02, SP3.03, SP4.02, ICV.01, ICV.02, IC1.01, IC1.02, IC2.01, IC2.02	Knowledge/ Understanding Thinking/ Inquiry Communications Application	- employ the design process and problem-solving activities to develop solutions and production plans for an alternative mass transit vehicle
3.2 Construct an Urban Mass Transit Vehicle/System	40 hours	TFV.01, TF1.02, SPV.01, SPV.02, SPV.04, SP1.01, SP1.03, SP3.03, SP4.02, SP4.03, ICV.02, IC1.01, IC1.02	Knowledge/ Understanding Thinking/ Inquiry Communications Application	- implement and modify production plans
3.3 Reflect on the Design Process and Mass Transit Vehicle	10 hours	TFV.01, TFV.02, TFV.04, SPV.01, SPV.02, SPV.03, SPV.04, ICV.01, ICV.02, TF1.01, TF1.02, TF2.01, TF2.02, TF2.03, TF3.01, TF3.02, TF3.03, TF3.04, TF3.05, SP2.01, SP2.02, SP3.03, SP4.02, IC1.01, IC1.02, IC2.01	Knowledge/ Understanding Thinking/ Inquiry Communications Application	- test and evaluate vehicle - make modifications and enhancements to vehicle - reflection

Activity 3.1: Design an Urban Transit Vehicle/System

Time: 10 hours

Description

Students are presented with a problem statement relating to mass transit. While completing the early stages of the design process they identify the technological problem or challenge and investigate and analyse existing modes and methods to determine possible solutions. Students determine the best solution and produce designs and production plans to be used in constructing and testing urban transit vehicles, systems, or models that satisfy the original problem. Emphasis is placed on using research and design skills to select a project that best addresses the problem statement and to finalize a production plan.

Strand(s) & Learning Expectations

Strand(s): Theory and Foundation, Skills and Processes, Impact and Consequences

Overall Expectations

TFV.01 - apply the design process to develop solutions, products, processes, or services in response to challenges or problems related to vehicles or vehicle systems;

TFV.02 - identify different forms of mass transit and explain how they interrelate with each other;

TFV.04 - research sources of energy and power transmission that could be used to fuel vehicles and transportation systems in the future;

SPV.01 - apply effective work practices and procedures as part of a team when developing models of mass-transit systems;

SPV.02 - develop and operate models of effective mass-transit systems;

SPV.03 - communicate effectively regarding the transportation sector using a variety of means;

SPV.04 - use mathematical and language skills effectively and apply technological and scientific principles to solve vehicle and mass-transit challenges;

ICV.01 - explain the social, economic, and environmental consequences and impact of the transportation sector on individuals, society, and the environment;

ICV.02 - effectively evaluate and implement safe work practices when performing transportation-related tasks.

Specific Expectations

TF1.01 - explain how human needs or wants related to transportation can be met through a new or improved vehicle or vehicle system;

TF1.02 - apply the design process to solve a variety of transportation technology challenges or problems;

TF2.01 - evaluate and compare the efficiency, capacity, and convenience of a variety of different mass-transit systems;

TF2.02 - describe the need for coordination among the different forms of mass transit;

TF2.03 - identify the infrastructure requirements of an efficient mass-transit system;

TF3.01 - describe a variety of energy sources and investigate the availability of future energy sources;

TF3.02 - analyse the requirements of converting various types of energy into power in terms of such things as the equipment required, efficiency, and costs;

TF3.03 - describe the different forms of energy required to power mass-transit systems after analysing their power output, accessibility, abundance, environmental impact, cost and conversion efficiency;

TF3.04 - explain the by-products produced by the conversion of a variety of energy sources;

TF3.05 - analyse and describe the power requirements of different vehicles and the energy source of each and its transmission method;

SP1.02 - function effectively in a model of a mass-transit organization in one or more areas of activity;

SP2.01 - select the most appropriate type of mass-transit system for a particular need;

SP2.02 - effectively model mass-transit systems using a variety of means including software programs or scale models;

SP3.03 - generate product specifications for their mass-transit model using engineering drawings, sketches and reports;

SP4.02 - use appropriate language in flow charts, operation and inspection charts, job descriptions, lists of tooling requirements, formal presentations and bills of material;

IC1.01 - identify potential harmful consequences of specific mass-transit activities for the individual and for society, and formulate alternatives to minimize these consequences;

IC1.02 - describe possible negative impacts of transportation activities on the environment and identify a variety of materials, processes, and waste-management methods to minimize them;

IC2.01 - identify safe work practices and recommend the safest and most appropriate method for a particular operation;

IC2.02 - develop and conduct effective safety audits and inspections of the school transportation facility and implement a plan to address any deficiencies.

Prior Knowledge & Skills

- Grade 11, College Preparation, Transportation Technology (TTJ3C) (prerequisite)
- A general understanding of research techniques and methods
- Knowledge and understanding of the design process
- An understanding of the safety requirements when working in a technical facility
- Skills in using basic hand and machine tool operations and procedures from TTJ3C

Planning Notes

The type of facility and equipment required in this activity is dependent on the solutions developed by students. For example, if the solution requires some metal fabrication, equipment such as welders and grinders may be required.

Bicycles are frequently used as a main component of the project. These can be acquired through donations of old or unclaimed bicycles from bicycle shops, the local Police Department, school staff, etc. Students may also bring old bicycles from home.

As multiple solutions and project themes are possible, it is at the teacher's discretion how many vehicles are constructed in the implementation stage.

