

Public and Catholic District School Board Writing Partnerships

Course Profile

Manufacturing Engineering Technology

Grade 11
College Preparation
TMJ3C

• *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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Course Overview

Manufacturing Engineering Technology, Grade 11, College Preparation, TMJ3C

Course Description

This course focuses on design principles; electronic, pneumatic, and hydraulic control systems; and traditional and advanced manufacturing processes. Students solve problems and make the critical decisions necessary to develop efficient production systems. They also study the range of career opportunities available in the manufacturing sector, and their educational requirements, and research the scope of the industry and the impact of its products on individuals, society, and the environment.

How This Course Supports the Ontario Catholic School Graduate Expectations

The role of Technological Education in the Catholic faith community is to enable students to develop and utilize their gifts and talents while creating products and processes that benefit others in a way that models Gospel values. The focus of the curriculum is to enable students to become critical and innovative problem solvers who question the use of resources and understand the implications of technological innovations. An emphasis on process as well as results ensures that students create products and provide services that recognize our God-given responsibility to respect the dignity and value of the individual and the community. Students also become aware of ethical issues and how they may be resolved using Christian values.

Course Notes

This course includes several ongoing activities that follow the Manufacturing Process (design, plan, analyse, fabricate, assess, and report). The course also serves as a cross-curricular platform that supports academic and technological expectations in other courses. It is important that the focus throughout the course be on the process not the product.

The sequencing of the units demonstrates a logical development of skills and knowledge. The units follow a typical design and manufacturing process, in which students identify a problem, design and plan for its production, fabricate the product, identify the quality requirements, and develop a post-production analysis. The first unit introduces students to project/process engineering and management. In this unit, students develop skills in project estimating, planning, material selection, project design, and process management. At this point, students begin to develop knowledge and skills in the preparation of design briefs and work schedules they can later use for other projects. Engineers and technologists are constantly faced with material selection problems. They are constantly striving for weight reduction, improved strength, and cost efficiency. Students have opportunities to investigate and evaluate materials while selecting their product material. Process planning also becomes critically important throughout the course. It is at this stage in the process that students benefit most. Project management is a likely destination for these students; therefore a strong emphasis should be placed on these activities as they relate to real manufacturing situations.

This course provides students with many hands-on activities. Through the fabrication and production part of the course, students develop an awareness of different manufacturing processes and control systems. These skills help students by expanding their knowledge base in preparation for leadership roles. As potential supervisors, students must also be familiar with health and safety issues. Students develop an understanding of the importance of health and safety as they relate to physical and personal well-being. They also understand the need to assume responsibility for their own safety and the safety of others.

Another important focus for students of this course is the post-analysis unit. As part of a management team, students must develop skills in analysing processes and product so that they may report on the efficiency of the system and suggest improvements.

Teamwork is an essential part of a successful process. Cooperative teamwork should be a positive experience, enhancing individual self worth. Students have opportunities throughout the course to develop team and interpersonal skills in dealing with conflict management. Driven by group projects, students develop a clear understanding of what it means to be an effective team member. An awareness of Gospel values is developed through reflection activities that explore technological implications to human well-being. Humanity can no longer remain complacent about technological development especially as it relates to moral issues. Students develop a clear understanding of the benefits and risks of technological growth and development. As part of the unit reflection, students write journals, which allows them to reflect on the content and comment on their learning experiences. Throughout the course, students are provided with opportunities to discuss and evaluate ethical issues that arise. In general, students acquire the knowledge, skills, and attitudes that allow them to use technology effectively, confidently, and ethically to enhance the human condition and protect the environment. To maintain the principles of Catholic social teaching with regard to the “Dignity of the Human Person”, accommodations are to be made so students do not lose dignity because of disability, poverty, lack of success, linguistic diversity, or race. Teachers foster a positive atmosphere accepting of the individual’s uniqueness, values, and needs.

Units: Titles and Time

* Unit 1	Project Engineering and Management	32 hours
* Unit 2	Production	50 hours
Unit 3	Quality Control	8 hours
Unit 4	Post-production Analysis	20 hours

* These units are fully developed in this Course Profile.

Unit Overviews

Unit 1: Project Engineering and Management

Time: 32 hours

Unit Description

Throughout the course, students apply the design process to develop solutions, products, processes, and process controls to solve a variety of manufacturing challenges or problems. Project engineering and management is an integral part of the design process. In this unit, students are introduced to product research and design; material properties, testing, and selection; process planning; production scheduling; and cost analysis. Using the design process and engineering standards, students demonstrate their knowledge of the concepts required to design, prototype, analyse, plan, and prepare a product idea for production. In evaluating product ideas, emphasis is placed on testing and prototyping. The skills and knowledge acquired in this unit can then be applied to other projects in the following units.

Technology, when placed at the service of God’s people, is to be developed for the benefit of all. Students develop an appreciation of the importance of decision-making based on Gospel values. Emphasis is placed on giving students a general understanding of Manufacturing and how our Catholic faith influences moral decision-making using an informed conscience. The designers and planners of the future must create, adapt, and evaluate new ideas in light of the common good with consideration of the impact to the socio-economic well-being of the region, province, and nation.

Unit Overview Chart

Activity	Time	Expectations	Assessment	Focus
1.1: Project Research	120 min	TFV.01, SPV.04, ICV.01, TF1.01,.02, TF2.05,.07, SP5.01; IC1.02 CGE1d, 2b,c, 4f,g, 5e	Application Knowledge/ Understanding Communication	Technological Systems Manufacturing Systems Design Process Product Research Group Dynamics
1.2: Developing Presentation and Working Drawings of the Wind-powered Generator	840 min	TFV.01, SPV.04, ICV.02, ICV.04; TF1.02; SP1.04, SP3.02, SP4.02, SP4.03, SP4.05; IC2.01, IC3.04 CGE2b,c, 3b, 4f, 5h	Knowledge/ Understanding Thinking/Inquiry Application Communication Learning Skills	Sketch Development Elements and Principles of Design Engineering Graphics Presentation Drawings Working Drawings Assembly Drawings Bill of Material CAD
1.3: Material Properties, Testing, and Selection	300 min	TFV.01, TFV.02, SPV.04, ICV.02, TF2.01,.02,.03,.04,.05, SP5.03, IC1.02, IC2.01 CGE1d, 2b,d, 4a, 7i	Thinking/Inquiry Communication	Material Identification, Selection, Properties, Testing, and Conditioning Environmental Impact
1.4: Modelling and Prototyping	180 min	TFV.01, TFV.02, SPV.04, ICV.02, TF1.02, SP1.05, IC2.01 CGE2a,c, 4b, 3b	Application Communication	Types of Models Modelling Techniques Selecting Material Building Prototypes
1.5: Developing Process Control Charts and Production Planning	300 min	TFV.01, TFV.03, TFV.04, SPV.01, SPV.03, TF1.02, SP1.01,.02,.03, SP4.01, IC2.02 CGE2b,c, 4b, 7i	Thinking/Inquiry Communication Application	Planning and Organizing Activities Production Flow Charts Control Systems Develop Project Management Systems
1.6: Cost Estimating and Analysis	180 min	SPV.04, SPV.05, SP1.01, SP4.04,.06, SP5.01,.03, CGE1d, 2c, 4b,f,g, 5c	Communication Application Knowledge/ Understanding Learning Skills	Estimating Process Product Cost Estimates Process Cost Estimates

Unit 2: Production

Time: 50 hours

Unit Description

This unit introduces students to the design and fabrication of an integrated product. Working from a context, students provide solutions to three separate engineering challenges. The products are then combined to form a controlled system. Using a variety of materials (metal, plastic, alloys, wood, or composite fibres) and following a manufacturing process (welding, cutting, machining, laminating, gluing, bonding, and forming), students produce prototypes. Through analysis of the prototypes using the ten technological concepts, students implement appropriate revisions and modifications. Students provide the solution to the contextual challenge by combining the results of the three activities.

We rely on each other and our technologies for support. Working as a part of a team provides opportunities to apply the Gospel values for the common good of all. Through the development of this project, students directly apply their God-given talents and Catholic faith traditions to gain a better understanding of product designing and process planning and their impact.

Unit Overview Chart

Activity	Time	Expectations	Assessment	Focus/Tasks
2.1: Wind-powered generator – Blades From Composites	1200 min	TFV.01,.02,.03, TF1.01,.02, TF2.04,.05, SPV.02,.04, SP1.04,.05, SP2.01,.03, SP4.05,.06, SP5.03, ICV.02, IC1.02, IC2.01,.05 CGE2a, 3b, 4b, 5e	Thinking/ Inquiry Application	Composites Wing design Blade construction
2.2: Wind-powered generator – tower and drive system	1200 min	TFV.01,.02,.03,.04, TF1.01,.02, TF2.03, SPV.01,.02,.04, SP1.05, SP2.01, SP4.02,.03,.06,.07, ICV.02, IC2.01,.05 CGE2b,e,c, 4c,f	Thinking/ Inquiry Application	Structures Mechanisms Drive systems
2.3: Wind-powered generator – power take off and controller	600 min	TFV.01,.04, TF1.02, TF2.06, SPV.02,.04, SP1.02, SP4.02,.06,.07, SP5.04, ICV.02, IC2.01 CGE5a,e, 7a	Thinking/ Inquiry Application	Generators Power control

Unit 3: Quality Control

Time: 8 hours

Unit Description

In this unit, students learn to ensure their product is made with quality and integrity. Throughout the manufacturing process, students learn the differences between destructive and non-destructive testing, physical inspection of work, meeting set specifications and tolerances, and statistical analysis. They develop an understanding of the importance of quality control within the evaluation of the product. By implementing consistency in methodology, students learn the value and integrity provided by quality systems requirements such as the ISO.

Students develop an appreciation of the importance of moral and ethical decision-making as they learn to think effectively and creatively to evaluate situations and solve problems. Students also exercise Christian leadership in the achievement of individual and group goals.

Unit Overview Chart

Activity	Time	Expectations	Assessment	Focus/Tasks
3.1: Quality Standards	1200 min	TFV.04, SPV.01, SP1.01 CGE2a, 3f, 5f	Knowledge/ Understanding Application	ISO 9000 QS 9000 Audit
3.2: Metrology and Precision Measurement	180 min	TFV.04, SPV.02, SP5.02, CGE2a, 3f, 5f	Knowledge/ Understanding Application	Standards Accuracy Devices Tests
3.3: Statistical Process Control	180 min	TFV.04, SPV.04, SP1.03, SP3.03, SP5.04 CGE2a, 3f, 5f	Application Communication	Normal Distribution Effects Interactions Tabulation

Unit 4: Post-production Analysis

Time: 20 hours

Unit Description

In this unit, students gain knowledge and experience by conducting a detailed analysis of their project/product in terms of cost impact, environmental impact, and production process and method improvement. They present their findings through technical reports and effective oral presentations utilizing technological enhancements such as presentation software and/or projection equipment. Students reflect upon their analysis and how the manufacturing of goods affect the common good in relation to Catholic social teachings.

Unit Overview Chart

Activity	Time	Expectations	Assessment	Focus
4.1: Using a Spreadsheet	240 min	SPV.04, SP1.01, SP4.04 CGE4b,f	Knowledge/ Understanding Application	Elements of Costing Spreadsheet Manipulation Costing Module
4.2: Developing the Product Cost	240 min	SPV.05, SP4.04, CGE1d	Knowledge/ Understanding Application	Developing the Data Time Standards Actual Production Time Direct vs. Indirect Costs Impact to Marketing
4.3: Technology and the Environment	240 min	ICV.0, IC1.01, IC1.02, CGE7i,j	Knowledge/ Understanding Thinking/Inquiry Communication	Waste Disposal Impact of Technology Participate in a Round Table Current Trends in Waste Management
4.4: Technical Writing	240 min	TFV.03, SP4.06,.07, SP5.01 CGE2d,e	Knowledge/ Understanding	Technical Writing Overview Format Content of the Report Target Audience Developing Technical Documents
4.5: Production Reporting and Presentation Techniques	240 min	SPV.05, SP4.06, SP5.03 CGE2c, 5e	Communication	Effective Presentations Use of Technology Selling Your Ideas

Teaching/Learning Strategies

Socratic Lesson

- oral presentation of information by the teacher (theoretical material is presented to the student at the appropriate stage of their activity)

Class Discussion

- students actively participate in discussing current issues

Collaborative/Cooperative

- small-group learning providing high levels of student engagement, interdependence, and conflict-management skills

Conferencing

- student-to-student discussion
- teacher-to-student discussion

Brainstorming

- group generation of initial ideas expressed without criticism or analysis

Design-solving Process

- a problem-solving approach using a prescribed series of steps

Independent Study

- exploration and research of a topic interesting to students

Report/Presentation

- oral and written presentations of the researched topics

Case Study

- investigation of real-life issues

Examples

- provide students with models or samples of student work from previous terms

Journal and Reflection Writing

- the practice of expressing ideas, experiences, and reflections

Community Involvement

- field trips to local manufacturing facilities
- engineering associations
- guest speakers
- recycling centres

Assessment & Evaluation of Student Achievement

The primary purpose of assessment, evaluation, and reporting is to improve student performance. Rubrics and checklists for performance of resource tasks, capability tasks, and learning skills are posted in the classroom. Assessment criteria for individual assignments are to be clearly posted in advance. A student should be aware on an ongoing basis of his or her standing relative to the Provincial Standard.

To evaluate projects and products, exemplars can be used as reference. These exemplars provide both the student and teacher with an up-to-date and ongoing means of monitoring the level of achievement attained.

Seventy per cent of the course grade is based on assessment and evaluation conducted throughout the course. Thirty per cent of the grade is based on a final evaluation in the form of an examination, performance, essay, and/or other culminating event.

Learning skills, effort, punctuality, and recorded absences are reported separately and are not considered in the percentage grade. Learning skills are reported as Needs Improvement, Satisfactory, Good, or Excellent.

Assessment/Evaluation Techniques

Personal Communication

- daily and/or weekly journals and logs
- student/teacher conferencing
- teacher/group conferencing

Paper-and-Pencil Tests

- unit tests/quizzes

Observation

- formal teacher observation
- informal teacher observation

Performance Assessment

- project research
- assigned exercises
- presentations
- drawing and sketching (design briefs)
- product assessment
- formal written reports

Reflection

- self-assessment
- peer assessment
- log/journal
- reflection papers

Assessment Tools

- checklists
- marking schemes
- project specification sheets
- rubrics
- anecdotal comments with suggestions for improvement

Accommodations

Teachers should be familiar with exceptional students' Individual Education Plans (IEPs) for legislated accommodations and consult with the appropriate staff. By doing this, teachers are aware of and can implement prescribed modifications and accommodations.

To maintain the principles of Catholic social teaching with regard to the Dignity of the Human Person, accommodations are to be made so students do not lose dignity because of disability, poverty, linguistic diversity, or race. Teachers foster a positive atmosphere accepting of individual's uniqueness, values, and needs.

The activities allow for a wide range of course delivery methods. This flexibility includes the following support for students who may require it. Teaching strategies may include:

- modifying approaches to evaluation;
- allowing the finished product/project/assignments to be presented in a variety of formats;
- allowing group work with peer mentors;
- grouping students either with varied skills or similar skills to allow for enhancement and/or remediation;

- checking with appropriate school personnel to make certain that all aids, environmental issues, and safety precautions are addressed. Discuss accommodations and make certain that the surroundings and environment meet the needs of all students to allow for positive experiences of success;
- providing appropriate modifications to teaching, learning, and evaluation strategies for ESL students to help them gain proficiency in English. Check with appropriate school personnel for assistance in making the accommodations;
- allowing for extra time writing tests, quizzes, and exams (see the Special Education staff for assistance);
- providing a list of topics and suggestions for an enrichment program;
- allowing for alternative assignments relevant to student's strength.

Resources

Publications

Browning, Heighington, Parvu, and Patillo. *Design and Technology*. McGraw-Hill Ryerson, 1993. ISBN 0-07-549650-X

Canadian Technology Human Resources Board. *Look Ahead, Get Ahead, Growing Career Opportunities for Technicians and Technologists*. Ottawa: Canadian Cataloguing in Publication Data. ISBN 0-9684007-8-7

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

Fowler and Horsley. *Technology*. Collins, 1999. ISBN 0-00-322036-2

Hacker, Michael and Robert Barden. *Technology in Your World*. Delmar Publishing, 1992. ISBN 0-8273-4425-2

Kibbe, Richard R., John Neely, and Roland Meyer. *Machine Tool Practices*. United States: Prentice Hall, 1999. ISBN 0-13-270232-0

Krar, Oswald. *Technology of Machine Tools*. McGraw-Hill, 1996. ISBN 0-02-803071-0

Oberg, E., D. Jones, H. Horten, and H. Ryffel. *Machinery Handbook*, 23rd ed. Industrial Press Inc. ISBN 0-8311-1200-X

Quinlan, C. *Orthographic Projection Simplified*. USA/New York, New York: Glencoe, 1996.

