TECHNOLOGY EDUCATION 11 AND 12

Metal Fabrication and Machining

Integrated Resource Package 2002
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This Integrated Resource Package (IRP) provides basic information teachers will require in order to implement the Metal Fabrication and Machining 11 and 12 curriculum. The information contained in this IRP is also available via the Ministry Website: http://www.bced.gov.bc.ca/irp/irp.htm

The following paragraphs provide brief descriptions about each section of the IRP.

THE INTRODUCTION

The Introduction provides general information about the Technology Education 11 and 12 curriculum as a whole, including special features and requirements. It also provides a rationale for teaching Metal Fabrication and Machining 11 and 12 in BC schools.

THE TECHNOLOGY EDUCATION 11 AND 12: METAL FABRICATION AND MACHINING CURRICULUM

The provincially prescribed curriculum for Metal Fabrication and Machining 11 and 12 is structured in terms of curriculum organizers. The main body of this IRP consists of four columns of information for each organizer. These columns describe:

- provincially prescribed learning outcome statements
- suggested instructional strategies for achieving the outcomes
- suggested assessment strategies for determining how well students are achieving the outcomes
- provincially recommended learning resources

**Prescribed Learning Outcomes**

Learning outcome statements are content standards for the provincial education system. Prescribed learning outcomes set out the knowledge, enduring ideas, issues, concepts, skills, and attitudes for each subject. They are statements of what students are expected to know and be able to do in each grade. Learning outcomes are clearly stated and expressed in observable terms. All learning outcomes complete the stem: “It is expected that students will …” Outcome statements have been written to enable teachers to use their experience and professional judgment when planning and evaluating. The outcomes are benchmarks that will permit the use of criterion-referenced performance standards. It is expected that actual student performance will vary. Evaluation, reporting, and student placement with respect to these outcomes depend on the professional judgment of teachers, guided by provincial policy.

**Suggested Instructional Strategies**

Instruction involves the use of techniques, activities, and methods that can be employed to meet diverse student needs and to deliver the prescribed curriculum. Teachers are free to adapt the suggested instructional strategies or substitute others that will enable their students to achieve the prescribed learning outcomes. These strategies have been developed by specialist and generalist teachers to assist their colleagues; they are suggestions only.

**Suggested Assessment Strategies**

The assessment strategies suggest a variety of ways to gather information about student performance. Some assessment strategies relate to specific activities; others are general. These strategies have been developed by specialist and generalist teachers to assist their colleagues; they are suggestions only.
Provincially Recommended Learning Resources

Provincially recommended learning resources are materials that have been reviewed and evaluated by BC educators in collaboration with the Ministry of Education according to a stringent set of criteria. These resources are organized as Grade Collections. A Grade Collection is the format used to organize the provincially recommended learning resources by grade and by curriculum organizer. It can be regarded as a “starter set” of basic resources to deliver the curriculum. These resources are typically materials suitable for student use, but they may also include information primarily intended for teachers. Teachers and school districts are encouraged to select those resources that they find most relevant and useful for their students, and to supplement these with locally approved materials and resources to meet specific local needs.

The recommended resources listed in the main body (fourth column) of this IRP are those that either present comprehensive coverage of the learning outcomes of the particular curriculum organizer or provide unique support to specific topics. Further information about these recommended learning resources is found in Appendix B.

The Appendices

A series of appendices provides additional information about the curriculum, and further support for the teacher.

- **Appendix A** lists the curriculum organizers and the prescribed learning outcomes for each grade for the curriculum.

- **Appendix B** consists of general information on learning resources as well as Grade Collection organizational charts and annotations for the provincially recommended resources. New resources are evaluated and added to the Grade Collections on a regular basis.

- **Appendix C** contains assistance for teachers regarding provincial evaluation and reporting policy. Prescribed learning outcomes have been used as the source for samples of criterion-referenced evaluations.

- **Appendix D** acknowledges the many people and organizations that have been involved in the development of this IRP.

- **Appendix E** provides information on provincially approved Grade 12 courses that may be offered as an extension to Metal Fabrication and Machining 11 and 12.


**Grade 11 • Health and Safety**

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**Prescribed Learning Outcomes**

The Prescribed Learning Outcomes column lists the specific learning outcomes for each curriculum organizer.

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**Suggested Instructional Strategies**

- Conduct a class discussion on personal experiences with regard to accidents. Have students discuss strategies for prevention.
- Engage students in a class discussion about the potential effects of a metal shop environment on one’s health. Have students bring in lists of specific health problems and safety hazards that could result from these effects.
- Invite a speaker from the WCB to give a presentation on the wide range of shop-related accidents. Have students prepare questions in advance. Following the presentation, have students break into groups and conduct a safety audit. Have each group share the information and then develop a “Shop Safety Guide” for the school metal shop.
- Engage students in a discussion as you assemble a disassembled oxy-acetylene setup. This provides an opportunity for students to observe and study all the safety features of the cylinders, regulators, flashback arrestors, hoses, etc., as you work.

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**Recommended Learning Resources**

The Recommended Learning Resources component is a compilation of provincially recommended resources that support the prescribed learning outcomes. A complete list including a short description of the resource, its media type, and distributor is included in Appendix B of the IRP.
Rationale for Technology Education

Technology is embodied in devices that extend human capabilities. It provides the tools to extend our vision, to send and receive sounds and images from around the world, and to improve health, lifestyle, economies, and ecosystems. As technology assumes an increasingly dominant force in society, technological literacy is becoming as essential as numeracy skills and the ability to read and write. In providing the fundamentals of technological literacy, technology education helps young people prepare to live and work in a world of continuously evolving technologies.

A technologically literate person uses tools, materials, systems, and processes in an informed, ethical, and responsible way. To be responsible members of society, students must be aware of the impact that ever-changing technology has on their lives. They need to reflect critically on technology’s role in society and consider its positive and negative effects. Technology education fosters the development of skills and attitudes that increase students’ ability to responsibly address the social and ethical issues of technological advancements.

To meet career challenges, students must be able to communicate effectively, make independent decisions, solve problems, work independently and cooperatively with individuals from diverse backgrounds, and become technically competent. Indeed, the Conference Board of Canada has identified these skills as critical to employment in the 21st century (see the Board’s “Employability Skills 2000+” brochure, available online at http://www.conferenceboard.ca/education/learning-tools/employability-skills.htm or from the Board at 255 Smyth Road, Ottawa, ON, K1H 8M7, Tel. 613-526-3280, Fax. 613-526-4857). In Technology Education 11 and 12 courses students have the opportunity to develop a variety of skills and abilities essential for employment in today’s economy.

Activities in Technology Education provide opportunities for students to develop, reinforce, and apply:

- numeracy skills as they calculate, estimate, and measure
- information skills as they identify, locate, gather, store, retrieve, process, and present information
- communication skills as they apply technology to communicate their design ideas, solutions, reflections, and products
- problem-solving skills as they identify, describe, and analyse problems, and test their ideas and solutions
- social and cooperative skills as they interact with others to solve problems and complete projects
- leadership and project-management skills as they set goals, plan, address challenges, and resolve conflicts
- physical skills as they carry out technological tasks using tools, equipment, and materials correctly, efficiently, and safely.

Technology Education Objectives

The aim of the Technology Education curriculum is to help students develop technological literacy and lifelong learning patterns that they need to live and work effectively in a changing technological society. To achieve this, the curriculum provides a framework for students to learn how to design and construct solutions to real-world problems and opportunities to put into practice what they have learned.

Technology Education should provide students with opportunities to:
• develop the ability to solve technological problems
• develop the ability to make things and explore technology
• develop the ability to deal ethically with technology
• develop lifelong learning patterns needed to function effectively in a changing technological environment
• acquire skills and attitudes needed to work with technology both independently and as a cooperative member of a group
• develop appropriate attitudes and practices with respect to work safety and personal health
• gain competence in working with tools, materials, and processes to produce high-quality work
• develop language and visual communication skills to investigate, explain, and illustrate aspects of technology
• apply and integrate skills, knowledge, and resources across disciplines and in technological activities
• explore and pursue technological careers and associated lifestyles
• become discerning users of materials, products, and technical services.

The Metal Fabrication and Machining 11 and 12 Curriculum

This Integrated Resource Package (IRP) sets out the provincially prescribed curriculum for the Technology Education 11 and 12: Metal Fabrication and Machining curriculum. Additional Technology Education 11 and 12 courses include:

• Automotive Technology (2001)
• Carpentry and Joinery (2001)
• Drafting and Design (2001)
• Electronics (2002)
• Industrial Design (1997)

The development of this IRP has been guided by the principles of learning:

• Learning requires the active participation of the student.
• People learn in a variety of ways and at different rates.
• Learning is both an individual and a group process.

Health and Safety

Safe work practices and procedures, and creating an understanding of what is required for a safe work environment, are absolutely essential. As students begin to work with tools and equipment, safety procedures must be introduced and reinforced throughout.

It is essential that teachers address the following questions before, during, and after an activity:

• Have safe work procedures been modelled?
• Have students been given specific instruction on how to use and handle equipment and tools safely and correctly?
• Have students been given specific instruction on how to use, handle, and dispose of hazardous materials?
• Are the tools and equipment in good repair, electrically safe, and suitably arranged for students?
• Are students being properly supervised?
• Do the facilities provide adequate lighting for detailed metal work and appropriate ventilation for activities?
• Have students been made aware of hazards in the facility area?
• Have students been made aware of appropriate school-based and industrial safety standards and procedures (WHMIS)?
Teachers should ensure that safety practices are implemented. The following is not an all-inclusive list, but a guide to help teachers establish a safe learning environment. Students should:

- wear appropriate attire and safety equipment
- follow established rules and routines
- select tasks that are within their abilities
- demonstrate safe work practices and attitudes
- show self-control and respect for the safety of themselves and others
- recognize hazards in work areas.

**Rationale for Metal Fabrication and Machining**

From earliest times, metal has been an integral part of our society. Metals are durable, versatile, and recyclable, found in everything from basic household items to sophisticated aerospace products.

The Metal Fabrication and Machining 11 and 12 curriculum is designed for students to learn foundational theory and basic practical skills related to machining, welding, fabrication, metallurgy, sheet metal, and art metal. For students, these high school courses provide opportunities to:

- develop marketable skills (to meet existing and anticipated new demands from industry)
- prepare for further study related to metal fabrication and machining (e.g., trades, engineering, manufacturing)
- design and create projects (e.g., build tools and equipment, jewellery, art metal)
- pursue personal interests
- develop practical life skills to enhance self-reliance, including the capacity to be critical consumers of metal products
- consider related social and ethical issues.

**Curriculum Organizers**

The prescribed learning outcomes for the courses described in this Integrated Resource Package are grouped under a number of curriculum organizers. These curriculum organizers reflect the main areas of Metal Fabrication and Machining that students are expected to address. They form the framework of the curriculum. The organizers are not equivalent in terms of number of outcomes or the time that students will require in order to achieve these outcomes. The sequence of the following set of curriculum organizers is not meant to convey an order of importance or instruction:

- Health and Safety
- Personal and Project Management
- Mathematical Applications
- Tools and Equipment
- Materials
- Cutting Processes
- Forming and Joining Processes

**Health and Safety**

The focus in this area is on:

- safe working practices and procedures
- creating and maintaining a healthy work environment.

Health and safety measures for both individuals and groups are addressed. These learning outcomes will be reinforced through all Metal Fabrication and Machining activities.

**Personal and Project Management**

Personal and Project Management emphasizes the personal, interpersonal, and organizational skills required in a working environment. This organizer also deals with career possibilities and with ethical and social issues.
**Mathematical Applications**

The practical application of mathematical skills is essential for success in fabrication and machining. The prescribed learning outcomes for this organizer address measurement, basic trigonometry, and geometry.

**Tools and Equipment**

This area emphasizes the development of safe and approved operational and maintenance skills associated with tools and equipment.

**Materials**

This organizer includes a focus on identifying and using a variety of metals (ferrous, non-ferrous, and precious metals). Students are expected to acquire an understanding of the composition and properties of commonly used metals. An understanding of metallurgy helps students become familiar with the most effective and appropriate ways of manipulating metals.

**Cutting Processes**

This area of the curriculum deals with the removal of material by various processes, for differing applications. The emphasis is on developing safe and appropriate cutting skills associated with methods such as machining and oxy-acetylene cutting. The use of CNC equipment is also introduced.

**Forming and Joining Processes**

This area of the curriculum focuses on the forming and joining of metals using a variety of techniques, in the context of various applications, including the creation of metal art and craft objects. Techniques addressed include welding, fabricating, forging, casting, and fastening.

**Suggested Instructional Strategies**

In this Integrated Resource Package, instructional strategies have been included for each curriculum organizer and grade. These strategies are suggestions only, designed to provide guidance for generalist and specialist teachers planning instruction to meet the prescribed learning outcomes. The strategies may be either teacher-directed, student-directed, or both.

There is not necessarily a one-to-one relationship between learning outcomes and instructional strategies, nor is this organization intended to prescribe a linear means of course delivery. It is expected that teachers will adapt, modify, combine, and organize instructional strategies to meet the needs of students and to respond to local requirements.

Teachers should include as many instructional methods as possible to present technical information. Blending live repairs with simulated (i.e., instructor-prepared) tasks will maximize learning. For optimum learning, a combined in-shop and in-class approach is recommended.

The suggested instructional strategies may be undertaken by individual students, partners, or small groups. Metal Fabrication and Machining 11 and 12 emphasizes skills needed in a changing society. As a result, emphasis is given to the following strategies:

- **Strategies that develop applied skills.**
  
  In order to see technology education, in general, as relevant and useful, students must learn how it can be applied to a variety of real workplace situations. Students learn more quickly and retain their learning better when they are actively involved in the learning process. Using a variety of activities with built-in learning situations will help students to
understand, identify, and solve problems that occur in life.

- **Strategies that foster the development of individual and group skills.**
  In the workplace, people need to know how to work effectively, individually and with others, to solve problems and complete tasks. Students need opportunities to work independently to enhance their organizational and self-evaluation skills. Students also need to experience the dynamics of group work to enhance their understanding of group problem-solving processes. Group work focuses on such skills as collaboration, communication, leadership, and cooperation.

- **Strategies that foster research and critical-thinking skills.**
  In order to make informed and responsible choices about the appropriate use of technology, students need to receive and process information critically. To develop decision-making and problem-solving skills, students need to be challenged to identify problems and develop solutions.

- **Strategies that use technology.**
  The ability to use technology to solve problems is a necessary skill in the workplace and in post-secondary education. Students use technology to access information, to perform calculations, and to enhance the presentation of ideas.

Other ways to enhance the program include:

- forming a Metal Fabrication and Machining club
- offering a career preparation program
- offering apprenticeship programs (some may include corporate sponsorship)
- constructing laboratory demonstration units
- arranging field trips
- holding a contest.

**Problem-Solving Models**

To develop decision-making and problem-solving skills, students need to be challenged to identify problems and develop solutions.

Models that describe problem-solving processes should be developed with students so they understand the recurring nature of solving real-world problems (i.e., as part of a problem is solved, new problems arise and some steps in the processes recur).

**Project Focus**

It is expected that students will complete various lab activities and produce various projects in each course. These activities and projects will form the basis upon which student learning will be assessed. The comprehensive nature of the activity or project will allow students to experience a sense of accomplishment and to demonstrate skills acquired in relation to a range of learning objectives.

**Technical Communication**

Technical communication skills must be an integrated part of the study of Metal Fabrication and Machining, in order to develop a student’s ability to effectively acquire and convey technical knowledge. Such skills will include:

- drawing and interpretation of schematic diagrams
- use of appropriate technical vocabulary
- verbal and written explanations of complex problems.
Suggested Assessment Strategies

Teachers determine the best assessment methods for their students. The assessment strategies in this document describe a variety of ideas and methods for gathering evidence of student performance. The assessment strategies column for a particular organizer always includes specific examples of assessment strategies. Some strategies relate to particular activities, while others are general and could apply to any activity. These specific strategies may be introduced by a context statement that explains how students at this age can demonstrate their learning, what teachers can look for, and how this information can be used to adapt further instruction.

Assessment is the systematic process of gathering information about students’ learning in order to describe what they know, are able to do, and are working toward. From the evidence and information collected in assessments, teachers describe each student’s learning and performance. They use this information to provide students with ongoing feedback, plan further instructional and learning activities, set subsequent learning goals, and determine areas requiring diagnostic teaching and intervention. Teachers base their evaluation of a student’s performance on the information collected through assessment.

Teachers determine the purpose, aspects, or attributes of learning on which to focus the assessment; when to collect the evidence; and the assessment methods, tools, or techniques most appropriate to use. Assessment focuses on the critical or significant aspects of the learning to be demonstrated by the student.

The assessment of student performance is based on a wide variety of methods and tools, ranging from portfolio assessment to pencil-and-paper tests. Appendix C includes a more detailed discussion of assessment and evaluation.

Integration of Cross-Curricular Interests

Throughout the curriculum development and revision process, the development team has done its best to ensure that relevance, equity, and accessibility issues are addressed in this IRP. Wherever appropriate for the subject, these issues have been integrated into the learning outcomes, suggested instructional strategies, and suggested assessment strategies. Although it is neither practical nor possible to include an exhaustive list of such issues, teachers are encouraged to continue ensuring that classroom activities and resources also incorporate appropriate role portrayals, relevant issues, and exemplars of themes such as inclusion and acceptance.

The Ministry, in consultation with experienced teachers and other educators, has developed a set of criteria for evaluating learning resources. Although the list is neither exhaustive nor prescriptive, most of these criteria can be usefully applied to instructional and assessment activities as well as learning resources. Brief descriptions of these criteria, grouped under the headings of Content, Instructional Design, Technical Design, and Social Considerations, may be found on pages 30 through 45 of Evaluating, Selecting, and Managing Learning Resources (2000), document number RB0065. This Ministry document has been distributed to all schools. Additional copies may be ordered from Office Products Centre, 1-800-282-7955 or (250) 952-4460, if in Victoria.
Gender Issues in Technology Education

The education system is committed to helping both male and female students succeed equally well. This is particularly important in the area of technology education, where female participation is low. Teaching, assessment materials, learning activities, and classroom environments should place value on the experiences and contributions of all people and cultivate interest and access for female students.

Teachers should consider the diversity of learning styles and watch for gender bias in learning resources, and bias in interaction with students. The following instructional strategies for technology education are provided to help teachers deliver gender-sensitive programs.

- Feature women who make extensive use of technology in their careers—perhaps as guest speakers or subjects of study in the classroom.
- Develop instruction to acknowledge differences in experiences and interests between young women and young men.
- Demonstrate the relevance of technology education to careers and to daily life in ways that appeal to a variety of students in the class or school. Successful links include sciences and environmental issues.
- Provide practical learning opportunities designed specifically to help young women develop confidence and interest in technology education and non-traditional roles.