Prior to commencing this activity the teacher should:

- develop a design challenge or problem statement that includes a simulated but realistic environmental and social problem that establishes a need for an alternative mass transit vehicle or system;
- ensure students have access to the library, computer lab, and other available resources as they conduct their research and work on elements of the portfolio and technical report;
- arrange access to Computer-Assisted Design (CAD) software in order to provide a valuable enrichment opportunity for students;
- acquire teaching aids and resource material such as posters, videos, handouts, etc., from other subject discipline areas (e.g., urban geography, science, computer science, etc.);
- arrange for guest speakers with experience in engineering and design, if desired.

This unit and its activities may be taught as a stand-alone entity, or may be combined as an integrated topic within the department or with other school subjects.

Teaching/Learning Strategies

- The teacher must ensure that all students know and observe safety precautions particular to each piece of equipment being used in the activity. A continued application of the Safety Passport is essential (Appendix A – Safety Passport).
- The teacher prepares students for the design challenge by discussing the fact that transportation is an integral part of our society, including social, economic, political and environmental issues and implications.
- Students begin with stages one and two of the design process (see Appendix 3.1.1 – Open-ended Problem Solving and the Design Process).
- Students categorize vehicles and transportation systems under the headings of land, air and marine, including examples of typical historical and present day vehicles and systems as well as some futuristic possibilities. Methods of structure, guidance, propulsion, control, and support systems are also listed for each vehicle and system.
- The teacher presents students with a design challenge statement such as: In the year 2020, demographics show the increased population density in major North American cities will create a saturation point in terms of emission output, number of transportation vehicles and infrastructure systems. Using the design process, identify the design problem statement in your own words describing the need to create an environmentally friendly urban transit vehicle that has integrated propulsion and energy conversion systems.
- The teacher provides and reviews a copy of the teacher-generated portfolio rubric with students
- Working in small groups, students develop a focus for the project by creating a specification and constraint list for their vehicle. This list defines what the design must do and the points over which there is control (i.e., the specifications) as well as those factors over which there is no control (i.e., the constraints). For example, the specifications might state that the cost of materials must not exceed \$100.00, the vehicle can accommodate up to four passengers, and the total mass should not exceed 50 kg. The constraints might include that the project completion deadline is the last day of school and the vehicle must be able to function in all kinds of weather.
- Using a variety of resources, students research and compile information relating to criteria such as energy, propulsion, controls, environmental impact, etc., focusing on what information already exists and what data would be useful in approaching this design challenge. The teacher introduces a portfolio concept as a method of collating and illustrating their work. Students use a computerized word processing program to record their findings.
- Students analyse their research data and develop a framework from which to work. This framework is used to identify a minimum of three possible solutions and the resources required to achieve them (see Appendix 3.1.2 – Choosing the Best Solution). Students produce as many freehand pencil sketches as possible to illustrate each of their solutions. The teacher discusses scale and proportion, drawing techniques, and orthographic and isometric drawing views.
- Students choose the best possible solution by completing an idea evaluation exercise. They develop evaluation criteria such as feasibility of construction, cost, safety of operation, servicing requirements, availability of materials, etc. (see Appendix 3.1.3 – Evaluating Solutions). The teacher provides students with instructions in weighting categories and describes scoring of the criteria. For example, a 1 (low) to 4 (high) rating scale establishes an accurate assessment of each category. Each group selects their best idea based on the highest total score. Students record reasons for choosing a particular solution in their design report.

- If time permits, students produce a model of their project to provide 3-dimensional views of the vehicle and to verify the operation of systems and controls (e.g., steering). The teacher provides information on prototype design and modelling techniques.
- The teacher provides instruction on creating scale drawings and students produce final working drawings (to scale) of their vehicle.
- Each group presents their designs to the class. They describe their solutions, the problems they encountered and the rationale behind their design decisions. The teacher discusses final design parameters and gives approval for groups to proceed with the implementation (construction) stages.

Assessment & Evaluation of Student Achievement

Assessment Strategy	Tool	Purpose	Achievement Chart Categories
Specification/Constraint List	Anecdotal comments	Formative	Knowledge/Understanding Thinking/Inquiry
Working Drawings	Anecdotal comments Checklist		Communication Application
Portfolio includes: Solutions Drawings Evaluations Notes	Rubric Anecdotal comments	Formative On-going throughout project	Knowledge/Understanding Thinking/Inquiry Communication
Presentation of Ideas	Marking Scheme Rating Scale	Summative	Thinking/Inquiry Communication
Completed Portfolio	Rubric	Summative	Knowledge/Understanding Thinking/Inquiry Communication

Accommodations

- Consult student IEPs for specific direction on individual accommodations.
- Ensure small group activities allow all students to participate.
- Modify timelines for completion of the activity to meet student need.
- Encourage student-to-student discussion and teacher-to-student conferencing throughout the activity.
- Opportunities for enrichment include:
 - having the student(s) work with the art/photography classes to create graphics and colour photos;
 - arranging a short work experience at a local postsecondary institution or industry that offers design specialties;
 - videotaping the various stages of the design process;
 - involving students in planning, implementing, and evaluation of learning experiences;
 - relating content to broad-based interdisciplinary issues, problems, or themes to allow for in-depth exploration of concepts;
 - providing students with opportunities to explore a self-selected topic in-depth, teaching skills related to effective independent inquiry;
 - giving students a chance to develop independent or self-directed problem-solving strategies;
 - providing opportunities for open-ended inquiry;
 - providing instruction and opportunities for using CAD or other computer-drawing programs.