Rorabaugh, Britt. *Mechanical Devices for the Electronics Experimenter*. McGraw-Hill, 1995. ISBN 0-07-053546-9

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

Spence, W.P. *Drafting Technology and Practice*. Peoria, Illinois: Glencoe, 1991. ISBN 0-02-676290-0

Swartz, Mark. *Get Wired, You're Hired*. Toronto: Canadian Association of Career Education and Employers, 1999. ISBN 0-921589-81-6

Write, Thomas R. *Technology Systems*. Goodheart-Willcox, 1992. ISBN 0-87006-896-2

Course Development Resources

Blueprints: A Resource Tool for Writing Catholic Secondary School Profiles. Catholic Curriculum Cooperative, Central Region.

Choices Into Action: Guidance and Career Education Program Policy For Ontario Elementary and Secondary Schools, 1999.

The Ontario Curriculum, Grades 11 and 12, Technological Education, 2000.

Ontario Secondary Schools, Grades 9 to 12, Program and Diploma Requirements, 1999.

Trafford, Larry. *Educating the Soul: Writing Curriculum for Catholic Secondary Schools*. Toronto: Institute for Catholic Education, 1998. ISBN 0-9699178-5-6

Software

Ministry-issued application software (OESS)

Spreadsheet software

CAD software

Word-processing software

Presentation software

Websites

Note: The URLs for the websites have been 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.

Material Search site

<http://www.recycle.net>

Site for student and graduate job seekers

<http://www.cacee.com>

Canada WorkinfoNet - source of career, education, and labour market information for Canadians

<http://www.workinfonet.ca>

Canlearn Interactive

<http://www.canlearn.ca>

Human Resource Development Canada Career information

<http://www.hrdc-drhc.gc.ca/maps/national/canada.shtml>

Ontario Association of Certified Technicians and Technologists - education and career information

<http://oacett.org/>

Human Resources

Computer Site Administrator from the board office or the school

Computer technicians (from the board office and/or community)

School Resource Technician/Librarian

School Chaplain

Special Education teacher

Parents employed in the Information Technology industry

OSS Considerations

This Grade 11 Manufacturing Technology Course is designated as a college preparation course. (See *The Ontario Curriculum, Grades 9 to 12, Program Planning and Assessment, 2000* for a description of the different types of Secondary School courses.) Students can use the course as a compulsory credit (1 additional credit in science Grade 11 or Grade 12) or technological education (Grades 9-12), or as an optional credit.

This course is designed to equip students with the knowledge and skills they need to meet the entrance requirements for college programs. Teaching and learning emphasize workplace applications of the course content, but also explore the theoretical material that underlies these practical applications. Students are introduced to practical and theoretical aspects of Manufacturing Technology. The curriculum provides opportunities for students to undertake hands-on practical activities, as well as to conduct research and analysis. Anti-discrimination education, equity, social justice issues, career goals, cooperative education, conflict resolution/violence prevention, and community partnerships are addressed. All of these support many of the Ontario Secondary School Policies.

Through a wide range of teaching strategies and accommodations, this course meets the needs of all students. Accommodations for exceptional students include specialized support and assessments to facilitate individualized learning. Students of linguistic diversity are accommodated through peer or individual help.

The career portion of this course allows students to learn about their interests, strengths, and aspirations. Students research a variety of career opportunities and learn to make appropriate educational choices related to their secondary school courses, post-secondary requirements, and workplace options. Career exploration throughout all units is available to students with specific reference to *Choices Into Action: Guidance and Career Education Program Policy for Elementary and Secondary Schools, 1999*.

The manufacturing process as a whole provides opportunities for many cross-curricular activities. From planning and design to production and analysis, students are constantly using the sciences, arts, and mathematics. Mathematics and arts are used in preparing drawings and dimensionally and statistically checking product. The sciences are used in selecting material requiring appropriate properties and structure. The planning and reporting phases provide opportunities for students to become more familiar with information technology and a variety of software packages. The production and quality control phases allow for integration with mathematics through measurements and statistical control. Technical briefs, written reports, and oral presentations enhance students' language and grammar skills as well as their communication skills.

Project-based, hands-on activities provide students with the opportunities to explore health and safety issues as they apply to the physical and personal well-being of students in the class, lab, and workplace. The activities ensure that students acquire the knowledge and skills relating to safe practices and proper use and handling of material. Because of the practical nature of this course, students apply what they learn in planned learning activities outside the classroom. This may include field trips, co-op placements, job shadowing, and outside community projects. This also helps to enhance their awareness of educational and career opportunities. It is through these experiences students develop an understanding of personal values as well as an ability to make ethical decisions reflective of Christian values.

Coded Expectations, Manufacturing Engineering Technology, Grade 11, College Preparation, TMJ3C

Theory and Foundation

Overall Expectations

TFV.01 · apply the design process to develop solutions, products, processes, or services in response to challenges or problems in manufacturing technology;

TFV.02 · identify appropriate materials and processes to produce products to meet human needs and wants;

TFV.03 · describe the production process required to develop a product;

TFV.04 · evaluate the types of control systems used in production processes and products.

Specific Expectations

The Design Process

TF1.01 – explain how a human need or want can be met through a new or improved product;

TF1.02 – apply the following steps of the design process to solve a variety of manufacturing 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.

Materials and Production Processes

TF2.01 – identify destructive and non-destructive tests to evaluate material choice;

TF2.02 – evaluate material properties using computers and report the results;

TF2.03 – investigate and evaluate the following materials before choosing the most appropriate materials for a product: metals (ferrous and non-ferrous), polymers (e.g., natural – wood, cellulose; synthetic – plastics), ceramics (e.g., clay, glass, oxides, cement, carbides), composites (e.g., filler, particle, laminate, flake, fibre), and natural materials;

TF2.04 – describe the conditioning processes that change a material’s physical and mechanical characteristics and properties;

TF2.05 – explain the three methods of conditioning materials: thermal conditioning, chemical conditioning, and mechanical conditioning;

TF2.06 – identify semiconductor devices, numeric controls, digital electronic devices, pneumatic and hydraulic devices and controls, and electrochemical devices, and describe how they are used in the production process.

Skills and Processes

Overall Expectations

SPV.01 · effectively plan, organize, direct, and control various manufacturing activities;

SPV.02 · use current technology and production skills in the development of a process or a product;

SPV.03 · operate a manufacturing system and analyse the efficiency of the system;

SPV.04 · use effective techniques to model and communicate product ideas, materials, and specifications;

SPV.05 · use mathematical and language skills effectively and apply technological systems and scientific principles to design material processing and management systems.

Specific Expectations

Organizational Skills

SP1.01 – develop systems for production, marketing, personnel, and financial control;

SP1.02 – use computers to help develop, operate, and control systems;

SP1.03 – apply the concepts of work flow, products per period of time, and defect rate when analysing and testing the efficiency of a production line;

SP1.04 – use appropriate techniques to sketch solutions to scale showing orthographic and isometric views;

SP1.05 – use appropriate techniques to mock up or model potential solutions to challenges;

SP1.06 – select and use appropriate software in the development of marketing strategies.

Technology and Production Skills

SP2.01 – use a wide variety of appropriate hand and machine tool skills in the assembly or fabrication of a product or manufacturing process;

SP2.02 – choose the most appropriate production method by conducting a test run in the manufacture of a product or process;

SP2.03 – analyse and explain the results of producing products in a particular manufacturing process;

SP2.04 – modify particular operations and tooling to improve the manufacturing process.

Quality Control Skills

SP3.01 – use a number of quality control processes when fabricating products;

SP3.02 – design and implement inventory and production control systems;

SP3.03 – use quality control methods such as statistical process control to monitor the efficiency of manufacturing processes, and record results using spreadsheets.

Communication Skills

SP4.01 – create process control charts that clearly outline the stages of the production process;

SP4.02 – use detailed working drawings and assembly drawings to depict the components of the product or process;

SP4.03 – develop a bill of material that indicates the specifications and quantity of a particular part of the product or process;

SP4.04 – conduct an accurate cost analysis of the final product or process;

SP4.05 – develop appropriate engineering drawings using a computer-aided drawing program;

SP4.06 – develop engineering reports that communicate the specifics of the product or process;

SP4.07 – prepare and present effective oral reports on the product or process.

Interdisciplinary Applications

- SP5.01** – explain the technological systems approach and how it relates to manufacturing: inputs (materials, labour, capital), processes (material processing), and outputs (for industry or the consumer market);
- SP5.02** – apply mathematical skills in spreadsheet analysis to measure to close tolerances machining speeds and production rates per unit of time and to control inventory, costs, quality, and sampling;
- SP5.03** – explain how science or scientific principles or practices apply to material selection and specifications, energy consumption, worker fatigue, material processing, and the design of ergonomically appropriate products that accommodate the human form;
- SP5.04** – use appropriate language in flow charts, operation and inspections charts, job descriptions, formal presentations, bills of material, and lists of tooling requirements or materials for quality control programs.

Impact and Consequences

Overall Expectations

- ICV.01** · demonstrate an ability to make informed decisions concerning the social, economic, and environmental consequences and impact of the manufacturing sector;
- ICV.02** · demonstrate the exemplary practices that are essential to safe work environments and practices;
- ICV.03** · identify the role of health and safety legislation in manufacturing technology programs in schools and in the manufacturing sector;
- ICV.04** · describe the career opportunities in manufacturing engineering.

Specific Expectations

Impacts

- IC1.01** – describe the social and economic consequences of manufacturing activity for individuals and for society;
- IC1.02** – describe the impact of manufacturing activity on the environment and identify a variety of materials, processes, and waste management methods to minimize negative impact.

Safety and Legislation

- IC2.01** – apply safe work practices in performing manufacturing-related processes;
- IC2.02** – identify potential hazards in their workplace by conducting safety audits and inspections;
- IC2.03** – describe specific components of the Occupational Health and Safety Act and the actions required on their part to adhere to the act;
- IC2.04** – describe the Workplace Hazardous Materials Information System (WHMIS) and explain the importance of consulting material safety data sheets (MSDS) whenever appropriate;
- IC2.05** – recognize the meaning of the hazard labels associated with WHMIS.

Education, Training, and Career Opportunities

- IC3.01** – describe the scope of career opportunities within the manufacturing sector;
- IC3.02** – identify the specific educational and training requirements necessary for careers in the manufacturing sector;
- IC3.03** – describe career programs such as cooperative education and the Ontario Youth Apprenticeship Program (OYAP);
- IC3.04** – distinguish among the careers of technician, technologist, and engineer and identify the education required for each.

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 1: Project Engineering and Management

Time: 32 hours

Unit Description

Throughout the course students apply the design process to develop solutions, products, processes, and process controls to solve a variety of manufacturing challenges or problems. Project engineering and management is an integral part of the design process. In this unit, students are introduced to product research and design; material properties, testing, and selection; process planning; production scheduling; and cost analysis. Using the design process and engineering standards, students demonstrate their knowledge of the concepts required to design, prototype, analyse, plan, and prepare a product idea for its production. In evaluating product ideas, emphasis is placed on testing and prototyping. The skills and knowledge acquired in this unit can then be applied to other projects in the following units.

Technology, when placed at the service of God's people, is to be developed for the benefit of all.

Students develop an appreciation of the importance of decision-making based on Gospel values.

Emphasis is placed on giving students a general understanding of Manufacturing and how our Catholic faith influences moral decision-making using an informed conscience. The designers and planners of the future must create, adapt, and evaluate new ideas in light of the common good with consideration of the impact to the socio-economic well-being of the region, province, and nation.

Unit Synopsis Chart

Activity	Time	Expectations	Assessment	Focus
1.1: Project Research	120 min	TFV.01, SPV.04, ICV.01, TF1.01, TF1.02, TF2.05, TF2.07, SP5.01, IC1.02 CGE1d, CGE2b, CGE2c, CGE4f, CGE4g, CGE5e	Application Knowledge/ Understanding Communication	Technological Systems Manufacturing Systems Design Process Product Research Group Dynamics
1.2: Developing Presentation and Working Drawings of the Wind-powered Generator	840 min	TFV.01, SPV.04, ICV.02, ICV.04, TF1.02, SP1.04, SP3.02, SP4.02, SP4.03, SP4.05, IC2.01, IC3.04 CGE2b, CGE2c, CGE3b, CGE4f, CGE5h	Knowledge/ Understanding Thinking/ Inquiry Application Communication Learning Skills	Sketch Development Elements and Principles of Design Engineering Graphics Presentation Drawings Working Drawings Assembly Drawings Bill of Material CAD
1.3: Material Properties, Testing, and Selection	300 min	TFV.01, TFV.02, SPV.04, ICV.02, TF2.01, TF2.02, TF2.03, TF2.04, TF2.05, SP5.03, IC1.02, IC2.01 CGE1d, CGE2b, CGE2d, CGE4a, CGE7i	Thinking/ Inquiry Communication	Material Identification, Selection, Properties, Testing, and Conditioning Environmental Impact
1.4: Modelling and Prototyping	180 min	TFV.01, TFV.02, SPV.04, ICV.02, TF1.02, SP1.05, IC2.01 CGE2a, CGE2c, CGE4b, CGE3b	Application Communication	Types of Models Modelling Techniques Selecting Material Building Prototypes

1.5: Developing Process Control Charts and Production Planning	300 min	TFV.01, TFV.03, TFV.04, SPV.01, SPV.03, TF1.02, SP1.01, SP1.02, SP1.03, SP4.01, IC2.02 CGE2b, CGE2c, CGE4b, CGE7i	Thinking/ Inquiry Communication Application	Planning and Organizing Activities Production Flow Charts Control Systems Develop Project Management Systems
1.6: Cost Estimating and Analysis	180 min	SPV.04, SPV.05, SP1.01, SP4.04, SP4.06, SP5.01, SP5.03 CGE1d, CGE2c, CGE4b, CGE4f, CGE4g, CGE5c	Communication Application Knowledge/ Understanding Learning Skills	Estimating Process Product Cost Estimates Process Cost Estimates

Activity 1.1: Project Research

Time: 120 minutes

Description

Students learn how to use a variety of media resources and research techniques to explore manufacturing processes and project ideas in preparation for the construction of a wind generator. Emphasis is placed on the design and construction process requirements as well as overall functionality (e.g., power generation). Guided by their God-given talents and the Catholic faith tradition, students discuss and consider how the project benefits the environment and contributes to the common good of others in a positive manner.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE1d - develop attitudes and values founded on Catholic social teaching and acts to promote social responsibility, human solidarity and the common good;

CGE2b - read, understand, and use written materials effectively;

CGE2c - present information and ideas clearly and honestly with sensitivity to others;

CGE4f - apply effective communication, decision-making, problem-solving, time and resource management skills;

CGE4g - examine and reflect on one's personal values, abilities and aspirations influencing life's choices and opportunities;

CGE5e - respect the rights, responsibilities and contribution of self and others.

Overall Expectations

TFV.01 - apply the design process to develop solutions, products, processes, or services in response to challenges or problems in manufacturing technology;

SPV.04 - use effective techniques to model and communicate product ideas, materials, and specifications;

ICV.01 - demonstrate an ability to make informed decisions concerning the social, economic, and environmental consequences and impact of the manufacturing sector.

Specific Expectations

TF1.01 - explain how a human need or want can be met through a new or improved product;

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

- identify what has to be accomplished (the problem);
- gather and record information, and establish a plan of procedures;

TF2.05 - identify factors that affect material selection;

TF2.07 - describe the advantages of using a variety of materials, such as different species of woods, metals and alloys, plastics, earth materials, and composite materials;

SP5.01 - explain the technological systems approach and how it relates to manufacturing: inputs (materials, labour, capital), processes (material processing), and outputs (for industry or the consumer market);

IC1.02 - describe the impact of manufacturing activity on the environment and identify a variety of materials, processes, and waste management methods to minimize negative impact.

Prior Knowledge & Skills

- Students should have:
 - group working skills (cooperative learning techniques from elementary and an understanding of personal responsibilities assigned by group);
 - Internet research skills and keyboarding skills (some knowledge of word-processing software, presentation software, and the Internet is an asset);
- Grade 10 Manufacturing Technology (TMJ2O) will be an asset.