Adapting Instruction for Diverse Student Needs

Technology education, particularly activity-based technology education, has traditionally been a significant area for pre-employment skill-development opportunities and an ideal area for students with special needs. Technology education, with its focus on the benefits of concrete, real-world experiences, provides students with opportunities to work effectively in group situations, focusing on observation and experimentation, and alternative methods of evaluation. For students with exceptional gifts or talents, this curriculum area is also ideal for creative learning experiences and critical-thinking activities. Opportunities for extension and acceleration are rich in technology education, and, for some students with special needs, this curriculum can provide opportunities to apply personal experiences to enrich their learning.

When students with special needs are expected to achieve or surpass the learning outcomes set out in the Technology Education 11 and 12 curriculum, regular grading practices and reporting procedures are followed. However, when students are not expected to achieve the learning outcomes, modifications must be noted in their Individual Education Plans (IEPs). Instructional and assessment methods should be adapted to meet the needs of all students. When students require adaptations in order to meet the regular learning outcomes, these too should be noted in an IEP. The following strategies may help students with special needs succeed in technology education.

Adapt the Environment

- cluster-group students with particular gifts or needs
- make use of preferential seating to enhance learning
- create a space with minimum distractions
- change the location of the learning activity to optimize concentration
- make use of cooperative grouping or pairing of learners
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Adapt Presentation or Instruction
- make extensions of activities for students with special gifts and talents
- offer choices for self-directed learning
- provide advance organizers of key technology education concepts
- demonstrate or model new concepts
- adjust the pace of activities as required
- change the wording of questions or instruction to match the student’s level of understanding
- provide functional, practical opportunities for students to practise skills
- use bilingual peers or volunteers to help ESL students (e.g., clarify safety rules)

Adapt Materials and Equipment
- use techniques to make the organization of activities more explicit (e.g., colour-code the steps used to solve a problem)
- use manipulatives
- provide large-print charts or activity sheets
- use opaque overlays to reduce the quantity of visible print
- highlight key points in written material
- provide software that defaults to a larger font size
- use adapted computer technology hardware and appropriate software
- provide alternative resources on the same concepts at an easier comprehension level
- use translated material for information (e.g., safety rules)
- provide or arrange opportunities for independent research (e.g., CD-ROM)

Adapt Methods of Assistance
- train and use peer tutors to assist students with special needs
- arrange for teacher assistants to work with individuals or small groups
- collaborate with support teachers to develop appropriate strategies for individual students with special needs

Adapt Methods of Assessment
- allow students to demonstrate their understanding of technology education concepts in a variety of ways (e.g., through murals, displays, models, oral presentations)
- match assessment tools to students’ needs (e.g., oral or open-book tests, tasks performed without time limits, teacher and student conferencing)
- set short-term achievable goals with frequent feedback (e.g., as students work on metal fabrication and machining projects)
- provide opportunities for students to do self-assessment and individualized goal setting
CURRICULUM

Metal Fabrication and Machining 11 and 12
It is expected that students will:

- consistently use safe work practices
- identify WHMIS symbols that apply to workplace materials
- demonstrate a knowledge of safety features and practices associated with oxy-acetylene equipment
- demonstrate a knowledge of safety features and practices associated with metal-related tools and equipment
- identify hazardous situations in the work environment and take appropriate action
- demonstrate good “housekeeping” techniques

Suggested Instructional Strategies

- Conduct a class discussion on personal experiences with respect to accidents. Have students discuss strategies for prevention.
- Engage students in a class discussion about the potential effects of a metal shop environment on one’s health. Have students brainstorm lists of specific health problems and safety hazards that could cause these effects.
- Invite a speaker from the WCB to give a presentation on the wide range of shop-related accidents. Have students prepare questions in advance. Following the presentation, have students break into groups and conduct a safety audit. Have each group share its information and then develop a “Shop Safety Guide” for the school metal shop.
- Engage students in a discussion, as you assemble a disassembled oxy-acetylene setup. This provides an opportunity for students to observe and study all the safety features of the cylinders, regulators, flashback arrestors, hoses, etc., as you work.
- With students gathered around, demonstrate how to plug in, start, shut off, and change the polarity on a constant current (stick welding) machine. Afterward, have one or more students repeat the demonstration. Provide feedback as the student works.
Suggested Assessment Strategies

- Have students work in pairs to identify the parts of an oxy-acetylene setup, explain their function, and demonstrate how they go together. Observe as they do this, noting to what extent they:
  - inspect for visible defects
  - correctly assemble the oxy-acetylene equipment
  - set gas pressures correctly
  - safety test for gas leakage
  - correctly shut down the equipment.
- As students work in the shop, observe the extent to which they are able to:
  - demonstrate safe use of tools and equipment
  - demonstrate safe handling of potentially hazardous materials
  - utilize safe and healthy work practices.
- Use multiple-choice and short-answer tests to assess students’ knowledge of safety regulations and of policies and procedures related to the use of equipment.

Recommended Learning Resources

Print Materials

- Exploring Metalworking: Fundamentals of Technology
- Jewelry: Two Books in One
- Machinery’s Handbook, 26th Edition
- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Technology of Machine Tools, 5th Edition
- Trades Common Core: Line J - Oxyacetylene Cut and Weld
- Welder Training Program: Level B
- Welder Training Program: Level C
- Welding Technology Fundamentals

Video

- Arc Welding Explained: Basic Principles
PRESCRIBED LEARNING OUTCOMES

It is expected that students will:

• interpret drawings and produce simple sketches to communicate design ideas
• identify, organize, and execute processes required to accomplish a task
• identify and organize task-related tools and materials
• identify environmental, social, and ethical considerations associated with metal fabrication and machining
• identify and utilize employability skills
• describe career opportunities that exist in metal-related industries

SUGGESTED INSTRUCTIONAL STRATEGIES

• Before students begin work on a project, have them fill in an organization and planning sheet that includes questions such as:
  - Do you have the tools and equipment required to complete the job?
  - Can this be finished in the requisite time?
  - Have the sub-tasks required to complete the project been properly identified and sequenced?
• Suggest a simple project and have each student produce:
  - one or more sketches
  - a bill of materials
  - a cutting list of all component parts
Have students divide up tasks (e.g., as in a simulated production line) to complete the project.
• Present the Conference Board of Canada’s list of Employability Skills 2000+. This is available online at http://www.conferenceboard.ca/education/learning-tools/employability-skills.htm or from the Board at 255 Smyth Road, Ottawa, ON, K1H 8M7, Tel. 613-526-3280, Fax. 613-526-4857. Have students suggest how the various employability skills might be applicable in a metal shop environment.
• After screening a career video, have students brainstorm ways in which their lives are influenced by fabrication and machining. Groups then select two occupations related to metal fabrication and machining (e.g., tool-and-die maker, goldsmith) and research the required training, financial compensation, and related responsibilities. Encourage students to examine a diverse range of jobs.
• Conduct a field trip or invite a guest speaker to consider occupations in the metal trades. Beforehand, have students develop a list of questions to ask. Afterward, have students briefly summarize what they learned.
• Have students display in the shop job postings or descriptions showing various occupations that people with metals training can pursue.
SUGGESTED ASSESSMENT STRATEGIES

- When assessing student-initiated projects, consider the extent to which these reflect:
  - creativity
  - knowledge of metal fabrication and machining processes
  - knowledge of material
  - effective cost and time management.

- As part of their work on an extended project, have students create and maintain a log of time spent on various aspects of the project (e.g., paper planning, design, material selection, tool and equipment set-up, cutting, assembly, redoing tasks where improvement is needed, finishing work). When the project is complete, have students reflect on their logs and use them as a basis for self-assessing how effectively they managed their time and resources.

- Individual students’ personal and project management skills can be assessed in relation to criteria such as:
  - classroom attendance (absences, lates, interruptions)
  - attention to clean-up routines, housekeeping
  - attire (appropriate to the shop situation)
  - ability to remain on task for extended periods of time (remain focused)
  - ability to organize and complete tasks
  - ability to share space, time, equipment, knowledge (experience)
  - extra work during student’s own time for self/teacher/others
  - the quality of in-class demonstrations carried out by the student
  - knowledge of appropriate terminology
  - ability to listen, interpret written material, follow oral instruction, and understand drawings related to the project/procedure
  - ability to foresee and assess an end result (e.g., Will it work properly, operate as intended?).

RECOMMENDED LEARNING RESOURCES

- Exploring Metalworking: Fundamentals of Technology
- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Technology of Machine Tools, 5th Edition
- Welder Training Program: Level C
PRESCRIBED LEARNING OUTCOMES

It is expected that students will:

- demonstrate the ability to use the following measuring instruments:
  - micrometers
  - tape measures and scales
  - dial indicators
  - calipers or other instruments that employ the Vernier scale
- demonstrate proficiency in adding, subtracting, multiplying, and dividing whole numbers, fractions, and decimals to perform layout and solve problems related to metal fabrication and machining
- estimate the solutions to calculations involving whole numbers, decimals, and fractions
- convert between Imperial and SI units
- demonstrate the application of basic geometry and basic trigonometry to solve problems related to angles and tapers
- explain the significance of tolerances
- interpret tables and charts

SUGGESTED INSTRUCTIONAL STRATEGIES

- Have students use calipers to measure inside and outside diameters and thickness of given objects.
- Have students measure samples to the nearest 1/32 in., 1/64 in., 1.0 mm, or .5 mm using a scale or tape measure.
- Have students use a dial indicator and base to measure the turning accuracy of a three-jaw chuck or dial in a milling machine vise.
- Have students calculate the speeds in rpm required for various cutting tools cutting various materials (e.g., 1/2 in. drill cutting aluminum, mild steel).
- Have students convert drawing measurements from imperial to metric and vice versa.
- Have students make a list of substitute metric drills for imperial drill bits and vice versa, using soft conversions or decimals (e.g., 1/2 in. = 13 mm, 10 mm = 3/8 in.).
- Have students learn all the decimal conversions in 1/16 inch increments up to 1 inch.
- Introduce the 3-4-5 rule: draw a square corner (90˚) with a 3-unit horizontal arm and a 4-unit vertical arm; the hypotenuse of this unfinished right-angle triangle should be 5 units. Have students use this to check the “squareness” of a built frame.
- To introduce trades-level trigonometry, sketch a right-angle triangle. Explain that regardless of the size of the triangle, if the angles remain constant, the ratio of the length of the sides also remains constant. Demonstrate how this is used to find the angle setting on a lathe for making a taper, by using the \( \tan \left( \frac{opp}{adj} \right) \) function.
- Introduce and have students use the Pythagorean theorem in given problems or tasks.
Suggested Assessment Strategies

- Give students a simple dimensioned drawing and have them make a cutting list of all the materials required. When assessing their lists, consider the extent to which
  - the lists are complete
  - the cutting measurements (specifications) are accurate
  - appropriate types of materials are identified.
- Assess students’ ability to read an imperial scale in 1/32 in. and 1/64 in. increments and a metric scale in .5 mm and 1 mm increments.
- Use in-class tests to assess students’ knowledge of the fraction-to-decimal and decimal-to-fraction conversions.
- Have students regularly estimate answers to various calculations they encounter as part of shop-related activities. Periodically ask them to assess how reasonable and accurate their estimates are and how useful and reliable particular estimates are.
- Invite students to find right-angle triangles in the shop. For each triangle they identify, have them measure the sides adjacent to the right angle and use the Pythagorean relationship to calculate the hypotenuse. Are their calculations accurate? Can they explain the process?
- Assess students’ ability to:
  - calculate speeds or rpm for various cutting operations
  - identify the appropriate rpm selection on a diagram of a lathe.

Recommended Learning Resources

Print Materials

- Exploring Metalworking: Fundamentals of Technology
- Jewelry: Two Books in One
- Machinery’s Handbook, 26th Edition
- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Practical Problems in Mathematics for Manufacturing, 4th Edition
- Practical Problems in Mathematics for Welders, 4th Edition
- Technology of Machine Tools, 5th Edition
- Welder Training Program: Level C
**Prescribed Learning Outcomes**

It is expected that students will:

- identify, describe, and use:
  - layout tools
  - measuring instruments
  - hand tools
  - lathe, milling, drilling, and grinding tools and equipment
  - welding machines, tools, and equipment
  - basic forging and casting tools and equipment
  - sheet metal tools and equipment
- describe proper maintenance procedures for:
  - lathe, milling, drilling, and grinding tools
  - oxy-acetylene and other welding tools
  - forging and foundry tools
  - hand tools
  - sheet metal tools
- identify needed repairs or replacements for broken or used parts
- perform basic maintenance procedures as directed
- properly store tools and equipment

**Suggested Instructional Strategies**

- After showing a video on a particular procedure, challenge students to recall implied or incidental information about tools or equipment employed (e.g., identification of tools, safety considerations, other possible uses).
- Following a demonstration, have groups of students repeat the process of changing oxy-acetylene cylinders.
- Using locked-out equipment, set up scenarios in which groups of students are challenged to diagnose and troubleshoot an equipment problem (e.g., loose chuck on a lathe, disengaged drive pin, misaligned chuck jaws).
- Organize students into teams to play “name that tool” (with possible bonus points for identification of its main applications).
- Have students use hand tools to build small items (e.g., a pencil box) out of sheet metal. The projects should involve the use of basic cutting, forming, and joining techniques (e.g., riveting).
- Provide students with plans for a small project. Ask them to describe the portable power tools required to build this project. Have students demonstrate the proper set-up for each tool and then build the project using only these tools.
**Suggested Assessment Strategies**

- Prior to assigning project work involving the use of tools or equipment that are new to the students, use a written or oral quiz to have them identify and describe the appropriate use(s) of particular tools or equipment. Assess the extent to which they:
  - use appropriate terminology in their identification
  - the identification is clear (e.g., they do not confuse two tools)
  - correctly identify safety features and procedures associated with the tool or equipment
  - distinguish between the primary application(s) and possible secondary applications
  - identify other tools or equipment capable of achieving similar results or serving comparable purposes.
- Observe and assess the extent to which students are able to locate particular tools or pieces of equipment in the metal shop.
- When assessing student project work, marks could be allocated for:
  - comprehension of theory involved
  - self-direction
  - amount of time required to complete the task
  - sizing
  - squareness of angles
  - appearance
  - proficiency in performing particular tasks.

**Recommended Learning Resources**

### Print Materials

- Exploring Metalworking: Fundamentals of Technology
- Jewelry: Two Books in One
- Machinery’s Handbook, 26th Edition
- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Technology of Machine Tools, 5th Edition
- Trades Common Core: Line J - Oxyacetylene Cut and Weld
- Welder Training Program: Level B
- Welder Training Program: Level C
- Welding Technology Fundamentals

### Video

- Arc Welding Explained: Basic Principles
- Arc Welding Explained: Gas Metal, Flux Cored - Arc Welding (MIG)
- Gas Tungsten Arc Welding: Getting Started
- Introduction to Welding Series: Shielded Metal Arc Welding
It is expected that students will:

- identify key developments in the history of metal production
- identify key stages in the production of iron and steel
- identify and describe the basic characteristics of common metals
- select metal stock whose size, structural shape, and finish are appropriate for specific applications
- identify common types and gauges of sheet metal
- use spark and file tests to identify ferrous metals
- describe and perform the processes of hardening and tempering
- describe the purposes of common surface treatments

Suggested Instructional Strategies

- Have students research and report to the class on such topics as:
  - annealing of non-ferrous metals
  - alloying of copper and tin in the Bronze Age
  - the history of steel smelting
  - the environmental impact of coal burning in the manufacturing of steel.
- Present samples of various structural shapes, (e.g., angle iron, flat bar, pipe) and provide a set of descriptions of the applications for each type of metal. Challenge students to match the sample with the appropriate description.
- Show students various projects and have them identify each part, its function, the material used, and the reason for using that material.
- Have students create a personal reference tool by cutting small samples of differing sheet metal stocks and stamping the thickness (in millimetres or thousandths of an inch) and the gauge number on each piece.
- Provide metal samples and have students identify these using the following tests:
  - spark
  - file
  - magnet
  - weight comparison.
- Have students explain and show the differences between:
  - hot rolled and cold rolled steel
  - ferrous and non-ferrous metals.
- Have students use a reference source to find and note the temperature ranges for:
  - forging
  - hardening
  - tempering.
- Have students list the key colours corresponding to heat-treating temperatures. Demonstrate that metal is non-magnetic when the transformation point is reached. Then have them forge a cold chisel or screwdriver and heat treat it.
- Have students find a variety of metal objects that have surface treatments such as:
  - etching
  - bluing
  - coatings (anodized, enamelled, powder coated, galvanized, painted)
  - buffing or polishing.
SUGGESTED ASSESSMENT STRATEGIES

- Have students describe the difference between oil quenching and water quenching, and identify the pros and cons of each type of quenching. Assess the accuracy of their differentiations and the completeness of their lists of pros and cons.
- Use a written or verbal quiz or report to assess students’ ability to identify the following characteristics of various metals:
  - ductility
  - malleability
  - corrosion characteristics
  - toughness
  - tensile strength.
- Have students suggest reasons for the use of surface treatments. Note the extent to which students are able to identify the functional (especially protective) as well as the aesthetic advantages of surface treatments.
- Conduct a class discussion on properties of steel to identify the extent to which students are able to identify and distinguish between cold rolled and hot rolled steels.
- Through a written or verbal quiz, have students identify and describe the dimensions of common shapes: flat, bar, round, square, octagonal, hexagonal, tubing, pipe, angle, channel, I-beam. Assess the extent to which they give dimensions consistently and accurately.
- When students select a project, have them explain the materials they would choose. Assess the suitability of their projected choices and their explanation of the reasons for making those choices.