Resources

Print

- Bohn, M. *Energy Technology: Power and Transportation*. Whitby, ON: McGraw Hill Ryerson, 1992.
- Bott, P.A. *Testing and Assessment in Occupational and Technical Education*. Needham Heights, MA: Allyn and Bacon, 1995.
- Duffy, James E. *Auto Electricity and Electronics Technology*. Illinois: Goodheart-Wilcox, 1995. ISBN 1-56637-053-1
- Erjavec, Jack. *Automotive Technology: A Systems Approach*, 3rd ed. USA: Delmar Thomas Learning, 2000. ISBN 0-7668-0673-1
- Finch, Richard. *Welder's Handbook*. USA: Berkley Publishing Group, 1997. ISBN 1-55788-264-9
- French, S. *Mechanical Drawing*, 12th ed. Whitby, ON: McGraw Hill Ryerson, 1997.
- Hutchison, J. and J. Karsnitz. *Design and Problem Solving in Technology*. Whitby, ON: McGraw Hill Ryerson, 1994.
- Jensen, Cecil H. and J.D. Helsel. *Engineering Drawing and Design*. Whitby, ON: Glencoe McGraw Hill. ISBN 0028017951
- Krar, Oswald. *Technology of Machine Tools*. ON: McGraw-Hill Ryerson, 1996. ISBN 0-02-803071.
- Loney, D.E. *Project Design: Teacher's Manual*. Englewood Cliffs, NJ: Prentice-Hall, 1995.
- McCauley, C. J. (Associate Editor). *Machinery's Handbook*, 26th ed. NY: Industrial Press Inc., 2000. ISBN 0-8311-2666-3
- Neuendorf, Steven. *Sheet Metal Practice and Pattern Development*, 3rd ed. ON: McGraw-Hill Ryerson. ISBN 0-07-548749-7
- Norman, Donald A. *The Design of Everyday Things*. New York: Doubleday, 1988. ISBN 0-385-26774-6
- Papanek, Victor. *Design for the Real World: Human Ecology and Social Change*. Chicago: Academy Publishers, 1999. ISBN 0897331532
- Schwaller, A. *Energy Technology: Sources of Power*, 2nd ed. Whitby, ON: McGraw Hill Ryerson, 1996.
- Schwaller, A. *Transportation*. Whitby, ON: McGraw Hill Ryerson, 1996.
- Schwaller, Anthony, E. *Motor Automotive Technology*. Cloud State University: Delmar, 1999. ISBN 0-8273-8354-1
- Toboldt, W., L. Johnson, and W. Gauthier. *Automotive Encyclopedia*. Toronto: Irwin Publishing, 2000. ISBN 1-56637-7137
- Wohlens, T. *Applying AutoCad 2000: A Step by Step Approach*. Whitby, ON: McGraw Hill Ryerson, 2000.
- Wright, R.T. *Technology*. Toronto: Irwin Publishing, 2000.

Magazines

- Komacek, S. "Transportation Technology Education." *Foundations of Technology Education*. 44 (10) (1995): 345-368

Videos

Several videos are available from The Learning Tree – www.autovideo2000.com
ICS Learning – www.icslearning.com

Videos on the design process and projects such as washing machines, bicycles, toys, and mobile homes are available from Classroom Video, 107 1500 Hartley Avenue, Coquitlam, BC V3K 7A1
Understanding Auto Technology and Repair Video Series. USA: Delmar, 2000.

Computerized Repair Manuals

Design Software (i.e., AutoCad LT)

Wohlens, T. *Applying AutoCad: A Step by Step Approach* for AutoCad Release 14. Windows Package. Whitby, ON: McGraw Hill Ryerson, 1998. ISBN 0-02-667638-9

Websites

Bad Designs – www.baddesigns.com

A scrapbook of illustrated examples of things that are hard to use because they do not follow human factors principles

Carleton University School of Industrial Design – www.id.carleton.ca
School of Industrial Design

CSA International – www.csa.ca

The Canadian Standards Association is a not-for-profit membership-based association

History of Technology – www.englilb.cornell.edu/ice/lists/historytechnology/historytechnology.html

History of Technology Resources available on the Internet

How Stuff Works – <http://www.howstuffworks.com/>

A website containing descriptions of how various technical devices function

How Things Work – www.howthingswork.com

A description of how various technologies work

Inner Auto – <http://www.innerauto.com/>

An exploration of inner functions of the automobile

International Directory of Design – www.penrose-press.com/IDD/search.html

A wide variety of resources on Design

Popular Mechanics – <http://www.popularmechanics.com>

A variety of articles from Popular Mechanics magazine

Popular Science – <http://www.popsci.com/popsci/>

A variety of articles from Popular Science magazine

Tech Streets – www.techstreet.com

Standards and information (ASTM, CSA, ISO, etc.)

Vocabulary definitions – <http://whatis.techtarget.com/>

Definitions for thousands of the most current IT-related words

Wired Magazine – www.wired.com

Trends and future directions of technology

Scottys – www.millenniumwave.com

Resources for teaching design

Associations

PEO (Professional Engineers Ontario), 25 Sheppard Ave. West, Suite 1000 Toronto, Ontario, Canada
www.peo.on.ca

OACETT (Ontario Association of Certified Engineering Technicians and Technologists), 285 McLeod Street, Ottawa, Ontario, Canada

Appendix 3.1.1

Open-ended Problem Solving and the Design Process

The steps or techniques in solving a problem are known as the problem-solving process. In technological education, this process is called ‘the design process.’ At the beginning of the design process students analyse a given set of conditions in order to identify a problem, a challenge, or a need. Students then work through a number of identifiable stages in order to arrive at a solution.