Planning Notes

- Prior to beginning the activity, ask students to define key terms for homework. Terms may include raw materials, research and development, design engineering, prototyping, and high volume vs. low volume production.
- Have an understanding of the various roles and activities associated with the manufacturing process (e.g., planning, scheduling, plastics forming, and machining) and the basics of electricity and power generation (Ohm's law, power law, and alternator theory).
- To enable students to research effectively, provide a list of websites that they can easily access. Check all websites prior to beginning this activity.
- Provide copies of plans and sketches of the product.
- Prepare an activity assignment sheet to inform students of the requirements of the final product. Discuss copyright laws and review any data, text, or images that students may wish to copy and/or print. As a supplemental activity, the teacher may arrange for a guest speaker(s). Be sure to provide opportunities to discuss ethics and morality of plagiarism and piracy.
- Lead a round table discussion of Catholic values related to product development and production (e.g., stewardship, human potential, and socio-economic responsibilities).

Teaching/Learning Strategies

The teacher should:

- convey the information through a variety of strategies such as whole group, brainstorming, and jigsaw, while using a guided practice technique followed by an opportunity for independent practice;
- explain the technological systems approach and how it relates to manufacturing: inputs (materials, labour, capital), processes (material processing), and outputs (for industry or the consumer market);
- discuss "key terms" homework assignment (e.g., raw materials, research and development, design engineering, prototyping, high volume production vs. job shops);
- review the manufacturing and design process and discuss project research plays a role in this process (Appendix G from the Grade 10 Manufacturing Technology [Catholic] profile);
- review and discuss the role of project research, how it affects the final fabrication of a project, and its effect on the environment, and society as a whole, in light of our Christian responsibilities;
- discuss various search techniques and the basics of electricity and power generation;

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- review group process (see Appendix J of the Grade 10 Manufacturing Technology [Catholic] profile);
 - demonstrate potential avenues to follow to enable all groups to obtain information relevant to their investigation;
 - arrange for students to experience a guest speaker(s) and/or a manufacturing facility tour;
 - provide access to various forms of media and technology;
 - encourage students to reflect upon their research and its relationship to everyday life and how it benefits or harms society;
 - provide an opportunity for the teams to present their findings to the class and how they reflect on their Christian upbringing.

Students should:

- research, using a variety of resources, (e.g., school Library/Resource Centre, websites, local power companies):
 - vertical and horizontal blade design efficiency;
 - trade-related jobs in manufacturing sector;
 - wind generators past and present;
 - impact on the environment;
 - reliability and economics of design;
 - structures such as towers (TV towers, lookout towers, etc.);
- provide a summary of their research detailing production activities, material requirements, and how it impacts on the human condition;
- form teams of two or three students;
- assign each team member a role, (e.g., note taker).

Assessment & Evaluation of Student Achievement

Strategies include Personal Communication, Observation, Performance Assessment, and Reflection and are assessed in reference to Appendix 1.1.1 and Appendix A (career research and sample oral presentation) of the Grade 10 Manufacturing Technology [Catholic] profile.

Application

- Each team submits a two-page word-processed summary of their research, which will be used in their project proposal, detailing websites and other media used, project to be constructed, material requirements, fabrication duties, and expected outcomes (e.g., power generated).

Knowledge and Understanding

- Student's initiative, Christian leadership, participation in a group, and the ability to discuss the associated Catholic values are assessed.
- Each team explains and demonstrates their research technique to the instructor.

Communication

- Reflections: Students self-assess their experiences through a reflective journal entry. The journal entries are evaluated through a rubric evaluation format (Appendix B of the Grade 10 Manufacturing Technology [Catholic] profile).

Accommodations

- Provide peer mentors, 1:1 assistance, varied skill groups, and computer assistance as needed.
- Allow the finished summary sheet to be presented in a variety of formats; accept oral contributions or point form rather than essay where language is an issue.
- Selectively group students so that they have support for remediation and/or enrichment.
- Allow tape-recorded summary if necessary.

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- Allow extra time for the summary sheet.
 - Provide support either verbally and/or with hard copy to ensure students have an understanding of group process and research skills.
 - Review the activity assignment sheet, as appropriate, and monitor progress.
 - Allow the finished research report to be presented in a variety of formats; accept oral contributions or point form rather than essay where language is an issue.
 - Assess students' research process as the emphasis rather than the final research paper.
 - Provide a sample report to show what is expected as end result.

Resources

Science text/encyclopedia (print and software e.g., *Encarta*)

Local power generation company

Guest speaker (professional organization, e.g., OACETT, APEO)

School Library/Resource Centre

Websites

Renewable Resource Data Centre – <http://rredc.nrel.gov/>

The Wind Works – <http://www.users.qwest.net/~jaybo/index.htm>

Picoturbine – <http://www.picoturbine.com/rotorsim.htm>

Illustrated History of Wind Power Development – <http://telosnet.com/wind/index.html>

Home Built Wind Power – <http://homepages.enterprise.net/hugh0piggott/books/>

Ontario Energy Board – <http://www.oeb.gov.on.ca>

Activity 1.2: Developing Presentation and Working Drawings of the Wind-powered Generator

Time: 840 minutes

Description

Students develop a design portfolio package of a wind- powered generator. The portfolio includes design sketches, presentation drawings, and working drawings. As part of a design team, students develop thinking, problem-solving, and graphic communications skills through brainstorming and sketch development of design ideas. Students are encouraged to reflect Gospel values and responsible attitudes as collaborative contributors to the team. This activity is designed to introduce students to a variety of drawing techniques used in the design industry. Students are shown how to sketch objects or ideas using oblique, isometric, perspective, and orthographic representation. Emphasis is placed on understanding the differences between these techniques and when they should be used. Through proper dimensioning and geometric tolerancing of the drawings, students identify production control monitoring strategies. The completed design portfolio can then be used in the production phase (Unit 2) of the manufacturing process.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE2b - read, understand, and use written materials effectively;

CGE2c - present information and ideas clearly and honestly with sensitivity to others;

CGE3b - create, adapt and evaluate new ideas in light of the common good;

CGE4f - apply effective communication, decision-making, problem-solving, time and resource management skills;

CGE5h - apply skills for employability, self-employment and entrepreneurship relative to Christian vocation.

Overall Expectations

TFV.01 - apply the design process to develop solutions, products, processes, or services in response to challenges or problems in manufacturing technology;

SPV.04 - use effective techniques to model and communicate product ideas, materials, and specifications;

ICV.02 - demonstrate the exemplary practices that are essential to safe work environments and practices;

ICV.04 - describe the career opportunities in manufacturing engineering.

Specific Expectations

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

- brainstorm a list of as many solutions as possible;
- produce presentation and working drawings, sketches, graphics, mathematical and physical models, or a prototype of the best solution;
- 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;

SP1.04 - use appropriate techniques to sketch solutions to scale showing orthographic and isometric views;

SP3.02 - design and implement inventory and production control systems;

SP4.02 - use detailed working drawings and assembly drawings to depict the components of the product or process;

SP4.03 - develop a bill of material that indicates the specifications and quantity of a particular part of the product or process;

SP4.05 - develop appropriate engineering drawings using a computer-aided drawing program;

IC2.01 - apply safe work practices in performing manufacturing-related processes;

IC3.04 - distinguish among the careers of technician, technologist, and engineer and identify the education required for each.

Prior Knowledge & Skills

- Students should have:
 - previous activity content regarding familiarity of the wind-powered generators;
 - completed the previous activity in developing a design portfolio of a product, selected product material, and planned the production of the product;
 - group work skills;
 - skills in cooperative learning techniques (effective interpersonal skills) and an understanding of personal responsibilities and commitment required for group activities;
 - basic skills in word processing used for journals/log entries;
 - respect for the rights, responsibilities, and contributions of self and others;
 - basic keyboarding skills (knowledge of using the keyboard for CAD drawing development);
 - mathematical skills relevant to drawing accuracy, measurement units, geometric shapes, as well as Cartesian Plane used in learning CAD.

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- Experience from the Grade 10 Manufacturing Technology activities would be an asset. This experience will provide students with knowledge of basic sketching and drawing standards as well as an understanding of Computer Aided Design and Drafting;
 - Art courses can also be an asset.

Planning Notes

- Ask students to define key terms for homework. Terms may include *design brief, portfolio, brainstorming, thumbnail sketches, design engineering, presentation drawings, and working drawings*.
- Be sure that all computers are in working order and that the CAD software is functional.
- Review all activities and prepare all handouts and materials necessary for the delivery of content.
- The activity is split into stages. The idea development (sketches) stage introduces students to design briefs and sketching techniques. Students progress to the presentation drawing stage where they develop pictorial sketches of the design proposal. The final stage includes detailing the design proposal through the development of working drawings complete with dimensions and geometric tolerances.
- Consult the Art Department for texts on sketching techniques and books on principles and elements of design if none are available your department. Ask Art instructors to describe their perspectives on the use of principles and elements of design.
- Consultation with the Computer Science teachers can also be helpful in understanding computer station safety precautions, (e.g., repetitive stress injuries, ergonomics, electromagnetic fields, posture).
- Create and/or gather teaching aids to act as visual aids when introducing orthographic views. A box with hinged sides will help in discussions of orthographic view development.
- A variety of simple objects such as wooden blocks cut in geometric shapes can also help. Solicit help from the Construction Technology teachers and students to create these visual aids.
- Demonstration of drawing techniques can be helpful. Use board or overheads.
- Prepare handout activities for each stage of the portfolio development.
- Create posters illustrating these techniques and put them up around the room so students always have something to refer to.
- Introduce sketching techniques in progression, starting with simple two-dimensional shapes and progressing to three-dimensional representation and the final addition of value and texture. Prepare several practice exercises, selecting components that allow a progression of activities for the same drawings. Students sketch the part, dimension it, add size tolerances, and add geometric tolerances.
- Graphic communication requires a lot of practice exercises to develop drawing skills, some of which may be completed for homework. Have students complete practice exercises individually. The final portfolio may be completed as design teams consider the number of drawings needed.
- Prepare individual file folders for students to store all sketches and drawings for future use. Students should also make copies to be used in production stages;
- As a supplemental activity, arrange for a guest speaker(s) and/or a field trip to a local manufacturer or engineering firm.

Teaching/Learning Strategies

The teacher should:

- provide a high level of student engagement, interdependence, and conflict-management skills. Monitor progress and provide feedback frequently, emphasizing collaborative and cooperative group efforts in light of Gospel values and keeping in mind the uniqueness and value of each person;

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- review lesson on group dynamics emphasizing collaborative and cooperative group efforts in light of Gospel values (see Appendix J from the Grade 10 Manufacturing Technology [Catholic] profile);
 - have students form design teams allowing for the individual to grow spiritually, intellectually, and socially as a reflective and creative thinker. The teacher may choose or modify the teams depending on individual strengths and weaknesses allowing students to recognize that each has God-given talents;
 - review the manufacturing and design process and discuss how engineering graphics plays a role in this process (Appendix G from the Grade 10 Manufacturing Technology [Catholic] profile);
 - introduce principles and elements of design and discuss how they are useful in presenting design proposals;
 - discuss the different drawing types. Be sure to identify the difference between presentation drawings and working drawings and discuss where in the design portfolio they belong;
 - emphasize the fact that sketches can be developed using any type of drawing techniques from two-dimensional orthographic representation to three-dimensional pictorial representation;
 - discuss simple sketching techniques for drawing shapes (squares, rectangles, and circles) and assign practice exercises for homework;
 - demonstrate how these shapes can then be converted to three-dimensional geometry using oblique, isometric, and perspective representation standards;
 - introduce the design challenge (the Wind-powered Generator). For Activity 1, as an example, the design challenge might state: “As owner/operator of a small manufacturing facility, you have been commissioned by a client to design and manufacture a prototype ‘propeller assembly’ for a wind-powered generator. Due to the high strength-to-weight requirements of the assembly, you are encouraged to investigate the possibility of fabricating the product from modern plastic-composite materials in an attempt to maximize the strength while minimizing the weight”;
 - through design team format, have students use all the learned techniques to brainstorm ideas for the design of the wind-powered generator;
 - be sure students add texture, value, colour, and other design elements to their proposals by emphasizing the importance of presentation in demonstrating their creative thinking skills;
 - introduce students to orthographic representation and assign practice exercises for homework;
 - discuss proper dimensioning standards for the orthographic drawings and have students dimension the homework exercises;
 - discuss size tolerancing and have students add tolerances to the homework exercises;
 - discuss geometric dimensions and how they relate to the production control process and have students add some basic geometric tolerances where applicable;
 - give students an overview (with criteria and instructions) of the drawing requirements for the design portfolio of the wind-powered generator;
 - use appendices as reference material to get things started;
 - discuss fasteners and weldments and have students determine how the generator will be assembled;
 - discuss assembly drawings and have students develop assembly and sub-assembly drawings for their wind-powered generator;
 - discuss bills of materials and have students add a bill to their assembly and sub-assembly drawings;
 - introduce CAD and have students convert their dimensioned hand drawings to formal CAD drawings;
 - discuss safety precautions associated with computer use, (e.g., repetitive stress injuries, ergonomics, electromagnetic fields, posture, breaks, etc.);
 - discuss format in assembling all student work in a portfolio package;
 - review journal/log writing format and criteria;

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- remind the students that a well kept journal of their activities will assist them in goal setting and in developing skills which will help them in the world of work;
 - as students work through the portfolio development, take a few minutes from each period to discuss career opportunities and educational requirements for design engineering and project management.

Students should:

- listen actively and critically to understand and learn in light of Gospel values;
- identify different types of sketching techniques and drawing types;
- participate in collaborative/cooperative learning through group brainstorming of product ideas;
- develop a design brief of the design challenge;
- develop design criteria and constraints for the design challenge;
- independently and as a group, sketch a variety of design ideas using appropriate sketching techniques;
- analyse their ideas and select the best design;
- apply their reasoning in solving the design challenge by writing a one-page rationale of how they chose their best design;
- using pictorial representation and principles of design, sketch the final design proposal;
- assemble the design brief, criteria/constraints, and brainstormed sketches;
- become familiar with drafting standards, allowing them to develop engineering drawings of their design proposal;
- develop a portfolio package containing presentation drawings and detail working drawings of their proposal;
- independently work on team-specified individual drawings, which are then assembled as a package;
- convert the drawing package to formal CAD drawings;
- assemble the design brief, criteria/constraints, idea development sketches, hand drawings, and CAD drawings in a package to be stored with their AEP files;
- describe their learning experiences in a reflective journal entry. In the entry, students also reflect on personal values as they apply to working within a group and on personal aspirations relating to engineering and drafting. The reflection journal should be completed for homework;
- become aware of ethical/moral issues involved in their decision making.

Assessment & Evaluation of Student Achievement

Assessment strategies and tools include opportunities for monitoring students' achievement levels as well as learning skills. They include communication, observation, performance assessment, reflection, conferencing, and tests/quizzes. Assessment tools include marking schemes for the activities, rubric assessments, tests, checklists, and anecdotal comments.

Application

- Students are assessed on their ability to draw a given object using sketching techniques and engineering standards learned. Using a checklist format (see Appendix I of the Grade 10 Manufacturing Technology [Catholic] profile), teachers check the hand-drawn detailed drawings of the wind-powered generator. The checklist may also be used in assessing homework exercises.
- The completed CAD drawings are evaluated individually or as a package using a rubric. The purpose of this assessment is to judge the student's ability in applying their communication skills graphically using engineering standards.

Thinking and Inquiry

- Teachers evaluate students' design brief, student-developed criteria and constraints, idea development sketches, and the written rationale in selecting their best design. A rubric may be used in the evaluation.

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- Upon completion of all drawings, students are assessed on their knowledge and understanding through a written test containing true/false, multiple-choice, and fill-in-the-blank questions and through a practical CAD test in which they convert a hand drawing to a CAD drawing.

Communication

- Reflections: Students self-assess their experiences through a reflective journal entry. The journal entries are evaluated through a rubric evaluation format (Appendix B of the Grade 10 Manufacturing Technology [Catholic] profile).

Learning Skills

- Through observation and conferencing, students can be assessed formally or informally. Checklists, anecdotal comments, or the Learning Skills rubric (see the Grade 10 Manufacturing Technology [Catholic] profile) help assess students. Teachers document the following:
 - skills pertaining to conflict management in light of Gospel teachings;
 - ability to work effectively as an interdependent, considerate team member;
 - initiative, leadership, and participation in a group (see Appendix E of the Grade 10 Manufacturing Technology [Catholic] profile);
 - work habits/homework (see Appendix 1.4.2 of the Grade 10 Manufacturing Technology [Catholic] profile).
- The Learning Skills rubric can also be used by students as a self-assessment tool.
- Conferencing assessment can take place on a daily basis. Provide encouragement and praise effort as tasks are completed, building on a positive self-image.