RECOMMENDED LEARNING RESOURCES

Print Materials

- Exploring Metalworking: Fundamentals of Technology
- Jewelry: Two Books in One
- Machinery’s Handbook, 26th Edition
- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Technology of Machine Tools, 5th Edition
- Trades Common Core: Line J - Oxyacetylene Cut and Weld
- Welder Training Program: Level B
- Welder Training Program: Level C
**PRESCRIBED LEARNING OUTCOMES**

*It is expected that students will:*

- perform cutting processes in a safe manner
- use common hand tools for cutting metal
- use common sheet metal cutting tools
- set up and perform the following cutting processes on a lathe:
  - facing
  - parallel turning to size
  - drilling
- set up and perform flat surface cutting and slotting on a milling machine
- set up and perform grinding processes using:
  - bench/pedestal grinders
  - portable grinders
  - abrasive cut-off saws
- set up and perform drilling and countersinking processes using a drill press
- set up and perform power sawing processes
- describe oxy-acetylene cutting
- set up and use oxy-acetylene equipment to perform short linear cuts freehand
- select the appropriate cutting tool for a given cutting task

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**SUGGESTED INSTRUCTIONAL STRATEGIES**

- Have students flame-cut pieces for subsequent arc welding exercises.
- Introduce new cutting processes or machinery by giving an exact demonstration of the approach and then having students practise.
- Show a video on using the lathe, milling machine, drill press, or pedestal grinder. Have students note and summarize any information about safety requirements and procedural steps.
- Provide illustrated reference material on features and use of shop machining tools and equipment. Have students refer to the material as the selection, setup, and application requirements for each cutting process are discussed.
- Before students engage in independent project work, observe to ensure they have:
  - correctly identified the cutting equipment and processes they intend to use
  - demonstrated an ability to perform these processes safely and correctly.
- Discuss the differences between climb and conventional milling. Have students suggest pros and cons of each.
- Present a machine part produced using cutting, and have students identify the cutting tools necessary to produce it.
- Have students describe the unique features of taper, plug, and bottoming taps and identify when each should be used.
- Have students describe the different dies and their advantages and disadvantages.
- Using a Tap Drill Chart, have students determine the correct tap drill size for a particular application.
- After safety lessons and demonstrations, have students use a lathe to complete a small project or practice exercise that involves:
  - facing, center-drilling, and turning to a diameter
  - facing, parallel turning, drilling, and tapping.
- Demonstrate backlash by having students physically move the mill table or lathe cross slide. Discuss potential problems associated with this and have students suggest solutions.
SUGGESTED ASSESSMENT STRATEGIES

- Observe and assess individual students’ proficiency with particular processes and equipment prior to allowing them to engage in independent project work.
- As students begin their project work, observe and record the extent to which they are able to set up, safety test, and use the lathe, milling machine, and drill press. Evaluate their responses to questions such as, “Why did you:
  - select and position that particular tool bit, milling cutter, or drill bit?
  - position your work that particular distance out from the chuck?
  - select that cutting speed and/or rate of feed?
  - set to that particular depth of cut (lathe, milling)?
  - set up and clamp your work in that manner (milling, drill press)?”
  “How could you:
  - control the depth of cut?
  - avoid machining undersize?
  - remove backlash before machining (lathe, milling)?”
  “Is this the safest way to perform this machining operation?”
- When students use a milling machine, a machining lathe, or a drill press, consider how well they are able to:
  - select and position the correct cutter(s) or tool bit(s)
  - set up the equipment for the intended job
  - choose the correct cutting speed and rate of feed
  - control the depth of cut (if applicable)
  - perform operations in the correct sequence
  - machine to standard shop tolerances.
- Use direct observation to assess student proficiency in:
  - selecting taps and dies
  - using the Tap Drill Chart
  - correctly selecting and applying taps and dies
  - using precision instruments (e.g., micrometer)
  - machining to specific dimension(s)
  - producing an acceptable surface finish.

RECOMMENDED LEARNING RESOURCES

Print Materials

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- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Technology of Machine Tools, 5th Edition
- Trades Common Core: Line J - Oxyacetylene Cut and Weld
- Welder Training Program: Level C
- Welding Technology Fundamentals
PRESCRIBED LEARNING OUTCOMES

It is expected that students will:

- execute forming and joining processes in a safe manner
- describe the characteristics and uses of the following common welding processes:
  - oxy-acetylene
  - SMAW (stick)
  - GMAW (wire feed)
- identify types and uses of common SMAW electrodes
- set up and join steel parts using fillet and butt welds in flat position
- identify and use a variety of common mechanical fastening methods
- demonstrate the ability to lay out, form, and join sheet metal using a variety of methods
- describe types and uses of casting
- produce a simple cast object using an open, closed, or lost wax mold
- identify uses and applications of forging processes
- shape a piece of metal using a forging process

SUGGESTED INSTRUCTIONAL STRATEGIES

- Demonstrate safe start-up and shut-down procedures for oxy-acetylene welding. Have each student repeat the process.
- Provide students with common SMAW electrodes and have individuals or small groups describe appropriate uses and characteristics.
- To introduce puddling using oxy-acetylene, demonstrate the procedure and have students run beads on thick sheet metal.
- Demonstrate the SMAW and GMAW processes. Have students complete a padding exercise (overlapping beads), and then a T-joint using these processes.
- Provide drawings of a project (or several small projects) showing the use of a variety of fastening and joining processes. After appropriate demonstrations and lessons, have students build the project(s) to demonstrate knowledge and ability.
- Have students build a sheet metal project (locker shelf, tool tray), utilizing as many appropriate forming and joining processes as possible.
- Have students design and create a jewellery item (e.g., pendant, brooch, ring) from sheet stock (e.g., silver, copper, brass).
- Have each student cast a ring using lost-wax process or a pendant using cuttlebone.
- Have students build a pencil holder and paperweight using:
  - one piece of steel plate as a base (50mm x 75mm)
  - two pieces of 1 1/2 in. x 1 1/2 in. long pipe
  - one piece of 3/4 in. x 3 in. long pipe
- Students are required to cut, face, and bevel the large pipes and cut the small pipe on one end to a 45° angle. Have them weld the large pieces of pipe together and attach to the plate, then attach the small pipe (45° end) to the plate. Beads along the steel plate and around the pipe provide a decorative touch.
**Suggested Assessment Strategies**

- Have students tack up a T-joint and weld the two pieces together. Break open some test pieces and assess the welds for:
  - slag inclusions
  - porosity
  - undercut
  - lack of fusion
  - penetration.
- Have students create a list of common threaded fasteners and state their uses. Assess the lists for:
  - accuracy
  - completeness
  - correct identification of fastener uses.
- Have students do padding exercises using GMAW (wire feed) and SMAW (stick feed). Then challenge small groups to successively arrange the various welds from best to worst and provide a rationale for their decisions. (See the Grade 11 Assessment Sample 2, *Padding with E-6010-11* in Appendix C for criteria associated with this.)
- When assessing completed students projects, consider:
  - the accuracy of their layouts
  - how well they have utilized their time
  - the quality of the finished product
  - the extent to which all safety requirements have been addressed.
- Have each student design and cast a ring, bracelet, or pendant. Focus assessment on:
  - the elegance and originality of the design
  - the extent to which appropriate materials have been selected, given the design
  - the quality of the casting
  - the care taken with the finishing.

**Recommended Learning Resources**

**Print Materials**

- Exploring Metalworking: Fundamentals of Technology
- Jewelry: Two Books in One
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- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Trades Common Core: Line J - Oxyacetylene Cut and Weld
- Welder Training Program: Level B
- Welder Training Program: Level C
- Welding Technology Fundamentals

**Video**

- Arc Welding Explained: Basic Principles
- Arc Welding Explained: Gas Metal, Flux Cored - Arc Welding (MIG)
- Gas Tungsten Arc Welding: Getting Started
- Introduction to Welding Series: Shielded Metal Arc Welding
**Prescribed Learning Outcomes**

*It is expected that students will:*

- consistently use safe work practices
- relate WCB and WHMIS regulations to their work environment
- analyse and evaluate potential workplace hazards and demonstrate appropriate action
- demonstrate an understanding of industrial hygiene, including air quality issues
- practise good “housekeeping” techniques

**Suggested Instructional Strategies**

- Demonstrate safe use of tools and equipment. Then have students use a variety of tools and equipment in accordance with prescribed safety procedures.
- As a class, have students conduct a monthly safety inspection of the metal shop and the equipment. Have them report their findings.
- Have students assess a variety of processes and determine the safety issues associated with metal shop processes such as:
  - oxy-acetylene cutting
  - welding
  - grinding
  - solvent and abrasive cleaning
  - machining.
- Have students in small groups consider ways of improving or modifying the work environment (e.g., tools, equipment, accessories, materials) that would eliminate or reduce safety hazards and help prevent accidents. Groups then report their findings to the class or produce a written report.
- Discuss hazards associated with the use of solvents and cleaning agents in a metal shop environment. Examples include the following:
  - many solvents will pass right through skin, and rubber gloves may be required
  - students should not weld on materials that are wet with any solvents (e.g., when thinners are exposed to the heat and light of an arc, deadly phosgene gas may be produced).
**Suggested Assessment Strategies**

- As students work in the shop, observe the extent to which they are able to:
  - demonstrate safe use of tools and equipment
  - demonstrate safe handling of potentially hazardous materials
  - utilize safe and healthy work practices.
- When students set up to work on a specific or project-related task, consider the extent to which their work spaces:
  - reflect an understanding of ergonomics
  - allow for flexibility of application.
- Use a checklist to record observations concerning students’ comprehension and application of safety procedures when using welding equipment. The checklist might include items such as:
  - appropriate personal safety gear (e.g., hand, skin, and eye protection; no nylon or polyester clothing)
  - consideration for safety of other students (e.g., use of screens)
  - work area is safe from flammable materials
  - correct welding technique.

**Recommended Learning Resources**

### Print Materials

- Jewelry: Two Books in One
- Machinery’s Handbook, 26th Edition
- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Technology of Machine Tools, 5th Edition
- Trades Common Core: Line J - Oxyacetylene Cut and Weld
- Welder Training Program: Level B
- Welder Training Program: Level C
- Welding Technology Fundamentals

### Video

- Arc Welding Explained: Basic Principles
- Fabricating a Tool Box
It is expected that students will:

- interpret orthographic and pictorial drawings
- produce detailed shop sketches
- describe and execute the processes required to complete a project
- organize task-related workspace
- communicate technical information effectively
- prepare a bill of materials and a cutting list
- apply responsible environmental and social considerations in metal fabrication and machining
- demonstrate proficiency in the application of employability skills
- identify strategies for successful transition from school to work or further education

Suggested Instructional Strategies

- Focusing on a specific project, have students perform a cost analysis exercise showing the costs of the various inputs required to deliver it to the end user (e.g., raw materials, labour, marketing and distribution costs).
- Have students conduct research to find out where and how metal waste can be re-claimed or recycled. Have them share their findings in class, discussing the pros and cons of various approaches to dealing with metal waste.
- Have students interview a college instructor or tradesperson, prepare a résumé, or visit a post-secondary school to identify available opportunities as well as qualifications and attributes needed for further work in metal fabrication and machining. Have them report on their findings.
- Have students design a flowchart showing the various steps involved in completing a project. The flowchart could include information on materials, equipment, processes, and completion scheduling.
- When students begin a new project or modify an existing project, have them sketch their plans and ideas before proceeding.
- As a class, discuss what makes a well-organized, safe work space.
- Invite employers to speak to the class about required employability skills (reliability, initiative, etc.). Follow up by having students discuss ways of practising these skills in the school setting.
Suggested Assessment Strategies

- Assess students’ initial project plans before they begin creating actual project items. Consider the extent to which:
  - working drawings effectively communicate ideas
  - project design concepts are appropriate.
- When assessing students’ in-class participation, consider the extent to which they exhibit appropriate employability skills.
- Have students disassemble a simple piece of equipment or shop apparatus, using an appropriate sequence and recording procedure. Assess the work by noting the extent to which students:
  - cleaned and labelled each part
  - sketched the item as a whole and the individual pieces during disassembly
  - marked and recorded which part was removed from which area
  - identified needed repairs, and parts to be fixed or ordered and replaced
  - completed work within specified timelines.
- Supply information about a piece of equipment that is broken and stuck in the bush. Have students in groups compile a list of what they would require to deal with the problem. Assess their work by considering how well they plan a response to the situation, using questions such as:
  - What hazards does the location present?
  - Do they have appropriate gear for the external conditions?
  - Can they collect the necessary materials?
  - Do they have a vehicle that can provide for their needs?
  - Are they aware of the repair time involved?
  - What contingency exists if time required is a lot longer than expected?
  - Are they skilled in the needed repairs?
  - Will part of the job call for special equipment or expertise (e.g., a welding truck)?
  - Where does the cost outweigh the effort?

Recommended Learning Resources

Print Materials

- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Technology of Machine Tools, 5th Edition
- Welder Training Program: Level C

Video

- Fabricating a Tool Box
PRESCRIBED LEARNING OUTCOMES

It is expected that students will:

• demonstrate proficiency in using a variety of measuring instruments
• demonstrate proficiency in using ratios, geometric concepts, and trigonometric formulae to solve layout and machining problems
• demonstrate proficiency in solving problems that involve variables for cutting feeds and speeds for drill, lathe, and milling processes

SUGGESTED INSTRUCTIONAL STRATEGIES

• Have students use an appropriate reference chart or machinery handbook to calculate speeds and feed rates for a variety of materials and cutters and for rpm (rate of travel).
• Have students measure various imperial and metric threads using a variety of methods.
• Challenge students to:
  - lay out and make a sheet metal funnel
  - lay out and make a sheet metal square to round transition.
• Have students calculate the circumference of a piece of stock and relate it to sfpm cutting rates suggested in the machinery handbook.
• Have students calculate the volume of a wax model and sprue and convert to weight in pewter, silver, or gold.
• Have students calculate the gear ratio for a mini-bike (engine running 3000 rpm with a $\varnothing$ 25 cm wheel going 25 km/h).
• Have students do the calculations related to generating a thread on a lathe.
• As a class, develop a formula for calculating rpm, given a cutting speed in sfpm (about 100 for H.S.S.):
  \[ \frac{CS \times 12}{\pi \times dia} \approx \frac{CS \times 4}{dia} \quad \text{if } CS = 100 \]
  Have students simplify this formula, then use it to calculate speeds for various sizes and types of metal.
**Suggested Assessment Strategies**

- Give students a shop drawing with some missing information that can be calculated from the supplied information using simple geometry or trigonometry. Assess students’ ability to:
  - select an appropriate computational procedure
  - correctly calculate the missing information.
- Use quizzes to reinforce and assess students’ ability to:
  - calculate cutting feeds and speeds
  - convert measurements between SI and Imperial units.
- Have students set rpm to cut a given item (specify size and metal). Assess the extent to which they:
  - can explain the reasons for the settings they have chosen
  - can describe the procedure they used to calculate the settings.
- As students operate machines, perform random checks to verify that they are using correct cutting speeds.
- As students gather information about a multiple-pulley drill press, observe to what extent they correctly identify the:
  - drive pulley sizes
  - driven pulley sizes
  - ratio of rpm increase or decrease.
- Have each student use a compass and rule to lay out the following shapes to prescribed sizes:
  - hexagon
  - octagon
  - right-angle triangle
  - rectangle
  - square
  - quarter circle.
  When assessing students’ results, look for:
  - evidence that proper methods have been used to develop geometric shapes
  - regularity of the sides of each figure
  - adherence to the prescribed size parameter
- Give students drawings of several tapered shafts to be machined. Have them calculate the compound slide angle setting to machine each shaft. Assess the extent to which students:
  - construct an appropriate right-angle triangle
  - use the correct trigonometry function
  - arrive at the correct angle setting.

**Recommended Learning Resources**

**Print Materials**

- Jewelry: Two Books in One
- Machinery’s Handbook, 26th Edition
- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Practical Problems in Mathematics for Manufacturing, 4th Edition
- Practical Problems in Mathematics for Welders, 4th Edition
- Technology of Machine Tools, 5th Edition
- Welder Training Program: Level C
**Prescribed Learning Outcomes**

It is expected that students will:

- explain the purposes of, and proficiently use, a variety of:
  - layout tools
  - hand tools
  - measuring instruments
  - forging and casting tools and equipment
  - sheet metal tools and equipment
- identify, explain the purposes of, and use the following cutting accessories:
  - carbide, high speed steel, and countersink and drill bits
  - end, slot, and face mills
  - reamers
- identify, explain the purposes of, and use the following work holding devices:
  - three-jaw chuck and four-jaw chuck
  - centres
- identify, explain the purposes of, and use the following welding equipment:
  - oxygen and acetylene regulators
  - heating, cutting, and welding tips
  - safety devices
  - oxygen and fuel cylinders and hoses
  - arc welding machines
- identify needed repairs or replacements for broken or used parts
- perform basic maintenance procedures, as directed, for:
  - lathe, milling, drilling, and grinding tools and machines
  - oxy-acetylene and other welding tools and machines
  - forging and foundry tools
  - hand tools
  - sheet metal tools and machines
- consistently demonstrate proper storage techniques for tools and equipment

**Suggested Instructional Strategies**

- Have students demonstrate the “rocking” technique when using inside and outside micrometers.
- Have students complete a research paper on EDM (electrical discharge machining) and its uses.
- As a class, discuss the various fuels used in oxy-fuel welding, and present the pros and cons of acetylene vs. other fuels (e.g., natural gas, propane).
- Group students and assign each group a simple project (e.g., drill press vise, cold chisel), providing drawings as required. Have each group:
  - determine which tools or equipment should be used to complete the project
  - explain the set-up requirements for the needed operations on each piece of equipment.
  As an extension, have the groups build the assigned item, using the appropriate tools and equipment.
- Divide the class into small groups and assign a tool or piece of equipment to each group. Have each group develop, and present to the class, a list of safe operating procedures and uses for the tool or equipment.
- Have students demonstrate their knowledge of safety requirements by properly setting up and using each piece of equipment.
- Have students work in groups to decide which piece of equipment they would choose if they had only one choice. Each group should provide a rationale for its decision, and describe the range of work possible and limitations of the selected piece of equipment.
- Have students debate the respective merits of lathes and milling machines to address the question, “Which is the most versatile piece of equipment?”


**SUGGESTED ASSESSMENT STRATEGIES**

- To what extent do students demonstrate appropriate “feel” when using measuring tools?
- Provide students with a project drawing and assess their ability to identify:
  - an appropriate sequence of operations
  - appropriate tools or equipment to be used.
- As students perform operations using tools and equipment, have them verbally describe what they are doing. Assess the extent to which they:
  - clearly understand the sequence of operations
  - include all necessary steps
  - make procedural decisions independently
  - make appropriate procedural decisions
  - take all requisite safety measures.
  
  Correct errors, omissions, or misunderstandings as the students work.
- Use short quizzes to assess students’ ability to:
  - identify particular tools and their purposes
  - explain how tools and equipment should be used
  - describe safety considerations associated with the use of particular tools.
- Assess students’ ability to use scales, micrometers, or Vernier calipers to measure the sizes of given pieces of metal.
- After students (working individually or in groups) determine the tools and equipment needed for a given project, have peers review and correct or supplement each others’ work.
- Display a variety of cutters, and assess each student’s ability to identify them and describe their uses.
- Develop a simple checklist of procedures associated with operating more sophisticated tools or equipment (e.g., wear eye protection, use micrometer properly). Use this to record each student’s performance.

**RECOMMENDED LEARNING RESOURCES**

**Print Materials**

- Jewelry: Two Books in One
- Machinery’s Handbook, 26th Edition
- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Technology of Machine Tools, 5th Edition
- Trades Common Core: Line J - Oxyacetylene Cut and Weld
- Welder Training Program: Level B
- Welder Training Program: Level C
- Welding Technology Fundamentals

**Video**

- Arc Welding Explained: Basic Principles
- Arc Welding Explained: Gas Metal, Flux Cored - Arc Welding (MIG)
- Fabricating a Tool Box
- Gas Tungsten Arc Welding: Getting Started
- Introduction to Welding Series: Shielded Metal Arc Welding
**Prescribed Learning Outcomes**

*It is expected that students will:*

- explain the basic principles of metallurgy
- describe the properties of a variety of metals
- interpret metal classification and identification systems
- perform, describe, and identify the uses of the following heat treatment processes:
  - normalizing
  - hardening
  - tempering
  - annealing
- describe various materials used in art metal and jewellery and their functions
- demonstrate a knowledge of the characteristics of plastics used in metal-related industries
- demonstrate a knowledge of the characteristics of bonding and gluing (adhesive) materials used in metal-related industries

**Suggested Instructional Strategies**

- Have students use a reference book to compile a list of classification systems for non-ferrous metals (e.g., gold, silver, brass, copper).
- Present the AISI/SAE numbers for several common steel alloys. Have students use a reference source to determine the type of alloy used and its carbon content (e.g., the “chrome-moly” steel in a bike frame is typically 4130).
- To help students understand annealing, have them file the ends smooth on a short piece of carbon steel (Ø 19 mm x 25 mm) and then weld a bead on one end. Have them use an old file to try filing the other end (it initially should be too hard). Now the student can anneal the piece for “machineability.”
- Have students explain the reason for selecting a particular material (including plastic) in a particular fabrication or machining situation.
- Have students use wax rods of various shapes to create wax models for pieces of jewellery.
- Have students select a project and explain their choice of material by listing the function of the part, the material used, and the reason for using that material.
- Show a video about destructive and nondestructive testing. Have students summarize the differences and comment on when each type would be appropriate.
- Have students design and complete a project that incorporates heat-treatment.
**Suggested Assessment Strategies**

- Have students develop a list of materials required to complete a process or a project. Evaluate the lists for completeness and relevance of included items.

- Have students prepare a written or oral report on the process involved in producing a particular metal, from mining through to smelting or alloying, as applicable. Assess the extent to which the reports:
  - are clear and concise
  - provide complete explanations
  - provide accurate information, drawing upon valid sources.

- Have students determine the carbon content of a metal sample using the spark test. Assess their ability to identify high and low carbon contents.

- Challenge students to explain (orally or in writing) the rationale for having AISI or SAE standards and associations. When assessing, consider the extent to which they recognize the importance of common standards in improving global trade networks.

- Have students explain why certain shapes have structural integrity, while others do not. Assess the extent to which their explanations recognize:
  - principles of geometry
  - different types of strength (tensile, shear, etc.)

- Use a written test to assess student familiarity with reading an SAE/AISI number chart.

- Ask students to relate the purposes and the pros and cons of various surface treatments: etching, bluing, coatings (anodizing, enameling, powder coating, chroming), buffing or polishing. Assess the extent to which students consider:
  - surface preparation requirements
  - corrosion resistance
  - durability
  - safety of application
  - environmental responsibility.

**Recommended Learning Resources**

### Print Materials

- Jewelry: Two Books in One
- Machinery’s Handbook, 26th Edition
- Machining Fundamentals: From Basic to Advanced Techniques
- Metalwork: Technology and Practice, 9th Edition
- Technology of Machine Tools, 5th Edition
- Trades Common Core: Line J - Oxyacetylene Cut and Weld
- Welder Training Program: Level B
- Welder Training Program: Level C
**Prescribed Learning Outcomes**

*It is expected that students will:*

- demonstrate proficiency in the use of common hand tools for cutting metal
- demonstrate proficiency in the use of common sheet metal cutting tools
- set up and perform the following cutting processes on a lathe:
  - facing, parallel, and taper turning
  - boring
  - threading
  - parting
- demonstrate proficiency in using a milling machine for squaring of materials, flat surface cutting, and keyway cutting
- demonstrate proficiency in cutting using:
  - bench/pedestal grinders
  - portable grinders
  - abrasive cut-off saws
- identify and describe the uses for precision grinding machines
- set up and use various cutting machines to perform countersinking, reaming, counter boring, and spot facing
- demonstrate proficiency in performing power saw cutting
- set up and use oxy-acetylene cutting equipment to pierce and to perform linear, circular, and bevel cuts
- select appropriate cutting tools for given cutting tasks
- describe CNC cutting processes
- describe air arc, plasma, high-pressure water, and laser cutting processes

**Suggested Instructional Strategies**

- Use printed reference materials or a video to introduce new cutting processes for the drill press, milling machine, and lathe. Follow with a class discussion.
- When introducing flat surface cutting or squaring operations using the milling machine, have students:
  - use an end mill, plain milling cutter, or face mill
  - employ the T-bolt and hold-down method, as well as the vise, to secure work.
- Have students use a milling machine to make a V-block with a keyway in the centre of one or more of the surfaces.
- Have students practise using a lathe to:
  - turn three different threads
  - turn a Morse taper centre drill holder.
- As part of their work on the lathe, have students:
  - produce work to specific dimensions using a micrometer or Vernier caliper and the graduated collars on the cross-slide
  - use the single point cutter and the boring bar for internal boring
  - use face plate, dog, and live centre for machining between centres
  - set up work in a four-jaw chuck, using a surface gauge and/or dial indicator
  - use the automatic feed system.
- Have students set up and use oxy-acetylene equipment to:
  - lay out and accurately cut a square plate
  - pierce a hole to fit a bolt
  - wash off the head of the bolt without damaging the plate.
- Use a video followed by class discussion to introduce CNC. Arrange a field trip to a shop that uses CNC equipment.
- Have students use sheet metal tools to cut and form a small project such as a locker shelf.
**Suggested Assessment Strategies**

- Provide students with a drawing of a specific project item and assess their ability to identify:
  - the most appropriate cutting processes
  - the appropriate sequence of operations when machining.
- Present students with a selection of milling cutters to assess students’ ability to correctly identify them and select appropriate cutters, given specific applications.
- While assessing cutting work, observe or monitor the extent to which students:
  - follow safe work practices
  - develop an appropriate machining sequence for given tasks
  - use precision instruments to machine to specific dimensions and produce accurate finished work
  - produce an acceptable surface finish.
- As students begin to use cutting processes, observe and consider the extent to which they are able to solve problems associated with:
  - cutter selection
  - setup of work and cutter
  - cutting speed and automatic feeding
  - dimension control and surface finish.
- To assess student comprehension and ability to machine a thread using the lathe, provide an assignment that requires the calculation of thread pitch, depth, and/or diameter. Note how well the student is able to set up the lathe and cut the thread to its calculated dimensions.
- Summative assessment of student’s ability to appropriately select and use cutting processes should occur in relation to prescribed practical assignments or student-selected projects.

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**Recommended Learning Resources**

**Print Materials**

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- Trades Common Core: Line J - Oxyacetylene Cut and Weld
- Welder Training Program: Level C
- Welding Technology Fundamentals

**Video**

- Fabricating a Tool Box
It is expected that students will:

- describe types and uses of a variety of joining and forming processes
- describe and use welding electrodes commonly employed in industry
- describe and apply the following common and advanced welding processes:
  - oxy-acetylene
  - SMAW (stick)
  - GMAW (wire feed)
  - GTAW (gas-tungsten arc welding)
  - resistance
- identify uses and applications of forging processes
- produce a forged object
- produce a cast object
- identify and describe common and industrial fastening methods
- explain the meaning of welding symbols in technical drawings
- demonstrate proficiency in producing arc welds in flat and horizontal positions
- join metals using the following oxy-acetylene welding methods:
  - braze welding
  - soldering
  - fusion welding

Prior to having students begin a project, provide relevant explanations and demonstrations, and assign practice welding exercises that might include:

- braze weld and fusion weld three consecutive 100 mm long beads, using oxy-acetylene
- SMAW and GMAW fillet welds
- 6010 or 6011 padding (overlapping beads covering a 75 mm x 75 mm square pad)
- 7018 padding.

Provide a list of projects that incorporate a variety of common or advanced forming and joining processes (i.e., welding, forging, casting, and fastening). Have students select and build one or more of these projects to demonstrate proficiency in using the forming and joining processes and any other needed processes (e.g., cutting).

Present students with a variety of welding situations (e.g., broken steel beam, torn sheet metal) and have them suggest an appropriate welding process. Discuss why some processes would work, and others would not. If SMAW is appropriate, have students discuss which electrodes would work well, which would not, and why.

Have students build a small utility box, 8 cm x 8 cm x 4 cm. They should use oxy-acetylene steel welds on all corners, and puddle along the top edge to round.

Invite a certified welder to demonstrate welding a fillet horizontally and vertically (up). Have students practise these welds while the guest welder observes and provides feedback.

Have students choose a piece of equipment (e.g., compressor, bicycle), list the different fastening methods used, and explain why each was used.

Have students forge a small tool to develop skills associated with the heat treatment and forging processes.
**SUGGESTED ASSESSMENT STRATEGIES**

- Have students list as many fastening methods as possible. Assess the comprehensiveness of their lists, looking for inclusions such as:
  - keys
  - pins
  - set screws
  - rivets
  - interference and clearance fits.

- When assessing students’ ability to produce a forged or cast object, consider the extent to which they produce an appropriate surface finish and exhibit:
  - safe work habits
  - effective use of time and other resources
  - design originality and elegance.

- Use the following checklist to assess students’ ability to set up oxy-acetylene welding equipment:
  - appropriate protective clothing worn
  - cylinders secured upright in cart
  - cylinder caps removed
  - cylinder valves “cracked” to remove dirt
  - regulators attached to cylinder valves (regulators closed)
  - flashback arrestors (RFCVs) attached to regulators — arrows matched to gas flow
  - hoses connected to regulator RFCVs
  - hoses blown out and matched to tanks
  - RFCVs attached to torch handle
  - hoses attached to handle RFCVs (torch valves closed)
  - welding tip attached to handle (hand-tightened only)
  - gas pressures adjusted correctly – acetylene first, oxygen next.

- Provide a diagram of the controls for GMAW (wire-feed) equipment. Have students describe the setup for a particular welding operation. Assess students’ ability to:
  - choose the correct electrode
  - use the correct electrode position
  - select appropriate amperage settings, given various types and thicknesses of metal or various types of joints.

- Assess students’ ability to:
  - identify the type of welding called for by each symbol on a welding drawing
  - recognize a variety of weld defects (see Grade 11, Forming and Joining Processes for criteria).

**RECOMMENDED LEARNING RESOURCES**

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- Introduction to Welding Series: Shielded Metal Arc Welding
APPENDICES

Metal Fabrication and Machining 11 and 12
APPENDIX A

Prescribed Learning Outcomes
**HEALTH AND SAFETY**

*It is expected that students will:*

<table>
<thead>
<tr>
<th>Grade 11</th>
<th>Grade 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>• consistently use safe work practices</td>
<td>• consistently use safe work practices</td>
</tr>
<tr>
<td>• identify WHMIS symbols that apply to workplace materials</td>
<td>• relate WCB and WHMIS regulations to their work environment</td>
</tr>
<tr>
<td>• demonstrate a knowledge of safety features and practices associated with oxy-acetylene equipment</td>
<td>• analyse and evaluate potential workplace hazards and demonstrate appropriate action</td>
</tr>
<tr>
<td>• demonstrate a knowledge of safety features and practices associated with metal-related tools and equipment</td>
<td>• demonstrate an understanding of industrial hygiene, including air quality issues</td>
</tr>
<tr>
<td>• identify hazardous situations in the work environment and take appropriate action</td>
<td>• practise good “housekeeping” techniques</td>
</tr>
<tr>
<td>• demonstrate good “housekeeping” techniques</td>
<td></td>
</tr>
</tbody>
</table>
**Personal and Project Management**

*It is expected that students will:*

<table>
<thead>
<tr>
<th>Grade 11</th>
<th>Grade 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>• interpret drawings and produce simple sketches to communicate design ideas&lt;br&gt;• identify, organize, and execute processes required to accomplish a task&lt;br&gt;• identify and organize task-related tools and materials&lt;br&gt;• identify environmental, social, and ethical considerations associated with metal fabrication and machining&lt;br&gt;• identify and utilize employability skills&lt;br&gt;• describe career opportunities that exist in metal-related industries</td>
<td>• interpret orthographic and pictorial drawings&lt;br&gt;• produce detailed shop sketches&lt;br&gt;• describe and execute the processes required to complete a project&lt;br&gt;• organize task-related workspace&lt;br&gt;• communicate technical information effectively&lt;br&gt;• prepare a bill of materials and a cutting list&lt;br&gt;• apply responsible environmental and social considerations in metal fabrication and machining&lt;br&gt;• demonstrate proficiency in the application of employability skills&lt;br&gt;• identify strategies for successful transition from school to work or further education</td>
</tr>
</tbody>
</table>
**Mathematical Applications**

*It is expected that students will:*

<table>
<thead>
<tr>
<th>Grade 11</th>
<th>Grade 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>• demonstrate the ability to use the following measuring instruments:</td>
<td>• demonstrate proficiency in using a variety of measuring instruments</td>
</tr>
<tr>
<td>- micrometers</td>
<td>• demonstrate proficiency in using ratios, geometric concepts, and trigonometric formulae to solve layout and machining problems</td>
</tr>
<tr>
<td>- tape measures and scales</td>
<td>• demonstrate proficiency in solving problems that involve variables for cutting feeds and speeds for drill, lathe, and milling processes</td>
</tr>
<tr>
<td>- dial indicators</td>
<td></td>
</tr>
<tr>
<td>- calipers or other instruments that employ the Vernier scale</td>
<td></td>
</tr>
<tr>
<td>• demonstrate proficiency in adding, subtracting, multiplying, and dividing whole numbers, fractions, and decimals to perform layout and solve problems related to metal fabrication and machining</td>
<td></td>
</tr>
<tr>
<td>• estimate the solutions to calculations involving whole numbers, decimals, and fractions</td>
<td></td>
</tr>
<tr>
<td>• convert between Imperial and SI units</td>
<td></td>
</tr>
<tr>
<td>• demonstrate the application of basic geometry and basic trigonometry to solve problems related to angles and tapers</td>
<td></td>
</tr>
<tr>
<td>• explain the significance of tolerances</td>
<td></td>
</tr>
<tr>
<td>• interpret tables and charts</td>
<td></td>
</tr>
</tbody>
</table>
**TOOLS AND EQUIPMENT**

*It is expected that students will:*

<table>
<thead>
<tr>
<th>Grade 11</th>
<th>Grade 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>• identify, describe, and use:</td>
<td>• explain the purposes of, and</td>
</tr>
<tr>
<td>- layout tools</td>
<td>proficiently use, a variety of:</td>
</tr>
<tr>
<td>- measuring instruments</td>
<td>- layout tools</td>
</tr>
<tr>
<td>- hand tools</td>
<td>- hand tools</td>
</tr>
<tr>
<td>- lathe, milling, drilling, and grinding</td>
<td>- measuring instruments</td>
</tr>
<tr>
<td>tools and equipment</td>
<td>- forging and casting tools and</td>
</tr>
<tr>
<td>- welding machines, tools, and</td>
<td>equipment</td>
</tr>
<tr>
<td>equipment</td>
<td>- sheet metal tools and equipment</td>
</tr>
<tr>
<td>- basic forging and casting tools and equipment</td>
<td>• identify, explain the purposes of, and</td>
</tr>
<tr>
<td>- sheet metal tools and equipment</td>
<td>use the following cutting accessories:</td>
</tr>
<tr>
<td>• describe proper maintenance</td>
<td>- carbide, high speed steel, and</td>
</tr>
<tr>
<td>procedures for:</td>
<td>countersink and drill bits</td>
</tr>
<tr>
<td>- lathe, milling, drilling, and grinding</td>
<td>- end, slot, and face mills</td>
</tr>
<tr>
<td>tools</td>
<td>- reamers</td>
</tr>
<tr>
<td>- oxy-acetylene and other welding</td>
<td>• identify, explain the purposes of, and</td>
</tr>
<tr>
<td>tools and equipment</td>
<td>use the following work holding devices:</td>
</tr>
<tr>
<td>- forging and foundry tools</td>
<td>- three-jaw chuck and four-jaw chuck</td>
</tr>
<tr>
<td>- hand tools</td>
<td>- centres</td>
</tr>
<tr>
<td>- sheet metal tools</td>
<td>• identify, explain the purposes of, and</td>
</tr>
<tr>
<td>• identify needed repairs or replacements</td>
<td>use the following welding equipment:</td>
</tr>
<tr>
<td>for broken or used parts</td>
<td>- oxygen and acetylene regulators</td>
</tr>
<tr>
<td>• perform basic maintenance procedures as directed</td>
<td>- heating, cutting, and welding tips</td>
</tr>
<tr>
<td>• properly store tools and equipment</td>
<td>- safety devices</td>
</tr>
<tr>
<td>• consistently demonstrate proper storage techniques for tools and</td>
<td>- oxygen and fuel cylinders and hoses</td>
</tr>
<tr>
<td>equipment</td>
<td>- arc welding machines</td>
</tr>
</tbody>
</table>

*For Grade 12 only:*

- perform basic maintenance procedures, as directed, for:
  - lathe, milling, drilling, and grinding tools and machines
  - oxy-acetylene and other welding tools and machines
  - forging and foundry tools
  - hand tools
  - sheet metal tools and machines

- consistently demonstrate proper storage techniques for tools and equipment
**Materials**

*It is expected that students will:*

<table>
<thead>
<tr>
<th>Grade 11</th>
<th>Grade 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>• identify key developments in the history of metal production</td>
<td>• explain the basic principles of metallurgy</td>
</tr>
<tr>
<td>• identify key stages in the production of iron and steel</td>
<td>• describe the properties of a variety of metals</td>
</tr>
<tr>
<td>• identify and describe the basic characteristics of common metals</td>
<td>• interpret metal classification and identification systems</td>
</tr>
<tr>
<td>• select metal stock whose size, structural shape, and finish are appropriate for specific applications</td>
<td>• perform, describe, and identify the uses of the following heat treatment processes:</td>
</tr>
<tr>
<td>• identify common types and gauges of sheet metal</td>
<td>- normalizing</td>
</tr>
<tr>
<td>• use spark and file tests to identify ferrous metals</td>
<td>- hardening</td>
</tr>
<tr>
<td>• describe and perform the processes of hardening and tempering</td>
<td>- tempering</td>
</tr>
<tr>
<td>• describe the purposes of common surface treatments</td>
<td>- annealing</td>
</tr>
<tr>
<td></td>
<td>• describe various materials used in art metal and jewellery and their functions</td>
</tr>
<tr>
<td></td>
<td>• demonstrate a knowledge of the characteristics of plastics used in metal-related industries</td>
</tr>
<tr>
<td></td>
<td>• demonstrate a knowledge of the characteristics of bonding and gluing (adhesive) materials used in metal-related industries</td>
</tr>
</tbody>
</table>
### Cutting Processes

*It is expected that students will:*

<table>
<thead>
<tr>
<th>Grade 11</th>
<th>Grade 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>• perform cutting processes in a safe manner</td>
<td>• demonstrate proficiency in the use of common hand tools for cutting metal</td>
</tr>
<tr>
<td>• use common hand tools for cutting metal</td>
<td>• demonstrate proficiency in the use of common sheet metal cutting tools</td>
</tr>
<tr>
<td>• use common sheet metal cutting tools</td>
<td>• set up and perform the following cutting processes on a lathe:</td>
</tr>
<tr>
<td>• set up and perform the following cutting processes on a lathe:</td>
<td>- facing</td>
</tr>
<tr>
<td>- facing</td>
<td>- parallel turning to size</td>
</tr>
<tr>
<td>- parallel turning to size</td>
<td>- drilling</td>
</tr>
<tr>
<td>• set up and perform flat surface cutting and slotting on a milling machine</td>
<td>• set up and perform flat surface cutting and slotting on a milling machine</td>
</tr>
<tr>
<td>• set up and perform grinding processes using:</td>
<td>• demonstrate proficiency in using a milling machine for squaring of materials, flat surface cutting, and keyway cutting</td>
</tr>
<tr>
<td>- bench/pedestal grinders</td>
<td>• demonstrate proficiency in cutting using:</td>
</tr>
<tr>
<td>- portable grinders</td>
<td>- bench/pedestal grinders</td>
</tr>
<tr>
<td>- abrasive cut-off saws</td>
<td>- portable grinders</td>
</tr>
<tr>
<td>• set up and perform drilling and countersinking processes using a drill press</td>
<td>- abrasive cut-off saws</td>
</tr>
<tr>
<td>• set up and perform power sawing processes</td>
<td>• identify and describe the uses for precision grinding machines</td>
</tr>
<tr>
<td>• describe oxy-acetylene cutting</td>
<td>• set up and use various cutting machines to perform countersinking, reaming, counter boring, and spot facing</td>
</tr>
<tr>
<td>• set up and use oxy-acetylene equipment to perform short linear cuts freehand</td>
<td>• demonstrate proficiency in performing power saw cutting</td>
</tr>
<tr>
<td>• select the appropriate cutting tool for a given cutting task</td>
<td>• set up and use oxy-acetylene cutting equipment to pierce and to perform linear, circular, and bevel cuts</td>
</tr>
<tr>
<td></td>
<td>• select appropriate cutting tools for given cutting tasks</td>
</tr>
<tr>
<td></td>
<td>• describe CNC cutting processes</td>
</tr>
<tr>
<td></td>
<td>• describe air arc, plasma, high-pressure water, and laser cutting processes</td>
</tr>
</tbody>
</table>
FORMING AND JOINING PROCESSES

It is expected that students will:

<table>
<thead>
<tr>
<th>Grade 11</th>
<th>Grade 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>• execute forming and joining processes in a safe manner</td>
<td>• describe types and uses of a variety of joining and forming processes</td>
</tr>
<tr>
<td>• describe the characteristics and uses of the following common welding processes:</td>
<td>• describe and use welding electrodes commonly employed in industry</td>
</tr>
<tr>
<td>- oxy-acetylene</td>
<td>• describe and apply the following common and advanced welding processes:</td>
</tr>
<tr>
<td>- SMAW (stick)</td>
<td>- oxy-acetylene</td>
</tr>
<tr>
<td>- GMAW (wire feed)</td>
<td>- SMAW (stick)</td>
</tr>
<tr>
<td>• identify types and uses of common SMAW electrodes</td>
<td>- GMAW (wire feed)</td>
</tr>
<tr>
<td>• set up and join steel parts using fillet and butt welds in flat position</td>
<td>- GTAW (gas-tungsten arc welding)</td>
</tr>
<tr>
<td>• identify and use a variety of common mechanical fastening methods</td>
<td>- resistance</td>
</tr>
<tr>
<td>• demonstrate the ability to lay out, form, and join sheet metal using a variety of methods</td>
<td>• identify uses and applications of forging processes</td>
</tr>
<tr>
<td>• describe types and uses of casting</td>
<td>• produce a forged object</td>
</tr>
<tr>
<td>• produce a simple cast object using an open, closed, or lost wax mold</td>
<td>• produce a cast object</td>
</tr>
<tr>
<td>• identify uses and applications of forging processes</td>
<td>• identify and describe common and industrial fastening methods</td>
</tr>
<tr>
<td>• shape a piece of metal using a forging process</td>
<td>• explain the meaning of welding symbols in technical drawings</td>
</tr>
<tr>
<td></td>
<td>• demonstrate proficiency in producing arc welds in flat and horizontal positions</td>
</tr>
<tr>
<td></td>
<td>• join metals using the following oxy-acetylene welding methods:</td>
</tr>
<tr>
<td></td>
<td>- braze welding</td>
</tr>
<tr>
<td></td>
<td>- soldering</td>
</tr>
<tr>
<td></td>
<td>- fusion welding</td>
</tr>
</tbody>
</table>
APPENDIX B

Learning Resources
General Information
APPENDIX B: LEARNING RESOURCES • General Information

**What is Appendix B?**

Appendix B consists of general information on learning resources, as well as Grade Collection information and alphabetical annotations of the provincially recommended resources.

**What is a Grade Collection?**

A Grade Collection is the format used to organize the provincially recommended learning resources by grade and by curriculum organizer. It can be regarded as a “starter set” of basic resources to deliver the curriculum. In many cases, the Grade Collection provides a choice of more than one resource to support curriculum organizers, enabling teachers to select resources that best suit different teaching and learning styles.

There may be prescribed learning outcomes either partially or not at all supported by learning resources at this time. Many of these are best met by teacher-developed activities. Teachers may also wish to supplement Grade Collection resources with locally selected materials.

**What kinds of resources are found in a Grade Collection?**

Learning resources in a Grade Collection are categorized as either comprehensive or additional. Comprehensive resources provide a broad coverage of the learning outcomes for most curriculum organizers. Additional resources are more topic specific and support individual curriculum organizers or clusters of outcomes. They provide valuable support for or extension to specific topics and are typically used to supplement or fill in the areas not covered by the comprehensive resources.

**How are Grade Collections kept current?**

Under the provincial continuous submissions process, suppliers advise the ministry about newly developed resources as soon as they are released. Resources judged to have a potentially significant match to the learning outcomes for individual IRPs are evaluated by practising classroom teachers who are trained by ministry staff to use provincial evaluation criteria. Resources selected for provincial recommendation receive Ministerial Order and are added to the existing Grade Collections. The ministry updates the Grade Collections on a regular basis on the ministry web site (http://www.bced.gov.bc.ca/irp_resources/1r/resource/gradcoll.htm). Please check this site for the most current version of Appendix B.

**How long do learning resources keep their recommended status?**

Learning resources will retain their recommended status for a minimum of five years after which time they may be withdrawn from the Grade Collections, thereby terminating their provincially recommended status. Decisions regarding the withdrawal of learning resources will be based on, but not limited to, considerations of curriculum support, currency, and availability. Schools may continue to use a learning resource after withdrawal provided local school board approval is obtained.

**How can teachers choose learning resources to meet their classroom needs?**

As outlined in Evaluating, Selecting and Managing Learning Resources: A Guide (Revised 2000), there are a number of approaches to selecting learning resources. Teachers may choose to use:

- provincially recommended resources to support provincial or locally developed curricula
- resources that are not on the ministry’s provincially recommended list (resources that are not on the provincially recommended list must be evaluated through a local, board-approved process).
The Ministry of Education has developed a variety of tools and guidelines to assist teachers with the selection of learning resources. These include:

- Grade Collection(s) in each IRP. Each Grade Collection begins with a chart which lists both comprehensive and additional resources for each curriculum organizer. The chart is followed by an annotated bibliography with supplier and ordering information (price and supplier information should be confirmed at the time of ordering).
- Resource databases on CD-ROM or on-line
- Sets of recommended learning resources are available in a number of host districts throughout the province to allow teachers to examine the materials first hand at regional displays.
- **Catalogue of Recommended Learning Resources**

**WHAT ARE THE CRITERIA TO CONSIDER WHEN SELECTING LEARNING RESOURCES?**

There are a number of factors to consider when selecting learning resources.

**Content**

The foremost consideration for selection is the curriculum to be taught. Prospective resources must adequately support the particular learning objectives that the teacher wants to address. Teachers will determine whether a resource will effectively support any given learning outcomes within a curriculum organizer. This can only be done by examining descriptive information regarding that resource; acquiring additional information about the material from the supplier, published reviews, or colleagues; and by examining the resource first-hand.

**Instructional Design**

When selecting learning resources, teachers must keep in mind the individual learning styles and abilities of their students, as well as anticipate the students they may have in the future. Resources should support a variety of special audiences, including gifted, learning disabled, mildly intellectually disabled, and ESL students. The instructional design of a resource includes the organization and presentation techniques; the methods used to introduce, develop, and summarize concepts; and the vocabulary level. The suitability of all of these should be considered for the intended audience.

Teachers should also consider their own teaching styles and select resources that will complement them. The list of recommended resources contains materials that range from prescriptive or self-contained resources, to open-ended resources that require considerable teacher preparation. There are recommended materials for teachers with varying levels and experience with a particular subject, as well as those that strongly support particular teaching styles.

**Technical Design**

While the instructional design of a package will determine the conceptual organization, it is the technical design that brings that structure into reality. Good technical design enhances student access and understanding. Poor technical quality creates barriers to learning. Teachers should consider the quality of photographs and illustrations, font size and page layout, and durability. In the case of video, audible and age-appropriate narration and variation in presentation style should be considered. When selecting digital resources, interactivity, feedback, constructive engagement, usability, and functionality are important.
Social Considerations

An examination of a resource for social considerations helps to identify potentially controversial or offensive elements which may exist in the content or presentation. Such a review also highlights where resources might support pro-social attitudes and promote diversity and human rights issues.

The intent of any Social Considerations screening process, be it at the local or provincial level, is not to remove controversy, but to ensure that controversial views and opinions are presented in a contextual framework.

All resources on the ministry’s recommended list have been thoroughly screened for social concerns from a provincial perspective. However, teachers must consider the appropriateness of any resource from the perspective of the local community.

Media

When selecting resources, teachers should consider the advantages of various media. Some topics may be best taught using a specific medium. For example, video may be the most appropriate medium when teaching a particular, observable skill, since it provides a visual model that can be played over and over or viewed in slow motion for detailed analysis. Video can also bring otherwise unavailable experiences into the classroom and reveal “unseen worlds” to students. Software may be particularly useful when students are expected to develop critical-thinking skills through the manipulation of a simulation, or where safety or repetition are factors. Print or CD-ROM resources can best be used to provide extensive background information on a given topic. Once again, teachers must consider the needs of their individual students, some of whom may learn better from the use of one medium than another.

Use of Information Technology

Teachers are encouraged to embrace a variety of educational technologies in their classrooms. To do so, they will need to ensure the availability of the necessary equipment and familiarize themselves with its operation. If the equipment is not currently available, then the need must be incorporated into the school or district technology plan.

What Funding Is Available for Purchasing Learning Resources?

As part of the selection process, teachers should be aware of school and district funding policies and procedures to determine how much money is available for their needs. Funding for various purposes, including the purchase of learning resources, is provided to school districts.

Learning resource selection should be viewed as an ongoing process that requires a determination of needs, as well as long-term planning to co-ordinate individual goals and local priorities.

Existing Materials

Prior to selecting and purchasing new learning resources, an inventory of those resources that are already available should be established through consultation with the school and district resource centres. In some districts, this can be facilitated through the use of district and school resource management and tracking systems. Such systems usually involve a computer database program (and possibly bar-coding) to help keep track of a multitude of titles. If such a system is put on-line, then teachers can check the availability of a particular resource via computer.
This section begins with an overview of the comprehensive resources for this curriculum, then presents Grade Collection charts for each grade. These charts list both comprehensive and additional resources for each curriculum organizer for the grade. The charts are followed by an annotated bibliography. Teachers should check with suppliers for complete and up-to-date ordering information. Most suppliers maintain web sites that are easy to access.
TECHNOLOGY EDUCATION 11 AND 12: METAL FABRICATION AND MACHINING GRADE COLLECTIONS

Each Grade Collection lists the recommended resources that match the greatest number of prescribed learning outcomes for that grade and subject.

Grade Collections are not prescriptive; they are intended to provide assistance and advice only. Teachers are encouraged to select additional resources to meet their specific classroom needs. It is recommended that teachers use the Technology Education 11 and 12: Metal Fabrication and Machining IRP when making resource decisions.

Resources that are identified through the Continuous Submission process as having strong curriculum match will be added to the Collections as they become available. Information about new Provincially Recommended Resources can be found at: www.bced.gov.bc.ca/irp_resources/lr/resource/res_main.htm

This site is updated and resources are organized according to the IRP.

Categories of Resources

Learning resources selected for each Grade Collection have been categorized as either comprehensive or additional.

- **Comprehensive resources** tend to provide a broad coverage of the learning outcomes for most curriculum organizers.

- **Additional resources** are more topic-specific and support individual curriculum organizers or clusters of outcomes. They are recommended as valuable support or extension for specific topics. Additional resources will typically be used to supplement or fill in the areas not covered by the comprehensive resources.

In many cases, Grade Collections provide more than one resource to support specific outcomes, enabling teachers to select resources that best match different teaching and learning styles.

Outcomes Not Supported By Resources

There may be prescribed learning outcomes either partially or not at all supported by learning resources at this time. Many of these could be met by teacher-developed activities.

Grade Collection Information

The following pages begin with an overview of the comprehensive resources for this curriculum, then present Grade Collection charts for each course. These charts list both comprehensive and additional resources for each curriculum organizer for the grade. Please confirm with the suppliers for complete and up-to-date ordering information. Each chart is followed by an annotated bibliography. There is also a chart that shows the alphabetical list of Grade Collection titles for each grade and a blank template that can be used by teachers to record their individual choices.

OVERVIEW OF COMPREHENSIVE RESOURCES FOR METAL FABRICATION AND MACHINING 11 AND 12

- **Exploring Metalworking: Fundamentals of Technology**  
  (Grade 11)

This comprehensive print package includes a textbook, workbook, and instructor’s guide. It can be considered an introductory course in the fundamentals of working with metal, using both hand and power tools.

*Exploring Metalworking* provides constructional details on carefully selected projects, and includes alternate designs and design variations which will help students design their own projects. The text consists of 19 chapters, as well as glossary, tables and index sections.
There are numerous illustrations, and over 100 projects and design problems. The projects range from constructing a wire wall plaque to using an NC milling machine. Most areas of metalworking are presented: foundry, lathe work, art metal, sheet metal, forging, jewelry making, etc.

- **Machining Fundamentals: From Basic to Advanced Techniques**  
  (Grades 11 and 12)

This is an excellent resource that deals specifically with the machining of metals. The advantages and disadvantages of various machining techniques are discussed, along with their suitability for particular applications.

*Machining Fundamentals* also covers newer processes such as laser machining and welding, water-jet cutting, chipless machining, and rapid prototyping. The importance of computer numerical control (CNC) in the operation of most machine tools, and its role in automated manufacturing is explored thoroughly.

Learning objectives are presented at the beginning of each of the 30 chapters, along with a list of selected technical terms. Throughout the book, technical terms are highlighted in bold italic type as they are introduced and defined. Review questions covering the content taught are presented at the end of each chapter.

The major topics are colour-coded, and safety notes are highlighted in red.

The entire resource package includes a textbook, workbook, and instructor’s manual.

- **Metalwork: Technology and Practice, 9th Edition**  
  (Grades 11 and 12)

*Metalwork: Technology and Practice* is a comprehensive resource that includes a 700-page textbook, an instructor’s resource guide, and a student workbook—provides laboratory experiences in metal fabrication. Technical terms are highlighted and listed in alphabetical order at the end of each unit, along with review questions. Measurements are given in U.S. Customary units followed by their S.I. Metric equivalents. Numerous illustrations enable the student to make connections easily between work in the school shop and industrial practice. A product section assists the student in learning and developing metalworking skills. Each product presentation includes a working drawing, pictorial drawing, list of materials, and suggested construction notes.

The instructor’s resource guide has several major components. For example: In Section II, the broad goals commonly accepted in Technology Education are discussed and then related to a general metalworking course. General guidelines are given for the identification of special needs students; and suggestions for encouraging the development of entrepreneurship, consumer awareness, and leadership. Section IV contains brief introductions to 23 parts of the textbook and summaries of content for each unit within a part. Lists of educational objectives for each unit and concise answers to each unit’s Review Questions are also included, followed by teaching suggestions for the entire part. Also included are an answer key, projects, visual masters, and a correlation chart that lists the science and math concepts covered in the textbook.

Each unit in the student workbook can serve as a review of the corresponding text material. Advanced students may be challenged by extra readings in the text and related assignments in the workbook.

Note: This resource does not cover any welding techniques.

- **Technology of Machine Tools, 5th Edition**  
  (Grades 11 and 12)

This comprehensive resource (869-page text, instructor’s manual, and workbook) has been designed as a cohesive teaching system to assist
teachers in presenting the most up-to-date
course in machine trades. It focuses on past and
present manufacturing equipment and
processes, and introduces new ideas that are on
the cutting edge of emerging technologies.
Some of the highlights include updates on
careers, modular training systems, electronics
and digital measuring tools, conventional and
programmable lathes, and CNC tools.

The instructor’s manual contains answers to all
textbook review questions, additional projects,
and answers to the workbook tests.

- **Welding Technology Fundamentals**
  (Grades 11 and 12)

This comprehensive 365-page text book and
accompanying Laboratory Manual cover the
equipment and techniques used for the welding
and cutting processes most often employed in
industry today. These processes are: oxyfuel gas
welding and cutting, shielded metal arc
welding, gas metal arc welding, flux cored arc
welding, gas tungsten arc welding, and
resistance welding.

The textbook contains information about
welding careers and the physics of welding.
Technical information regarding weld
inspection and testing, welder qualification,
drawing interpretation, and welding symbols is
also included. Each of the eight sections covers
a group of related welding or cutting processes.
The laboratory manual consists of lessons that
include objectives and instructions; many
include one or more assigned jobs. Welding
symbols used in the manual, describe the
sample joints and welds for each job
assignment.

Equivalent SI metric measurement units are
shown in parentheses following US
conventional measurements.

Note: Drawings in the laboratory manual are
not to scale.
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APPENDIX B

Learning Resources
Complete listings
### Appendix B: Metal Fabrication and Machining 11 and 12 • Grade Collections

#### Arc Welding Explained: Basic Principles

**General Description:**
Twenty-four-minute video provides a pre-handson introduction for new welding students. Students are introduced to several important principles that apply to the various types of arc welding processes. The video is easy to follow and supports, in particular, the Forming and Joining Curriculum Organizer of the IRP.

**Audience**
General

**Category:** Student, Teacher Resource

**Grade Level:**

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**Year Recommended in Grade Collection:** 2002

**Supplier:** B.C. Learning Connection Inc.
#4 - 8755 Ash Street
Vancouver, BC V6P 6T3

**Tel:** (604) 324-7752  **Fax:** (604) 324-1844

**Toll Free:** 1-800-884-2366

**Price:** $26.00

**ISBN/Order No:** TE0050

**Copyright:** 1999

#### Arc Welding Explained: Gas Metal, Flux Cored - Arc Welding (MIG)

**General Description:**
Twenty-four-minute video provides a pre-handson introduction for new welding students. The video provides an introduction to the important principles that apply to gas metal and flux cored arc welding. The information is delivered in an easy-to-understand way, and supports particularly the Forming and Joining Curriculum Organizer of the IRP.

**Audience**
General

**Category:** Student, Teacher Resource

**Grade Level:**

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**Tel:** (604) 324-7752  **Fax:** (604) 324-1844

**Toll Free:** 1-800-884-2366

**Price:** $26.00

**ISBN/Order No:** TE0051

**Copyright:** 1999

#### Exploring Metalworking: Fundamentals of Technology

**Author(s):** Walker, J.

**General Description:**
This comprehensive resource, 2003 edition, includes a textbook, workbook and instructor's guide. The text consists of 19 chapters, as well as glossary, tables and index sections. It is an excellent introduction to the fundamentals of working with metal, using both hand and power tools. It is easy to read and contains numerous safety notes throughout. Most areas of metalworking are presented: foundry, lathe work, art metal, sheet metal, forging, jewelry making, etc. The text also demonstrates how to organize and operate a small manufacturing business in a school lab.

**Audience**
General

**Category:** Student, Teacher Resource

**Grade Level:**

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**Year Recommended in Grade Collection:** 2002

**Supplier:** Thomson Nelson
1120 Birchmount Road
Scarborough, ON M1K 5G4

**Tel:** (416) 752-9448  **Fax:** (416) 752-8101

**Toll Free:** 1-800-268-2222/1-800-668-0671

**Web Address:** www.nelson.com

**Price:**
- Student Text: $58.95
- Workbook: $20.50
- Instructor's Manual: no charge

**ISBN/Order No:**
- Student Text: 1-56637-992-X
- Workbook: 1-56637-993-8
- Instructor's Manual: 1-56637-994-6

**Copyright:** 2003

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#4 - 8755 Ash Street
Vancouver, BC V6P 6T3

B.C. Learning Connection Inc.

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**Tel:** 1-800-884-2366  **Fax:** (604) 324-1844

**Year Recommended in Grade Collection:** 2002

**Price:** $26.00

**ISBN/Order No:** TE0051

**Copyright:** 1999
### Fabricating a Toolbox

**General Description:**
Twenty-minute video demonstrates the processes used in the fabrication of a large tool box: marking up, cutting out, folding, guillotining, spot welding, oxy welding, and drilling. Most procedures and practices used in sheet metal work are covered. The video gives a very detailed visual explanation of the process. The project itself is of an advanced nature and would be most suitable for Grade 12 students. The video also comes with blueprints for fabrication.

**Audience**
General

**Category:** Student, Teacher Resource

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** Supplier:** B.C. Learning Connection Inc.
#4 - 8755 Ash Street
Vancouver, BC V6P 6T3

| Tel: | (604) 324-7752 | Fax: | (604) 324-1844 |

| Price: | $26.00 |
| ISBN/Order No: | TE0068 |
| Copyright: | 1998 |

### Gas Tungsten Arc Welding: Getting Started

**General Description:**
Seventeen-minute video demonstrates gas tungsten arc welding and how it operates, as well as giving students some basic exercises to help them get started. Close-up arc shots detail key welding techniques. The video comes with a 23-page study guide.

**Audience**
General

**Category:** Student, Teacher Resource

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** Supplier:** B.C. Learning Connection Inc.
#4 - 8755 Ash Street
Vancouver, BC V6P 6T3

| Tel: | (604) 324-7752 | Fax: | (604) 324-1844 |

| Price: | $26.00 |
| ISBN/Order No: | TE0066 |
| Copyright: | 1999 |

### Introduction to Welding Series: Shielded Metal Arc Welding

**General Description:**
Twelve-minute video explains the differences between AC and DC arc welding machines, and how arc welding works. Use of safety equipment and set-up/shutdown instructions are explained step by step.

**Audience**
General

**Category:** Student, Teacher Resource

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** Supplier:** B.C. Learning Connection Inc.
#4 - 8755 Ash Street
Vancouver, BC V6P 6T3

| Tel: | (604) 324-7752 | Fax: | (604) 324-1844 |

| Price: | $26.00 |
| ISBN/Order No: | TE0067 |
| Copyright: | 1998 |

### Jewelry: Two Books in One

**Author(s):** Coles, M.

**General Description:**
This full-colour, 128-page resource is designed in a die-cut format and provides an excellent introduction to jewellery making. The introduction includes chapters on tools, equipment, safety procedures and materials. The techniques and projects are clearly illustrated with informative step-by-step photographs. Projects are described on the top section of the page, with the basic techniques demonstrated on the bottom section. The student is introduced to the basic skills, e.g., sawing and filing, through to the more advanced tasks like mitering and stone setting. The resource also includes a glossary; informative tables re: ring sizes, metal gauges, metal properties; an index; and a "gallery" featuring the work of professional jewellers.

**Audience**
General

**Category:** Student, Teacher Resource

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** Supplier:** Sterling Publishing Co., Inc.
387 Park Avenue South
New York, NY 10016

| Tel: | (212) 532-7160 | Fax: | (212) 213-2495 |

| Web Address: | www.sterlingpub.com |
| Price: | $31.16 |
| ISBN/Order No: | 0-8069-4822-1 |
| Copyright: | 1999 |
Appendix B: Metal Fabrication and Machining 11 and 12

Machine Tool and Manufacturing Technology

Author(s): Krar, S. et al.

General Description:
This 692-page text supports a significant portion of the Metal Fabrication and Machining IRP in a very comprehensive manner. The resource covers information on the major machines and their related processes, including the drill press, milling machine and lathe. There is also a large section on CNC machines and programming. Other manufacturing technologies covered include Artificial Intelligence (AI), Electrical Discharge Machining (EDM), Just-In-Time manufacturing (JIT), Lasers, and Robotics. Large bullets printed in blue draw the reader's attention to safety concerns as well as key points. This is a good, daily-use text for students in a senior machine shop environment. It provides a comprehensive foundation of information to accompany the many operations, projects, and activities found in a metal shop. Both Imperial and Metric measurements are used. Large bullets printed in blue draw the reader's attention to safety concerns, as well as key points. Note: A few of the computer pictures are dated, and the computer section of the textbook should be revised so that it is up-to-date.

Audience
General

Category: Student, Teacher Resource

Machine Tool Practices, Seventh Edition

Author(s): Kibbe, R. et al.

General Description:
This is an excellent technical resource, particularly for teachers and advanced students. An instructor's manual and a workbook supplement the textbook. The instructor's manual includes a Power Point CD, and the workbook is project oriented, i.e., not just a series of exercises. Shop tips, safety tips, career tips and new or developing technology are emphasized in colour boxes throughout the text.

Audience
General

Category: Teacher Resource

Machinery's Handbook, Twenty-Sixth Edition

Author(s): Oberg, E. et al.

General Description:
This comprehensive reference book is used extensively in industry. It encompasses over 2,000 pages of information about machining, welding and mechanical applications. Industry standards for metals and plastics are given along with standards for forming, joining and cutting these materials. This book is truly the definitive reference source for anyone working with metal.

Audience
General

Category: Teacher Resource
**Machining Fundamentals: From Basic to Advanced Techniques**

Author(s): Walker, J.

General Description:
This resource, consisting of textbook, workbook and instructor's manual, deals specifically with the machining of metals. It covers newer processes such as laser machining and welding, water-jet cutting and chipless machining. It also explores the importance of computer numerical control (CNC) in the operation of most machine tools, and its role in automated manufacturing. Major topics are colour-coded, and safety notes are highlighted in red.

Audience
General

Category: Student, Teacher Resource

**Metalwork: Technology and Practice, Ninth Edition**

Author(s): Repp, V.

General Description:
This comprehensive resource, consisting of a textbook, instructor's resource guide and a student workbook provides laboratory experiences in metal fabrication. It covers generic machine shop practices with references to all areas of metal working machines. Each chapter contains a section on “key words” for review and review questions at the end of each chapter. Questions are relevant to the chapter and are systematic. The instructor's resource guide includes an answer key, projects, and visual masters.

Audience
General

Category: Student, Teacher Resource

**Practical Problems in Mathematics for Manufacturing, 4th Edition**

Author(s): Davis, D.

General Description:
This book offers practical exercises in metal shop-related math. It provides the student with realistic mathematical problems. Reading verniers and micrometers are covered for both imperial and metric. Topics range from basic arithmetic to more advanced areas such as trigonometry. This is a useful resource for the machine and welding shops. An instructor's guide, which includes answers to every problem in the student text and solutions to many of the problems, has not been evaluated.

Audience
General

Category: Student, Teacher Resource
**Practical Problems in Mathematics for Welders, Fourth Edition**

**Author(s):** Schell, F.

**General Description:**
This softcover book, prepared by welders, covers mathematical applications for welders. In addition to basic mathematical concepts, it covers volumes and areas. The text offers students a step-by-step approach to the mastery of essential skills in mathematics as they apply to the welding shop. An instructor's guide, which includes answers to every problem in the student text and solutions to many of the more complicated problems, has not been evaluated.

**Audience**
General

**Category:** Student, Teacher Resource

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**Technology of Machine Tools, Fifth Edition**

**Author(s):** Krar, S. et al.

**General Description:**
This comprehensive resource, consisting of a text, instructor's manual and workbook thoroughly familiarizes the student and teacher in machining processes. Some of the highlights include updates on careers, electronics and digital measuring tools, conventional and programmable lathes and CNC tools. The instructor's manual contains answer keys to textbook review questions and to the workbook tests.

**Audience**
General

**Category:** Student, Teacher Resource

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**Trades Common Core: Line J - Oxyacetylene Cut and Weld**

**General Description:**
The Line J resource of the Trades Common Core learning guides has been revised to address the new WCB Occupational Health and Safety regulations. The resource deals with the identification of gases, components and handling procedures of oxy-fuel cutting and welding; the assembly of a portable outfit; the performance of cuts and pierce holes welding mild steel; and brazing lap joints. The contents include information and instruction, examples and diagrams and self-tests with answers.

**Audience**
General

**Category:** Student, Teacher Resource
Welder Training Program - Level B

General Description:
The Welding Training Program is divided into three levels, beginning with the C level as the first level, followed by level B as the intermediate level, and level A as the final level. Within each level, the training program is modularized. All the skills required of a welder are divided into separate lines or units, and training materials are developed for each line. These lines consist of Practical Lines (P-lines) and Related Knowledge (RK-lines). Each line is divided into Competencies, which are, in turn, divided into precisely focused activities called Learning Tasks.

The Level B series is packaged a set containing 8 booklets by Module/Line code. Level B follows Level C in that it is the next stage in advancement. It describes the GTAW process and its application, starting with very basic and then advancing. It contains eight booklets: P7 (Shielded Metal Arc Welding-SMAW), P8 (Flux Cored Arc Welding-FCAW), P9 (Flux Cored Arc Welding-FCAW), P10 (Gas Tungsten Arc Welding-GTAW), RK4 (Welding Control and Inspection Procedures), RK5 (Welding Codes, Standards and Specifications), RK6 (Blueprint Reading), and RK7 (Welding Metallurgy).

Welder Training Program - Level C

General Description:
The Welding Training Program is divided into three levels, beginning with the C level as the first level, followed by level B as the intermediate level, and level A as the final level. Within each level, the training program is modularized. All the skills required of a welder are divided into separate lines or units, and training materials are developed for each line. These lines consist of Practical Lines (P-lines) and Related Knowledge (RK-lines). Each line is divided into Competencies, which are, in turn, divided into precisely focused activities called Learning Tasks.

Level C, the initial or introductory level, contains 10 booklets specific to welder training: P1 (Introduction and Program Orientation), P2 (Oxy-fuel Cutting), P3 (Gas Welding and Braze Welding), P4 (Shielded Metal Arc Welding - SMAW), P5 (Air Carbon Arc Gouging), P6 (GMAW & FCAW), RK-1 (Material Handling), RK2A (Blueprint Reading), RK2B (Math), and RK3 (Welding Metallurgy).

Booklets can be purchased individually, or as a package of all ten.

Welding Technology Fundamentals

Author(s): Bowditch, W. et al.

General Description:
This comprehensive 365-page text and accompanying laboratory manual cover all aspects of the welding trade. They also provide information about welding careers, drawing interpretation and welding symbols. Each of the eight sections in the text focuses on a group of related welding or cutting processes. The laboratory manual consists of lessons that include objectives and instructions.

Caution:
Chapter on welder certification is for US only.

Grade Level:
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Year Recommended in Grade Collection: 2002

Supplier: Thomson Nelson
1120 Birchmount Road
Scarborough, ON M1K 5G4

Tel: (416) 752-9448 Fax: (416) 752-8101
Toll Free: 1-800-268-2222/1-800-668-0671

Web Address: www.nelson.com

Price: Student Text: $72.50 Laboratory Manual: $23.95


Copyright: 1997
APPENDIX C

Assessment and Evaluation
Prescribed learning outcomes, expressed in observable terms, provide the basis for the development of learning activities, and assessment and evaluation strategies. After a general discussion of assessment and evaluation, this appendix uses sample evaluation plans to show how activities, assessment, and evaluation might come together in a particular technology education program.

Assessment and Evaluation

Assessment is the systematic gathering of information about what students know, are able to do, and are working toward. Assessment methods and tools include: observation, student self-assessments, daily practice assignments, quizzes, samples of student work, pencil-and-paper tests, holistic rating scales, projects, oral and written reports, performance reviews, and portfolio assessments.

Student performance is evaluated from the information collected through assessment activities. Teachers use their insight, knowledge about learning, and experience with students, along with the specific criteria they establish, to make judgments about student performance in relation to prescribed learning outcomes.

Students benefit most when evaluation is provided on a regular, ongoing basis. When evaluation is seen as an opportunity to promote learning rather than as a final judgment, it shows learners their strengths and suggests how they can develop further. Students can use this information to redirect efforts, make plans, and establish future learning goals.

Evaluation may take different forms, depending on the purpose. Criterion-referenced evaluation should be used to evaluate student performance in classrooms. It is referenced to criteria based on learning outcomes described in the provincial curriculum. The criteria reflect a student’s performance based on specific learning activities. When a student’s program is substantially modified, evaluation may be referenced to individual goals. These modifications are recorded in an Individual Education Plan (IEP).

Norm-referenced evaluation is used for large-scale system assessments; it is not to be used for classroom assessment. A classroom does not provide a large enough reference group for a norm-referenced evaluation system. Norm-referenced evaluation compares student achievement to that of others rather than comparing how well a student meets the criteria of a specified set of learning outcomes.

Criterion-Referenced Evaluation

In criterion-referenced evaluation, a student’s performance is compared to established criteria rather than to the performance of other students. Evaluation referenced to prescribed curriculum requires that criteria are established based on the learning outcomes listed under the curriculum organizers for Metal Fabrication and Machining 11 and 12.

Criteria are the basis of evaluating student progress; they identify the critical aspects of a performance or a product that describe in specific terms what is involved in meeting the learning outcomes. Criteria can be used to evaluate student performance in relation to learning outcomes. For example, weighting criteria, using rating scales, or performance rubrics (reference sets) are three ways that student performance can be evaluated using criteria.

Samples of student performance should reflect learning outcomes and identified criteria. The samples clarify and make explicit the link between evaluation and learning outcomes, criteria, and assessment. Where a student’s performance is not a product, and therefore not reproducible, a description of the performance sample should be provided.
Criterion-referenced evaluation may be based on these steps:

**Step 1** Identify the expected learning outcomes (as stated in this Integrated Resource Package).

**Step 2** Identify the key learning objectives for instruction and learning.

**Step 3** Establish and set criteria. Involve students, when appropriate, in establishing criteria.

**Step 4** Plan learning activities that will help students gain the knowledge or skills outlined in the criteria.

**Step 5** Prior to the learning activity, inform students of the criteria against which their work will be evaluated.

**Step 6** Provide examples of the desired levels of performance.

**Step 7** Implement the learning activities.

**Step 8** Use various assessment methods based on the particular assignment and student.

**Step 9** Review the assessment data and evaluate each student’s level of performance or quality of work in relation to criteria.

**Step 10** Where appropriate or necessary, assign a letter grade that indicates how well the criteria are met.

**Step 11** Report the results of the evaluations to students and parents.
The samples in this section show how a teacher might link criteria to learning outcomes. Each sample is based on prescribed learning outcomes taken from one or more organizers. The samples provide background information to explain the classroom context; suggested instructional tasks and strategies; the tools and methods used to gather assessment information; and the criteria used to evaluate student performance.

**HOW THE SAMPLES ARE ORGANIZED**

There are five parts to each sample:

- identification of the prescribed learning outcomes
- overview
- planning for assessment and evaluation
- defining the criteria
- assessing and evaluating student performance.

**Prescribed Learning Outcomes**

This part identifies the organizer or organizers and the specific prescribed learning outcomes selected for the sample.

**Overview**

This is a summary of the key features of the sample.

**Planning for Assessment and Evaluation**

This part outlines:

- background information to explain the classroom context
- instructional tasks
- the opportunities that students were given to practise learning
- the feedback and support that were offered to students by the teacher
- the ways in which the teacher prepared students for the assessment.

**Defining the Criteria**

This part illustrates the specific criteria, which are based on prescribed learning outcomes, the assessment task, and various reference sets.

**Assessing and Evaluating Student Performance**

This part includes:

- assessment tasks or activities
- the support that the teacher offered students
- tools and methods used to gather the assessment information
- the way the criteria were used to evaluate the student performance.

**EVALUATION SAMPLES**

The samples on the following pages illustrate how a teacher might apply criterion-referenced evaluation in Metal Fabrication and Machining 11 and 12.

- Metal Fabrication and Machining 11
  *Tin Box*
  Page C-8

- Sample 2: Metal Fabrication and Machining 11
  *Padding with E6010-11*
  Page C-12

- Sample 3: Metal Fabrication and Machining 12
  *Making Tapers on a Lathe*
  Page C-16

- Sample 4: Metal Fabrication and Machining 12
  *Making a Cold Chisel*
  Page C-18
\textbf{\large \textsc{SAMPLE 1: METAL FABRICATION AND MACHINING 11}}

\textbf{Topic: Tin Box}

\textbf{Prescribed Learning Outcomes:}

It is expected that students will:

\textit{Health and Safety}

- demonstrate a knowledge of safety features and practices associated with metal-related tools and equipment

\textit{Personal and Project Management}

- identify, organize, and execute processes required to accomplish a task
- identify and organize task-related tools and materials

\textit{Mathematical Applications}

- demonstrate the ability to use the following measuring instruments:
  - micrometers
  - tape measures and scales
  - dial indicators
  - calipers or other instruments that employ the Vernier scale

\textit{Tools and Equipment}

- identify, describe, and use:
  - layout tools
  - measuring instruments
  - …
  - sheet metal tools and equipment

\textit{Cutting Processes}

- use common sheet metal cutting tools

\textit{Forming and Joining Processes}

- demonstrate the ability to lay out, form, and join sheet metal using a variety of methods

\textbf{OVERVIEW}

The teacher developed a unit on working with sheet metal. Students were shown a finished tin box and supplied with specifications for the finished item (i.e., dimensions, gauge of metal). Following instruction, students worked individually to produce their own tin box. The focus of evaluation was on:

- pattern development
- set-up and safe use of tools and equipment.

\textbf{Planning for Assessment and Evaluation}

- Students were asked to develop a pattern for their box and to produce a list of the steps required to complete it (e.g., a flow chart showing sequence).
- The teacher demonstrated proper layout procedures. Proper set-up of sheet metal tools and equipment and how to use them safely and correctly were also discussed and demonstrated.
- Students moved to work stations to complete their tasks.
- Once one student box was completed, the teacher discussed the options for attaching corners and demonstrated various methods of joining the corners.

\textbf{Defining the Criteria}

\textit{Health and Safety}

To what extent do the students:

- listen carefully to safety instructions
- select proper materials and tools to complete the task
- use the equipment safely
- clean up after themselves?

\textit{Personal and Project Management}

To what extent do the students:

- use appropriate amounts of material, without wasting any
• complete tasks within allotted time
• demonstrate teamwork and sharing (e.g., of tools, time on equipment)?

Mathematical Applications
To what extent do the students:
• make accurate measurements when drawing their layout
• correctly size their patterns
• carefully square their corners
• accurately transfer their patterns to the sheet metal?

Tools and Equipment and Cutting Processes
To what extent do the students:
• select appropriate tools for various aspects of the job
• use the sheet metal cutting tools properly?

Forming and Joining Processes
To what extent do the students:
• follow teacher-demonstrated technique for forming and joining sheet metal
• use appropriate quantities of fastener (e.g., solder, flux)?

Assessing and Evaluating Student Performance

Health and Safety
The teacher constantly monitored students to ensure they followed safe work practices (classroom observation). A rating scale (see Safety Rating Scale) was used to evaluate safety performance. In addition, the teacher collected information on student performance from safety quizzes.

Personal and Project Management
The teacher ensured that students had an appropriate list of steps and assessed this as part of overall project assessment (see “Tin Box Rating Sheet”).

Mathematical Applications, Tools and Equipment and Cutting Processes
The teacher observed students’ ability to accurately measure and lay out components by checking students’ patterns before they began to cut. The teacher also observed as students selected and used tools to cut the sheet metal, recording assessments on the “Tin Box Rating Sheet.”

Forming and Joining Processes
The teacher observed students’ ability to form and join materials to produce a high-quality, accurate box. Boxes were submitted for teacher evaluation according to criteria on the “Tin Box Rating Sheet.”
## Safety Rating Scale

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<th>Rating</th>
<th>Criteria</th>
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<tr>
<td>Outstanding</td>
<td>The student has an exceptional “heads-up” attitude toward safety issues and demonstrates an outstanding understanding of safety issues and procedures in both theory and practical application. The student works safely with minimal teacher supervision and encourages other students to do so as well.</td>
</tr>
<tr>
<td>Competent</td>
<td>The student has a serious attitude toward safety issues and follows all safety instructions given by the teacher. On quizzes, she or he demonstrates good background knowledge about safety issues. The student completes the operating procedure sheet on each machine before using the equipment. Before working, the student takes necessary safety precautions. The student lifts and carries objects correctly with respect to both health and safety. The student does not endanger other members of the group or class when working.</td>
</tr>
<tr>
<td>Unacceptable</td>
<td>The student either cannot identify safety issues and appropriate safety measures or can identify them in a quiz situation but does not apply them except when working under excessive supervision. The student sometimes engages in horseplay that endangers self and/or others.</td>
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## Tin Box Rating Sheet

<table>
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<tr>
<th>Behaviour</th>
<th>Teacher Rating (0-5)</th>
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<tr>
<td>• follows safe work procedures</td>
<td></td>
</tr>
<tr>
<td>• works well with other students</td>
<td></td>
</tr>
<tr>
<td>• cleans work area, replaces tools</td>
<td></td>
</tr>
</tbody>
</table>

## Quality of Work

| Pattern: flow chart complete (no steps missing) and steps correctly ordered |                      |
| Pattern: dimensions are accurate                                           |                      |
| Pattern: corners are square and layout is correct                         |                      |
| Process: tools are appropriate (selection) and properly used (application) |                      |
| Process: equipment is properly set up                                     |                      |
| Final Product: overall shape conforms to model (dimensions, squareness)   |                      |
| Final Product: joints are tight-fitting and secure, without excessive fastener (e.g., solder, flux) |                      |
| Final Product: surface appearance is “clean” – no surface blemishes or hammer marks – and the box has no dangerous sharp edges |                      |

**TOTAL** (out of 60 possible)

## Rating Scale

- 5 Always or entirely
- 4 Evident, with minor exceptions or errors
- 3 Somewhat evident
- 2 Sporadically evident
- 1 Insufficient or inadequate
- 0 Not at all
Topic: Padding with E6010-11

**Prescribed Learning Outcomes:**
It is expected that students will:

**Health and Safety**
- consistently use safe work practices
- demonstrate a knowledge of safety features and practices associated with metal-related tools and equipment

**Personal and Project Management**
- identify and utilize employability skills

**Tools and Equipment**
- identify, describe, and use:
  - ...  
  - welding machines, tools, and equipment

**Cutting Processes**
- set up and use oxy-acetylene equipment to perform short linear cuts freehand

**Forming and Joining Processes**
- execute forming and joining processes in a safe manner

**Overview**
The teacher planned a unit in which students worked with a partner to acquire and develop SMAW (stick feed welding) skills.

**Planning for Assessment and Evaluation**
The teacher had students cut out 3 in. x 3 in. square of 1/2 in. plate, using oxy-acetylene torches. The teacher then discussed safety considerations related to SMAW (stick feed welding), and specifically explained:

- the type of rod to use
- polarity
- appropriate amperage.

A demonstration of padding was then performed for the whole class.

As students prepared to work in their pair groupings, the teacher repeated the SMAW demonstration for smaller groups of four students. Each pair then had an opportunity to share a machine to do their own padding. One pair watched and helped with reminders about procedure and safety while the other pair welded.

**Defining the Criteria**

**Health and Safety**
To what extent do the students:

- follow demonstrated safety procedures
- consistently display a respect for safety considerations when working in pairs or groups
- encourage others to work safely
- exhibit personal preparedness with respect to clothes, jewellery, and protective equipment
- remain focused on tasks when using shop equipment
- when asked, give safety reasons for following particular procedures?

**Personal and Project Management**
To what extent do the students:

- cooperate with partners when working on tasks together?

**Tools and Equipment**
To what extent does the student:

- demonstrate proper use of SMAW machines, including
  - correct polarity
  - appropriate amperage setting
  - correct grounding of work piece?
Cutting Processes
To what extent does the student:
• set up oxy-acetylene equipment with appropriate pressure settings on torch to perform short linear cuts, freehand
• produce finished work with
  - square edges
  - minimal slag
  - dimensional accuracy?

Forming and Joining Processes
To what extent does the student:
• take care to produce a good quality result
• maintain good bead width
• maintain bead straightness
• maintain bead overlap consistency
• produce an appropriate bead shape?

Assessing and Evaluating Student Performance

Health and Safety
The teacher observed students as they conducted assigned hands-on activities. This observation resulted in a specific safety evaluation built into the evaluation of their hands-on work on the padding activity (see the 1st criterion identified in the “Padding Activity Evaluation Criteria” performance rating scale). It also became part of an ongoing, course-long assessment and evaluation of safety performance, which took account of student scores on safety quizzes as well as of the teacher’s observations whenever hands-on activities were assigned. On each occasion, the same criteria were applied (see the table titled, “Detailed Criteria for Safety Assessment”).

Personal and Project Management
The teacher observed individual students as they worked together. The observation of how well the students communicated, helped each other with the assigned task, and remained focused on their work was evaluated using the established criteria (see “Defining the Criteria” above, and the table titled, “Padding Activity Evaluation Criteria”).

Tools and Equipment
The teacher observed how the students applied their understanding of polarity, amperage set-up, and grounding.

Cutting Processes
Assessment of students’ cutting work was again based on teacher observation.

Forming and Joining Processes
The teacher collected students’ finished padding samples and evaluated them, using the “Quality of Work” criteria included on the bead “Padding Activity Evaluation Criteria.”
## Padding Activity Evaluation Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Student Rating</th>
<th>Teacher Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Behaviour</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• follows safety procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• works well with other students assigned to the job at hand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• treats others with respect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• puts in a full class of work</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Punctuality</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• starts work quickly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• starts clean-up at the appropriate time, and performs it quickly and efficiently</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quality of Work</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• bead width</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• bead straightness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• overlap consistency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• bead shape</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Teacher Comments**

**Rating Scale**

- 5: Always
- 4: Most of the time
- 3: Some of the time
- 2: Occasionally
- 1: Rarely
- 0: Never
### Detailed Criteria for Safety Assessment

<table>
<thead>
<tr>
<th>Rating</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outstanding</strong></td>
<td>The student has an exceptional “heads-up” attitude toward safety issues and demonstrates an outstanding understanding of safety issues and procedures in both theory and practical applications. The student works safely with minimal teacher supervision and encourages others to do so as well.</td>
</tr>
<tr>
<td>(e.g., 8-10 marks)</td>
<td></td>
</tr>
<tr>
<td><strong>Competent</strong></td>
<td>The student has a serious attitude toward safety issues and follows all safety instructions given by the teacher. On quizzes, she or he demonstrates good background knowledge about safety issues. The student completes the operating procedure sheet on each piece of shop equipment before using it. Before working, the student takes necessary safety precautions. The student lifts and carries objects correctly with respect to both health and safety. The student does not endanger other members of the group or class when working.</td>
</tr>
<tr>
<td>(e.g., 4-7 marks)</td>
<td></td>
</tr>
<tr>
<td><strong>Unacceptable</strong></td>
<td>The student either cannot identify safety issues and appropriate safety measures, or can identify them in a quiz situation but does not apply them except when working under excessive supervision. The student sometimes engages in horseplay that endangers self and/or others.</td>
</tr>
<tr>
<td>(e.g., 0-3 marks)</td>
<td></td>
</tr>
</tbody>
</table>
Sample 3: Metal Fabrication and Machining

Topic: Making Tapers on a Lathe

Prescribed Learning Outcomes:
It is expected that students will:

Mathematical Applications

- demonstrate proficiency in using a variety of measuring instruments
- demonstrate proficiency in using ratios, geometric concepts, and trigonometric formulae to solve layout and machining problems

Cutting Processes

- set up and perform the following cutting processes on a lathe:
  - facing, parallel, and taper turning
  - ...

Overview

The teacher planned a unit in which students would learn how to use a simple trigonometric function to calculate the angle setting on a lathe in order to turn a taper.

Planning for Assessment and Evaluation

The teacher provided an overview of the trigonometry needed to determine the angles for a taper, given the lengths of sides (or the lengths of sides, given angles). Ratios, charts, and correct use of calculator functions were explained. As part of the explanation, the teacher introduced the following simple memory aid for deciding which trigonometry calculation is needed:

A demonstration of how the mnemonic works was provided by the teacher: “The sides of any right-angle triangle can be designated OPP (opposite the given angle), ADJ (adjacent to the given angle), and HYP (hypotenuse). If OPP = 4, and the angle where HYP and ADJ meet is 20°, the circle showing ADJ and OPP identifies the calculation needed to determine ADJ:

\[ \text{ADJ} = \frac{4}{\tan 20°} = 10.9899 \text{ (rounds off to 11)} \]

The circle showing OPP and HYP identifies the calculation needed to determine HYP:

\[ \text{HYP} = \frac{4}{\sin 20°} = 11.6952 \]

These calculations can be performed using a calculator and verified using the Pythagorean formula, \( a^2 + b^2 = c^2 \).”

The teacher used several diagrams and samples to demonstrate the application of the trigonometry to practical problems frequently encountered in metal fabrication and machining. For example:

- Find the length of the diagonal brace.
- What is the angle of cut for (A)?
- What is the angle of cut for (B)?

The students were then assigned to turn the following taper on a lathe:
Instructions:
- Calculate the angle setting for the compound slide.
- Set up the lathe and machine the part.
- Measure and document the sizes of the final product you have created.

DEEPING THE CRITERIA

Mathematical Applications

To what extent do the students:
• accurately measure the large diameter
• accurately measure the small diameter
• accurately measure the length of the taper
• develop the correct right-angle triangle from the drawing of the taper
• perform the appropriate calculations
• perform the needed calculations correctly?

Cutting Processes

To what extent are the students able to:
• set up the lathe correctly (compound, etc.)
• produce accurately sized tapers
• produce tapers with an acceptable quality of finish
• consistently employ safe and appropriate work practices when using the lathe?

ASSESSING AND EVALUATING STUDENT PERFORMANCE

The teacher observed students as they worked, then asked students to submit their finished tapers, which were graded. Evaluation data and marks were recorded on a “Taper Turning Evaluation Record.”

Taper Turning Evaluation Record

<table>
<thead>
<tr>
<th>Student Name:______________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement</td>
</tr>
<tr>
<td>• Small</td>
</tr>
<tr>
<td>• Large</td>
</tr>
<tr>
<td>• Length</td>
</tr>
<tr>
<td>• Totals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Small</th>
<th>Large</th>
<th>Length</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student measurement</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
</tr>
<tr>
<td>Teacher measurement</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
</tr>
<tr>
<td>Difference</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
</tr>
<tr>
<td>Mark for measurement</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
</tr>
<tr>
<td>Machining</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
</tr>
<tr>
<td>Mark for accuracy</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
</tr>
<tr>
<td>Mark for finish</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
<td>/5</td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td>/45</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sample 4: Metal Fabrication and Machining 12

Topic: Making a Cold Chisel

Prescribed Learning Outcomes:
It is expected that students will:

Personal and Project Management
- describe and execute the processes required to complete a project
- organize task-related workspace
- demonstrate proficiency in the application of employability skills

Materials
- describe the properties of a variety of metals
- interpret metal classification and identification systems
- perform, describe, and identify the uses of the following heat treatment processes:
  - normalizing
  - hardening
  - tempering
  - annealing

Forming and Joining Processes
- produce a forged object

Overview
The teacher developed a unit focusing on forging and heat treatment. This was introduced with a demonstration of how a cold chisel can cut mild steel. A question-and-answer session addressed how this is possible. Students were then given basic reference notes on:
- the differences between CTS and MS (carbon content)
- the spark test (used to distinguish CTS and MS)
- the correct method of cutting CTS
- forging (correct tempers, etc.)
- normalizing (removal of stresses from forging, reasons for normalizing)
- hardening (non-magnetic, cherry red quenching technique, room-temperature water/oil)
- tempering (chart of colours)
- annealing.

After reviewing and discussing the reference notes, the teacher demonstrated how to successfully make a cold chisel and the differences between normalizing and annealing. Students were asked to create a procedure summary sheet of their own and then make their own cold chisels as a basis for evaluation.

Planning for Assessment and Evaluation
- Students were asked to create a procedure summary sheet of their own based on their observation of the teacher demonstration and the preceding discussion and review of notes.
- Once the teacher had reviewed the procedure summary sheets to ensure that they contained complete, accurate information, the task of having each student make a cold chisel was assigned and criteria for assessment were discussed.
- Students made their own cold chisels, to specified dimensions, following their procedure summaries. As they worked, the teacher supervised and questioned them about various aspects of heat treatment, to reinforce their grasp of key concepts.
- Students tested their finished chisels for functionality and completed a self-evaluation, based on the criteria.

Defining the Criteria

Personal and Project Management
To what extent do the students:
- follow safety procedures
- make effective use of time and resources by beginning work promptly and remaining on-task and focused
- display enthusiasm for learning
• demonstrate respect for equipment by beginning clean-up at the appropriate time, performing it quickly and efficiently, and returning tools and materials to the correct location as soon as possible to facilitate use by other shop users?

**Materials and Forming and Joining Processes**

To what extent do the students:

• produce a procedure summary sheet that is:
  - complete
  - clear and easy to follow
  - accurate in its description of needed steps and cautions?

• display a good understanding of:
  - the distinction between CTS and MS
  - the procedure for cutting CTS
  - the requirements for successful forging
  - the requirements for successful heat treatment?

• forge a cold chisel that:
  - conforms to specified dimensions
  - is normalized correctly
  - is successfully hardened
  - is successfully tempered
  - has an appropriate surface finishing
  - is functional (i.e., properly serves its intended purpose)?

**ASSESSING AND EVALUATING STUDENT PERFORMANCE**

To evaluate each student’s personal and project management skills, the teacher used a five-point rating scale, keyed to the criteria previously defined.

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent; criterion met to an exceptional or unusual degree</td>
</tr>
<tr>
<td>4</td>
<td>Very good; criterion met in a very effective way</td>
</tr>
<tr>
<td>3</td>
<td>Good; criterion met in a competent and effective manner</td>
</tr>
<tr>
<td>2</td>
<td>Satisfactory; criterion met but with considerable room for improvement</td>
</tr>
<tr>
<td>1</td>
<td>Minimally acceptable; criterion met to some extent</td>
</tr>
<tr>
<td>0</td>
<td>Not evident; criterion not met</td>
</tr>
</tbody>
</table>

A similar scale was used to rate students’ ability relative to materials and to forming and joining processes. In this instance, however, students were asked to undertake a self-evaluation of their procedure summary sheets and chisel-making work, using a similar five-point rating scale keyed to each of the criteria defined for materials and for forming and joining processes.

The teacher then completed an identical evaluation of each student’s work on the knowledge and skills associated with the project. Discrepancies between the teacher’s and the student’s evaluations were discussed individually with each student, and the two evaluations were blended to create a final grade for the materials and for the forming and joining processes aspects of the project. This, in turn, was combined with the evaluation that the teacher had produced of each student’s personal and project management skills to create an overall evaluation of student’s work on this project.
APPENDIX D

Acknowledgments
Many people contributed their expertise to this document. The project coordinator was Adrienne Gnidec O’Henly of the Curriculum Branch, working with ministry personnel and our partners in education. We would like to thank all who participated in this process.

**THE IRP WRITING AND RESOURCE EVALUATION TEAM**

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School District No. 35 (Langley)
APPENDIX E

Offering a Metal Fabrication and Machining Program in Your School
The Metal Fabrication and Machining 11 and 12 curriculum sets out the Prescribed Learning Outcomes for an introductory Metal Fabrication and Machining program in a secondary school. These learning outcomes define the knowledge, skills and attitudes that will give students a general knowledge in Metal Fabrication and Machining.

Schools may decide to build on the Metal Fabrication and Machining 11 and 12 program by offering additional courses that provide more in-depth study of metal work. Other Metal Fabrication and Machining courses for which provincially prescribed learning outcomes have been developed include the following:

- Metal Fabrication and Machining 12: Advanced Fabrication
- Metal Fabrication and Machining 12: Advanced Machining
- Metal Fabrication and Machining 12: Advanced Welding
- Metal Fabrication and Machining 12: Art Metal and Jewellery
- Metal Fabrication and Machining 12: CNC Processes
- Metal Fabrication and Machining 12: Forging and Foundry
- Metal Fabrication and Machining 12: Sheet Metal

Although complete IRPs are not provided for these courses, the learning outcomes are provincially prescribed, and students can use these courses to meet the Applied Skills Foundation Studies requirement. The increased proficiency that students develop by taking these courses will better prepare them to pursue future post-secondary, career, or avocational opportunities in Metal Fabrication and Machining. At the same time, offering one or more of these courses enables a school’s Metal Fabrication and Machining program to maintain relevance to students’ needs.

Teachers are encouraged to integrate a variety of topics and instructional approaches to develop Metal Fabrication and Machining courses that align with the Prescribed Learning Outcomes. They should take advantage of the available resources and facilities, and take into account the different interests, learning styles, and abilities of learners.

In addition to offering courses based on provincially prescribed outcomes identified in this document (including this appendix), schools may continue to develop and offer local courses that extend the scope or go beyond the learning outcomes in curriculum developed by the Ministry. Locally developed (LD) courses must be approved by the school board as per the Ministry’s Local Programs Order.
### Metal Fabrication and Machining 12: Advanced Fabrication

This course expands on the fundamentals taught in Metal Fabrication and Machining 11 and 12 through a focus on structural design and fabrication using steel. Students are provided with an opportunity to improve their knowledge and skills in this area through project-based learning.

<table>
<thead>
<tr>
<th>Curriculum Organizer</th>
<th>Prescribed Learning Outcomes</th>
</tr>
</thead>
</table>
| ▶ Health and Safety  | **It is expected that students will:**  
  • relate WCB regulations and the WHMIS classification system to their own work environments  
  • consistently apply safe work habits when completing personal fabrication projects  
  • identify and implement safety and accident prevention procedures for the work site  
  • demonstrate an understanding of industrial hygiene, including air quality issues |
| ▶ Personal and Project Management | **It is expected that students will:**  
  • prepare a bill of materials and a cutting list  
  • organize tools and workspace  
  • demonstrate employability skills  
  • describe possible career paths associated with metal fabrication  
  • demonstrate comprehension of technical drawings, including welding symbols |
| ▶ Mathematical Applications | **It is expected that students will:**  
  • demonstrate proficiency in using a variety of measuring instruments and layout tools  
  • perform calculations for material and project costs  
  • use geometry and trigonometry to solve problems related to metal fabrication |
| ▶ Materials | **It is expected that students will:**  
  • explain the effects on steel of heat, welding, and cold forming  
  • describe the properties of the various materials used in the fabrication of tools and machinery  
  • interpret metal classification and identification systems  
  • use and identify the purposes of a variety of finishes |
| ▶ Tools and Equipment | **It is expected that students will:**  
  • explain the purposes of and proficiently use:  
    - measuring instruments  
    - oxy-acetylene equipment  
    - arc welding equipment  
    - cut-off machines |
| ▶ Forming and Joining Processes | **It is expected that students will:**  
  • describe and proficiently use a variety of welded joints, including fillet, T, and butt joints  
  • demonstrate an understanding of weld shrinkage and distortion and use methods to counteract these problems  
  • demonstrate proficiency in accurately producing a variety of structures and machinery, using industry-standard fabricating techniques  
  • identify, describe, and use a variety of fasteners  
  • use heating and cooling to straighten steel components |
## METAL FABRICATION AND MACHINING 12: ADVANCED MACHINING

<table>
<thead>
<tr>
<th>Curriculum Organizer</th>
<th>Prescribed Learning Outcomes</th>
</tr>
</thead>
</table>
| ▶ **HEALTH AND SAFETY**           | *It is expected that students will:*  
  - consistently apply safe and healthy work practices in a metal shop  
  - consistently demonstrate the safe use of tools and equipment  
  - describe and evaluate potential workplace hazards with respect to:  
    - specialized machine shop equipment  
    - volatile materials associated with metal work  |
| ▶ **PERSONAL AND PROJECT MANAGEMENT** | *It is expected that students will:*  
  - interpret engineering drawings                                                                                                                                                                                                 |
| ▶ **MATHEMATICAL APPLICATIONS**    | *It is expected that students will:*  
  - measure to within 1/10,000th of an inch  
  - perform a variety of machining-related calculations including those that:  
    - involve the use of advanced trigonometry  
    - relate to angle degrees, minutes, and seconds  
    - relate to hardness testing  
    - relate to gear reductions  |
| ▶ **TOOLS AND EQUIPMENT**         | *It is expected that students will:*  
  - proficiently use standard machine shop equipment, including:  
    - taper attachments  
    - lathe dogs  
    - threading tools and cutters  
  - identify and describe uses for:  
    - surface grinders  
    - optical comparatives  
    - EDM  
  - maintain and sharpen a variety of cutting tools  
  - produce specialized tool holders, including boring bars and fly cutters  |
| ▶ **MATERIALS**                   | *It is expected that students will:*  
  - identify, describe, and select for specific applications various materials, including:  
    - specialty steels  
    - composites  
    - plastics associated with metal work  
    - acid resistant materials  
    - metals with varying degrees of hardness, including copper, aluminum, and brass  
    - cutting fluids  |
| ▶ **CUTTING PROCESSES**           | *It is expected that students will:*  
  - identify, describe, and produce a variety of fits  
  - identify and describe the following types of cutting machines:  
    - EDM  
    - plasma arc  
    - water injection  
    - laser  
    - CNC flame and machining equipment  
  - produce form-cutting profiles  
  - demonstrate a knowledge of new machining techniques, including CNC machining |
**Metal Fabrication and Machining 12: Advanced Welding**

This course extends the fundamentals taught in Metal Fabrication and Machining 11 and 12 through a specialized focus on the welding and associated fabrication skills needed to become proficient in this area. Students improve their knowledge and skills through project-based learning.

<table>
<thead>
<tr>
<th>Curriculum Organizer</th>
<th>Prescribed Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health and Safety</strong></td>
<td>It is expected that students will:</td>
</tr>
<tr>
<td></td>
<td>• consistently apply safe and healthy work practices</td>
</tr>
<tr>
<td></td>
<td>• consistently demonstrate the safe use of tools and equipment</td>
</tr>
<tr>
<td></td>
<td>• describe and evaluate potential workplace hazards</td>
</tr>
<tr>
<td></td>
<td>• practise good housekeeping techniques</td>
</tr>
<tr>
<td><strong>Personal and Project Management</strong></td>
<td>It is expected that students will:</td>
</tr>
<tr>
<td></td>
<td>• produce and interpret complex shop drawings</td>
</tr>
<tr>
<td></td>
<td>• prepare bills of material and cutting lists</td>
</tr>
<tr>
<td></td>
<td>• communicate technical information precisely, correctly, and efficiently</td>
</tr>
<tr>
<td></td>
<td>• plan and efficiently execute all aspects of a welding project</td>
</tr>
<tr>
<td><strong>Mathematical Applications</strong></td>
<td>It is expected that students will:</td>
</tr>
<tr>
<td></td>
<td>• use relevant geometric and trigonometric functions to calculate angles and sizes</td>
</tr>
<tr>
<td><strong>Tools and Equipment</strong></td>
<td>It is expected that students will:</td>
</tr>
<tr>
<td></td>
<td>• proficiently use the following:</td>
</tr>
<tr>
<td></td>
<td>- measuring and layout tools</td>
</tr>
<tr>
<td></td>
<td>- a variety of cutting and grinding tools</td>
</tr>
<tr>
<td></td>
<td>- SMAW, GMAW, GTAW, and oxy-acetylene welding processes</td>
</tr>
<tr>
<td></td>
<td>• perform maintenance on welding equipment</td>
</tr>
<tr>
<td><strong>Forming and Joining Processes</strong></td>
<td>It is expected that students will:</td>
</tr>
<tr>
<td></td>
<td>• produce fillet and V-groove welds in the flat, horizontal, and vertical positions using SMAW electrodes E6011 and E7018 and GMAW</td>
</tr>
<tr>
<td></td>
<td>• produce oxy-acetylene fusion fillet welds in the flat, horizontal, and vertical positions on gauge metal</td>
</tr>
<tr>
<td></td>
<td>• produce GTAW fillet welds in the flat, horizontal, and vertical positions on gauge metal</td>
</tr>
</tbody>
</table>
## Metal Fabrication and Machining 12: Art Metal and Jewellery

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<tr>
<th>Curriculum Organizer</th>
<th>Prescribed Learning Outcomes</th>
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| **Health and Safety**           | *It is expected that students will:*  
  - consistently apply safe and healthy work practices  
  - consistently demonstrate the safe use of tools and equipment  
  - describe and demonstrate the safe handling of materials  
  - demonstrate basic knowledge of jewellery-related materials that may cause allergic reactions |
| **Tools and Equipment**         | *It is expected that students will:*  
  - maintain and store tools in a safe and appropriate manner  
  - identify specialty tools and their uses  
  - select the appropriate tool to perform a specific operation or procedure |
| **Joining and Forming Processes** | *It is expected that students will:*  
  - identify methods of casting  
  - cast with single-use and reusable patterns, using sand moulds, lost wax, or cuttlebone impression methods  
  - demonstrate use of brazing, soft solder, silver solder, and adhesives, and select the appropriate fastening method for various situations  
  - differentiate between precious, semi-precious, and non-precious metals  
  - apply design principles and processes to produce a piece of jewellery  
  - make wire rings to produce chains for bracelets and necklaces  
  - demonstrate techniques involving forge work or other forms of blacksmithing  
  - apply planishing and other cold working techniques to a variety of metals  
  - combine shapes and materials into artifacts or sculptures by bending, shaping, soldering, brazing, or welding  
  - produce two-dimensional and three-dimensional metal art  
  - describe various methods of mounting precious and semi-precious stones and gems |
| **Personal and Project Management** | *It is expected that students will:*  
  - demonstrate the ability to design, plan, and complete a project efficiently  
  - select and apply appropriate finishing processes for metal art or jewellery projects  
  - produce a material and cost sheet for an art metal or jewellery piece  
  - identify components of design that make a project aesthetically pleasing  
  - describe the origins of the use of silver and gold  
  - describe the social significance of jewellery, with reference to various historical and contemporary societies  
  - identify post-secondary opportunities in art metal and in gold- and silver-smithing |
**METAL FABRICATION AND MACHINING 12: CNC PROCESSES**

This course expands on the fundamentals taught in Metal Fabrication and Machining 11 and 12 through a focus on metal work performed using computer numeric control (CNC) equipment. Students are provided with an opportunity to improve their knowledge and skills in this area through project-based learning.

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| **Health and Safety**                 | *It is expected that students will:*  
  - consistently use safe work practices  
  - relate Workers’ Compensation Board and WHMIS regulations to a CNC workplace  
  - demonstrate a knowledge of industrial hygiene, including issues related to air quality and the use of cutting fluids  
  - describe and implement safety and accident prevention practices |
| **Personal and Project Management**   | *It is expected that students will:*  
  - demonstrate employability skills  
  - formulate a plan for manufacturing a product using CNC processes  
  - describe possible career paths associated with metal fabrication |
| **Mathematical Applications**         | *It is expected that students will:*  
  - demonstrate proficiency in the use of measuring instruments for metal fabrication and machining  
  - demonstrate proficiency in using three-axis graphing techniques \( (x, y, z) \)  
  - perform accurate calculations for cutting speeds and feeds  
  - use trigonometry and geometry to locate bolt circles, arcs, and straight lines |
| **Tools and Equipment**               | *It is expected that students will:*  
  - describe features and uses of CNC equipment  
  - explain the purposes of and make proficient use of:  
    - measuring tools  
    - carbide and high-speed-steel cutting tools  
    - work-holding devices and fixtures  
  - perform basic inspection and maintenance procedures on CNC machinery  
  - install and set up cutting tools and holders  
  - identify and explain the purposes of common CNC machines used for metal fabrication and machining  
  - accurately set tool lengths, offsets, and work locations |
| **Manual Programming Processes**      | *It is expected that students will:*  
  - describe and use common G and M codes to program:  
    - straight line moves  
    - circular moves  
    - “canned” cycles  
    - turning diameters  
    - thread turning  
    - facing  
  - write and execute programs to make small industry-standard parts, including threaded spindles, shaft couplers, and flanges  
  - trouble-shoot their programs to correct errors and increase efficiency |
### Metal Fabrication and Machining 12: CNC Processes (cont’d)

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<tr>
<td><strong>COMPUTER-ASSISTED MANUFACTURING (CAM) PROCESSES</strong></td>
<td>It is expected that students will:</td>
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<td>• describe the purposes and characteristics of computer-assisted manufacturing</td>
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<td>• use a computer-assisted manufacturing program to design 2D and 3D products and to generate the related code</td>
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<td>• transfer computer-assisted design (CAD) drawings to a computer-assisted manufacturing (CAM) program and generate tool paths</td>
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## Metal Fabrication and Machining 12: Forging and Foundry

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| **Health and Safety** | *It is expected that students will:*  
  • relate Workers’ Compensation Board and WHMIS regulations to their own work environments  
  • identify and implement safety and accident prevention procedures  
  • demonstrate an understanding of ventilation, fire, and burn hazards |
| **Personal and Project Management** | *It is expected that students will:*  
  • demonstrate employability skills  
  • create and interpret working drawings and other technical materials  
  • develop a comprehensive work plan for a project |
| **Mathematical Applications** | *It is expected that students will:*  
  • produce cost estimates for forging and foundry projects, including materials and fuel  
  • calculate the volumes and weights of materials needed for specific casting projects  
  • estimate and verify percentage of shrinkage for the various metals used in casting  
  • apply a shrink rule to the creation of a reusable pattern |
| **Materials** | *It is expected that students will:*  
  • identify and describe the characteristics of various materials used for casting and forging, including malleability, ductility, melting point, and machinability  
  • demonstrate preparations required for pouring, including degassing and flux |
| **Casting** | *It is expected that students will:*  
  • identify and use casting equipment  
  • demonstrate proper gating procedures when using a sand mould  
  • differentiate between one-piece, split-and-match-plate, master, and grand-master patterns  
  • construct and apply a reusable pattern  
  • employ a single-use pattern to produce a cast object  
  • cast and complete an object having specified dimensions and surface finish |
| **Forging** | *It is expected that students will:*  
  • identify and use blacksmithing tools  
  • describe the processes of annealing, hardening, and tempering and when to apply them  
  • demonstrate annealing, hardening, and tempering procedures  
  • identify the heat-treating properties of common steel alloys, including C1020 and C4140  
  • demonstrate hot and cold shaping of ferrous and non-ferrous metals  
  • create functional forged tools  
  • create wrought iron or decorative forged objects |
**METAL FABRICATION AND MACHINING 12: SHEET METAL**

This course expands on the fundamentals taught in Metal Fabrication and Machining 11 and 12 through a focus on sheet metal fabrication. Students are provided with an opportunity to improve their knowledge and skills in this area and extend their awareness of employment opportunities that exist in the sheet metal trade.

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| **HEALTH AND SAFETY** | *It is expected that students will:*  
  • consistently demonstrate a safe and healthy work attitude in the metal shop  
  • demonstrate an appreciation for the special precautions required to handle sheet metal  
  • consistently demonstrate the safe use of specialized sheet metal tools and equipment  
  • identify potential workplace hazards and take appropriate precautions to deal with them, including use of protective gear and preparation of emergency response measures |
| **PERSONAL AND PROJECT MANAGEMENT** | *It is expected that students will:*  
  • demonstrate employability skills  
  • interpret sheet metal blueprints and building specifications  
  • produce sheet metal drawings and develop a comprehensive work plan for a sheet metal project  
  • describe possible career paths associated with sheet metal work |
| **MATHEMATICAL APPLICATIONS** | *It is expected that students will:*  
  • describe and demonstrate the application of geometry to sheet metal pattern development  
  • perform calculations involving:  
    - the perimeters, areas, and volumes of regular shapes  
    - weights and thicknesses of both ferrous and non-ferrous metals  
    - the use of both Imperial and SI metric units of measure  
    - costing variables associated with sheet metal work |
| **MATERIALS** | *It is expected that students will:*  
  • demonstrate an understanding of gauge schedules and sizing standards for both ferrous and non-ferrous sheet metals  
  • describe the properties and uses of:  
    - common sheet metals, including zinc, copper, and pre-painted galvanized iron  
    - expanded and perforated sheet metals  
    - screen |
### Tools and Equipment

**It is expected that students will:**
- describe and proficiently use the tools and equipment required for the following sheet metal fabrication processes:
  - layout
  - measuring
  - cutting
  - forming
  - punching
  - fastening
  - soldering
  - clinching
  - welding (spot welding and wire-feed welding)
- maintain (sharpen) and repair sheet metal hand tools

### Forming and Joining Processes

**It is expected that students will:**
- describe and perform the processes involved in the layout and fabrication of products based on the flat plane, cylinder, and right angle
- describe and perform:
  - layout and forming of elbows
  - seams
  - edging (hems)
  - notching
  - riveting
  - soldering