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

The design process has six stages.

Develop a Focus

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

Develop a Framework

Students identify various possible solutions and the resources required to achieve them. They evaluate each of these alternatives in terms of quality, cost, durability, expectations, specifications, etc. They determine whether the various resources are available and record their findings in the design report. During this stage they may discover they need to redefine the problem.

Choose the Best Solution

Students consider such factors as what materials, tools, and resources are available, the amount of time needed to carry out difficult procedures, and any relevant ergonomic and aesthetic requirements. If necessary, they construct and evaluate a model. Based on the results of these activities they choose the solution that seems best. They record the reasons for choosing a particular solution in the design report and develop a draft plan of action, which may include preliminary drawings.

Appendix 3.1.1 (Continued)

Implement a Plan

Students try out different ways of achieving the best solution and construct the product, process, or system. For physical products, they make a full-sized prototype using production-type materials. They develop a production plan. As they assess every aspect of the construction phase, they may want to make changes to the production plan. They may even modify the original conception of the product to reflect ideas that emerge during construction or to solve problems they did not think of when they began the process. Students record any and all such changes in the design report.

Reflect on the Process and the Product

Students evaluate the process used and the results in light of their own expectations and the reactions of their peers and the client. As a result of their evaluation or testing, they may decide to modify the production process, the product or even the original definition of the problem. Also, at this stage they complete the design report.

Present the Results

The final product and the final design report are presented to the client or peers to communicate the results.

Note: Adapted by Dr. A.M. Hill (Queen's University) from The Ministry of Education and Training. (1995). Broad-based Technological Education. Grades 10, 11 and 12, pp. 8-10

Appendix 3.1.2

Choosing the Best Solution

Brainstorm to generate ideas/solutions for your technological project. Select several ideas from the solutions generated in the brainstorming exercise. Draw rough sketches for the ideas.

Three Ideas: Complete an attribute analysis for each idea (indicate details on the rough sketches)	
Idea 1:	Idea 2:
Idea 3:	Materials and Tools Needed: Idea 1: Idea 2: Idea 3:

Appendix 3.1.3

Evaluating Solutions

Evaluate your ideas according to your evaluation criteria for the best solution. Do this by creating a chart to rate each idea.	
Criteria	Weighting
Idea 1	
Idea 2	
Idea 3	
Total	
Name of Best Solution and Reasons: Select one idea from the ideas generated that will be the actual technological project that you will produce. The idea is selected by applying your evaluation criteria above and selecting the idea with the highest score.	

Note: Adapted by Dr. A.M. Hill (Queen's University) from The Ministry of Education and Training. (1995). Broad-based Technological Education. Grades 10, 11 and 12, pp. 8-10

Activity 3.2: Construct an Urban Mass Transit Vehicle/System

Time: 40 hours

Description

Students continue to apply the design process by constructing their project using the production plan created and approved by the teacher in Activity 3.1: Design an Urban Transit Vehicle/System. Emphasis is placed on the safe use of equipment, efficient individual and collaborative work habits, and the correct use of the design process whenever a modification to the plan occurs.

Strand(s) & Learning Expectations

Strand(s): Theory and Foundation, Skills and Processes, Impact and Consequences

Overall Expectations

TFV.01 - apply the design process to develop solutions, products, processes, or services in response to challenges or problems related to vehicles or vehicle systems;

SPV.01 - apply effective work practices and procedures as part of a team when developing models of mass-transit systems;

SPV.02 - develop and operate models of effective mass-transit systems;

SPV.04 - use mathematical and language skills effectively and apply technological and scientific principles to solve vehicle and mass-transit challenges;

ICV.02 - effectively evaluate and implement safe work practices when performing transportation-related tasks.

Specific Expectations

TF1.02 - apply the following steps of the design process to solve a variety of transportation technology challenges or problems;

SP1.01 - design a mass-transit enterprise incorporating the five major areas of activity: research and development, production, marketing, industrial relations, and financial affairs;

SP1.03 - simulate the execution of the four typical functions of management: planning (setting goals and a course of action), organizing (structuring the job into manageable tasks), directing (assigning tasks and supervising their completion), and controlling (comparing results against the outlined plan);

SP3.03 - generate product specifications for their mass-transit model using engineering drawings, sketches, and reports;

SP4.02 - use appropriate language in flow charts, operation and inspection charts, job descriptions, lists of tooling requirements, formal presentations, and bills of material;

SP4.03 - apply the technological systems approach to solving a transportation challenge, taking each of the following into consideration: inputs – all the resources needed to accomplish the goals of the system (e.g., people, knowledge, materials, energy, finance, capital); process – the scheme of purposeful actions and practices that make up the technical aspects of the system; outputs – the goal or ends to which the inputs and processes are applied; and feedback – the mechanisms that provide preferred direction for the system;

IC1.01 - identify potential harmful consequences of specific mass-transit activities for the individual and for society, and formulate alternatives to minimize these consequences;

IC1.02 - describe possible negative impacts of transportation activities on the environment and identify a variety of materials, processes, and waste-management methods to minimize them.

Prior Knowledge & Skills

- Grade 11, College Preparation, Transportation Technology (TTJ3C) (prerequisite)
- An understanding of the rules and safety requirements of the technical facility
- An understanding of tool and machine operation and procedures

Planning Notes

The type of facility and equipment required in this activity is dependent on the solutions developed by students.