Accommodations

Activities can be modified to meet the needs of all learners. It may be necessary to apply some of the following accommodations:

- Allow students a choice in using a preferred technique (e.g., oblique vs. isometric drawing). Although they should be able to identify the different techniques, teachers may allow students to select the one with which they are most comfortable and use it exclusively in subsequent assignments.
- Provide more complicated drawing exercises to those students who have prior knowledge and skills or who demonstrate abilities above the expectations. Other students may need to start with tracing a drawing or transferring drawings using grids. When appropriate assess the process as opposed to the product (final drawings/sketches).
- Provide hard copies of instructions and drawing process guide that are well spaced, clear, and have readable font and suitable font size. Monitor portfolio development through daily conferencing, reviewing and repeating instructions at each of the drawing stages.
- Assess quality vs. quantity as appropriate. Allow for fewer drawings maintaining quality.
- Use organizers for new vocabulary, step-by-step drawing process, required due dates, and homework.
- Assist those students having difficulty with unit conversion and measurement skills by providing peer/buddy system and teacher input.
- Provide a glossary of new terms and definitions and diagrams/sketches with labels;
- Pair experienced students with those who are not yet familiar with the techniques. Some students have obtained knowledge of drawing techniques in previous art and/or technology courses.
- Provide isometric grid paper for students having difficulty with freehand sketching of isometric representations.
- Provide completed assignments as examples.
- Support understanding of any mathematical concepts/difficulties through peer support/buddy system or teacher assistance.

- Conference regularly, monitoring ongoing work completion of homework, design portfolio development, and journals/logs.
- Have students enhance their design portfolio by adding more difficult drawings (isometric, oblique, or perspective). This can be done freehand or using CAD modelling options. As an example, in addition to plotting the airfoil shapes for the propeller blades, students are encouraged to provide virtual models of their project using 3-D solids on CAD.
- Challenge students by having them develop isometric exploded assemblies and sub-assemblies of the wind-powered generator. The drawings illustrate how components are assembled (similar to do-it-yourself-kit drawings).
- Challenge students by having them prepare for and write the AutoCAD Level 1 Certification Exam (If your school uses AutoCAD). The preparation will need to be completed independently and may take more than one term. See website resources for details (autodesk.com).

Resources

Publications

French E., C. Svensen, J. Helsel, and B. Urbanick. *Mechanical Drawing, CAD-Communications*, 12th ed. Peoria, Illinois: Glencoe, McGraw-Hill, 1997. ISBN 0-02-667958-2 (Student Text)

ISBN 0-02-677959-0 (Teacher's Resource Binder) ISBN 0-02-667961-2 (Student Workbook)

Negus M. *Introduction to Drafting*. Toronto: McGraw-Hill Ryerson Ltd., 1983.

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

Ragan, Rosalind. *Arttalk*, 3rd ed. Glencoe, McGraw Hill. ISBN 0-02-662434-6

Spence, W.P. *Drafting Technology and Practice*. Peoria, Illinois: Glencoe, 1991. ISBN 0-02-676290-0

Todd, R., K. Todd, and D. McCrory. *Introduction to Design and Technology*. Thomson Learning Tools, 1996. ISBN 0-538-64465-6 (Student Text)

ISBN 0-538-64466-4 (Teacher's Resource Guide)

ISBN 0-538-64465-6 (Portfolio and Activities Resource)

Wallach, P. *Metric Drafting*. California: Collier Macmillan Publishers, 1979.

Websites

Ontario Association of Certified Technicians and Technologists – <http://www.oacett.org/>

Association of Professional Engineers – <http://www.apegga.com>

Autodesk e-learning – <http://www.autodesk.com>

Ontario Curriculum Centre – www.curriculum.org

Grade 10 Manufacturing Technology [Catholic] profile

Catholic Social Teachings, Food for Thought – <http://osjspm.org/cst/>

Search in Ingredients. Key Themes

Video

Visual Design, Elements and Principles. Burnaby: Classroom Videos, Unit C, 9005 Centaurus Circle, Burnaby, BC, V3J 7N4, (604) 420-3066. 20 min.

Computer Software

CAD software

Word-processing software (e.g., *WordPerfect*)

Engstrom, D. and L. Hatch. *Design Brief Manager Software*. Glencoe, McGraw Hill, 1995. For use with *Introduction to Design & Technology* (see Publications).

Human Resources

Guest speakers: local professionals (survey class for parents, friends and family employed in manufacturing sector)

Special Education/Resource staff and Art/Math/Science teachers

School Chaplain

School, Board, or community computer technician

Other

Board computer policies

Local manufacturing industry

Canadian Professional Engineering Association

Society of Manufacturing Engineers

Activity 1.3: Material Properties, Testing, and Selection

Time: 300 minutes

Description

Students research and test a variety of available materials. Materials are major resources used by students to design, build, and evaluate their prototypes. Students decide what materials are most suitable in the designing and building of the wind-powered generator through destructive and non-destructive testing. Testing is performed on chosen materials to determine the properties of the metal, wood, cloth, plastics, and ceramics used by students. Students gain respect for the environment and use its resources wisely for they will have to share God's great Earth with future generations.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE1d - develop attitudes and values founded on Catholic social teaching and act to promote social responsibility, human solidarity, and the common good;

CGE2b - read, understand, and use written materials effectively;

CGE2d - write and speak fluently one or both of Canada's official languages;

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

CGE7I - respect the environment and use resources wisely.

Overall Expectations

TFV.01 - apply the design process to develop solutions, products, processes, or services in response to challenges or problems in manufacturing technology;

TFV.02 - identify appropriate materials and processes to produce products to meet human needs and wants;

SPV.04 - use effective techniques to model and communicate product ideas, materials, and specifications;

ICV.02 - demonstrate the exemplary practices that are essential to safe work environments and practices.

Specific Expectations

TF2.01 - identify destructive and non-destructive tests to evaluate material choice;

TF2.02 - evaluate material properties using computers and report the results;

TF2.03 - investigate and evaluate the following materials before choosing the most appropriate materials for a product: metals (ferrous and non ferrous), polymers (e.g., natural – wood, cellulose; synthetic – plastic), ceramics (e.g., clay, glass, oxides, cement, carbides), composites (e.g., filler, particle, laminate, flake, fibre), and natural materials;

TF2.04 - describe the conditioning process that changes a material's physical and mechanical characteristics and properties;

TF2.05 - explain the three methods of conditioning materials: thermal conditioning, chemical conditioning, and mechanical conditioning;

SP5.03 - explain how science or scientific principles or practices apply to material selection and specifications, energy consumption, worker fatigue, material processing, and the design of ergonomically appropriate products that accommodate the human form;

IC1.02 - describe the impact of manufacturing activity on the environment and identify a variety of materials, processes, and waste management methods to minimize negative impact;

IC2.01 - apply safe work practices in performing manufacturing-related processes.

Prior Knowledge & Skills

The students should have:

- completed the previous activity in developing a design portfolio of the wind-powered generator;
- competence in blueprint reading;
- research skills (Internet and publications);
- interactive and collaborative group skills;
- skills in co-operative learning techniques (effective interpersonal skills) and an understanding of personal responsibilities and commitment required for group activities;
- basic skills in word processing used for journals and log entries;
- respect for the rights, responsibilities, and contributions of self and others.

Planning Notes

- Ensure chart paper, magic markers, and an overhead projector are available for use during class.
- Develop overheads defining and explaining various types and uses of materials used in industry, including ferrous and non-ferrous metals, polymers (e.g., natural - wood cellulose; synthetic – plastics), ceramics (e.g., clay, glass, oxides, cement, carbides), composites (e.g., filler, particle, laminate, flake, fibre), and natural materials. Have samples available for student viewing.
- Make arrangements with the Construction Technology teacher and arrange a construction shop tour, showing students various types of wood that may be used (e.g., spruce, pine, cedar, and oak).
- Prepare a cutting torch and proper welding goggles to demonstrate to students the different characteristics of metals, such as steel, stainless steel, brass, and aluminum, under extreme heat.
- Book a computer lab for student research on the Internet.
- Student material selection charts are presented as part of their research.

Teaching/Learning Strategies

The teacher should:

- review the manufacturing and design process and discuss how material research and selection plays a role in this process (Appendix G from the Grade 10 Manufacturing Technology [Catholic] profile);
- explain to students the various types of materials used in the making of a common everyday item (e.g., a juice box, a pencil, a computer disc, a speaker for the school's PA system);
- discuss characteristics of materials: material structure, material properties, material classifications;
- explain the three methods of conditioning materials: thermal, chemical, and mechanical conditioning. Use steel manufacturing and processing as an example. Show videos, if available;
- heat up a piece of steel with the cutting torch to show students how the material's physical characteristics and properties change (e.g., the metal turns red, easy to bend);
- heat up a piece of aluminum with the cutting torch to show students how the material's physical characteristics change (e.g., metal does not change in colour, and turns into a liquid);

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- discuss metallurgy and explain to students the different characteristics of various metals (e.g., titanium has an excellent strength to weight ratio);
 - describe the conditioning process that changes a material's physical and mechanical characteristics and properties;
 - encourage an open discussion on the types of materials that might be used to build the wind generator and how these materials will be tested;
 - have an open discussion encouraging participation from all students on the types of materials to use in the construction of the wind-powered generator. Have students write materials on chart paper;
 - have students write down all their brainstorming ideas on the chart paper;
 - show students various types of materials that can be used for the wind generator components (plastics, wood, copper wire, fibreglass, aluminum);
 - make students aware of health and safety when dealing with certain materials and testing equipment;
 - have students clean up classroom and shop areas.

Students should:

- demonstrate a confident and positive sense of self and respect for the dignity and the welfare of others;
- form groups and discuss how various materials are processed and tested;
- use the Internet to research and evaluate the following materials before choosing the most appropriate for the wind generator: ferrous and non-ferrous metals, polymers (e.g., natural – wood, cellulose; synthetic – plastic), ceramics (e.g., clay, glass, oxides, cement, carbides), composites (e.g., filler, particle, laminate, flake, fibre), and natural materials;
- research the following mechanical properties of materials: Strength, Tensile Strength, Compression Strength, Fatigue Strength, and Impact Strength;
- choose materials that they feel are appropriate in the construction of the wind generator;
- describe their learning experiences in a reflective journal entry. In the entry, students reflect on personal values as they apply to working within a group, recognizing their own abilities and strengths and the uniqueness of each person. Students also reflect on personal aspirations relating to engineering and planning.

Assessment & Evaluation of Student Achievement

Communication

- Reflections: Students self-assess their experiences through a reflective journal entry. The journal entries are evaluated through a rubric evaluation format. (See Appendix B of the Grade 10 Manufacturing Technology [Catholic] profile.)

Thinking and Inquiry

- Students identify, through a written report, the materials necessary to fabricate the wind-powered generator. A rubric can be used to assess their achievement level. The criteria must include consideration for environmental impact.

Accommodations

Activities can be modified to meet the needs of all learners by applying accommodations such as the following:

- Repeat instructions and frequently monitor progress, providing feedback through suggestions, comments, or questions about work.
- Simplify expectations on the assignment in progress and completion (e.g., shorten length of report).
- Allow the finished assignment to be presented orally, written, or in point form.
- Allow extra time for completion.
- Provide a list of topics and suggestions for enrichment and remediation.

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- Involve student in self-assessing their research techniques working with peer/buddy.
 - Selectively group so that varied abilities, interests, and skills are addressed.
 - Make hard copy of overhead work for those students who have difficulty copying from the overhead.
 - Use chart format to record information from research. Suggest format of chart to assist student with amount of material necessary.
 - Monitor completion of work done at home, or out of classroom, and encourage ongoing and mandatory use of reflective journals.
 - Foster an atmosphere of acceptance of individual differences and needs.

Resources

Publications

Hutchinson, John and John Karsnitz. *Design and Problem Solving in Technology*. Glencoe, McGraw-Hill, 1994. ISBN 0-8273-5244-1

Todd, R., K. Todd, and D. McCrory. *Introduction to Design and Technology*. Thomson Learning Tools, 1996. ISBN 0-538-64465-6 (Student Text)

ISBN 0-538-64466-4 (Teacher's Resource Guide)

ISBN 0-538-64465-6 (Portfolio and Activities Resource)

Websites

<http://www.alleghenytechnologies.com>

<http://www.asm-intl.org>

Video

New Steel, Doorway to the Future. CSTE (Canadian Steel Trade and Employment Congress), Youth Employment Strategy, 10 min.

Heat treating videos from ASM

Computer Software

Word-processing software (e.g., *WordPerfect*)

New Steel, Doorway to the Future. CSTE (Canadian Steel Trade and Employment Congress), Youth Employment Strategy. CD accompanied by video and binder resource.

Engstrom, D., and L. Hatch. *Design Brief Manager Software*. Glencoe, McGraw Hill, 1995. For use with *Introduction to Design & Technology* (see Publications).

Activity 1.4: Modelling and Prototyping

Time: 180 minutes

Description

Students hold discussions on the development and manufacturing of the prototype for their wind-powered generator. The prototype is inspected and tested to ensure a quality final product. This activity allows students to test various types of materials that may be used for their design. The finished product will result in a cheap source of electrical current that will have a positive effect on the environment.

Students are given the opportunity to become aware of their Christian responsibility to the environment and others.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE2a - listen actively and critically to understand and learn in light of the Gospel values;

CGE2c - present information and ideas clearly and honestly and with sensitivity to others;

CGE4b - demonstrate flexibility and adaptability;

CGE3b - create, adapt, and evaluate new ideas in light of the common good.

Overall Expectations

TFV.01 - apply the design process to develop solutions, products, processes, or services in response to challenges or problems in manufacturing technology;

TFV.02 - identify appropriate materials and processes to produce products to meet human needs and wants;

SPV.04 - use effective techniques to model and communicate product ideas, materials, and specifications;

ICV.02 - demonstrate the exemplary practices that are essential to safe work environments and practices.

Specific Expectations

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

- 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;

SP1.05 - use appropriate techniques to mock up or model potential solutions to challenges;

IC2.01 - apply safe work practices in performing manufacturing-related processes.

Prior Knowledge & Skills

- The student should have:
 - completed the previous activity, developing a design portfolio and selecting product material;
 - competence in blueprint reading;
 - research skills (Internet and publications);
 - interactive and collaborative group skills;
 - skills in co-operative learning techniques (effective interpersonal skills) and an understanding of personal responsibilities and commitment required for group activities;
 - basic skills in word processing and keyboarding used for journals and log entries
 - respect for the rights, responsibilities, and contributions of self and others.
- Experience from the Grade 10 Manufacturing Technology activities would be an asset.

Planning Notes

- Ask students to define key terms for homework. Terms may include *conceptual models, physical models, computer-generated models, prototypes, plexiglass, polystyrene, and foamcore.*
- Book a television and video machine for the duration of activity.
- Have overhead projector available for use.
- Prepare an overhead on the design process.
- Consult the Art Department to see if the class could use some clay carving instruments.
- Display materials used to build mock-up models and prototypes.
- Have sketches and designs of wind-powered generators on hand for student viewing.

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- Divide the class into groups (according to class size).
 - Have various types of physical model examples on overhead to show students.
 - Have commonly-used prototype building materials on hand (e.g., wood, clay, styrofoam, paper, and paperboard) to show students.
 - Provide examples of materials list for common products (e.g., clipboards, yo-yo).

Teaching/Learning Strategies

The teacher should:

- review the manufacturing and design process and discuss how prototyping plays a role in this process (Appendix G from the Grade 10 Manufacturing Technology [Catholic] profile);
- provide a high level of student engagement, interdependence, and conflict-management skills;
- monitor progress and provide feedback frequently, emphasizing collaborative and co-operative group efforts in light of Gospel values;
- review design process with students and discuss how the prototype plays a very important role in the evaluation of the product;
- discuss homework assignments defining key terms;
- discuss various types of models and model materials;
- discuss modelling techniques.

Students should:

- participate in a class discussion in the reviewing of the design process;
- discuss the types of materials used in developing mock-up and prototypes for their activity and discuss their impact on the environment;
- form groups to build a prototype, using the design portfolio developed in previous activities;
- in groups, divide the workload by having some students prototype the blades while other members prototype the tower and other project components.

Assessment & Evaluation of Student Achievement

Assessment strategies and tools include opportunities for monitoring students' achievement levels as well as learning skills. They include communication, observation, performance assessment, reflection, and conferencing.

Application

- Students are assessed on their ability to construct a scaled prototype of the components making up the wind-powered generator. A rubric may be used in the evaluation of the prototype.

Communication

- Reflections: Students self-assess their experiences through a reflective journal entry. The journal entries are evaluated through a rubric evaluation format (Appendix B of the Grade 10 Manufacturing Technology [Catholic] profile).