Prior to commencing this activity the teacher should:

- obtain the use of any special equipment (such as welders) that may be required to construct the project;
- make any arrangements necessary to ensure the safe operation of special equipment in the shop. Such arrangements might include:
 - adding temporary ventilation devices, which could include adapting the vehicle exhaust system in the shop;
 - setting up screened areas for welding and grinding;
 - preparing lessons and demonstrations for correct use of equipment;
 - arranging for the manufacturing teacher to assist with lessons or demonstrations;
 - providing protective clothing such as welding aprons, masks and gloves;
- designate storage area for student projects;
- obtain a supply of materials to supplement the materials brought in by students. A few lengths of steel pipe can be purchased inexpensively and can be used by students as structural members in their projects;
- ensure students have completed Activity 3.1: Design an Urban Transit Vehicle/System and have an approved production plan.

Teaching/Learning Strategies

- The teacher and students discuss the appropriate behaviours in a technical facility for the construction phase of this project by addressing student behaviour and work habits in the shop. Special emphasis is placed on safety and students' need to work carefully and cooperatively with others.
- A tour of the facilities may be provided to point out areas of concern and to reintroduce shop policies and equipment precautions.
- The teacher ensures that all students are aware of and observe safety precautions particular to each piece of equipment being used in the activity, and are familiar with the Safety Passport (Appendix A). Students demonstrate safe and competent use of equipment.
- Students are taught the safe use of the equipment and processes that are used during the construction phase. For example, the welder is discussed and demonstrated. All students in the area of the demonstration must be wearing protective clothing and a welding mask. The ventilation system must be turned on. The angle grinder is demonstrated. Students are shown how to use the grinder correctly and how to control the direction in which the grindings are being projected. Special emphasis is placed on the operator's awareness of their surroundings, including the proximity of others, when using equipment. All persons in the area must wear eye and/or face protection.
- Students are given opportunities to practise and to demonstrate safe and acceptable use of all equipment. No student may use equipment until the teacher has observed and documented competency.

- Using their production plans as reference, student groups determine if they have sufficient resources for completing their project. If resources are determined to be inadequate, a plan of action (e.g., obtaining additional resources or re-allocating the ones on hand) must be decided upon and documented.
- The teacher may provide an example of a production process. (Appendix 3.2.1 – A Sample Solution is an example in which group members construct a mass transit vehicle that is propelled using the energy of its riders.)
- With teacher direction, each group assigns the construction of the subsystems of their system/vehicle to group members.
- As students complete their subsystems, they assemble them together into a complete system. Modifications of the production plan may be required (with teacher approval) to allow for assembly challenges. All modifications are documented.

Assessment & Evaluation of Student Achievement

Task/Product	Tool	Purpose	Achievement Chart Categories
Skills Demonstration	Safety Passport	Diagnostic	Knowledge/Understanding Application
Construction of: Frame Drive system Expansion unit	Observation Checklist	Formative	Thinking/Inquiry Application
Assembly of Product	Observation Checklist	Formative	Thinking/Inquiry Application
Portfolio	Rubric	Summative	Knowledge/Understanding Thinking/Inquiry Communication Application

Accommodations

- Change timelines for completion of the activity to meet student need.
- Extend practice time for students experiencing difficulties with technical skills.

Resources

Print Materials

Fogarty, D., J. Blackstone, and T. Hoffman. *Production and Inventory Management*, 2nd ed. Cincinnati, OH: 1991. ISBN 0-538-07461-2

French, S. *Mechanical Drawing*, 12th ed. Whitby, ON: McGraw Hill Ryerson, 1997.

Hutchison, J. and J. Karsnitz. *Design and Problem Solving in Technology*. Whitby, ON: McGraw Hill Ryerson, 1994.

Loney, D.E. *Project Design: Teacher's Manual*. Englewood Cliffs, NJ: Prentice-Hall, 1995.

Norman, Donald A. *The Design of Everyday Things*. New York: Doubleday, 1988. ISBN 0-385-26774-6

Quilan, C. *Orthographic Projection Simplified*. Toronto: McGraw-Hill Ryerson Ltd., 1996. ISBN 0-02-677320-1

Schwaller, A. *Transportation*. Toronto: McGraw Hill Ryerson, 1996.

Schey, John A. *Introduction to Manufacturing Processes*. Toronto: McGraw-Hill, 1997.
ISBN 0-07-055279-7

Wohlrs, T. *Applying AutoCad 2000: A Step by Step Approach*. Whitby, ON. McGraw Hill Ryerson, 2000.

Wright, R.T. *Technology*. Toronto: Irwin Publishing, 2000.

Videos

Videos on the design process and projects such as washing machines, bicycles, toys, and mobile homes are available from Classroom Video, 107 1500 Hartley Avenue, Coquitlam, BC V3K 7A1

Software

Wohlrs, T. *Applying AutoCad: A Step by Step Approach* for AutoCad Release 14. Windows Package. Whitby, ON: McGraw Hill Ryerson, 1998. ISBN 0-02-667638-9

Websites

Bad Designs – www.baddesigns.com

A scrapbook of illustrated examples of things that are hard to use because they do not follow human factor principles

How Stuff Works – <http://www.howstuffworks.com/>

A website containing descriptions of how various technical devices function

Popular Mechanics – <http://www.popularmechanics.com>

A variety of articles from Popular Mechanics magazine

Popular Science – <http://www.popsci.com/popsci/>

A variety of articles from Popular Science magazine

Scottys – www.millenniumwave.com

Resources for teaching design

Appendix 3.2.1

A Sample Solution

Group members work individually and collectively in the construction of subsystems of the project.

Frame

- Students construct the frame according to the design drawings. Three bicycles are modified and reassembled into a tricycle configuration. The lead unit is a complete bicycle with the rear wheel removed. The two trailing units are complete bicycles (of the same size) with the front wheels removed. The forks on the trailing units are cut off and welded to the frames, to allow for handlebars that do not turn. The three units are welded together using additional materials, such as the steel pipe. Care must be taken that the completed frame follows the design, provides enough rigidity, and does not interfere with the drive system.
- A cargo area is created between the rear wheels of the trailing units. This could be constructed using materials donated by businesses in the community.
- The rear of the unit must have a coupling device to accommodate the expansion unit.

Drive system

- Students construct the drive system according to the design drawings. The lead unit (rather than the rear wheel) uses the existing chain and sprocket assembly to drive a shaft. The rear wheel is removed from the bicycle and is dismantled, and the hub (with gear cluster) is attached to the shaft. The existing derailleur system is maintained to provide the operator with the ability to change gear ratios. The shaft is supported by pillow block bearings, and extends to a point in line with the inner front sprocket of the left rear unit. Chain couples the two sprockets together. The outer sprocket drives the rear wheel of the left rear unit.
- The right rear unit utilizes the existing drive system and operates independently of the other two units.
- Guards for chains and sprockets must be fabricated and installed to provide for the safety of the operators.

Expansion Unit

- Students construct one or more add-on units that can be attached to the rear of the previous unit. An add-on unit is similar in design to the two trailing units but has only two wheels and a coupling device in place of the lead unit, allowing it to be attached to the rear of the main vehicle. Each side of the expansion unit is operated independently.
- Each expansion unit has a coupler attached to the rear to allow for other expansion units to be attached.
- As students complete their subsystems, they assemble them onto the frame. Modifications of the production plan (with teacher approval) may be required to allow for the seamless integration of subsystems. All modifications are documented.

Activity 3.3: Reflect on the Design Process and Mass Transit Vehicle Product

Time: 10 hours

Description

Students complete the final two stages of the design process as they reflect on the process and product and evaluate, test, modify, and enhance their urban transit vehicle. Students assess aspects of the construction phase and make modifications necessary to change or enhance the product as a result of their evaluation. For example, enhancement to the product may include the incorporation of light and control systems, a revised braking system, or the addition of an auxiliary power unit. Student team members submit a design report and make a presentation to the class upon completion of the urban transit vehicle project.

Strand(s) & Learning Expectations

Strand(s): Theory and Foundation, Skills and Processes, Impact and Consequences

Overall Expectations

TFV.01 - apply the design process to develop solutions, products, processes, or services in response to challenges or problems related to vehicles or vehicle systems;

TFV.02 - identify different forms of mass transit and explain how they interrelate with each other;

TFV.04 - research sources of energy and power transmission that could be used to fuel vehicles and transportation systems in the future;

SPV.01 - apply effective work practices and procedures as part of a team when developing models of mass-transit systems;

SPV.02 - develop and operate models of effective mass-transit systems;

SPV.03 - communicate effectively regarding the transportation sector using a variety of means;

SPV.04 - use mathematical and language skills effectively and apply technological and scientific principles to solve vehicle and mass-transit challenges;

ICV.01 - explain the social, economic, and environmental consequences and impact of the transportation sector on individuals, society, and the environment;

ICV.02 - effectively evaluate and implement safe work practices when performing transportation-related tasks.

Specific Expectations

TF1.01 - explain how human needs or wants related to transportation can be met through a new or improved vehicle or vehicle system;

TF1.02 - apply the steps of the design process to solve a variety of transportation technology challenges or problems;

TF2.01 - evaluate and compare the efficiency, capacity, and convenience of a variety of different mass-transit systems;

TF2.02 - describe the need for coordination among the different forms of mass transit;

TF2.03 - identify the infrastructure requirements of an efficient mass-transit system;

TF3.01 - describe a variety of energy sources and investigate the availability of future energy sources;

TF3.02 - analyse the requirements of converting various types of energy into power in terms of such things as the equipment required, efficiency, and costs;

TF3.03 - describe the different forms of energy required to power mass-transit systems after analysing their power output, accessibility, abundance, environmental impact, cost, and conversion efficiency;

TF3.04 - explain the by-products produced by the conversion of a variety of energy sources;

TF3.05 - analyse and describe the power requirements of different vehicles and the energy source of each and its transmission method;

SP2.01 - select the most appropriate type of mass-transit system for a particular need;
SP2.02 - effectively model mass-transit systems using a variety of means including software programs or scale models;
SP3.03 - generate product specifications for their mass-transit model using engineering drawings, sketches, and reports;
SP4.02 - use appropriate language in flow charts, operation and inspection charts, job descriptions, lists of tooling requirements, formal presentations, and bills of material;
IC1.01 - identify potential harmful consequences of specific mass-transit activities for the individual and for society, and formulate alternatives to minimize these consequences;
IC1.02 - describe possible negative impacts of transportation activities on the environment and identify a variety of materials, processes, and waste-management methods to minimize them;
IC2.01 - identify safe work practices and recommend the safest and most appropriate method for a particular operation.