Learning Skills

- Through observation and conferencing, students can be assessed formally or informally. Checklists, anecdotal comments, or the Learning Skills rubric (see the Grade 10 Manufacturing Technology [Catholic] profile) serve to help assess students. The teacher documents the student's:
 - skills pertaining to conflict-management in light of Gospel teachings;
 - ability to work effectively as an interdependent considerate team member;
 - initiative, leadership, and participation in a group (see Appendix E of the Grade 10 Manufacturing Technology [Catholic] profile).

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- Student's work habits/homework can be assessed using a checklist (see Appendix 1.4.2 of the Grade 10 Manufacturing Technology [Catholic] profile).
 - Conferencing assessment can take place on a daily basis. Provide encouragement and praise effort as tasks are completed, building on a positive self-image.

Accommodations

Activities can be modified to meet the needs of all learners by applying accommodations such as the following:

- Repeat instructions and frequently monitor progress, providing feedback through suggestions, comments, or questions about work.
- Allow extra time for completion.
- Use a material that will allow simplification of model building.
- Provide a list of topics and suggestions for enrichment and remediation.
- Selectively group so that varied abilities, interests, and skills are addressed.
- Monitor completion of work done and encourage ongoing and mandatory use of reflective journals.
- Challenge students by providing opportunity to add additional components to the wind generator model (e.g., landscaping, people, homes, etc.).
- Provide sample prototypes as examples.
- Encourage an atmosphere accepting of other's uniqueness, needs, and values.

Resources

Hutchinson, John and John Karsnitz. *Design and Problem Solving in Technology*. Glencoe, McGraw-Hill, 1997. ISBN 0-8273-5244-1

Todd, R., K. Todd, and D. McCrory. *Introduction to Design and Technology*. Thomson Learning Tools of International Thomson Publishing, 1996. ISBN 0-538-64465-6 (Student Text)
ISBN 0-538-64466-4 (Teacher's Resource Guide)
ISBN 0-538-64465-6 (Portfolio and Activities Resource)

Activity 1.5: Developing Process Control Charts and Production Planning

Time: 300 minutes

Description

Students explore the two key factors in production engineering, productivity, and cost. Students are required to design and build a wind-powered generator. Students record their progress and achievements as well as cost using production flow charts. They conduct a series of tests on the various parts of the wind-powered generator to analyse and form a conclusion as to which materials will be suitable and cost efficient for their design. Students are made aware of the importance of the production flow charts in the designing, manufacturing, and cost of the final product. Students also develop production charts that pertain to the storage and disposal of waste materials generated in manufacturing of their product. They are made aware of their Christian responsibilities to take care of the environment and use its resources wisely. Students work primarily in groups and present their ideas clearly and honestly and with sensitivity to others.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE2b - read, understand, and use written material effectively;

CGE2c - present information and ideas clearly and honestly and with sensitivity to others;

CGE4b - demonstrate flexibility and adaptability;

CGE7i - respect the environment and use resources wisely.

Overall Expectations

TFV.01 - apply the design process to develop solutions, products, processes, or service in response to challenges or problems in manufacturing technology;

TFV.03 - describe the production process required to develop a product;

TFV.04 - evaluate the types of control systems used in production processes and products;

SPV.01 - effectively plan, organize, direct, and control various manufacturing activities;

SPV.03 - operate a manufacturing system and analyse the efficiency of the system.

Specific Expectations

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

- evaluate the prototype and determine the resources, including computer applications, required to produce it;

SP1.01 - develop systems for production, marketing, personnel, and financial control;

SP1.02 - use computers to help develop, operate, and control systems;

SP1.03 - apply the concepts of work flow, products per period of time, and defect rate when analysing and testing the efficiency of a production line;

SP4.01 - create process control charts that clearly outline the stages of the production process;

IC2.02 - identify potential hazards in their workplace by conducting safety audits and inspections.

Prior Knowledge & Skills

- The student should have:
 - completed the previous activity in developing a design portfolio of a product, selecting product material, and building the prototype;
 - competence in blueprint reading;
 - research skills (Internet and publications);
 - interactive and collaborative group skills;
 - skills in co-operative learning techniques (effective interpersonal skills) and an understanding of personal responsibilities and commitment required for group activities;
 - basic skills in word processing and keyboarding used for journals and log entries;
 - respect for the rights, responsibilities, and contributions of self and others;
 - basic writing skills (spelling and grammar).
- Experience from the Grade 10 Manufacturing Technology activities would be an asset.

Planning Notes

- Make sure before the class starts that an overhead projector is available for you to use during class.
- Prepare an overhead of types of planning charts (operation process, flow process, operation sheet).
- Prepare an overhead of a sample plant layout and material flow chart.
- Have overhead examples of plant layouts with safety areas labelled for hazardous materials.
- Have samples of common everyday items (pens, yo-yo, binder, paper clip, light bulb) in the classroom.

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- Prepare an example plan of how the waste generated by manufacturing a wind-powered generator (e.g., metal shavings from machining parts and drilling holes, machine and cutting oil) should properly be disposed of.
 - Book computer lab (if necessary).
 - Allow use of computers in the development of operation process, flow process, and operation sheet.
 - Have students write a journal reflecting on their experiences throughout this activity.

Teaching/Learning Strategies

The teacher should:

- review the manufacturing and design process and discuss how production planning plays a role in this process (Appendix G from the Grade 10 Manufacturing Technology [Catholic] profile);
- present overheads of various types of operation process, flow process, operation sheet;
- discuss safety rules and building regulations required by law that must be considered when developing a plant layout and material flow chart (proper ventilation on paint booths and material storage);
- discuss with students the importance of identifying potential hazards to self and others in their workplace by conducting safety audits and inspections;
- divide students into small groups depending on class sizes;
- have samples of common everyday items (pens, yo-yo, binder, paper clip, light bulb) in the classroom;
- discuss with students the type of planning charts required to build and evaluate their wind generator;
- discuss with students the importance of taking the fragile environment into consideration when developing process charts;
- discuss with students the types of recycling offered to the manufacturing industry that pertain to the building and testing of the wind-powered generator (e.g., scrap metal recycling, waste oil collection);
- escort class to the computer lab to develop operation process charts, flow process charts, and operation sheets;
- make sure that students have recorded their daily progress in their journal.

Students should:

- listen actively and critically to understand and learn in light of Gospel values;
- apply the design process to develop solutions, products, processes, or service in response to challenges or problems in manufacturing technology, keeping in mind their Christian responsibilities to this world;
- identify potential hazards in the workplace by conducting safety audits and inspections;
- form small groups depending on class size;
- discuss and produce a process chart for the following items: pens, yo-yo, binder, paper clip, light bulb;
- effectively plan, organize, direct, and control various types of manufacturing activities pertaining to the wind-powered generator;
- use computers to help develop, operate, and control systems;
- create process control charts that clearly outline the stages of the production process;
- respect the environment and use its resources wisely in production and testing of the generator;
- record daily progress in a journal.

Assessment & Evaluation of Student Achievement

Thinking and Inquiry

- Students determine material flow and production procedures through research and brainstorming. Students identify production procedures in a one-page report, including a rationale for choices made.

Application

- Students develop material flow charts, operation sheets, and plant layouts identifying timelines for each phase of the product development process. The charts also identify materials and equipment required. A rubric can be developed to assess the chart. A checkpoint system should be used to monitor the progress at each stage.

Communication

- Reflections: Students self-assess their experiences through a reflective journal entry. The journal entries are evaluated through a rubric evaluation format. (See Appendix B of the Grade 10 Manufacturing Technology [Catholic] profile.) Considering Activities 1.3 and 1.4 are short activities, students should write one journal entry for both.

Accommodations

The following are suggested accommodations, if required:

- Repeat instructions and provide feedback frequently through suggestions, comments, or questions.
- Proofread journals before submission. Mark work for errors in Spelling and Writing/Grammar/specific terminology in a respectful way so that the effort remains workable without deducting marks for spelling, etc., except on proofread and final draft pieces.
- Frequently monitor flow charts and daily work handed in for understanding and completion. Review with peer/buddy if appropriate.
- Allow extra time for completion at home.
- Simplify expectations on the assignment in progress and completion (e.g., shorten length of report).
- Involve student in self-assessing their research techniques working with peer/buddy.
- Pair students with varied abilities, interests, and skills.
- Provide sample process charts and other material as examples.
- Conferencing assessment can take place on a daily basis. Be sure to provide encouragement and praise effort as tasks are completed, building on a positive self-image.
- Selectively group so that varied abilities, interests, and skills are addressed.
- Foster an atmosphere of acceptance of individual differences and needs.

Resources

Publications

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

Hutchinson, John and John Karsnitz. *Design and Problem Solving in Technology*. Glencoe, McGraw-Hill, 1997. ISBN 0-8273-5244-1

Todd, R., K. Todd, and D. McCrory. *Introduction to Design and Technology*. Thomson Learning Tools of International Thomson Publishing, 1996. ISBN 0-538-64465-6 (Student Text)

ISBN 0-538-64466-4 (Teacher's Resource Guide)

ISBN 0-538-64465-6 (Portfolio & Activities Resource)

Computer Software

Spreadsheet software

Word-processing software (e.g., Corel *WordPerfect*)

Activity 1.6: Cost Estimating and Analysis

Time: 180 minutes

Description

Students gain knowledge and experience analysing and summarizing their wind generator project in terms of cost impact (production and job shop labour, material costs, and revenue generated (kilowatt hours produced)) as they relate to product development. Emphasis is placed on using math concepts (area, volume, and time) as well as raw material costs (\$ per length, \$ per kg), to compute the final project cost. Students present their findings through a spreadsheet and oral report. During this activity, students reflect upon their analysis and how the manufacturing of goods affects the common good in relation to Catholic social teachings.

Strand(s) & Learning Expectations

Ontario Catholic School Graduate Expectations

CGE1d - develop attitudes and values founded on Catholic social teaching and act to promote social responsibility, human solidarity and the common good;

CGE2c - present information and ideas clearly and honestly with sensitivity to others;

CGE4b - demonstrate flexibility and adaptability;

CGE4f - apply effective communication, decision-making, problem-solving, time, and resource management skills;

CGE4g - examine and reflect on one's personal values, abilities and aspirations influencing life's choices and opportunities;

CGE5e - respect the rights, responsibilities, and contribution of self and others.

Overall Expectations

SPV.04 - use effective techniques to model and communicate product ideas, materials, and specifications;

SPV.05 - use mathematical and language skills effectively and apply technological systems and scientific principles to construct products that adhere to design specifications and meet quality control standards.

Specific Expectations

SP1.01 - develop systems for production, marketing, personnel, and financial control;

SP4.04 - conduct an accurate cost analysis of the final product or process;

SP4.06 - produce effective oral and written reports on the product or process;

SP5.01 - apply mathematics to work with integers to order operations, to work with decimals and fractions, to make percent/decimal/fraction conversions, and to make imperial and metric conversions- all within the context of manufacturing design and production;

SP5.03 - use appropriate language in technical manuals, reports, and presentations.

Prior Knowledge & Skills

The student should have:

- completed the previous activity in developing a design portfolio of a product, selected product material, and planned the production of the product;
- competence in blueprint reading;
- group work skills (co-operative learning techniques from elementary school and an understanding of personal responsibilities assigned by group);
- basic math skills (area, volume, measurement, conversions, monetary computation);
- keyboarding skills (some knowledge of word-processing software, presentation software, and the Internet is an asset).

Planning Notes

- In preparation for this activity the teacher will have an understanding of the various roles and activities associated with the costing of a product or process.
- The teacher should be familiar with the development and use of spreadsheet software.
- To enable students to produce an effective and meaningful cost analysis, provide a variety of examples that detail the steps involved in costing a product or process.
- Provide a glossary of production costing terms.
- The activity assignment sheet informs students of the requirements of the final product cost report. As a supplemental activity, the teacher may arrange for a guest speaker(s).
- In preparation for this activity, lead a round table of Catholic values related to product development and production (e.g., stewardship, human potential, socio-economic responsibilities).

Teaching/Learning Strategies

The teacher should:

- convey cost analysis information through a variety of strategies such as whole group, brainstorming, and jigsaw, while using a guided practice technique followed by opportunity for independent practice;
- review the manufacturing and design process and discuss how cost analysis plays a role in this process (Appendix G from the Grade 10 Manufacturing Technology [Catholic] profile);
- review group process (see Appendix J of the Grade 10 Manufacturing Technology [Catholic] profile);
- discuss the manufacturing processes and finished project/product while introducing key terms (e.g., raw materials, direct/indirect labour, time sheets, piece rate, flat rate, budgeting, cost justification, pay back, profit, loss, labour standards, production efficiency, high volume vs. low volume production);
- review and discuss the role of project research and how it affects the final fabrication and cost of a project, as well as its effect on the environment and society as a whole;
- discuss various search techniques;
- demonstrate potential avenues to follow to enable all groups to obtain information relevant to their project/product cost;
- encourage students to reflect on the project, its relationship to everyday life, and its benefits to society;
- encourage students to discuss their projects and make a list of activities associated with cost;
- provide an opportunity for the teams to present their findings to the class and how they reflect on their Christian values and upbringing.

Students should:

- as a team, assign each team member a task (e.g., note taker, researcher, typist);
- provide a spreadsheet summary of their project detailing production activity cost, material cost, revenue generated, and pay back time;
- provide a one-page written statement of how the project impacts on the human condition.

Assessment & Evaluation of Student Achievement

Application

- Each team submits a spreadsheet summary of their project, detailing labour cost, material cost, overall project cost, revenue generated, and expected pay-back period. A rubric may be used to evaluate the student's level of achievement.

Knowledge/Understanding

- Students write a short quiz assessing their knowledge and understanding of the content.

Communication

- Each team submits a one-page, word-processed reflection of how their project impacts on the human condition. The paper can be evaluated through a rubric evaluation format (Appendix B of the Grade 10 Manufacturing Technology [Catholic] profile).

Learning Skills

- Student's initiative, Christian leadership, participation in a group, and the ability to discuss the associated Catholic values are assessed orally through student-teacher conferencing.
- Conferencing assessment can take place on a daily basis. Be sure to provide encouragement and praise effort as tasks are completed, building on a positive self-image.

Accommodations

- Provide a sample report to show what is expected as end result.
- Support and encourage those students who have difficulty with math concepts and pair/group to support understanding.
- It may be necessary to modify criteria for written and oral reports allowing for variations in communicating the reports.
- Group students so that varied abilities, interests, and skills are addressed.
- Challenge students to present cost analysis through spreadsheets and slide-show presentations.

Resources

Publications

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

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

Video

Meridian Education Corporation. *Manufacturing Technology Series*. Mississauga, ON: McIntyre Media Limited, 1999. 63.8 min.

Computer Software

Spreadsheet software

Word-processing software (e.g., Corel *WordPerfect*)

Presentation software (e.g., Corel *Presentation*)

Other

Local industry

Unit 2: Production

Time: 50 hours

Unit Description

This unit introduces students to the design and fabrication of an integrated product. Working from a context, students provide solutions to three separate engineering challenges. The products are then combined to form a controlled system. Using a variety of materials (metal, plastic, alloys, wood, or composite fibres) and following a manufacturing process (welding, cutting, machining, laminating, gluing, bonding and forming), students produce prototypes. Through analysis of the prototypes using the ten technological concepts, students implement appropriate revisions and modifications. Students provide the solution to the contextual challenge by combining the results of the three activities.

Unit Synopsis Chart

Activity	Time	Expectations	Assessment	Focus/Tasks
2.1: Wind-powered Generator – Blades from Composites	1200 min	TFV.01, TFV.02, TFV.03, TF1.01, TF1.02, TF2.04, TF2.05, SPV.02, SPV.04, SP1.04, SP1.05, SP2.01, SP2.03, SP4.05, SP4.06, SP5.03, ICV.02, IC1.02, IC2.01, IC2.05 CGE2a, 3b, 4b, 5e	Thinking/ Inquiry Application	Composites Wing design Blade construction
2.2: Wind-powered Generator – Tower and Drive System	1200 min	TFV.01, TFV.02, TFV.03, TFV.04, TF1.01, TF1.02, TF2.03, SPV.01, SPV.02, SPV.04, SP1.05, SP2.01, SP4.02, SP4.03, SP4.06, SP4.07, ICV.02, IC2.01, IC2.05 CGE2b, 2e, 3c, 4c, 5e	Thinking/ Inquiry Application	Structures Mechanisms Drive systems
2.3: Wind-powered Generator – Power Take Off and Controller	600 min	TFV.01, TFV.04, TF1.02, TF2.06, SPV.02, SPV.04, SP1.02, SP4.02, SP4.06, SP4.07, SP5.04, ICV.02, IC2.01 CGE5a, 5e, 7a	Thinking/ Inquiry Application	Generators Power control

Activity 2.1: Wind-powered Generator – Blades from Composites

Time: 1200 minutes

Description

Students create a set of blades for a wind-powered generator, incorporating the use of composite materials and related processes. Students research and apply design processes to determine the appropriate configuration of the device to comply with a production plan and budget limitations. Working as a team towards a common goal, students gain an understanding of the importance of quality control and accuracy of the manufactured product, as well as adherence to the production plan. This project activity is ideally suited for integration with the other activities, 2.2: Tower and Drive System and 2.3: Power Take-off and Controller, within the wind power theme of the production unit. The teacher may choose to assign these activities to the class simultaneously or sequentially. Also, as in the other activities, the product is developed from the business plan, designed, and fabricated; then the prototype is tested, evaluated, and commissioned.