Prior Knowledge & Skills

- Grade 11, College Preparation, Transportation Technology (TTJ3C) (prerequisite)
- Research techniques and methods
- Knowledge and understanding of the design process
- Word processing skills
- Rules and safety requirements of the technical facility
- Tool and machine operation and procedures

Planning Notes

Prior to commencing this activity, the teacher should:

- ensure students continue to follow a design/problem-solving model. **Note:** students must complete each stage of the model before proceeding;
- ensure students have access to the library, computer lab, and other available resources as they continue their research and work on final elements of the portfolio and technical report;
- ensure that software is available to record data and compile the design report;
- acquire teaching aids and resource material such as posters, videos, handouts, etc. from other subject discipline areas (e.g., urban geography, science, computer science, etc.);
- arrange for community professionals with experience in engineering and design to assist with judging of vehicles and providing positive feedback to the students;
- arrange a celebration day for students to display and describe their vehicles. Media, trustees, school administration, and the student body in general may be invited to this celebration.

The operation of any vehicle by a student requires permission of the parent/guardian as well as the Board/Principal's permission. If there is any doubt as to the safeness of the vehicle then it must not be used until all safety concerns have been addressed.

Teaching/Learning Strategies

- When the construction stage of vehicle development is finished, students review the four completed stages of the design process and then describe the final two stages necessary to complete both process and product (Appendix 3.1.1 – Open-ended Problem Solving and the Design Process). Students learn that the production of the vehicle is only one aspect (implementation stage) of the complete design process. Each component must be tested as it is constructed, e.g., test welds and wheel alignment.
- After reflecting on their experiences and the fabricated product, students evaluate and test their vehicle to ensure it functions as intended, and that it solves the problem that was originally stated. Prior to testing, the teacher needs to ensure that operator and spectator safety is included as a critical element in the testing procedure. Students and the teacher should perform a vehicle safety check prior to this event (Appendix 3.3.1 – Vehicle Safety Inspection Checklist).
- Modifications or enhancements to the vehicle can be done at this point. These changes reflect ideas that emerge during construction or solve problems that occurred along the way.
- Enhancements can vary but may include adding an auxiliary power system to the vehicle. This assists in vehicle operation when the load is greatest. Students can add an electric motor or chainsaw engine to their urban transit vehicle as examples of how alternative power units can be used to transport people or goods in an energy efficient way.
- To accommodate this power system, students modify their original designs by adding an engine to the front forks of their vehicle. This modification uses a small friction wheel attached to the place that the chainsaw clutch was once located. A bracket allows the engine to be lifted by a cable (brake lever on the handlebars) to engage and disengage the drive wheel from the front tire. This allows a “push” start every time the engine is dropped onto the front wheel. A “kill” switch and throttle control complete the modification.
- Any modification or enhancement to the vehicle requires students to update their design and production plans to reflect these upgrades. In addition, students complete Appendix 3.3.2 – Reflect on the Process and Product, which illustrates a process and product revision list. This worksheet is inserted in the design report in the Reflection on the Process and Product stage.
- Students perform a variety of performance tests on their vehicles under the supervision of the teacher. Students must not operate any vehicles without direct teacher supervision.
- Students communicate their results in the report or final stage. Working in their groups, students plan, prepare, and present their project to the class. Each member of the group is responsible for a portion of the presentation. In the presentation students provide an events summary that includes:
 - a description of how their project was able to solve the design challenge or problem statement;
 - the ideas and designs they identified;
 - how they arrived at their final solution;
 - the production sequence and construction aspects of the vehicle;
 - modifications and enhancements that were made;
 - how their project addresses the topics of energy, power, control, environmental, and social issues.
- Students submit a design report and portfolio of their project. The design report must be word-processed and professional in appearance. The portfolio contains all relevant supporting documents, such as sketches, diagrams, pictures, contacts, etc. The teacher analyses all formative assessment components and completes a summative evaluation of the portfolio and presentation using a rubric or marking scheme.

Assessment & Evaluation of Student Achievement

Task/Product	Tool	Purpose	Achievement Chart Category
Safety Check	Safety Passport	Diagnostic	Knowledge/Understanding Application
Vehicle Testing/Evaluation	Checklist Observation	Formative Summative	Communication Application
Modification Design Brief	Anecdotal Comments Conferencing	Formative	Thinking/Inquiry Communication
Revision List	Conferencing	Formative	Thinking/Inquiry
Report Presentation	Rubric	Summative	Knowledge/Understanding Thinking/Inquiry Communication Application
Portfolio	Rubric	Summative	Knowledge/Understanding Thinking/Inquiry Communication Application

Resources

Print Materials

- Bohn, M. *Energy Technology: Power and Transportation*. Whitby, ON: McGraw Hill Ryerson, 1992.
- Bott, P.A. *Testing and Assessment in Occupational and Technical Education*. Needham Heights, MA: Allyn and Bacon, 1995.
- Carlson, D., L. Wormser, and C. Ulberg. *At Roads End: Transportation and Land Use Choices for Communities*. USA: Island Press, 1995. ISBN 1559633387
- Daiber, Robert and Thomas L. Erikson. *Manufacturing Technology Today and Tomorrow*. USA: Glencoe/McGraw-Hill Educational Division, 1991. ISBN 0-02-675751-6
- Erjavec, Jack. *Automotive Technology: A Systems Approach*, 3rd ed. USA: Delmar Thomas Learning, 2000. ISBN 0-7668-0673-1
- Franklin, U. *The Real World of Technology*. Toronto: Anansi Press, 1990.
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- Hutchison, J. and J. Karsnitz. *Design and Problem Solving in Technology*. Whitby, ON: McGraw Hill Ryerson, 1994.
- Jensen, Cecil H. and J.D. Helsel. *Engineering Drawing and Design*. Whitby, ON: Glencoe McGraw Hill. ISBN 0028017951
- Loney, D.E. *Project Design: Teacher's Manual*. Englewood Cliffs, NJ: Prentice-Hall, 1995.
- Midwood, D. et.al. *Assess For Success*. Toronto: O.S.S.T.F. Educational Services Committee, 1994.
- Norman, Donald A. *The Design of Everyday Things*. New York: Doubleday, 1988. ISBN 0-385-26774-6
- Papanek, Victor. *Design for the Real World: Human Ecology and Social Change*. Chicago: Academy Publishers, 1999. ISBN 0897331532
- Schwaller, A. *Energy Technology: Sources of Power*, 2nd ed. Whitby, ON: McGraw Hill Ryerson, 1996.
- Schwaller, A. *Transportation*. Whitby, ON: McGraw Hill Ryerson, 1996.