The project facilitates:

- application of the design process in selecting appropriate design options and manufacturing processes;
- investigation of the physical and structural properties of state-of-the-art plastic composite materials;
- use of (manual or CAD) drafting systems;
- use of mechanical and adhesive fasteners;
- safe and proper use of a variety of tools and manufacturing processes;
- implementation of a quality control plan and testing process.

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 in manufacturing technology;

TFV.02 - identify appropriate materials and processes to produce products to meet human needs and wants;

TFV.03 - describe the production process required to develop a product;

SPV.02 - use current technology and production skills in the development of a process or a product;

SPV.04 - use effective techniques to model and communicate product ideas, materials, and specifications;

ICV.02 - demonstrate the exemplary practices that are essential to safe work environments and practices.

Specific Expectations

TF1.01 - explain how a human need or want can be met through a new or improved product;

TF1.02 - apply the following steps of the design process to solve a variety of manufacturing 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;

TF2.04 - describe the conditioning processes that change a material's physical and mechanical characteristics and properties;

TF2.05 - explain the three methods of conditioning materials: thermal conditioning, chemical conditioning, and mechanical conditioning;

SP1.04 - use appropriate techniques to sketch solutions to scale showing orthographic and isometric views;

SP1.05 - use appropriate techniques to mock up or model potential solutions to challenges;

SP2.01 - use a wide variety of appropriate hand and machine tool skills in the assembly or fabrication of a product or manufacturing process;
SP2.03 - analyse and explain the results of producing products in a particular manufacturing process;
SP4.05 - develop appropriate engineering drawings using a computer-aided drawing program;
SP4.06 - develop engineering reports that communicate the specifics of the product or process;
SP5.03 - explain how science or scientific principles or practices apply to material selection and specifications, energy consumption, worker fatigue, material processing, and the design of ergonomically appropriate products that accommodate the human form;
IC1.02 - describe the impact of manufacturing activity on the environment and identify a variety of materials, processes, and waste-management methods to minimize negative impact;
IC2.01 - apply safe work practices in performing manufacturing-related processes;
IC2.05 - recognize the meaning of the hazard labels associated with WHMIS.

Planning Notes

- Activities 1, 2, and 3 can be performed simultaneously or sequentially. This activity is directly related to Activities 2.2 and 2.3. The design and planning may be accomplished in Unit 1.
- With a vast array of wind-powered generator configurations in existence, from traditional farm windmill to modern high-tech wind turbine, this open-ended activity is ideal for providing students with a variety of design alternatives. Although instructions are provided to aid in building one prototype, the Internet may be the most useful tool in helping students (and teacher) through the initial design stage. Field trips to local wind-generating power facilities may provide further enrichment.
- The implementation of this activity, and the appropriate application of composite materials and processes, is primarily dependent on the comfort level of the instructor.
- Specialized tools, such as a hot-wire cutter assembly or a vacuum pump for vacuum bagging, can be acquired or custom made at a relatively low cost.
- Prior to beginning work on the project, students should be made aware of all safety procedures, WHMIS, and MSDS within the manufacturing shop.
- Good ventilation and dust control is necessary.
- Dust masks and rubber gloves must be available when laminating and sanding composites.
- Consider physical size of the project(s) due to costs of some composite materials.
- Provide computer-aided design software for plotting airfoil shapes and virtual modelling of project using 3-D solids and word-processing software for the Design Report including project management.
- Access to an engine lathe is required for turning the mounting hub.

Prior Knowledge & Skills

Experience from the Grade 10 Manufacturing Technology activities is an asset. This provides students with the skills required for plotting propeller airfoils on CAD using X-Y coordinates, cutting and shaping polystyrene foams with the use of a hot-wire, and hand lay-up techniques using fibreglass cloth and epoxy resin systems. Basic awareness of machining skills and previous experience with the use of a variety of hand tools is also of benefit.

Teaching/Learning Strategies

- The design challenge is presented: “As owner/operator of a small manufacturing facility, you have been commissioned by a client to create a prototype ‘propeller assembly’ for a wind-powered generator. Due to the high strength-to-weight requirements of the assembly, you are encouraged to investigate the possibility of fabricating the product from modern plastic-composite materials in an attempt to maximize the strength while minimizing the weight.”

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- Students are divided into groups of two or three.
 - The groups are assigned the tasks of researching the various configurations of wind-powered generators (refer to appendices for examples), completing sketches of possible prototypes, and presenting those findings to the rest of the class. Key points to consider at this time are the history and evolution of designs, physical size, complexity, efficiency, reliability, and environmental impacts. A variety of resources are used to facilitate this stage including Internet websites, magazines, photos, libraries, catalogues, journals, power companies, etc. A pre-existing product may also be previewed.
 - Students are made aware of any set design criteria, financial limitations, and time constraints.
 - Students (with the guidance of the teacher) select a design configuration for fabrication.
 - Groups (depending on available time and money) may wish to produce more than one prototype or divide the tasks required to build a single unit. For example, in the event of a design with a multiple blade configuration, groups could be assigned the task of building one of the blades, a weather vane, or the mounting hub.
 - Other groups could create a graphic design/logo for the project or generate a set of as-built engineering drawings for inclusion in the design report.
 - As composite materials can be expensive, students are made aware of cost and introduced to manufacturing techniques that minimize material wastage. This introduces the notion of available resources driving the design, especially when mass production is anticipated and the cost of waste becomes considerable.
 - The teacher provides instruction and demonstration when a new process or machine tool is introduced.
 - Students are instructed and reminded to work in a safe and efficient manner, showing consideration to the rest of the class with regard to safety, behaviour, and space and equipment availability.
 - See Appendix 1.1 - Instructions for the Creation of a Prototype Blade Assembly Using Composite Materials for specific information on these aspects of the construction.

Design Report

Groups create and submit a design report, based on daily journal notes, containing the following:

- the context;
- the design challenge;
- project performance specifications and design constraints;
- all preliminary sketches and notes;
- a production plan;
- manual or CAD drawings of prototypes;
- an analysis of the product and process.

Assessment & Evaluation of Student Achievement

Assessment should be ongoing and feedback to the students should be immediate in order to promote student learning. This project is high in process content and substantial learning will occur during the production. The final product will not necessarily reflect the learning. Assessment criteria should be posted in advance. See Appendix 1.2 - Fabrication Rubric for a sample assessment/evaluation tool.

Accommodations

Teachers should review each student's Individual Education Plan (IEP) and consult with the appropriate Special Education teachers.

Activities can be modified to meet the needs of all learners by applying various accommodations such as:

- increasing time allowed for activities;
- enhancing or compacting content;
- assisting during evaluation processes;
- providing peer tutoring assistance where possible;
- choosing groups to balance different abilities;
- ensuring that all equipment is easily accessible.

For enrichment, students may:

- use CAD to create a virtual model using 3-D solids;
- design and fabricate a blade that tapers in width and thickness from root to tip or with a varying degree of pitch (twist) from root to tip as they presents a greater manufacturing challenge;
- design and fabricate alternate blade configuration (i.e., vertical axis as opposed to horizontal axis), a device for statically balancing the blades, or a device for accurately setting the blade angles of attack in the hub;
- experiment with blades using alternate airfoil shapes.

Resources

Books

Krar, S.F. and J.W. Oswald. *Technology of Machine Tools*. New York: McGraw-Hill Ryerson, 1996. ISBN 0-02-803071

Marshall, Andrew C. *Composites Basics*, 4th ed. Marshall Consulting – Publisher 720 Appaloosa Drive, Walnut Creek, CA 94596.

Powell, F.E. *Windmills and Wind Motors*. Algrove Publishing Ltd., 1999. ISBN 0-921335-84-9

Selig, Donovan, Fraser. *Airfoils at Low Speed*. H.A. Stokely – Publisher 1504 North Horseshoe Circle, Virginia Beach, VA 23451

Catalogues

Fibreglass Factory Outlet Catalogue

5205 Timberlea Blvd., Mississauga, ON L4W 2S3, Phone: (905) 629-3178 Fax: (905) 629-2638

‘West System’ User Manual and Product Guide; Advanced Vacuum Bagging Techniques

Gougeon Brothers Inc., P.O. Box 908, Bay City, MI 48707-0908

Phone: (517) 684-7286 Fax: (517) 684-1374

Websites

Styrofoam, Insulating the World – www.dow.com/styrofoam/

Epoxy Products for Building and Repair – www.westsystem.com

Windy City Alternative Power Inc. – www.alternativepower.net

American Windmills Home Page – www.windmills.net

Airfoil Incorporated – www.airfoils.com

Airfoil Coordinates Database – <http://amber.aae.uiuc.edu/~m-selig/ads.html>

Other

Canadian Wind Energy Association, Suite 250-2415 Holly Lane, Ottawa, ON K1V 7P2

Ontario Ministry of Energy, Phone: 1-800-ENERGY1

Niagara Mohawk Power Corporation Advanced Wind Turbine Technology Project, Syracuse, NY

Activity 2.2: The Wind-powered Generator – Tower and Drive System

Time: 1200 minutes

Description

In this activity, students learn how to produce a product which is the supporting structure and drive system for a wind generator, which supplies alternate power to the manufacturing facility or to a private home. Various types of wind-powered generators have been designed and put in service over the last 50 years. Students are challenged to research, design, and build a tower and drive system for a wind generator.

Explored in this activity are Drive Ratio, Gears, Belt drives, Rim Speed (velocity), Bearings, Machining, Welding, and Fabrication. Prevailing wind factors, environmental impact, and economics of the product are also researched. Students are encouraged to develop new and innovative design concepts. They also explore the use of various products available to manufacture the tower (plastics, aluminum alloys, wood, and metal.)

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 in manufacturing technology;

TFV.02 - identify appropriate materials and processes to produce products to meet human needs and wants;

TFV.03 - describe the production process required to develop a product;

TFV.04 - evaluate the types of control systems used in production processes and products;

SPV.01 - effectively plan, organize, direct, and control various manufacturing activities;

SPV.02 - use current technology and production skills in the development of a process or a product;

SPV.04 - use effective techniques to model and communicate product ideas, materials, and specifications;

ICV.02 - demonstrate the exemplary practices that are essential to safe work environments and practices.

Specific Expectations

TF1.01 - explain how a human need or want can be met through a new or improved product;

TF1.02 - apply the following steps of the design process to solve a variety of manufacturing 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;

TF2.03 - investigate and evaluate the following materials before choosing the most appropriate materials for a product: metals (ferrous and non-ferrous), polymers (e.g., natural - wood, cellulose; synthetic - plastics), ceramics (e.g., clay, glass, oxides, cement, carbides), composites (e.g., filler, particle, laminate, flake, fibre), and natural materials;

SP1.05 - use appropriate techniques to sketch solutions to scale showing orthographic and isometric views;

SP2.01 - use a wide variety of appropriate hand and machine tool skills in the assembly or fabrication of a product or manufacturing process;

SP4.02 - use detailed working drawings and assembly drawings to depict the components of the product or process;

SP4.03 - develop a bill of material indicating the specifications and quantity of a particular part of a product or process;

SP4.06 - develop engineering reports that communicate the specifics of the product or process;

SP4.07 - prepare and present effective oral reports on the product or process;

IC2.01 - apply safe work practices in performing manufacturing-related processes;

IC2.05 - recognize the meaning of the hazardous labels associated with WHMIS.

Prior Knowledge & Skills

- Previous experience from Grade 10 Manufacturing Technology will be an asset.
- Awareness of the design process.
- Awareness of safe work rules and practices in the classroom and work labs.
- Have some working knowledge of hand and machine tools and work process.
- Knowledge and use of safe work passports and use of a daily journal.

Planning Notes

- Activities 1, 2, and 3 can be performed simultaneously, or sequentially. This activity is directly related to Activities 2.1 and 2.3. The design and planning stages may be accomplished in Unit 1.
- Provide instruction whenever a new process or piece of equipment is introduced.
- This activity is open-ended. Students are given the criteria of designing a tower and drive system for a wind-powered generating device. Based on the creativity of students, this activity may vary in design between vertical or horizontal style mills and their structures.
- The design and fabrication of the product should be based on research of the history of alternate power generation. Field trips to local wind-generating power facilities provide enriched research information.
- The instructions for production of a sample full-size solution are provided in Appendices 1 and 2.
- Students may be limited to building functional models rather than full-size prototypes.

Teaching/Learning Strategies

- This activity involves many different strategies, including brainstorming, problem solving, group work, resource-based learning, activity-based learning, Socratic lessons, demonstration lessons.
- Prior to starting work in the labs, students should be made aware, or reminded, of all safety procedures, WHMIS, and MSDS within the manufacturing shop. Students should obtain safe work passports for equipment that is used for the first time.
- The project begins with the teacher explaining all expectations, time constraints, and set criteria (design and build a tower and drive system for a wind-powered generator) that must be met.
- Use of a design process enables students to identify the problem (e.g., produce alternate power to supplement a manufacturing facility or private home) and work towards solving it.

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- Using a variety of resources (e.g., school Library/Resource Centre, websites, local power companies), students research:
 - vertical and horizontal blade design efficiency;
 - trade-related jobs in manufacturing sector;
 - wind generators past and present;
 - impact on the environment;
 - reliability and economics of design;
 - structures such as towers (TV towers, lookout towers, etc.).
 - Working in groups of four to six, students research and brainstorm ideas.
 - Students work with rough sketches of their designs and modify until a final solution is reached.
 - The teacher helps students with a feasibility study of their final solution.
 - Students maintain journals, logs, and records of their progress throughout the project.
 - As-built drawings may form part of the final report.
 - Provisions for basic ideas are provided in Appendix 1 – Instructions for the Creation of a Prototype Blade Assembly Using Composite Materials and Appendix 2 – Wind-powered Generator Project.
 - Students use a variety of hand and machine tools with lessons on machining, welding, fasteners, velocity, ratio, and drive systems. As well, lessons pertaining to the use of bearings, bushings, pulleys, and couplings helps the student’s overall skills, knowledge, and success rate.

Assessment & Evaluation of Student Achievement

Assessment should be ongoing and feedback to students should be immediate in order to promote student learning. This project is high in process content and substantial learning occurs during production. The final product does not necessarily reflect the learning. Assessment criteria should be posted in advance. See Appendix 2.3 – Checklist for Wind Generator Project for a sample checklist.

The following areas are assessed using checklists and conferencing:

- sketches and mechanical technical drawings;
- selection of materials (e.g., metals, plastics, alloys);
- journals and logs;
- quality and integrity of work;
- group work;
- design analysis, project evaluation, and future modifications;
- safety in the workplace;
- mechanical fundamentals (power transmission, fabrication, alignment, layout);
- peer evaluation, teacher-student conferences, and self-evaluation.

Accommodations

- Teachers should review each student’s Individual Education Plan (IEP) and consult with the appropriate Special Education teachers.
- Written tests should be designed to suit the reading and writing levels of the students.
- Teachers are encouraged to modify and expand teaching strategies to accommodate different learning styles. This may include:
 - modified approaches to evaluation;
 - oral testing and student demonstrations of acquired skills;
 - conferencing/discussion and one-on-one teacher assistance;
 - observation of process rather than hands-on;
 - student-to-student discussion and teacher-to-student discussion to encourage, confidence, and motivation;

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- small-group learning;
 - flexible timelines;
 - adaptation of handouts;
 - peer assistance and tutoring.

Enriched Activity

Teachers wishing to enrich the project may have students add a braking system to the shaft of the wind generator. An easy way to accomplish this is to use a set of brake discs and calipers from a small car.

- Remove the drive pulley from bottom of the shaft.
- Slide coupling and braking system up the shaft approximately 16 inches and lock it in place.
- Fabricate a mounting bracket for the caliper. Mount the caliper in place.
- Install the hydraulic unit and brake handle or foot pedal.

Resources

Books

Bolt, Brian. *Mathematics Meets Technology*. Cambridge University Press, 1992. ISBN 0-521-37692-0

Browning, K., G. Heighington, V. Parvu, and D. Patillo. *Design and Technology*. Toronto: McGraw-Hill Ryerson, 1993. ISBN 0-07-549650

Krar, S.F. and J.W. Oswald. *Technology of Machine Tools*. New York: McGraw-Hill Ryerson, 1996. ISBN 0-02-803071

Powell, F.E. *Windmills and Wind Motors*. Algrove Publishing Limited, 1999. ISBN0-921335-84-9

Province of British Columbia, Ministry of Labour. *Millwright Manual*, 2nd ed. Units 2, 8, 9, 10, 11, 12, 13, and 23, 1996.

Websites

Windy City Alternative Power Inc. – www.alternativepower.net

Oasis Montana Inc., Alternative Energy and Design – www.oasismontana.com/ampair.html

Americans Windmills Home Page – www.windmills.net

Windmill Project, Beltmolen Fulton, Il. – www.hippowebdesign.com/fulton/index.html

Activity 2.3: Wind-powered Generator – Power Take Off and Controller

Time: 600 minutes

Description

Students design and manufacture a system that joins to a variable speed output shaft for the generation and storage of electrical energy using available technology. In this example, automotive parts are adapted to provide one solution.

Strand(s) & Learning Expectations

Overall Expectations

TFV.01 - apply the design process to develop solutions, products, processes, or services in response to challenges or problems in manufacturing technology;

TFV.04 - evaluate the types of control systems used in production processes and products;

SPV.02 - use current technology and production skills in the development of a process or a product;

SPV.04 - use effective techniques to model and communicate product ideas, materials, and specifications;

ICV.02 - demonstrate the exemplary practices that are essential to safe work environments and practices.

Specific Expectations

TF1.02 - apply the following steps of the design process to solve a variety of manufacturing 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;

TF2.06 - identify semiconductor devices, numeric controls, digital electronic devices, pneumatic and hydraulic devices and controls, and electrochemical devices, and describe how they are used in the production process;

SP1.02 - use computers to help develop, operate, and control systems;

SP4.02 - use detailed working drawings and assembly drawings to depict the components of the product or process;

SP4.06 - develop engineering reports that communicate the specifics of the product or process;

SP4.07 - prepare and present effective oral reports on the product or process;

SP5.04 - use appropriate language in flow charts, operation and inspections charts, job descriptions, formal presentations, bills of material, and lists of tooling requirements or materials for quality control programs;

IC2.01 - apply safe work practices in performing manufacturing-related processes.

Prior Knowledge & Skills

- Experience from Grade 9 Integrated Technologies, Grade 10 Technological Design, Communications Technology, Manufacturing Technology, or Transportation Technology will be an asset.

Planning Notes

- Activities 1, 2, and 3 can be performed simultaneously or sequentially. This activity is directly related to Activities 2.1 and 2.2.
- Students design and assemble a DC voltage power generating system to charge storage batteries. The DC power from the batteries can be used for whatever purpose is required: remote site power, cottage power, or a stand-alone power resource for third-world countries.
- Students research the main sections (alternator, voltage regulation, battery storage, and electrical safety devices) and then decide how to construct the project.
- Modify the project as to the types of alternators and batteries that are available.
- The alternator, regulator, and battery are used in automobiles and can be obtained from automotive suppliers and scrap auto parts dealers.

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- Alternative solid-state voltage regulator designs are available from electronic project books and magazines.
 - Form links with colleges, universities, and industry involved in similar projects.

Teaching/Learning Strategies

- This activity addresses fundamental electronic control of the power output from the wind generator system. The appendices provide the basic information required to achieve the desired results.
- The teacher should allow students to provide solutions.
- Each section of the power generation (alternator, voltage regulation, battery storage, and electrical safety devices) can be assigned to groups (two or three students) to be researched and prototyped. Each group shares/reports the information found and puts their findings in their final overall design, simulating the process a large company would undertake to bring a system into production.
- Safe practice is a priority at all times. Safe handling and use of hand and power tools must be taught or reviewed.
- Students work with automobile alternators that can produce high current (50 or more amperes) and automobile batteries, which can also produce large amounts of current that could cause burns and/or fire (Appendix 3.1 – Sample System). Care must be taken that positive and negative terminals are kept isolated. The batteries contain sulfuric acid that can cause chemical burns. Safety equipment (glasses, aprons, rubber gloves, face shields, eye wash stations) must be made available to students.
- Safe handling of batteries and powered electrical circuits must be taught to students and they must be able to demonstrate that they have the knowledge to work with the equipment.

Assessment & Evaluation of Student Achievement

Assessment should be ongoing and feedback to students should be immediate in order to promote student learning. This project is high in process content and substantial learning occurs during the production. The final product does not necessarily reflect the learning. Assessment criteria should be posted in advance.

- Students keep a project log for this project. (Appendix 3.3 – Project Log Sheets)
- A checklist may be used for Wind Generator Construction. (Appendix 3.2 – Checklist)
- Students maintain a journal, evaluated for completeness, clarity, and consistency, containing:
 - schematics and diagrams – hand drawn or CAD;
 - lists and costs of materials;
 - sources of materials and information;
 - group information sharing and brainstorming shown as bubble charts.
- When labs or reports are completed, students can be tested on knowledge by either written or oral tests.
- The teacher and students evaluate the completed project for mechanical and electrical quality.

Accommodations

- Teachers should review each student's Individual Education Plan (IEP) and consult with the appropriate Special Education teachers.
- Written tests should be designed to suit the reading and writing levels of the students.
- The teacher is encouraged to modify and expand teaching strategies to accommodate different learning styles. This may include:
 - modified approaches to evaluation;
 - oral testing and student demonstrations of acquired skills;
 - conferencing/discussion and one-on-one teacher assistance;
 - observation of process rather than hands-on;

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- student-to-student discussion and teacher-to-student discussion to encourage confidence and motivation;
 - small-group learning;
 - flexible timelines;
 - adaptation of handouts;
 - peer assistance and tutoring.

Resources

Books

Petruzella, Frank. *Introduction to Electricity & Electronics Book 1*. Toronto: McGraw-Hill Ryerson Press, 1986. ISBN 0-07-548899-X

Petruzella, Frank. *Introduction to Electricity & Electronics Book 2*. Toronto: McGraw-Hill Ryerson Press, 1986. ISBN 0-07-548900-7

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NACA 2412 Coordinates (Panel code to compute NACA 2412 airfoil coordinates)

<http://research.nps.navy.mil/panel/panel.html>

Appendix 1.1

Instructions for the Creation of a Prototype Blade Assembly Using Composite Materials

Although a variety of wind-powered generator configurations exist (Appendix B - Horizontal Axis Machine Drawing and Appendix C - Vertical Axis Machine Drawing), this section provides step-by-step instructions for fabricating a conventional constant-chord, two-bladed propeller assembly designed to operate facing directly into the wind and turn on a horizontal shaft (refer to general arrangement drawing, Appendix D - Sample Wind Generator Blade Configuration Drawing). Each blade is 120cm long x 25cm wide. This gives an overall rotor diameter of approximately 2.55 m including the hub section. The blades are fastened into the hub section at approximately an 8-degree angle to the wind. The airfoil is the MB253515.

Fabricating the Airfoil Templates

Using the X-Y coordinates provided in on the NACA 2412 Coordinates website (see Resources) and CAD, plot the airfoil shape for the blade scaled to a chord length of 25 cm. Glue the airfoil plots to a piece of masonite or laminate and band-saw two airfoil templates, being careful to be as accurate as possible. Remove the saw marks and polish the edges smooth by block sanding with fine sandpaper.

Hot-wire Cutting the Foam Core

Cut a sheet of extruded polystyrene rigid foam 60 cm long x 25 cm wide. Attach the airfoil templates to the ends of the foam blank temporarily with drywall screws, making sure they are aligned and oriented properly. Using a hot-wire cutter, carefully cut the foam blank to match the profile templates by slowly pulling the hot-wire through the foam across the templates. Complete this process on both sides of the airfoil templates. Note: Refer to Appendices 25 and 26 of the Grade 10 Manufacturing Technology [public] profile for more information on hot-wire cutting of foams.

As each blade is 120 cm long, two 60 cm-long foam cores need to be cut per blade and joined. Once the hot-wiring is complete, sand and trim the leading and trailing edges of the cores to match the templates as closely as possible, and butt glue the cores end-to-end with 5-minute epoxy, creating two 120cm-long blades.

Prior to laminating the blades, it is necessary to install a mounting shaft for later attaching the blade to the mounting hub. This can be accomplished by bonding an aluminum or steel tube into the bottom end of the foam blade core. A 45 cm length of 25 mm diameter tubing with 30 cm bonded into the foam is adequate, with 15 cm of tubing extending out of the bottom of the blade for attachment to the hub. Cut a slot for the tubing with a razor knife and straight edge, or a hot-wire loop attached to the terminals on a soldering gun. Locate the slot so that the tubing is bonded approximately 20% of the chord length behind the leading edge. Positioning the majority of the blade area behind the mounting shaft adds to the aerodynamic stability of the blade. Bond the tubing in place and fare in the remainder of the slot with a mixture of epoxy and filler.

Appendix 1.1 (Continued)

Laminating the Foam Blade Cores

For information regarding resin systems and available composite materials, refer to Appendix A - Resin Systems. Prior to the application of resin and cloth to the upper surface of the foam blade cores, cover the bottom of the cores with masking tape to prevent excess resin from pooling on the foam. Mix a minimal amount of epoxy resin and hardener according to the manufacturer's instructions and apply uniformly in a thin layer over the top of the foam with a plastic squeegee. Carefully lay a piece of 10-oz. fiberglass cloth, cut slightly oversize, onto the wet resin and smooth out any wrinkles with the squeegee. Be sure to wear rubber gloves when working with wet resin. Add resin to any areas of the cloth that appear to be dry, being careful not to use any more resin than is required to wet out the cloth. Repeat this process for two additional layers of 10-oz. cloth. For additional stiffness, replace the middle layer of 10-oz. cloth with one layer of 6-oz. carbon fibre. After the resin hardens, trim the edges of the laminate flush with the core and file smooth. Always wear a dust mask, rubber gloves, and safety glasses when filing or sanding the laminate. Invert the blade core and repeat the lamination sequence on the underside. **Note:** To increase the strength-to-weight ratio of the blade, vacuum bag the wet laminate and allow to cure. Refer to the technical manual on Vacuum Bagging Techniques before attempting this process. Lightly sand the entire laminate and apply filler material with a squeegee over the surface of the blade, one side at a time. Filler material is made by mixing fairing compound with epoxy resin to a consistency of whipped cream. The filler material covers imperfections in the laminate and fills the weave of the hardened fiberglass cloth. Once the filler material is cured, block sand it smooth and prime with automotive primer. Complete this process for additional blades. As finished blades require accurate balancing, attempts should be made to regulate the amount of resin and filler used on each blade.

Fabricating the Mounting Hub

There are many design options for fastening the blades to a power-takeoff shaft. Care must be taken to fabricate an assembly that is strong, thus safe. Never stand in line with, or closely in front of the rotating wind-generator blades.

One option is to machine a 20 to 25 cm diameter disk from aluminum plate, bored and threaded to fit the diameter of the power-takeoff shaft. First, turn down the diameter of the shaft to form a square backing shoulder to ensure plate alignment. Thread the shaft and hub to a close tolerance, and secure the hub to the shaft with a front locking nut.

If available, use an indexing head to accurately drill the holes for the blade mounting shafts into the sides of the hub. Once the blade angle of attack has been accurately set, pin or firmly anchor the blade shafts in place with locking screws. **Note:** Set the blades into the hub with the flatter bottom surface of the airfoil facing the windward side. The rounded leading edge of the blades should angle into the wind. (Eight degrees is a good starting point.)

Statically balance the blades on the shaft by adding multiple layers of paint or securely mounting weights to the lighter blade. If the design allows it, test the blade assembly in the wind, varying the blade angle of attack in an attempt to achieve the 'optimum' angle, determined by the maximum propeller rpm while 'under load'. **Caution:** Never stand in line with, or closely in front of, the rotating blades, as blade or hub failure could occur at any time.

Appendix A

Resin Systems

There are primarily two types of resin systems on the market today. One involves the bonding of multiple layers of glass cloth and matting with a polyester resin binder, while the other uses an epoxy resin binder. Although more expensive than polyester, the epoxy laminate is stronger and more impact resistant. In addition, the solvents in epoxy resin are compatible with polystyrene foam. **Note:** Do not use polyester resin when laminating over polystyrene foam, as the solvents in the resin will cause the foam to melt. It is good practice to always pre-test the compatibility of the foam and resin prior to a lay-up.

Epoxy laminating resin is available at larger hardware stores or those specializing in boat repair supplies. 'West System' epoxy resin is perhaps the most commonly available brand, is quite user-friendly, and is backed up with a variety of useful technical manuals and product information. Be sure to read and adhere to the manufacturer's recommendations regarding safety when working with epoxy resins.

Laminating Fibres

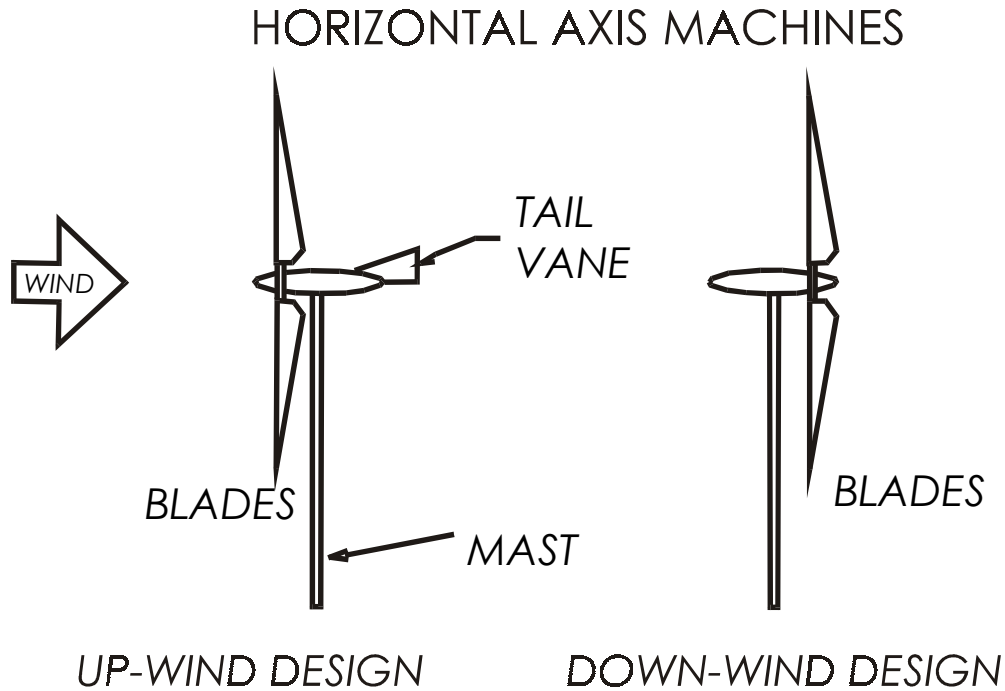
There is a variety of fibre materials available for laminating over foam with epoxy. The most common and least expensive is woven fibreglass cloth. The most common type is referred to as 'E-Glass' and is sized by weight in ounces per square yard. Although less common, S-Glass, an aircraft grade of fibreglass cloth, is also available with a considerably higher tensile strength and price tag. There is also a non-woven fibreglass mat available, which is easy to use and conforms well to compound curves. It does not, however, have the strength of the woven materials and tends to absorb much more resin. This product is sized by the weight in ounces per square foot!

Woven 'Kevlar' is also an option if impact resistance and lightness are required. It is costly, however, and can be more difficult to use. Carbon fibre is the stiffest of the readily available woven fibres possessing a higher tensile strength-to-weight than steel. Although expensive, it is easy to use and a good choice when stiffness and lightweight is essential.

In many industrial applications, carbon fibre or Kevlar cloth is purchased from the supplier pre-impregnated with an epoxy resin designed to cure at high temperatures. Although this type of laminate provides the highest strength-to-weight ratio, it is less practical, having a limited shelf life and requiring specialized equipment for safe and proper use.

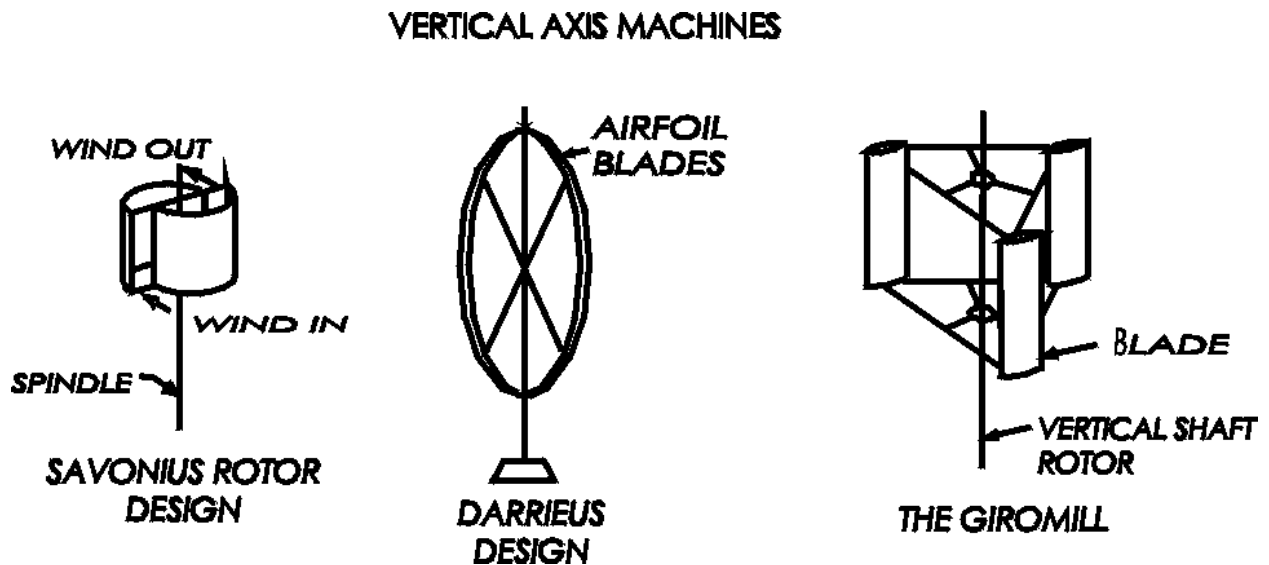
Appendix B

Horizontal Axis Machines



Appendix C

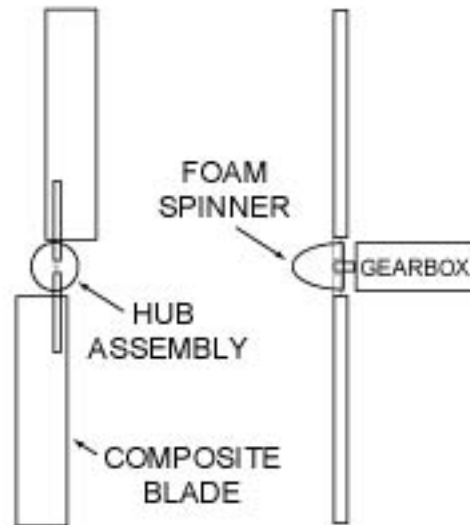
Vertical Axis Machines



Appendix D

Sample Wind Generator Blade Configuration

SAMPLE WIND GENERATOR BLADE CONFIGURATION



Appendix 1.2

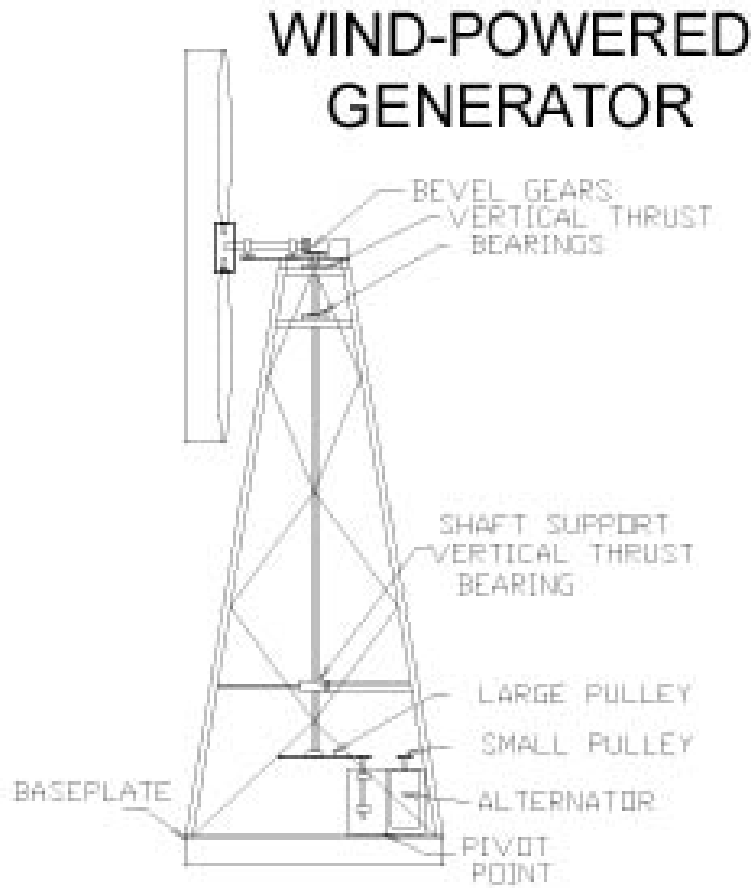
Fabrication Rubric

Criteria	Level 1 (50-59%)	Level 2 (60-69%)	Level 3 (70-79%)	Level 4 (80-100%)
Understanding of concepts	- demonstrates limited understanding of relationship between production methods and material	- demonstrates some understanding of relationship between production methods and material	- demonstrates considerable understanding of relationship between production methods and material	- demonstrates thorough and insightful understanding of relationship between production methods and material
Thinking skills	- uses thinking skills with limited effectiveness in the design process	- uses thinking skills with moderate effectiveness in the design process	- uses thinking skills with considerable effectiveness in the design process	- uses thinking skills with a high degree of effectiveness in the design process
Communication of information	- communicates ideas and information, such as drawings, sketches, or daily logs, with limited clarity and accuracy	- communicates ideas and information, such as drawings, sketches, or daily logs, with moderate clarity and accuracy	- communicates ideas and information, such as drawings, sketches, or daily logs, with considerable clarity and accuracy	- communicates ideas and information, such as drawings, sketches, or daily logs, with a high degree of clarity and accuracy
Application of procedures, equipment, and technology	- demonstrates limited ability to use equipment and technology safely and correctly	- demonstrates some ability to use equipment and technology safely and correctly	- uses equipment and technology safely and correctly	- demonstrates and promotes safe and correct use of equipment and technology
Making Connections	- makes connections with limited effectiveness	- makes connections with moderate effectiveness	- makes connections with considerable effectiveness	- makes connections with a high degree of effectiveness

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

Appendix 2.1

Wind-powered Generator Project



Appendix 2.2

Sample Fabrication Details for Wind-powered Generator Tower and Drive

This sample uses 2.5 mm (.100") wall metal tubing for the tower legs. ABS plastic pipe can also be used.

- Cut a piece of 12 mm (½") plate steel for the base 1.8 m square (6' x 6'). Drill 4-12 mm (½") anchor bolt holes 15 cm x 15 cm (6" x 6") from each corner.
- Cut two pieces of 50 cm x 50 cm (20" x 20") plate 12 mm (½") thick for the shaft support plates.
- Drill a 12 mm (½") hole in the centre of the plates - these are for the shaft to go through.
- Drill and tap holes for 37 mm (1 ½") vertical thrust flange mounted bearings in both plates
- Mount the bearings. Do not tighten them until later.
- Cut four pieces of square tubing 3.9 m (13') long.
- Tack weld the legs onto the four corners of the baseplate (minimum two tacks). The angle is approximately 10 degrees.
- Tack weld one of the shaft support plates in place at 3.6 m (12') and the other on the top. Carefully align the two bearings to each other. (A piece of 37 mm (1 ½") shafting will help accomplish this.)
- Once the tower is up and aligned, welds can be finished. Two lifts of scaffolding work nicely here as the student can work safely around the tower. (Safety harnesses are required.)
- The cross-braces are made of 12 mm (½") round bar stock and may be welded next. This secures the tower and keeps it square. They are placed approximately every 1.5 m (5') and cross in the middle; they are also on all sides.
- The top plate is now made and installed. It is made from 9 mm (3/8") mild steel plate and is 90 cm x 50 cm (36" x 20"); it has a 50 mm (2") clearance hole placed 25 cm x 25 cm (10"x10") from one side so that it lines up with the shaft holes in the tower plates. Weld four 25 mm x 50 mm (1"x2") pieces of square tubing on a pattern of 50 cm x 50 cm (20" x 20") on the bottom of the plate so that it clears the top bearing.
- With the tower secure, students may install the main shaft, which is 37 mm diameter x 3 m (1½" x 10') cold rolled steel round bar stock. Leave 75 mm (3") protruding above the top bearing and through the top plate so that the bevel gear can be mounted.
- On the centre line of the top plate drill and tap holes for blade shaft bearings. (The placement depends on the bearings selected.)
- Machine a piece of hot rolled steel bar stock to 25 mm (1") diameter and cut it to 60 cm (24"); this is where you mount the blade and the other bevel gear. Install bearings, blade, blade shaft, and bevel gear.
- You should now have the tower up and the shafts in place and need to secure the drive shaft in order to stop it from rotating.
- The next step is to mount the bottom stabilizer bearing. You will have to fabricate a bearing mounting bracket (slot the holes so the bearing can be aligned) and stand-offs approximately 90 cm (3') from the bottom of the tower. Weld them in place.
- Mount the bottom 50 cm (20") pulley.
- Fabricate a plate for mounting the alternator or generator.
- Fabricate a 19 mm (¾") secondary jackshaft 30 cm (12") in length and a mounting plate for it.
- These two plates are mounted on the baseplate with the jackshaft being able to pivot in order to tighten the belts. Although only one pulley is shown in the drawing, two pulley systems are recommended.

Appendix 2.3

Checklist for Wind Generator Project

Team Members: _____

Expectations	Inconsistent	Satisfactory	Good	Outstanding
- use design process				
- use extensive research techniques				
- understand bearing types				
- develop innovative designs				
- understand drive ratios				
- develop troubleshooting skills				
- develop safe work practices				
- increase knowledge of hand and power tools				
- use computers and word processors				
- plot out and use fabrication guidelines				
- use various building material (wood, plastic)				
- work well as a group				

Appendix 3.1

Sample System

The Alternator

- The alternator is connected to the windmill via belts, gears, etc. Whatever method is used, the assembly must be encased to protect operators and extremes of weather through the use of shields and guards.
- The wires should be tie-wrapped together to maintain system integrity.
- The recommended wire to use is 14-gauge stranded insulated. The stranded wire provides flexibility and withstands nicks when the insulation is stripped and there is any vibration from the windmill turning.
- Terminal strips and terminal connectors are used to connect the sections together. The strips and connectors make it easier to connect/disconnect the wires without damage being done.
- Power output is monitored for DC voltage and current at the alternator.
- The DC voltage meter with a range of 0 to 25 volts can be used. It is connected parallel to the terminals of the alternator.
- The DC ammeter (current) 0 to 100 amps is connected in series on the positive side of the circuit.
- A disconnect switch can be installed to disconnect the alternator from the circuit for safety reasons. The switch should be capable of handling 24 volts DC at 100 amps. The switch is connected in series on the positive side of the circuit before the ammeter.

The Regulator

- The DC voltage is regulated to provide a constant voltage to the batteries.
- Two types of regulators can be used: automotive vibration or solid state (transistor).
- Automotive vibration voltage regulator is connected between the alternator and the battery. It is connected on the positive side of the circuit (diagram 1a). Voltage is applied to the regulator from the positive terminal via a switch, which activates the regulation circuit (diagram 1a).
- The wire going to the battery to/from the alternator is 8- or 10-gauge. The larger size is required to be able to handle the current flow. Wires of 14-gauge are used for connecting the field coil and the rest of the circuit.
- All wires have terminal connectors on to facilitate easy connection/disconnection to terminal strips.
- A solid state Voltage regulator is connected between the alternator and the battery. It is connected on the positive side of the circuit. Voltage is applied to the regulator from the positive terminal via a switch, which activates the regulation circuit (diagram 1b).
- The wire going to the battery to/from the alternator is 8 or 10 gauge. The larger size is required to handle the current flow. Wires of 14 gauge are used for connecting the field coil and rest of the circuit.
- The regulator is mounted on a board and is in a weatherproof box or container.
- The regulator is a built-in component of the alternator (diagram 1c). Therefore only the appropriate wires need to be connected to the battery. The wire going to the battery to/from the alternator is 8- or 10-gauge. The larger size is required to be able to handle the current flow. Wires of 14-gauge are used for connecting the field coil and the rest of the circuit.

Appendix 3.1 (Continued)

The Battery

- The battery is connected to the regulator via terminal strips, terminals, and 8- or 10-gauge stranded wire.
- A fuse and fuse holder or circuit breaker is connected in series with the positive terminal (50-amp limit)
- A switch is also connected in series between the fuse and the rest of the system positive terminal.
- The DC voltage meter with a range of 0 to 25 volts can be used. It is connected parallel to the terminals of the battery, using 22 gauge stranded insulated wire.
- The DC ammeter (current) 0 to 100 amps is connected in series on the positive side of the circuit.
- The battery is in a separate weather container or box that is also acid-proof. Ventilation for the battery is important in the design of the enclosure.

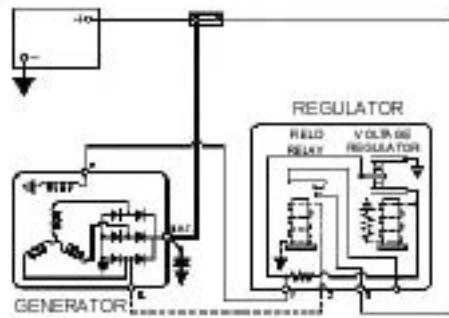


diagram 1a

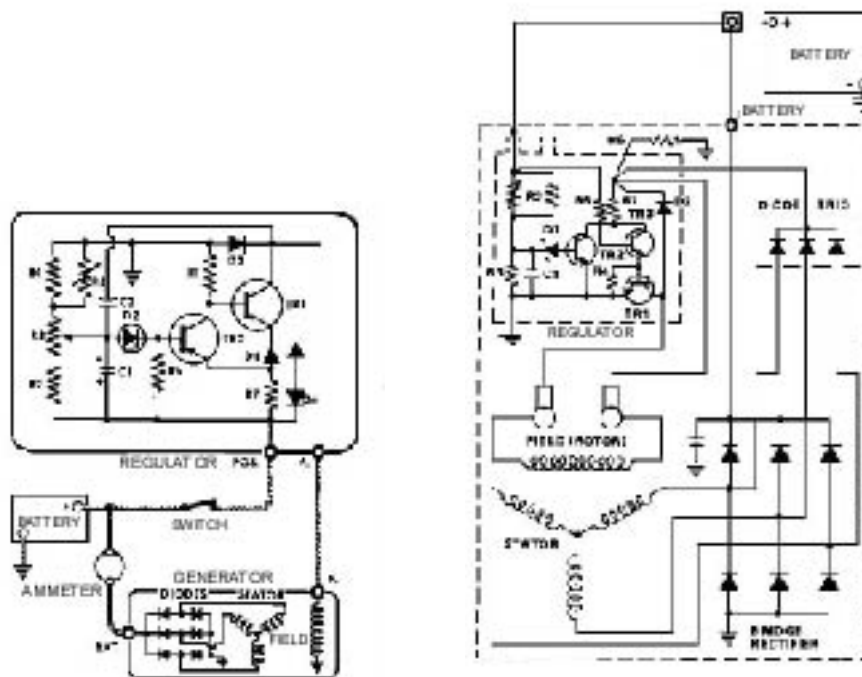


diagram 1b

diagram 1c

Appendix 3.2

The Wind Generator Construction Checklist

Team Members: _____

Expectations Project team will:	Needs to be reworked	Meets Some Standards	Meets Production Standards	Surpasses Requirements
Demonstrate working knowledge of the alternator				
Demonstrate working knowledge of the regulator				
Demonstrate working knowledge of the battery/maintenance				
Demonstrate knowledge of overall project				
Demonstrate knowledge of safety devices				
Demonstrate knowledge and understanding of design process				
Demonstrate research of ideas				
Develop new innovations for alternative power generation				

Appendix 3.3

Project Log Sheets

Team Members: _____

Name of part made	Description of section made/tested	Date