Schwaller, Anthony, E. *Motor Automotive Technology*. Cloud State University: Delmar, 1999. ISBN 0-8273-8354-1

Sperling, Daniel. *Future Drive: Electric Vehicles and Sustainable Transportation*. USA: Island Press. 1995. ISBN 155963328X

Toboldt, W., L. Johnson, and W. Gauthier. *Automotive Encyclopedia*. Toronto: Irwin Publishing, 2000. ISBN 1-56637-7137

Wohlers, T. *Applying AutoCad 2000: A Step by Step Approach*. Whitby, ON: McGraw Hill Ryerson, 2000.

Wright, R.T. *Technology*. Toronto: Irwin Publishing, 2000.

Magazines

Komacek, S. "Transportation Technology Education." *Foundations of Technology Education*. 44 (10) (1995): 345-368.

Software

Microsoft Encarta Encyclopaedia. CD-ROM. Microsoft #X03-52495

Presentation software such as Corel Presentation or Microsoft Power Point

Wohlers, T. *Applying AutoCad: A Step by Step Approach* for AutoCad Release 14. Windows Package. Whitby, ON: McGraw Hill Ryerson, 1998. ISBN 0-02-667638-9

Videos

Understanding Auto Technology and Repair Video Series Delmar, 2000.

Videos on the design process and projects such as washing machines, bicycles, toys, and mobile homes are available from Classroom Video, 107 1500 Hartley Avenue, Coquitlam, BC V3K 7A1

Websites

Air Quality Program - Pollution Probe – <http://www.pollutionprobe.org/air/index.htm>

Pollution Probe is a Canadian environmental organization that deals with issues such as air quality

Alternative Fuels Data Center – <http://www.afdc.doe.gov/>

A one-stop shop for all your alternative fuel and vehicle information needs

American Public Transportation Association – <http://www.apta.com/>

An international organization representing the transit industry

Bad Designs – www.baddesigns.com

A scrapbook of illustrated examples of things that are hard to use because they do not follow human factors principles

BP-Educational Services – <http://www.bpes.com>

Educational resources and information

Canada Transportation Development Centre – <http://www.tc.gc.ca/tdc/>

The Transportation Development Centre (TDC) is Transport Canada's research organization

Carleton University School of Industrial Design – www.id.carleton.ca

School of Industrial Design

C.A.R.S. (Canadian Automotive Repair and Service) Council – <http://www.cars-council.ca/>

Addresses the human resource training and development needs of the Canadian automotive repair and service industry

How Stuff Works – <http://www.howstuffworks.com/>

A website containing descriptions of how various technical devices function

How Things Work – www.howthingswork.com

A description of how various technologies work

Industry Canada – http://strategis.ic.gc.ca/sc_indps/sectors/engdoc/tran_hpg.html

A description of various transportation sectors in the Canadian economy

Inner Auto – <http://www.innerauto.com/>

An exploration of inner functions of the automobile

International Directory of Design – www.penrose-press.com/IDD/search.html

A wide variety of resources on Design

Online Ethics Centre for Engineering and Science – <http://onlineethics.org>

Resources for understanding and addressing ethically significant problems in engineering

Ontario Power Generation Info Center – <http://www.opg.com/info/learning.asp>

OPG's Info Centre is intended to help you understand our business and the technology behind our business

Popular Mechanics – <http://www.popularmechanics.com>

A variety of articles from Popular Mechanics magazine

Popular Science – <http://www.popsci.com/popsci/>

A variety of articles from Popular Science magazine

Presentations.Com – <http://www.presentations.com/>

Provides several links on strategies for a good presentation and information on software applications

Society of Automotive Engineers – <http://www.sae.org/about/index.htm>

The Society of Automotive Engineers is your one-stop resource for technical information

Wondrously Advantageous Ventures in Education – www.millenniumwave.com

Resources for teaching design

Associations

PEO (Professional Engineers Ontario) 25 Sheppard Ave. West, Suite 1000 Toronto, Ontario, Canada

– www.peo.on.ca

OACETT (Ontario Association of Certified Engineering Technicians and Technologists) 285 McLeod Street, Ottawa, Ontario, Canada

Appendix 3.3.1

Vehicle Safety Inspection Checklist

#	Component or System	Pass	Fail
1	Safety Features		
2	Body and Frame		
3	Quality and Stability of Welds		
4	Control Systems (Brakes/Steering)		
5	Running Gear		
6	Chassis System		
7	Finishing Techniques		

Appendix 3.3.2

Reflect on the Process and Product

Reflect on the process to produce your design idea and on the actual product. Address any “fail” criterion identified in the Inspection Checklist. Describe what you would change for an improved product design.

Process Revisions:
Product Revisions: