Saskatchewan
Learning

Machining 10, 20, 30 Curriculum Guide

A Practical and Applied Art

Saskatchewan Learning
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Introduction

Within Core Curriculum, the Practical and Applied Arts (PAA) is a major area of study that incorporates five traditional areas of Business Education, Work Experience Education/Career Education, Computer Education, Home Economics Education and Industrial Arts Education. Saskatchewan Learning, its educational partners, and other stakeholders have collaborated to complete the PAA curriculum renewal. Some PAA curriculum guides have been updated by integrating, adapting, or deleting some components; some Locally Developed Courses have been elevated to provincial status; and some new guides have been developed. A companion document, *Practical and Applied Arts Handbook*, provides background on Core Curriculum philosophy, perspectives, and initiatives. The Handbook provides a renewed set of goals for PAA. It presents additional information about the PAA area of study, including guidelines about work study and related transition-to-work dimensions. A *Practical and Applied Arts Information Bulletin* provides direction for administrators and others. Lists of recommended resources from all guides are compiled into a PAA bibliography with periodic updates.

Philosophy and Rationale

A study of the development of technology shows that industry has progressed from the time when everything was made by hand to the present fully automated manufacturing of products. Machining skills have played an essential role in all technological advances. The renewed Machining Curriculum is designed to facilitate and promote the development of the machining skills needed to operate today's advanced machine tools.

The *Machining 10, 20, 30 Curriculum Guide* is designed to enable students to acquire an appreciation of machining. Opportunities are explored for a variety of applications of design through the use of different materials, processes, and finishing. A strong foundation is built by a firm emphasis on the manipulation and application of hand tools, equipment, and materials in a variety of fabricating situations. This course provides relevant, practical applications for students to develop machining and business skills, as well as gain practical employment skills.

Aim, Goals and Foundational Objectives

Aim

To provide students with opportunities to acquire knowledge and develop skills in machining.

It is highly recommended that students have the opportunity to develop skills with hand tools and manual-controlled machine tools. This is an essential beginning before automatic and computer-controlled machining.

Goals

Health and Safety: To obtain the knowledge and skill required to safely perform bench work and machine tool operations.

Awareness: To gain an understanding of practical uses for skills from other subject areas.

Career and Employment: To help students make informed career decisions based on their experiences.

Personal Development: To enhance self-esteem through success with equipment, materials and techniques used.

Independent Learning: To learn independent work practices.

Communication: To learn to communicate effectively in a non-traditional classroom environment.

Foundational Objectives

Foundational objectives are the major, general statements that guide what each student is expected to achieve for the modules of the Practical and Applied Arts curriculum guidelines. Foundational objectives indicate the most important knowledge, skills, attitudes/values, and abilities for a student to learn in a subject. Both the Foundational Objectives for Machining 10, 20 and 30 and the Common Essential Learnings (CELs) Foundational Objectives to be emphasized are stated in this document. Some of these statements may be repeated or enhanced in different modules for emphasis. The Foundational Objectives of the Core Modules of the Machining curriculum include:

- To develop proficiency in the safe use of hand and machine tools.
- To read, observe, and understand all of the information provided on drawings.
- To be able to select and safely use the proper tool for the job.
- To identify and explain health and safety hazards in the workplace so that the potential for personal injury and damage to the equipment and the environment are minimized.
- To understand the properties and uses of different materials used in machining.
- To be able to use and understand the terminology related to machining in context.
- To be able to produce parts to meet given specifications.
- To increase self-esteem from success with the equipment, materials, and techniques used.
- To become aware of the variety of jobs and career opportunities in the machining trades.
- To create an awareness of apprenticeship programs and opportunities in Saskatchewan.
- To handle, use, and dispose of materials safely.
- To be knowledgeable about the impact of new technologies in the machining industry.
- To learn about the evolution of machine tools.
- To gain an overview of the different machining processes.
- To understand the evolving role of a machinist.

All of the subject and CELs Foundational Objectives are stated at the beginning of each module.

Common Essential Learnings (CELs)

The incorporation of the Common Essential Learnings (CELs) into the instruction and assessment of the Practical and Applied Arts curriculum offers many opportunities to develop students' knowledge, skills, and abilities. The purpose of the CELs is to assist students with learning concepts, skills and attitudes necessary to make transitions to career, work, and adult life.

The CELs establish a link between the transition-to-work dimensions and Practical and Applied Arts curriculum content. The transition-to-work dimensions included in the Practical and Applied Arts curricula are: apprenticeship, career exploration/development, community project(s), employability skills, entrepreneurial skills, occupational skills, personal accountability, processing of information, teamwork and work study/experience. Throughout the Practical and Applied Arts curricula, the CELs objectives are stated explicitly at the beginning of each module and are coded in this document, as follows:

COM	=	Communication
NUM	=	Numeracy
CCT	=	Critical and Creative Thinking
TL	=	Technological Literacy
PSVS	=	Personal and Social Values and Skills
IL	=	Independent Learning

Selected learning objectives for the CELs are included throughout the modules. It is anticipated that teachers will find additional ways to incorporate the CELs into their classroom instruction.

Course Components and Considerations

The *Machining 10, 20, 30 Curriculum Guide* offers three courses of 100 hours each of module development. The introductory course outlined at the 10 level incorporates a number of core modules that provide the foundation for the suggested themes at the 20 and 30 levels. There is a graduated level of tool and equipment development throughout the courses, with most of the hand tools being used at the 10 level and power tools being introduced at the 20 and 30 levels.

It is important to remember that when a student has successfully completed a module, credit cannot be given for that module again. The suggested configurations of courses will help create flexibility and meet the needs of the student or community. Many of the machining course modules have been identified as intermediate level. These modules may be used at all grade levels to facilitate greater flexibility. Teachers are encouraged to pursue the variety of options through community partnerships that will enable the use of speakers, mentorships, and business sites for work study.

The Machining Curriculum is intended to be flexible to allow for the different variations in facilities, materials, equipment, and the time available to teach machining. The introductory level modules are developed for students who have no previous metal working experience. The intermediate and advance modules build on competencies developed at the introductory level.

Work Study Components

This module permits the student to apply school-based learning to workplace settings in the community. Students are provided with an opportunity to experience the optional work study component through appropriate placements. If time credit in the workplace is desired, it is required that the student work with a journeyperson in the trade. For more information regarding time credit, consult *High School to Apprenticeship: Link to the Future* (2003). Module 37: Work Study Preparation and Follow-up Activities must be covered prior to and following the work study module. The *Practical and Applied Arts Handbook* has detailed information in the "Work Study Guidelines". Students who have previously taken a work study module may cover content developed by Saskatchewan Labour found in the *Career and Work Exploration10, 20, A30, B30 Curriculum Guide* and the *Practical and Applied Arts Handbook*. These content references include:

- Labour Standards
- Occupational Health and Safety Act and
- Workplace Hazardous Materials Information System (WHMIS).

Creating Partnerships for Work Study

Partnerships are important to the success of the work study component. The three distinct partners that play an important role are industry/business, the school, and the student.

Personal contact is the best approach to building partnerships. One should begin by making a presentation to colleagues within the school, to the student body, to school board members, to parents, and to local businesses. It is important to outline the curriculum and the benefits and responsibilities for each of the partners.

See the modules outlined in the curriculum and the "Work Study Guidelines" in the *Practical and Applied Arts Handbook* for further information on work study.

Portfolios

A personal career portfolio is a valuable organizer of student projects and assignments. It encourages students to collect examples of their work as they progress through the various activities, labs, and projects. Selecting particular items to include in a portfolio encourages students to reflect on what they have learned or accomplished and what they have yet to learn. Portfolio items may include: journal notes, drafts, photographs, audio or video tapes, computer discs, sketches, drawings, etc. Portfolios may be used for peer, teacher, and self-assessment and as a format to present selected works to parents, post-secondary institutions, or potential employers. In addition, the portfolio can demonstrate the link between home, school, and community in the student's education. Each student should have a portfolio representing his or her work during the course.

The portfolio helps students:
- reflect on personal growth and accomplishment
- see links between home, school, and community education and activities
- collect materials to prepare applications for post-secondary education and scholarship program entrance
- collect materials to prepare for employment applications
- focus on career planning.

The portfolio helps teachers:
- provide a framework for independent learning strategies for the student
- communicate student learning from one school year to another in a specific area of study
- identify career planning needs for students
- assess and evaluate the student's progress and achievement in a course of study.

The portfolio helps post-secondary institutions:
- determine suitable candidates for awards and scholarships
- evaluate candidates for program entrance
- evaluate prior learning for program placement.

The portfolio helps the community:
- reflect on the involvement in a student's education and the support offered to learners
- demonstrate the link between the home, school, and community in education.

The portfolio helps potential employers:
- identify employable skills desired in future employees
- provide evidence of knowledge and skill development of potential employees.

Working Portfolio

Students collect work over time in a working folder. Each student should also keep a journal of observations, critiques, ideas, and reflections as part of his or her working portfolio. Items in this portfolio may be used for the purpose of reflection, for ongoing and summative evaluations, for peer, teacher and self-evaluations, and for documenting skill development and mastery.

Working portfolios may be used for purposes of conferencing between student and teacher, teacher and parent, teacher and teacher, or student and student. When a teacher examines a student's portfolio in order to make a decision regarding student progress, the information it contains may become documented evidence for the evaluation.

A daily journal may also become a part of a working portfolio as a means of tracking the student's use of time and to record progress on ideas that are being developed. This will provide the student with a focus for self-directed or independent learning, as well as an anecdotal record for part of the course evaluation.

Presentation Portfolio

To compile a presentation portfolio, students should select items from their working portfolio. The presentation portfolio should cover the range of students' experiences and should display their best efforts. The preparation of a presentation portfolio can be an assessment strategy. It is strongly suggested that students at the 30 level prepare a presentation portfolio suitable for submission to potential employers or post-secondary institutions.

Through collecting, selecting and reflecting, students are able to compile presentation portfolios that display their best collection of work.

Extended Study Modules

The extended study module is designed to provide schools with an opportunity to meet current and future demands that are not addressed by current modules in the renewed PAA curriculum.

The flexibility of this module allows a school/school division to design one new module per credit to complement or extend the study of existing pure core modules and optional modules. The extended study module is designed to extend the content of the pure courses and to offer survey course modules beyond the scope of the selection of PAA modules.

The list of possibilities for topics of study or projects for the extended study module approach is as varied as the imagination of those involved in using the module. These optional extended study module guidelines, found in the *Practical and Applied Arts Handbook*, should be used to strengthen the knowledge, skills, and processes advocated in the PAA curriculum in which the extended study module is used.

It is recommended that a summary of any extended study module be sent to the Regional Superintendent of Curriculum and Instruction to establish a resource bank of module topics.

For more information on the extended study module, refer to the *Practical and Applied Arts Handbook*.

Career Development

Saskatchewan Learning is committed to the infusion of career development competencies across curricula as part of a broad career development strategy for Saskatchewan. Saskatchewan students will be better equipped to achieve fulfillment in personal, social, and work roles through exposure to a career building process.

In 2001, the Department adopted the *Blueprint for Life/Work Designs* as the scope and sequence for the integration of career development competencies into Core Curriculum. The Blueprint outlines the skills, knowledge and attitudes that are essential tools for effectively managing life/work development. This framework, which describes career development competencies from early childhood through adulthood, was developed through the collaboration of representatives of Canadian provinces and territories and is published by the National Life/Work Centre, a not-for-profit organization that supports career development. The cornerstone of the Blueprint is the matrix of eleven competencies grouped into three sections: personal management, learning and work exploration, and life/work building.

The career development framework includes the continuous development of the following competencies:

A. Personal Management:
    1. Building and maintaining a positive self-image
    2. Interacting positively and effectively with others
    3. Changing and growing throughout one's life

B. Learning and Work Exploration:
   4. Participating in life-long learning supportive of life/work goals
   5. Locating and effectively using life/work information
   6. Understanding the relationship between work and society/economy

C. Life/Work Building:
   7. Securing, creating, and maintaining work
   8. Making life/work enhancing decisions
   9. Maintaining balanced life and work goals
   10. Understanding the changing nature of life/work roles
   11. Understanding, engaging in, and managing one's own life/work building processes

Each of the eleven competencies has been further categorized into four developmental levels roughly corresponding to Elementary Level, Middle Level, Secondary Level, and Adult Level. Within each level of a competency are a number of general learning objectives, referred to in the Blueprint as indicators. These objectives are grouped within learning stages of acquisition, application, personalization, and actualization. A comprehensive description of all of the eleven career development competencies may be found at www.blueprint4life.ca.

This curriculum guide reflects the career development competencies within the curriculum objectives, instructional activities, and suggested student assessment processes.

Resources

To support the principle of Resource-based Learning, a variety of instructional resources have been evaluated and recommended. See the Machining section of *Practical and Applied Arts: A Bibliography* (2003) for a list of annotated resources. Teachers should also consult the Practical and Applied Arts Resources website at www.sasked.gov.sk.ca/curr_inst/iru/paares.html for access to the online bibliographies, updates, websites, journals, videos and discussion areas.

The on-line version of this guide is accessible at www.sasked.gov.sk.ca/docs/paa.html. It will be "Evergreened", as appropriate.

Assessment and Evaluation

Student assessment and evaluation is an important part of teaching as it allows the teacher to plan and adapt instruction to meet the specific needs of each student. It also allows the teacher to discuss the current successes and challenges with students and report progress to the parent or guardian. It is important that teachers use a variety of assessment and evaluation strategies to evaluate student progress. Additional information on evaluation of student achievement can be found in the Saskatchewan Education documents *Student Evaluation: A Teacher Handbook* (1991) and *Curriculum Evaluation in Saskatchewan* (1991).

Assessment and evaluation throughout the Machining 10, 20, 30 courses should be based on the learning objectives that are outlined in the curriculum. It is important to use a variety of assessment techniques to ensure accurate student evaluation. The design of an evaluation matrix/scheme should reflect the amount of time devoted to each of the modules taught in the course.

Here is a sample evaluation scheme:

Portfolios	20%
Tests (written)	10%
Project work	25%
Homework and Assignments	10%
Classroom Presentations	10%
Work Study	25%

If work study was not offered, some time could be used for project development involving larger projects that might include the optional extended study module available in this guide.

For more information about student evaluation refer to the *Practical and Applied Arts Handbook* or *Student Evaluation: A Staff Development Handbook* (Saskatchewan Professional Development Unit, 1999).

For information about program evaluation refer to the *Saskatchewan School-Based Program Evaluation Resource Book* (1989).

For information about curriculum evaluation refer to *Curriculum Evaluation in Saskatchewan* (Saskatchewan Education, 1991).

Module Overview

Module Code	Modules	Suggested time (hours)
MACH01	Module 1: Introduction to Machining (Core)	2-4
MACH02A, B, C	Module 2A, B, C: Safety (Core)	1-5
MACH03	Module 3: Using Technical Drawings (Core)	5-7
MACH04A	Module 4A: Simple Measurement (Core)	3-5
MACH04B	Module 4B: Adjustable Measuring Tools (Core)	3-5
MACH04C	Module 4C: Measuring with Gauges (Core)	3-5
MACH05	Module 5: Layout Work (Core)	5-10
MACH06	Module 6: Hand Tools (Core)	10-15
MACH07	Module 7: Fasteners (Core)	3-5
MACH08	Module 8: Jigs and Fixtures (Optional)	5-7
MACH09	Module 9: Cutting Fluids (Optional)	2-4
MACH10	Module 10: Drills and Drilling Machines (Core)	5-10
MACH11	Module 11: Offhand Grinding (Core)	5-8
MACH12	Module 12: Saws and Cutoff Machines (Core)	5-7
MACH13	Module 13: Metal Characteristics (Optional)	3-5
MACH14	Module 14: Heat Treatment of Metals (Core)	3-5
MACH15	Module 15: Metal Finishing (Optional)	2-4
MACH16	Module 16: Career Opportunities (Core)	3-5
MACH17A	Module 17A: The Lathe, Introduction (Core)	5-7
MACH17B	Module 17B: Lathe Cutting Tools (Core)	5-7
MACH17C	Module 17C: Cutting Speeds and Feeds on the Lathe (Core)	5-7
MACH17D	Module 17D: Mounting Work Between Centres on the Lathe (Optional)	2-4
MACH17E	Module 17E: Turning Between Centres on the Lathe (Core)	5-10
MACH17F	Module 17F: Lathe Chucks (Optional)	2-4
MACH18	Module 18: Cutting Tapers on the Lathe (Optional)	3-5
MACH19	Module 19: Cutting Screw Threads on the Lathe (Core)	10-15
MACH20	Module 20: Additional Lathe Operations (Optional)	5-10
MACH21	Module 21: Band Machining (Core)	5-10
MACH22	Module 22: Broaching Operations (Core)	5-10
MACH23A	Module 23A: Introduction to the Milling Machine (Core)	5-10
MACH23B	Module 23B: Milling Machine Cutters (Optional)	3-5
MACH23C	Module 23C: Setting a Milling Machine (Optional)	3-5
MACH24	Module 24: Operating a Vertical Milling Machine (Core)	10-15
MACH25	Module 25: Operating a Horizontal Milling Machine (Optional)	10-15
MACH26	Module 26: Gear Cutting Operations (Optional)	5-10
MACH27	Module 27: Precision Grinding (Core)	5-10
MACH28	Module 28: Work Holding Devices and Surface Grinding (Optional)	15-20
MACH29	Module 29: Additional Grinding Techniques (Optional)	3-5
MACH30	Module 30: Numerical Control (Optional)	3-5
MACH31	Module 31: Automated Multi-machine Manufacturing (Optional)	3-5
MACH32	Module 32: Quality Control (Optional)	3-5
MACH33	Module 33: Electro-machining Processes (Optional)	2-4
MACH34	Module 34: Non-traditional Machining Techniques (Optional)	2-4
MACH35	Module 35: Other Machining Processes (Optional)	2-4
MACH36A, B, C	Module 36A, B, C: Machining Project Options (Optional)	20-35
MACH37A, B, C	Module 37A, B, C: Work Study Preparation and Follow-up Activities (Optional)	5-10

MACH38A, B, C	Module 38A, B, C: Work Study (Optional)	25-50
MACH88	Module 88: Apprenticeship in Saskatchewan (Optional)	2-5
MACH99A, B, C	Module 99A, B, C: Extended Study (Optional)	5-20

Suggested Course Configurations

Module Code	Module	Suggested time (hours)
Machining 10		
MACH01	Module 1: Introduction to Machining (Core)	2-4
MACH02A	Module 2A: Safety (Core)	3-5
MACH03	Module 3: Using Technical Drawings (Core)	5-7
DRAF03	Module 3: Sketching and Freehand Drawing Fundamentals (Optional)	5-15
MACH04A	Module 4A: Simple Measurement (Core)	3-5
MACH05	Module 5: Layout Work (Core)	5-10
MACH06	Module 6: Hand Tools (Core)	10-15
MACH07	Module 7: Fasteners (Core)	3-5
MACH08	Module 8: Jigs and Fixtures (Optional)	5-7
MACH09	Module 9: Cutting Fluids (Optional)	2-4
MACH10	Module 10: Drills and Drilling Machines (Core)	5-10
MACH11	Module 11: Offhand Grinding (Core)	5-8
MACH12	Module 12: Saws and Cutoff Machines (Core)	5-7
MACH13	Module 13: Metal Characteristics (Core)	3-5
MACH14	Module 14: Heat Treatment of Metals (Core)	3-5
MACH15	Module 15: Metal Finishing (Optional)	2-4
MACH16	Module 16: Career Opportunities (Core)	3-5
MACH36A	Module 36A: Machining Project Options (Optional)	20-35
MACH37A	Module 37A: Work Study Preparation and Follow-up Activities (Optional)	5-10
MACH38A	Module 38A: Work Study (Optional)	25-50
MACH99A	Module 99A: Extended Study (Optional)	5-20
	Minimum	**100**
Machining 20		
MACH02B	Module 2B: Safety (Core)	1-3
MACH04B	Module 4B: Adjustable Measuring Tools (Core)	3-5
DRAF31	Module 31: Reading Technical Drawings (Blueprints) (Optional)	2-5
MACH17A	Module 17A: The Lathe, Introduction (Core)	5-7
MACH17B	Module 17B: Lathe Cutting Tools (Core)	5-7
MACH17C	Module 17C: Cutting Speeds and Feeds on the Lathe (Core)	5-7
MACH18	Module 18: Cutting Tapers on the Lathe (Optional)	3-5
MACH20	Module 20: Additional Lathe Operations (Optional)	5-10
MACH21	Module 21: Band Machining (Core)	5-10
MACH22	Module 22: Broaching Operations (Core)	5-10
MACH23A	Module 23A: Introduction to the Milling Machine (Core)	5-10
MACH23B	Module 23B: Milling Machine Cutters (Optional)	3-5
MACH27	Module 27: Precision Grinding (Core)	5-10
MACH30	Module 30: Numerical Control (Optional)	3-5
MACH31	Module 31: Automated Multi-machine Manufacturing (Optional)	3-5
MACH32	Module 32: Quality Control (Optional)	3-5
MACH33	Module 33: Electro-machining Processes (Optional)	2-4
MACH34	Module 34: Non-traditional Machining Techniques (Optional)	2-4
MACH35	Module 35: Other Machining Processes (Optional)	2-4
MACH36B	Module 36B: Machining Project Options (Optional)	20-35
MACH37B	Module 37B: Work Study Preparation and Follow-up Activities (Optional)	5-10

MACH38B	Module 38B: Work Study (Optional)	25-50
MACH99B	Module 99B: Extended Study (Optional)	5-20
	Minimum	**100**
Machining 30		
MACH02C	Module 2C: Safety (Core)	1-3
MACH04C	Module 4C: Measuring with Gauges (Core)	3-5
MACH17D	Module 17D: Mounting Work Between Centres on the Lathe (Optional)	2-4
MACH17E	Module 17E: Turning Between Centres on the Lathe (Core)	5-10
MACH17F	Module 17F: Lathe Chucks (Optional)	2-4
MACH19	Module 19: Cutting Screw Threads on the Lathe (Core)	10-15
MACH20	Module 20: Additional Lathe Operations (Optional)	5-10
MACH22	Module 22: Broaching Operations (Core)	5-10
MACH23C	Module 23C: Setting a Milling Machine (Optional)	3-5
MACH24	Module 24: Operating a Vertical Milling Machine (Core)	10-15
MACH25	Module 25: Operating a Horizontal Milling Machine (Optional)	10-15
MACH26	Module 26: Gear Cutting Operations (Optional)	5-10
MACH28	Module 28: Work Holding Devices and Surface Grinding (Optional)	15-20
MACH29	Module 29: Additional Grinding Techniques (Optional)	3-5
MACH36C	Module 36C: Machining Project Options (Optional)	20-35
MACH37C	Module 37C: Work Study Preparation and Follow-up Activities (Optional)	5-10
MACH38C	Module 38C: Work Study (Optional)	25-50
MACH88	Module 88: Apprenticeship in Saskatchewan (Optional)	2-5
MACH99C	Module 99C: Extended Study (Optional)	5-20
	Minimum	**100**

Core and Optional Modules

Module 1: Introduction to Machining (Core)

Suggested time: 2-4 hours **Level:** Introductory
Prerequisite: None

Foundational Objectives
- To learn about the evolution of machine tools.
- To gain an overview of the different machining processes.
- To understand the evolving role of a machinist.
- To be able to use and understand the terminology related to machining in context.

Common Essential Learnings Foundational Objectives
- To explore the evolution of technological innovation within machining with a focus on the social forces that spawned the innovations and the steps involved in the development. (TL)
- To understand the essential role machinists play in the development of all technological advances. (PSVS)
- To recognize the inevitability of profound change due to advancements in technology and be prepared to influence change by continuing to learn on an ongoing basis. (IL)

	Learning Objectives	Notes
1.1	To understand how machine tools evolved.	Review the evolution of machining from the first metal work to the present machining processes. Have the students discuss how machine tools might be created when there were no machine tools to make the new machines. Review the different types of hand and machine tool operations.
1.2	To describe the operation of the basic machine tools. (COM)	Have the students collect pictorial examples of basic machine tools including: • lathes • drills • grinders • mills • saws • broaches.
1.3	To describe the application of non-traditional machining processes.	These processes include a variety of electrical and chemical processes used to machine materials. The most commonly used in industry today are: • Laser machining with the use of an intense light beam to cut or drill surfaces. • Hydrodynamic machining when water forced through a jet at very high pressure is used as the cutter. • Electrochemical processes where electricity passes through a chemical medium and removes material in a precise manner.
1.4	To understand how machining processes became automated.	The development of fully automated machining processes includes the numerical control system for programming machining operations. Have the students discuss how this system of operations, now directed by a computer (computer numerical control, CNC) has changed the manufacturing industry.

	Learning Objectives	Notes
1.5	To explore the role machining has in all types of manufacturing. (CCT)	Have students name different products to discover if that product does not require the skill of a machinist somewhere in its manufacture or production.

Module 2A, B, C: Safety (Core)

Module 2A: Safety (Core)

Suggested time: 3-5 hours **Level:** Introductory
Prerequisite: None

Foundational Objectives
- To be able to use and understand the terminology related to machining in context.
- To identify and explain health and safety hazards in the workplace so that the potential for personal injury and damage to the equipment and the environment are minimized.
- To develop proficiency in the safe use of hand and machine tools.

Common Essential Learnings Foundational Objectives
- To use imaging in order to enhance their learning. (CCT)
- To develop skills in the use of equipment and materials common to the machining industry. (IL)
- To develop workplace skills, knowledge, and attitudes that may lead to successful employment. (PSVS)

Learning Objectives	Notes
2.1 To recognize and apply safe working practices in the working area. (CCT)	Use lecture and discussion methods. Students should be required to make notes based on these discussions. In the work areas, demonstrate and identify the items with which students must be familiar. Be sure to indicate the location of necessary safety and first-aid equipment. Topics to discuss should include: eye protection, protective clothing and footwear, health hazards, safe handling and storage of chemicals, ventilation, reporting accidents, safety procedures, cleanup, tool use, equipment maintenance, and material storage. Follow workplace procedures and emphasize risk control concerning: • cleanliness • tool and material handling • slips and falls • proper electrical safety • harassment and violence. General information regarding the Labour Standards Act, Occupational Health and Safety and Workplace Hazardous Materials Information System (WHMIS) is found in the *Practical and Applied Arts Handbook* and the *Career and Work Exploration 10, 20, A30, B30 Curriculum Guidelines*. Specific information about hazards is available from Saskatchewan Labour or is found in the bibliography of recommended resources.

	Learning Objectives	Notes
2.2	To apply accident prevention principles and techniques to ensure safe, injury free work. (CCT)	Safety is a topic to be emphasized throughout the machining courses. Constant reminders of the need for safe work procedures are important. Invite a local industry safety officer to discuss typical safety programs and why industry places so much emphasis on safety. Have the students make safety posters for the shop.
2.3	To recognize the safety hazards associated with machining and take the necessary preventive measures to avoid personal injury and injury to others.	Have the students examine WHMIS materials and the Materials Safety Data Sheets (MSDS) that are available for the equipment they will be handling during the course. Materials to support this objective are available from Saskatchewan Labour.
2.4	To understand the regulations for occupational health and safety with respect to the machining industry.	Refer to Occupational Health and Safety Regulations accessible from Saskatchewan Labour. Consider using Occupational Health and Safety personnel and video resources to present and discuss safety standards and safe work habits.

Module 2B: Safety (Core)

Suggested time: 1-3 hours
Prerequisite: Module 2A

Level: Intermediate

Review or repeat Module 2A as required before proceeding with the Intermediate level course.

Module 2C: Safety (Core)

Suggested time: 1-3 hours
Prerequisite: Module 2B

Level: Advanced

Review or repeat Module 2A as required before proceeding with the Advanced level course.

Module 3: Using Technical Drawings (Core)

Suggested time: 5-7 hours **Level:** Introductory
Prerequisite: None

Foundational Objectives
- To read, observe, and understand all of the information provided on drawings.
- To be able to use and understand the terminology related to machining in context.

Common Essential Learnings Foundational Objectives
- To ask pertinent questions in order to further their own understanding. (COM)
- To use reference materials to clarify information. (COM)
- To appreciate the concept of scale and proportion in technical drawings. (NUM)
- To use, in conjunction with other methods and understanding, quantitative problem-solving tools such as tables of conversion factors or tables of equivalences. (NUM)

	Learning Objectives	Notes
3.1	To read all types of dimensions and related information on technical drawings. (COM)	Have the students discuss the following: • The importance of accurate drawings to ensure all parts, no matter where they are made, will be interchangeable and fit properly in new assemblies and in similar assemblies made at an earlier date. • Reason for standardized symbols, lines, and figures. • The importance of the American National Standards Institute (ANSI). The symbols revised by ANSI and the symbols they replace. • The drafting Alphabet of Lines. • The variety of information found on drawings and how it is used. • The various types of drawings used in machine shops. • Methods used to reproduce drawings. • Drawing sizes. • Geometric Tolerances and Dimensions and why it is used. It is important to emphasize to students that a machinist: • always works to the dimensions, tolerances, and surface finishes specified on a drawing. • never scales a dimension from a drawing.
3.2	To identify and explain the information found on a technical drawing. (COM)	This type of information might be found in: • a bill of materials list • title block • the symbols and abbreviations as they apply to different trades. Further information on reading technical drawings can be found in the *Drafting and Computer-Aided Design 10, 20, 30 Curriculum Guide,* Module 31.

	Learning Objectives	Notes
3.3	To list and describe the various types of drawings common to machine work.	Have the students prepare or collect a variety of drawings including detail, assembly, subassembly and exploded view and explain the possible uses for each type. Show prints of a simple assembly drawing of a project that will be made by the class. Show a completed sample of the object shown on the print.
3.4	To explain the basics of geometric dimensioning and tolerancing.	Have the students prepare a list of terms and their uses that are used for dimensioning and tolerancing in machining.

Module 4A: Simple Measurement (Core)

Suggested time: 3-5 hours **Level:** Introductory
Prerequisite: None

Foundational Objectives
- To be able to use and understand the terminology related to machining in context.
- To be able to produce parts to meet given specifications.

Common Essential Learnings Foundational Objectives
- To use fractions and decimals in order to better understand machining. (NUM)
- To read commonly used dials, meters, and scales and understand how to interpret these readings. (NUM)
- To understand the meaning of precision and determine the most appropriate degree of precision for a particular task. (NUM)

	Learning Objectives	Notes
4.1	To measure accurately with a steel rule to 1/64" (0.5 mm).	Demonstrate how to use rules and discuss: • the various types of rules • how to read and use the various types of rules • how to handle and care for rules so they will retain their accuracy. Have the students measure a number of samples to practice their skill.
4.2	To measure angles accurately using a protractor. (NUM)	Have the students layout a variety of angles -- acute, right, obtuse, straight and reflex.
4.3	To use measurements in calculations that would be common in machining.	Students will need to be able to perform basic calculations (adding, subtracting, multiplying, dividing, percentage) with both decimals and fractions, including mixed and improper fractions. Examples in the context of machining should be provided and opportunity to demonstrate and further develop those skills should be provided when necessary.

Module 4B: Adjustable Measurement Tools (Core)

Suggested time: 3-5 hours **Level:** Intermediate
Prerequisite: Module 4A

Review or repeat Module 4A as required before proceeding with the Intermediate level course.

	Learning Objectives	Notes
4.4	To measure accurately with a micrometer caliper. (NUM)	Discuss the importance of proper care and cleaning of the micrometer. Demonstrate the use of micrometers for the students and discuss: • the various types of micrometers • how to read both the thousandths of an inch-based and metric-based micrometers • the correct way to use micrometers • the proper way to store micrometers so they will retain their accuracy • that students should be expected to be able to measure to an accuracy of 0.001" (0.002 mm).
4.5	To use Vernier measuring tools to make accurate measurements. (NUM)	Demonstrate for the students how to use a Vernier scale and discuss: • the various types of measuring tools that use a Vernier scale • how to read inch- and metric-based Vernier scales • the correct way to handle a Vernier scaled tool • the proper way to care for Vernier so they will retain their accuracy • that students should be expected to be able to measure to an accuracy of 0.001" (0.002 mm).
4.6	To measure angles accurately using a universal Vernier bevel.	Demonstrate how to use Vernier Measuring Tools and discuss: • the various types of Vernier calipers • how to read dial calipers • how to read the universal bevel protractor • the correct way to use Vernier and dial calipers • the proper way to care for Vernier measuring tools so they will retain their accuracy • students should be expected to be able to measure to an accuracy of 0°5'.
4.7	To calculate and use degree of precision, absolute error, and relative error.	Students should recognize that with any measuring device there is a margin of error, as no measuring instrument is infinitely precise. Students should be able to calculate the maximum possible error for any measuring device they use, and calculate the absolute error and relative error for any measurement they make. The relationship between absolute error and tolerance should be discussed, and implications for the manufacturing process should be examined.

Module 4C: Measuring with Gauges (Core)

Suggested time: 3-5 hours **Level:** Advanced
Prerequisite: Module 4B

Review or repeat Module 4B as required before proceeding with the Advanced level course.

	Learning Objectives	Notes
4.8	To identify and describe the types of gauges used in machining. (COM)	Demonstrate and discuss how gauges and dial indicators are used and cared for. It is important that students understand the care and maintenance requirements of these types of measuring tools.
4.9	To measure using dial indicator gauges. (TL)	Have the students demonstrate the correct method used to take measurements using a dial indicator.
4.10	To use helper measuring tools used in a machine shop.	Have the students practice measuring on sample project parts that they will be making. If some types of tools are not available, contact a tool manufacturer to demonstrate the tools for the students.

Module 5: Layout Work (Core)

Suggested time: 5-10 hours **Level:** Introductory
Prerequisite: Modules 3 and 4

Foundational Objectives
- To develop proficiency in the safe use of hand and machine tools.
- To identify and explain health and safety hazards in the workplace so that the potential for personal injury and damage to the equipment and the environment are minimized.

Common Essential Learnings Foundational Objectives
- To ask pertinent question in order to further their own understanding. (COM)
- To sequence a series of instructions so the process progresses constructively. (COM)

	Learning Objectives	Notes
5.1	To understand the need to do layout work. (TL)	Have the students list the reasons for doing the layout procedure.
5.2	To understand the purpose of each layout tool.	Have the students gather the following material and equipment: layout dye, scriber, hermaphrodite caliper, divider, surface gage, squares, combination set, hammer, and punches. Review the safe handling and use of layout tools and the need to protect layout equipment from becoming damaged.
5.3	To demonstrate the safe use of layout tools. (PSVS)	For a demonstration on precision layout work, have the following equipment available: • Vernier height gage • right angle plate • parallels • V-blocks • straight edge • Vernier bevel • protractor • surface plate.
5.4	To follow a basic procedure for basic layout. (IL)	Have the students demonstrate the layout tools they will be using. This should include: • safe handling of layout tools • preparing metal for layout with layout dye • procedural steps for making a simple layout • laying out angles • the use of parallels, V-blocks and angle plate in layout work • the proper way to use and care for measuring tools • care of the surface plate.
5.5	To follow a machining sequence using hand tools. (IL)	Have the students complete a small project that requires the use of layout and hand tools to complete. A drill-grinding gauge or a right angle square are useful projects at the Introductory level.

Module 6: Hand Tools (Core)

Suggested time: 10-15 hours **Level:** Introductory
Prerequisite: Module 2

Foundational Objectives

- To develop proficiency in the safe use of hand and machine tools.
- To identify and explain health and safety hazards in the workplace so that the potential for personal injury and damage to the equipment and the environment are minimized.
- To be able to select and safely use the proper tool for the job.

Common Essential Learnings Foundational Objectives

- To use text aids such as diagrams to learn technical terms associated with the hand tools used in machining. (COM, TL)
- To equip the student with the knowledge needed to recognize and correct unsafe working conditions. (CCT)

	Learning Objectives	Notes
6.1	To identify common machine shop hand tools. (TL)	Emphasize the need for proper storage of tools to prevent damage or loss.
6.2	To use the appropriate hand tool for the job being done. (TL)	Review the risks involved in using the wrong tool for the job. Selecting the proper size of hammer or a hacksaw blade with the proper number of teeth per inch are examples that might be used to illustrate this point. Have students work in pairs and present demonstrations and explanations on proper care and use for the hand tools used in machining.
6.3	To recognize tools in need of repair. (IL)	Review the health and safety risks that might result from using a damaged tool. Have students inspect tools and identify those that are need of repair. Tools will need to be sharpened or replaced from time to time. Have the students learn to recognize when a tool needs maintenance and to report its condition. Note: Students will learn to sharpen tools in the modules where the tool is used. At the Introductory level identifying any problems is sufficient.
6.4	To properly clean hand tools and the work area.	Have the students recognize the importance of keeping tools clean and the work area well organized. For example, it will be necessary to clean files as they are used to remove waste that will lodge in the teeth of the file. Refer the Students to *The Occupational Health and Safety Act, 1993* as well as the *Regulations* for further information regarding the need for maintaining a clean work area.

Module 7: Fasteners (Core)

Suggested time: 3-5 hours **Level:** Introductory
Prerequisite: None

Foundational Objectives
- To demonstrate knowledge of different materials and their applications in the machining industry.

Common Essential Learnings Foundational Objective(s)
- To be knowledgeable about the impact of new technologies in the machining industry. (TL)

	Learning Objectives	Notes
7.1	To identify the different kinds of fasteners a machinist might use.	The following items will aid in teaching this module: • A selection of fastener styles and types for examination. • A selection of adhesives suitable for bonding metal.
7.2	To describe situations where these fasteners are used. (COM)	Have students identify a variety of nut and bolt styles that illustrate permanent and non-permanent applications for a variety of Unified National Coarse (UNC) and Unified National Fine (UNF) threaded fasteners and give an example of a typical application. Compare these fasteners with thread forming and thread cutting screws. Have the students identify different types and styles of fasteners that are not threaded. Include a variety of pins, rivets, and keys identifying applications for each type of fastener.
7.3	To select the proper fastening device for a specific job. (CCT)	Have the students discuss the following: • Why there are so many types of fasteners. • How threaded fasteners are measured. • How to identify metric fasteners. • How to identify National Coarse Series fasteners. • Thread nomenclature. • The various fasteners available in the shop. • What problems are encountered when inch-based and metric-based fasteners are used on the same product. • The use of stainless steel fasteners. • Why aircraft application fasteners are so expensive. • Where adhesives are used to join metal parts.
7.4	To describe how parts are joined using chemical fastening techniques. (COM)	Have the students describe situations where adhesives would be used and where their use would not be suitable. Bond samples of metal using different adhesives and then test the strength of the bond by conducting a destructive test. Review the need for the safe, proper handling of adhesives and the use of proper safety equipment with the students.

Module 8: Jigs and Fixtures (Optional)

Suggested time: 5-7 hours **Level:** Introductory
Prerequisite: Module 1

Foundational Objectives
- To increase self-esteem from success with the equipment, materials, and techniques used.
- To gain an overview of the different machining processes.

Common Essential Learnings Foundational Objective(s)
- To explore the technical implications of present technology and of impending technological developments as they arise in the field of machining. (TL)

	Learning Objectives	Notes
8.1	To understand the advantages of using jigs and fixtures. (CCT)	Have the students discuss the following: • Describe how a jig differs from a fixture. • The purposes for jigs and fixtures. • The various types of jigs and fixtures. It is important to realize that jigs are developed to save time when an action is repeated many times. A jig is created to be a time saving tool where a large number of repetitions of the same operation are required. The need for precise duplication of a task is the reason for this type of tool.
8.2	To list different types of jigs. (TL)	Have students find examples of different types of jigs and explain their use in a production process. Have students design and build a simple template jig for a project they will be making. This could be as simple as making a jig to guide a drill bit to create a hole to hang up a tool.
8.3	To give examples of fixtures and explain their purpose. (COM)	Have the student find examples of different types of fixtures and explain their use in a production process. A common example of a fixture is a drill press vise. The fixture holds the workpiece while operations are performed on it. Have students design and build a simple fixture to be used with a project on a lathe, grinder, or drill press.
8.4	To be able to identify the different types of jigs and fixtures.	Have students research and collect examples of jigs and fixtures. If possible arrange a tour of a local manufacturing company that uses jigs and fixtures.

Module 9: Cutting Fluids (Optional)

Suggested time: 2-4 hours **Level:** Introductory
Prerequisite: Module 1

Foundational Objectives
- To identify and explain health and safety hazards in the workplace so that the potential for personal injury and damage to the equipment and the environment are minimized.
- To gain an overview of the different machining processes.
- To understand the properties and uses of different materials used in machining.

Common Essential Learnings Foundational Objectives
- To handle, use, and dispose of materials safely. (TL)
- To interpret and report results of learning experiences. (IL)

	Learning Objectives	Notes
9.1	To understand the purpose of cutting fluids. (IL)	Have students collect literature on cutting fluids from different manufacturers. Have the students list the functions served by cutting fluid.
9.2	To describe the properties of different types of cutting fluids. (COM)	Have the students research the properties of a variety of cutting fluids to discover that different fluids are used for different applications. Collect samples of as many different cutting fluids as possible for comparison.
9.3	To describe different methods of application for each type of cutting fluid.	Have the students do research to find when each type of cutting fluid is used and when certain types of cutting fluids should not be used.
9.4	To describe the safe use, storage, and disposal of each type of cutting fluid. (COM)	Stress safety concerns with the different types of cutting fluids and the application of cutting fluids. If mist or vapour is present as a result of the cutting process, a respirator is necessary in addition to eye protection. Proper safety equipment must be worn when working with or handling cutting fluids. Discuss with the students the proper method to dispose of oil in an environmentally responsible fashion. Many communities have an oil collection site where used oil is stockpiled for recycling.

Module 10: Drills and Drilling Machines (Core)

Suggested time: 5-10 hours **Level:** Introductory
Prerequisite: Modules 1 and 2

Foundational Objectives
- To develop proficiency in the safe use of hand and machine tools.
- To learn about the evolution of machine tools.
- To increase self-esteem from success with the equipment, materials, and techniques used.

Common Essential Learnings Foundational Objective(s)
- To learn technical terms associated with the subject area. (COM, TL)

	Learning Objectives	Notes
10.1	To understand the operation of a drilling machine. (TL)	Have the students list the styles and types of drilling machines, work-holding devices, jigs, and setups as well as the variety of drill press machining operations. Have the students identify the parts of the drill press and how a drill press is sized.
10.2	To name the parts of a twist drill. (COM)	Have students research the manufacturing process for twist drills and identify the parts of a twist drill as part of an exercise to describe how a drill cuts a hole.
10.3	To understand the procedures that will ensure safe drilling operations. (PSVS)	Have students prepare a poster of safety rules, including personal safety equipment, that should be followed when using drills or drill presses. Have students demonstrate the safe use of various types of hold down devices. Have students do demonstrations of safe tool operations. An example of what can happen when a loose sleeve comes in contact with a drill bit can be demonstrated with a scrap of fabric laid on a piece of wood and touched by the rotating drill bit.
10.4	To understand the use of cutting speed and feed tables. (NUM)	Have students demonstrate the use of speed and feed tables by adjusting drill press speed to determine proper settings for drilling in a variety of metals.

	Learning Objectives	Notes
10.5	To operate drilling equipment used in machining operations. (PSVS)	Have the students demonstrate the setup sequence and operation of a drill press and portable drills. The use of a centre finder or a punch to mark the hole location to guide the drill is recommended. Remind students of the need to wear the proper safety equipment for the operation they are doing. Select projects like a drill gauge plate as an exercise to develop skill with drills and the drilling operations. This project could then be used to determine drill size when the stamped size on the shank has become illegible. Students should practice using the drill press on flat and round stock with a number of different types of material. Review the purpose and use of cutting fluid.
10.6	To describe and compare the various drill series that are available.	Have the students determine the common drill series available in sets from tool dealers. There are also different levels of quality available in drill bits that students might experiment with to determine the cost effectiveness of buying cheaper or more expensive drill bits. Have students find examples of other types of drills and drill sizes that would be useful in machining operations.
10.7	To sharpen a twist drill bit.	The three factors for students to remember when sharpening a twist drill are: • maintaining the dead centre • lip clearance • length and angle of the lip Have students practice drill bit sharpening using old or dull bits. It is important that students do not allow the bit to overheat as it will lose its temper. Allow hot bits to cool in the air, not in water. The rapid change in temperature resulting from dipping in water will make the metal in the bit brittle. A poster assignment of drill bit sharpening problems might be useful to help students recognize any problems they encounter during their sharpening practice. A project to consider for the students is a drill point gauge that helps to check and maintain the dead centre and lip angle when a drill bit is sharpened. A purchased gauge might act as a template for the project.
10.8	To perform countersinking operations on a drill press. (IL)	The students could demonstrate the purpose of countersinking by flush mounting a flat head fastener. It might be possible to find high speed steel (HSS) drills that have a countersink built into the drill rod.

	Learning Objectives	Notes
10.9	To perform counterboring and spotfacing operations on a drill press.	These operations both provide a flat surface against which to tighten a fastener. Have students demonstrate the counterbore procedure by preparing the drilled hole for a fastener that is set below a flat work surface. Have students demonstrate the spotfacing procedure by preparing a hole for a fastener that is set on a rough or irregular work surface.
10.10	To demonstrate the use of a drill press to assist tapping a drilled hole.	The drill press can be used as a steady rest for the tap to keep the tap aligned vertically during the tapping procedure. The drill press has a dead centre clamped in the drill chuck and positioned on the top of the tap. As the tap is turned by hand, the drill press handwheel or lever moves the quill down as the tap moves through the drilled hole. **Remember the drill press is used as a guide and is not turned on during this operation.** A tap is not designed to be used in a drill chuck (without a tapping attachment to reduce drill press speed) and to do so would shatter the tap.
10.11	To demonstrate the use of a reamer.	Have students select the appropriate reamer and ream a pre-drilled hole to produce a smooth surface. A reamer will also provide a hole that is round. Some drills and drill presses can cut distorted out-of-round holes. The reamer is the tool to use to insure the hole produced is round.

Module 11: Offhand Grinding (Core)

Suggested time: 5-8 hours **Level:** Introductory
Prerequisite: Modules 1 and 2

Foundational Objectives
- To develop proficiency in the safe use of hand and machine tools.
- To gain an overview of the different machining processes.
- To be knowledgeable about the impact of new technologies in the machining industry.

Common Essential Learnings Foundational Objectives
- To equip the student with the knowledge needed to recognize and correct unsafe working conditions. (CCT)
- To be aware of safety issues and to value the importance of safe work practices. (PSVS)

	Learning Objectives	Notes
11.1	To identify and describe the use of each of the different types of offhand grinders.	Have the students identify different types of offhand grinders and the situations when each is best suited. Have the students compare when it is best to use a dry-type grinder or a wet-type grinder.
11.2	To identify structural characteristics of grinding wheels.	Have students identify and list the characteristics of different types of abrasives that are used for grinding wheels. The list should include synthetic materials as well.
11.3	To identify operating characteristics of grinding wheels. (TL)	Have the students list the characteristics that should be considered when a grinding wheel is selected. They might consider size, shape, thickness, abrasive size and type, bonding agent, hardness, and operating speed limitations.
11.4	To dress and true a grinding wheel.	Have the students dress and true a grinding wheel. This is an operation that will create a lot of debris and dust. Make certain the students are wearing appropriate safety equipment and a dust mask.
11.5	To prepare a grinder for safe operation. (PSVS)	Review the inspection procedure for the grinder and have the students: • determine if the selected grinding wheel is appropriate for the task • check grinding wheels for any defects that would make them unsafe to use (chips and cracks) • properly adjusted tool rest and the possible need for adjustment during the grinding procedure • correctly place all guards and spark deflectors • use of required personal safety protective equipment
11.6	To describe and demonstrate procedures to perform offhand grinding safely.	The students could make posters for use in the shop that contain the safety information necessary for correct selection of grinding tools, maintenance, and safe machine tool operation.

Learning Objectives	Notes
	Students can practice offhand grinding skills using various thicknesses of scrap steel. Skill building with grinding operations should be done with smaller machines to allow students to gain confidence in their abilities. Choose a variety of scrap steel samples that have different properties. The properties can be identified by the patterns of the sparks they emit. Students need to understand what metals can or cannot be ground on shop grinding machines. When demonstrating offhand grinding techniques, be sure that: • equipment is properly adjusted with all guards and safety devices in place • students are wearing approved eye protection • grinding wheels are solid, dressed, and running true.

Module 12: Saws and Cutoff Machines (Core)

Suggested time: 5-7 hours **Level:** Introductory
Prerequisite: Modules 1 and 2

Foundational Objectives
- To develop proficiency in the safe use of hand and machine tools.
- To gain an overview of the different machining processes.

Common Essential Learnings Foundational Objective(s)
- To distinguish between quantitative situations where precision is required and those where approximations are acceptable. (NUM)

	Learning Objectives	Notes
12.1	To identify the types of saws and cutoff machines commonly found in machine shops.	Have the students collect pictures as examples of different types of cutting tools used in the machining trade and describe how they operate. Have the students draw and label the features of the different types of power saws.
12.2	To use correct criteria for selecting the correct cutting blade for various tasks. (CCT)	Have the students select the correct blade for cutting different types of metals. The hardness and the shape of the metal (rounds, flats, pipe, and angles) being cut will also have a bearing on the saw blade selected.
12.3	To install a blade and ready the machine for use. (TL)	Have the students carefully read the instruction manuals that come with the saws to learn how to properly install and tension the blade. The students should review the safety rules required when handling saw blades as they are sharp. New saw blades will be coiled. When releasing the coil, caution is urged as the coil will spring free.
12.4	To be able to position the material to prepare for cutting safely.	Have students demonstrate the proper way to prepare, mount and secure material in preparation for cutting. Different types of material will require different cutting speeds or the feed pressure to cut properly. Students could prepare a chart to show various materials and their individual requirements.
12.5	To be able to safely use the sawing and cutoff machines.	Students could prepare a safety video on the safety precautions to be observed when power sawing.
12.6	To be able to diagnose sawing problems. (CCT)	Have the students review samples of material that illustrate cutting problems Have the students troubleshoot the problems and solve them.

Module 13: Metal Characteristics (Optional)

Suggested time: 3-5 hours **Level:** Introductory
Prerequisite: None

Foundational Objectives
- To understand the properties and uses of different materials used in machining.
- To use correct machining methods for different types of materials.
- To safely machine different types of material.

Common Essential Learnings Foundational Objectives
- To use and understand the terminology related to machining in context. (COM)
- To use reference material to enhance learning. (COM)

	Learning Objectives	Notes
13.1	To explain different metal classifications.	Have the students determine whether a metal is a ferrous or a nonferrous metal and create a list of metals and their properties. The properties to examine include: • base metal or an alloy • ferrous metals include cast iron, steel, alloy steel, sintered, steel and stainless steel • non-ferrous metals do not contain iron as a basic ingredient.
13.2	To describe the characteristics of types of steel.	Have the students prepare a chart of alloying elements that could be added to steel and the effect the element produces to enhance the steel's properties. Students could also collect samples of different steels and experiment with them to see how they differ. Things to examine might include: • Hardness: Does the sample mark easily when scratched? • Flexibility: Can the sample be bent? • Colouration: Is the sample shiny or dull? Have the students prepare samples of mild steel and, using a range of temperatures and an ordinary oven, create samples that show the colouration that occurs when ferrous metals are heat treated. The students can then describe the colour's characteristics. The students could do a spark test with a grinding wheel to determine the grade of steel and put their observations on a chart or poster.

	Learning Objectives	Notes
13.3	To identify the characteristics of non-ferrous metals.	Have students prepare a list of non-ferrous metals and their characteristics. List the advantages that these metals have when compared to ferrous metals. The common non-ferrous metals students could review include: • aluminum • magnesium • titanium.
13.4	To identify other types and classifications of metals that may be machined.	The other types of metals the students could collect examples of or research include: • Copper based alloys: copper, brass, bronze, and beryllium copper • High temperature metals: nickel alloys, molybdenum, tantalum, and tungsten • Rare metals: scandium, yttrium, cerium, euporium, langthanum, and holmium.
13.5	To handle and store metal safely. (PSVS)	Review with the students the safety requirements to be observed when moving heavy materials. It is important for the students to recognize the potential for injury that heavy metal bars and plates can create as their weight is not always related to their size.
13.6	To identify metal products using standardized codes. (TL)	Have the students identify a number of samples by using the appropriate code and/or the colour coding system established by the Society of Automotive Engineers (SAE), the Aluminum Association Designation System, and the American Iron and Steel Institute (AISI).

Module 14: Heat Treatment of Metals (Core)

Suggested time: 3-5 hours **Level:** Introductory
Prerequisite: Module 2

Foundational Objectives
- To understand the properties and uses of different materials used in machining.
- To gain an overview of the different machining processes.

Common Essential Learnings Foundational Objectives
- To be able to use and understand the terminology related to machining in context. (COM)
- To handle materials in a safe and efficient way. (IL, PSVS)

	Learning Objectives	Notes
14.1	To understand the reasons for heat treating metals. (TL)	Everyday items must be heat treated to fulfill their function. Have the students list reasons why metals might be heat treated and provide examples of those applications.
14.2	To list the properties and characteristics of metals that can be heat treated.	Most metals that are heat treated are ferrous metals. Have the students explain why some metals can be heat treated and others cannot. Make a list of nonferrous metals that may be heat treated.
14.3	To describe different ways that metals are heat-treated.	Have the students list and describe the various methods of heat treating metals and the results which are obtained for each method. Include the following heat treatment methods: • stress-relieving • annealing • normalizing • hardening • surface hardening • case hardening • tempering (drawing). The hardening process can be accomplished in a variety of ways usually requiring additional heat treatment.
14.4	To describe different methods of heating and quenching metals.	Have the students discuss methods of heating metals. List the procedures and methods used to quench metals that are being heat treated. A colour chart of temperatures would help the students to identify the temperature range for ferrous materials that the students are heating for tempering.
14.5	To harden and temper carbon steel samples. (IL)	Have students heat samples of carbon steels to a variety of predetermined temperatures and record the colours of the steel as the temperature of the furnace or oven they are using is raised. An ordinary kitchen convection oven will provide an opportunity for students to experiment with colours and heat treating. The colours obtained at lower temperatures will tend toward the bluer end of the colour spectrum.

	Learning Objectives	Notes
14.6	To describe hardness testing techniques and methods.	The students might collect information on the different types of hardness testing equipment that are available and the purpose that this type of testing is used for in the machining industry. If possible have the students temper a carbon steel sample and compare its characteristics with a sample of the same material that has not been tempered in order to see the effects of this process.
14.7	To describe and demonstrate the safety precautions that must be taken when heat-treating metals. (PSVS)	Review with the students the safety precautions needed when they are handling hot metals. There are also ventilating precautions to be observed when hot metals are quenched.

Module 15: Metal Finishing (Optional)

Suggested time: 2-4 hours **Level:** Introductory
Prerequisite: Module 1

Foundational Objectives
- To gain an overview of the different machining processes.
- To be able to produce parts to meet given specifications.

Common Essential Learnings Foundational Objectives
- To be able to use and understand the terminology related to machining in context. (COM)
- To understand the terms and symbols used to determine surface roughness. (COM)

	Learning Objectives	Notes
15.1	To describe how the finish of a machined surface is designated. (COM)	Have the students use diagrams and correct terms to explain how and why a standard for metal finishing is required.
15.2	To explain the relationship between the quality of a machined surface and production costs.	The students might examine the tradeoffs that finishing and cost have to offer in terms of cost input and economic return
15.3	To identify the set of numbers and symbols indicating surface roughness.	Have the students prepare a chart of the texture symbols and roughness values that are part of the standardized system that describes degrees of surface roughness. If possible, have the students compare samples that have different surface roughness. This would help to develop an appreciation for the requirements that some machining operations require.
15.4	To describe the purposes of metal finishing. (COM)	There are many reasons and methods used to finish metal. Have the students list the different ways that metal can be finished and the reasons for that method.
15.5	To demonstrate finishing techniques. (IL)	The students can apply finishing techniques that are appropriate for the metal projects they have selected in other modules.
15.6	To demonstrate the application of an organic coating. (IL)	The students will be familiar with the process of applying organic coatings in woodworking. The students could apply a paint coat to their project in a number of different ways, as a demonstration of organic finishing. Discuss the following processes with students: • Inorganic coatings and the application processes and materials involved. • Why the chemical blackening process is used. • Mechanical finishes and their processes of application.
15.7	To list the types of inorganic coatings used in industry.	The inorganic coating methods of anodizing, electro-brightening, and porcelain (vitreous coating) are the common types of inorganic coatings. Another inorganic coating method is to use chemical blackening, a black oxide coating, to enhance machined surfaces and increase wear resistance.

Module 16: Career Opportunities (Core)

Suggested time: 3-5 hours **Level:** Introductory
Prerequisite: None

Foundational Objectives
- To become aware of the variety of jobs and career opportunities in the machining trades.
- To create an awareness of apprenticeship programs and opportunities in Saskatchewan.

Common Essential Learnings Foundational Objectives
- To develop students' abilities to access knowledge. (IL)
- To promote both intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences, and objects in meaningful contexts. (CCT)
- To recognize that learning is continuous from birth to death. (IL)

	Learning 0bjectives	Notes
16.1	To explore the designated trades.	Students will define apprenticeship. Generate a list with students of apprenticeship trades and a definition of an apprentice. Outline the advantages and disadvantages of apprenticeship.
16.2	To explore how the Secondary Level curriculum articulates with Level I of the trade. (COM)	Show students the training plan. Explain how completing all the objectives and covering the appropriate modules can prepare them to challenge the Level One exam.
16.3	To generate a list of career opportunities related to the machining industry. (COM)	Students will create a list of different career opportunities in the upholstery industry. Encourage students to use a variety of sources for information: guidance counsellors, libraries, community resources, career software packages, personal interviews, government resources, websites, etc.
16.4	To identify personal skills and interests that may lead to career exploration. (CCT)	Ask each student to create an inventory of personal interests and skills. Have each student examine his or her list to determine how these interests and skills may be combined with career opportunities in the upholstery industry in the community. Websites that will be of interest when conducting research can be found in the bibliography.
16.5	To determine skills and interests that enhance career decisions. (CCT)	From the list created, ask the students to select two choices of possible occupations for further research. Investigate the choices including: • description of work duties • what personal qualities individuals should possess • how personal interests and skills correspond to choice • process to become certified within the trade/career • length of education and training • school locations • cost of education and upgrading • trends within the business or career • the best and worst parts of the job • beginning salary • opportunities for advancement.

Learning Objectives	Notes
	If a student engages in work study, he or she may investigate career links within the community for possible work study placements. The student may conduct an interview of the professional/tradesperson as part of his or her experience. Refer to Appendix D, Career Research Interview Questions.

Module 17A: The Lathe, Introduction (Core)

Suggested time: 5-7 hours **Level:** Intermediate
Prerequisite: Modules 1 and 2

Foundational Objectives
- To be able to produce parts to meet given specifications.
- To increase self-esteem from success with the equipment, materials, and techniques used.

Common Essential Learnings Foundational Objectives
- To be able to use and understand the terminology related to machining in context. (COM)
- To use the correct terms to describe the various cutting operations preformed on a lathe. (TL)

	Learning Objectives	Notes
17.1	To identify and describe the function of the various parts of a machinist's lathe.	Have students draw and label a diagram of a lathe and describe the operating characteristics of the various components. Some lathes have a large number of parts and accessories important to the operation of the machine. This may be an opportunity to divide students into groups to report on major components of a lathe.
17.2	To describe how a machinist's lathe operates. (COM)	The lathe is a versatile tool and capable of many single and compound operations. Have the students describe the various operations that can be performed on the lathe and how the lathe size is determined. Arrange a tour of a machine shop, if possible, to look at the machinist's lathe tools.
17.3	To understand the precautions necessary when preparing to operate a lathe.	The students could make a checklist to help prepare a lathe for operation. The students should establish a routine to follow before turning on the lathe that includes regular maintenance and lubrication requirement items. The lathe will need to be cleaned each time it is used to remove waste and other contaminants that might cause corrosion to the lathe. This should be the last operation done on a lathe every time it is used.
17.4	To list the precautions and personal safety equipment needed to operate a lathe. (COM)	Students need to be reminded of the importance of wearing proper clothing that is in good repair and appropriate for the task they are undertaking. The use of eye protection and other safety equipment will be required for different operations with the lathe.

Module 17B: Lathe Cutting Tools (Core)

Suggested time: 5-7 hours **Level:** Intermediate
Prerequisite: Modules 1, 2, and 17A

	Learning Objectives	Notes
17.5	To describe the different styles and types of lathe tool cutters. (COM)	Have students prepare a chart of various types of cutters and the type of work that each cutter style performs. The most common cutters that students use will be made from high speed steel (HSS). Other types of cutters have inserts or carbide tips and can be run at much higher cutting speeds. These are specialized tools and are costly but should be reviewed as they are widely used in industry. Have students make a tool board with the nine basic categories of cutting tools.
17.6	To sharpen HSS lathe cutting tools. (IL)	Have students begin by preparing a step by step guide to follow when making a cutting tip with tool steel. Begin with the easier to shape profiles to give the student confidence and a tool that will accomplish a beginning task such as, a roughing out tool. It may be easier for the students to follow if a sample pattern for them to copy is available as they follow the grinding sequence for their version of the tool. Have students examine other HSS cutting tools and how they are shaped for different types of turning. Demonstrate the purpose of a chipbreaker incorporated with the cutting tip to prevent long continuous chips that may become tangled in the lathe as the work is turned.
17.7	To safely and correctly use American and Turret tool holders.	Lathes may have different styles of tool holders and students will need to be aware of how to correctly secure the cutter into the holder they will be working with as well as to make the correct adjustments.

	Learning Objectives	Notes
17.8	To safely set up and operate a lathe using cutting tools. (IL, TL)	After completing a demonstration of all the necessary steps to follow to setup the lathe, have the students set up a simple project to operate the lathe. Students will be doing only very simple operations to demonstrate their ability to start and operate the lathe.
17.9	To sharpen a cutting tool. (TL)	It will also be necessary to sharpen cutting tools from time to time. Therefore, students will need to know how to tell when the cutter they are using has become dull. Students should learn how to handle sharpened cutting tools to prevent injury and premature cutting tool wear.

Module 17C: Cutting Speeds and Feeds on the Lathe (Core)

Suggested time: 5-7 hours **Level:** Intermediate
Prerequisite: Modules 1, 2, and 17B

	Learning Objectives	Notes
17.10	To read a cutting speed and feed chart to determine the correct cutting speed for the material being machined.	Have the students list the factors that affect cutting speeds and feeds. The students could do a video or a class presentation on how lathe speed and carriage feed is set for different materials. Review the cutting operation with the students and have them give reasons for making different types of cuts. The students also need to know how the depth of cut is determined on lathes. Demonstrate the difference between roughing cuts and finishing cuts. Ensure that all students are wearing approved eye protection during all machining operations.
17.11	To calculate correct speed and feed based on the material used, the size of the part being machined, and the cutter being used.	The students should do calculations to determine cutting speeds and feeds for a variety of materials. Have students demonstrate the use of the formula: $\frac{4(CS)}{D}$=R.P.M. Students will need some time working on project problems to become confident at calculating the speed they should run their lathe for different applications. Give them a project assignment where they need to calculate several problems related to lathe speeds and feeds.

Module 17D: Mounting Work Between Centres on the Lathe (Optional)

Suggested time: 2-4 hours **Level:** Advanced
Prerequisite: Modules 1, 2, and 17C

	Learning Objectives	Notes
17.12	To identify various work holding attachments. (TL)	Have the students identify the various work holding devices that can be used on a lathe. Discuss and demonstrate the various work holding attachments set up on the lathe. Have the students select the proper holding device and demonstrate its use. Review the safety precautions that must be observed when mounting the attachments on the lathe and when the attachments are being used.
17.13	To select and use a centre drill. (TL)	Have the students prepare stock material for turning between centres. They will need to locate and centre-punch the centre of the stock and select the correct centre drill to prepare both ends of the material for securing in the lathe.
17.14	To check for centre alignment. (TL)	Have the students demonstrate how to check a lathe to be certain the headstock and tailstock centres are aligned. Turning a shaft of consistent diameter and flipping it end for end would prove the centre alignment of the lathe. Students could also demonstrate the adjustment methods that can be used on the lathe to true the alignment.
17.15	To correctly position the tool holder and cutting tool. (TL)	Most lathes that students will use have a round tool post and hold a single tool holder. Have the students identify the different styles and the correct application for each type of tool holder. Have the students demonstrate the correct method of fastening the cutting tools to the tool holder and positioning the tool holder in the tool post.
17.16	To safely mount and prepare material for turning between centres. (IL)	Have the students review the following and then demonstrate the turning between centres operations: • Set up a lathe for turning between centres. • Properly drill center holes. • Check for center alignment. • Select the proper size lathe dog. • Properly mount work between centres. • Emphasize the safety precautions that must be observed when turning between centres. • Turn to a shoulder. • Perform grooving or necking operations. • Safely perform parting operations.

Module 17E: Turning Between Centres on the Lathe (Core)

Suggested time: 5-10 hours **Level:** Advanced
Prerequisite: Modules 1, 2, and 17D

	Learning Objectives	Notes
17.17	To face material mounted on the lathe. (IL)	Have the students face the material and list the purpose for this operation.
17.18	To describe the rough turning and finishing sequence on a plain turned surface. (COM)	Have students discuss and demonstrate on a mild steel sample rough turning to a specified size and then finish turning a smooth surface to the final size requirement.
17.19	To demonstrate the cutting characteristics of a variety of cutting toolbits. (TL)	The students can prepare a single piece of stock to use as a reference using a variety of different cutting toolbits. If a variety of toolbits are not available students could prepare a chart of the different types and their uses.
17.20	To demonstrate shoulder turning.	There are three common shoulder turning operations. Have the students demonstrate the procedures needed to complete the three types of shoulder cuts.
17.21	To describe the procedure for filing and polishing. (COM)	If cutting tools are kept sharp, the need for these procedures is minimized. It should be mentioned that these procedures are not a substitute for a properly sharpened cutting toolbit.

Module 17F: Lathe Chucks (Optional)

Suggested time: 2-4 hours **Level:** Advanced
Prerequisite: Modules 1, 2, and 17A

	Learning Objectives	Notes
17.22	To describe various types of chucks used on a machinist's lathe. (COM)	Have students compare the different styles of chucks and the types of jobs each is best suited to perform. Demonstrate the use of the Jacobs chuck for small turning applications in the tailstock and headstock.
17.23	To safely turn work mounted in a chuck.	Have the students demonstrate how the various types of chucks are used. Have students report on the following: • The advantages and disadvantages of the 3-jaw universal chuck. • The installation of jaws in the universal chuck. • The advantages and disadvantages of the 4-jaw independent chuck. The 4-jaw independent chuck is very important in machine shops today and students need to have this chuck demonstrated to them completely. • How to centre work in an independent chuck. • How to mount and remove chucks safely. Emphasize the safety precautions that must be observed when turning work mounted in a chuck. **Caution students to never leave the chuck wrench in the lathe chuck. The only time the wrench should be in the chuck is while the student's hand is on it and he or she is adjusting the chuck.** • Facing stock in a chuck will demonstrate whether the cutting tool is above or below center.
17.24	To face material mounted in a chuck on the lathe. (IL)	Have the students face the material and list the reasons for this operation.

Module 18: Cutting Tapers on the Lathe (Optional)

Suggested time: 3-5 hours **Level:** Intermediate
Prerequisite: Module 17C

Foundational Objectives
- To gain an overview of the different machining processes.
- To be able to use and understand the terminology related to machining in context.

Common Essential Learnings Foundational Objectives
- To increase self-esteem from success with the equipment, materials, and techniques used. (PSVS)
- To be able to use and understand the terminology related to machining in context. (COM)
- To be able to calculate the amount of taper using the various formulae. (NUM)

	Learning Objectives	Notes
18.1	To describe how to turn a taper on a lathe. (COM)	Have the students set up the lathe and demonstrate the various ways tapers can be cut. Discuss the advantages and disadvantages of the various methods used to cut tapers.
18.2	To calculate tailstock setover needed to turn a taper. (NUM)	Have the students solve problems for projects that require: • how to calculate tailstock setover using mathematical formulae whether taper per inch (TPI), taper per foot (TPF), or taper dimensions are known • the mechanical methods used to setover the tailstock • types of taper attachments and how to set them • how to measure tapers.
18.3	To calculate taper when using a taper attachment. (NUM)	This is a guide that can be attached to most lathes and is the preferred method used to cut tapers. Have students examine both the plain and telescoping taper attachments.
18.4	To safely set up a lathe and turn a taper.	Emphasize the safety precautions that must be observed when cutting tapers. Have students measure the tapers they have created using a taper plug gauge and also a micrometer.

Module 19: Cutting Screw Threads on the Lathe (Core)

Suggested time: 10-15 hours **Level:** Advanced
Prerequisite: Module 17C

Foundational Objectives
- To gain an overview of the different machining processes.
- To be able to use and understand the terminology related to machining in context.

Common Essential Learnings Foundational Objectives
- To learn and use the language and terms of the machining trade. (COM)

	Learning Objectives	Notes
19.1	To describe various applications for screw threads. (COM)	The students could research the different ways that screw threads have been used. This need not be limited to fasteners but might also include ideas like moving grain with an auger or water using an Archimede's screw. Students could build models of different applications for screw threads.
19.2	To identify the terms related to screw threads.	Have the students review thread nomenclature and prepare labeled diagrams of different screw thread forms.
19.3	To describe the various forms of screw threads.	Have the students collect examples of different screw thread forms and give examples of their application. Emphasize safety precautions to be observed when cutting threads on a lathe.
19.4	To cut external screw threads on a lathe. (IL)	Have the students develop a checklist to follow before they begin this procedure. Explain the procedure and demonstrate cutting external threads. Points to include: • How to sharpen lathe threading tools. • Setting up a lathe to cut 60 degrees threads. • Using the thread dial. • Threading tool cutting action. • Using cutting fluid. • Ending the thread cut.
19.5	To demonstrate the cutting of different kinds of threads on the lathe. (IL)	Student projects could demonstrate cutting the following thread types: • right hand threads • left hand threads • square threads • acme threads.

	Learning Objectives	Notes
19.6	To cut internal threads on a lathe. (IL)	Have the students explain the procedure and then demonstrate the procedure for cutting internal threads. This procedure is more difficult as the thread cutting is blind to the operator and is optional.
19.7	To measure threads. (NUM)	There are different methods used to measure threads. The simplest way to measure threads when close tolerances are not specified is to use a screw pitch gage or trial fitting with a fastener. Have students use “the three wire method” and if possible use a thread micrometer if one is available.

Module 20: Additional Lathe Operations (Optional)

Suggested time: 5-10 hours **Level:** Advanced
Prerequisite: Module 17C

Foundational Objectives
- To operate a lathe to do boring, drilling, reaming, filing, polishing, and knurling operations.
- To be able to produce parts to meet given specifications.

Common Essential Learnings Foundational Objectives
- To be able to use and understand the terminology related to machining in context. (COM)
- To learn and use the language and terms of the machining trade. (COM)
- To increase self-esteem from success with the equipment, materials, and techniques used. (PSVS)

	Learning Objectives	Notes
20.1	To identify various work holding devices. (COM)	Have the students identify and describe the function of different types of work holding devices, in addition to lathe chucks.
20.2	To set up steady and follower rests properly. (TL)	Have the students set up and demonstrate the use of both rests on a project that requires additional support as it is worked.
20.3	To machine an internal surface by boring. (IL)	Have students identify the differences between internal (boring) and external (conventional) cutting operations on the lathe. When demonstrating the operation, discuss selection and positioning of the boring bar and the precautions that cutting by "feel" require.
20.4	To perform drilling operations on the lathe. (IL)	Have students set up and demonstrate the procedure for drilling with a stationary drill with drill sizes less than one-half inch held in a Jacob's chuck. As well, for drills creating holes larger than one-half inch, it is necessary to use taper shank drills. If the taper does not fit in the tailstock, it will be necessary to use a lathe dog to hold the drill while the handwheel is used to move the bit into the work. Have students use a centre drill to ensure accuracy. Holes that are over one-half inch in diameter will require a pilot hole. Be certain to use a cutting fluid during this drilling operation. Review the safety procedures that need to be followed when drilling.

	Learning Objectives	Notes
20.5	To demonstrate the use of a reamer on the lathe.	Have students select the appropriate reamer and ream a pre-drilled hole to produce a smooth inner surface. A reamer will also provide a hole that is accurate and round. Some drills can cut distorted out-of-round or off-centre holes. The reamer is the tool to use to ensure that the hole produced is round. Do not use a **hand reamer** with a lathe that will be under power. **Machine reamers** are used for the operation that is carried out under power on the lathe. The cutting speed for a reamer is generally about two-thirds the speed used to cut the hole being reamed.
20.6	To select and install a mandrel.	The students can install a manufactured hardened steel or machined mandrel made from mild steel to fit the requirements for the assigned turning task.
20.7	To perform grinding operations on a lathe.	It is possible to attach a tool post grinder to do various operations that include sharpening tools or truing lathe centres. Internal and external grinding attachments are also available to do finish work. Care needs to be taken to cover exposed areas of the lathe when grinding to prevent dust and grit from falling on moving parts and creating excessive wear. Discuss with students: • reasons that filing and polishing on the lathe should be kept to a minimum • a safe way to file.
20.8	To perform milling operations on a lathe.	Have students demonstrate the milling procedure if possible. There are limited horizontal milling operations that can be done on the lathe.
20.9	To discuss the possible industrial applications of the lathe.	Have students research and report on the variety of industrial applications for which a lathe can be used. Students could report on large industrial or computer numerical control (CNC) lathes used in manufacturing to machine repetitive turnings or the smaller manually operated lathes for limited production or custom work (as the lathes used in schools).
20.10	To use a lathe file.	Have the students identify the differences between a mill file and a long angled lathe file. Have the students demonstrate the proper safety precautions to use when filing and why it is better to file left-handed than right handed.

	Learning Objectives	Notes
20.11	To describe the procedure for knurling. (COM)	Have the students discuss and demonstrate the following: • reasons for knurling work • different types of knurls • different styles of knurling tools • lathe speeds and feeds to use for knurling • how to set up the lathe for knurling.
20.12	To perform knurling on a lathe. (IL)	The procedure will produce a gripping surface on the stock material. A handle for a project is an example of an opportunity for students to practice their skill with the knurling tool.
20.13	To polish on the lathe.	The quality of the finish will depend on the coarseness of the abrasive cloth that is being used to polish the surface. Aluminum oxide is used for ferrous metals and silicon carbide for non-ferrous metals. Have students finish all assignments with a finishing polish to provide the cleanest surface. A few drops of oil during the final passes will help to prevent oxidization of the surface. Alternatively, if the product is to be used as a display, it could be coated with a permanent finish.

Module 21: Band Machining (Core)

Suggested time: 5-10 hours **Level:** Intermediate
Prerequisite: Modules 1, 2, 9, and 12

Foundational Objectives
- To develop proficiency in the safe use of hand and machine tools.
- To gain an overview of the different machining processes.
- To prepare and carry out band machining operations.
- To handle, use, and dispose of materials safely.

Common Essential Learnings Foundational Objective(s)
- To use the technical terminology specific to the machining trade. (COM)

	Learning Objectives	Notes
21.1	To describe the operation and function of a band machine. (COM)	Have students prepare a sketch of a band machine and a description of the operating features.
21.2	To describe the advantages of band machining. (COM)	The students could look for similar machines that use a continuous blade system to cut material and describe the advantages that the vertical band machine holds as compared to the other saws. The students could collect samples or drawings of the different types of work that each type of saw is capable of producing.
21.3	To choose the appropriate blade for the task. (CCT)	Have students list the different types and characteristics (different widths, sets, and tooth forms) of the saw blades used in band machines. Students need to know blade terminology and how to select a blade to match the job or material requirements. (COM)
21.4	To install a blade on a band machine. (TL)	Caution students about handling saw blades. Care needs to be taken when pre-welded blades are uncoiled as they will open up like a spring. Heavy gloves should be worn to work with blades to avoid injury. Have the students practice handling and mounting different sizes and types of blades. Make certain the teeth are running in the downward direction through the table and that correct tension has been applied to the blade. The blade guides and tracking will need to be adjusted for different sizes of blades.

	Learning Objectives	Notes
21.5	To operate a band machine safely. (PSVS)	The students could do demonstrations to prove that they can safely follow the set-up and operate the saw. The demonstration should include: • correct procedure to follow when changing blades • to handle, use and dispose of materials safely • possible band machining problems and how to correct them • determining and setting the proper cutting speed • setting the cutting speed • selecting and adjusting cooling fluids • straight sawing • contour sawing • using power feed (if available).
21.6	To describe other operations which are done on banding machines. (COM)	The additional operations for students to describe include: • band filing • band polishing • friction sawing • types of specialty blades and their applications.
21.7	To prepare and weld a blade and mount it on the band machine.	Have the students demonstrate the procedures to prepare a blade for welding. Most band machines have a built-in blade shear, grinder, welder, and annealer designed for the welding operation. The procedure should include the following steps: • Shear the blade to square the ends. • Determine the amount of material consumed by the welding process. • Remove teeth from the blade to maintain correct tooth spacing and set. • Set-up and weld the blade according to the manufacturer's instructions. • Anneal the blade to remove the brittleness created by the welding process. • Grind the band weld, avoiding the teeth. • Mount the blade on the tool as indicated in 17.4. Students could also prepare a set of welded blade sections illustrating different welding problems that might occur when welding blades and steps to correct them. In addition, a set of scrap blade sections could be used to illustrate the steps needed to weld a blade.

Module 22: Broaching Operations (Core)

Suggested time: 5-10 hours **Level:** Advanced
Prerequisite: Modules 1 and 2

Foundational Objectives
- To develop proficiency in the safe use of hand and machine tools.
- To gain an overview of the different machining processes.

Common Essential Learnings Foundational Objectives
- To learn and use the language and terms of the machining trade. (COM)
- To be able to use and understand the terminology related to machining in context. (COM)

	Learning Objectives	Notes
22.1	To describe purpose, procedure, and advantages of the broaching operation.	Have students identify the types of broaching operations and the need for this type of tool. The students can prepare a labeled diagram of the sections of a broaching tool and explain the different cutting operations performed by each section on the tool. The students could prepare a list of the advantages or reasons for broaching.
22.2	To broach a keyway. (IL)	Have students set up and cut a keyway using a keyway broach and an arbor press. If this is not possible to do in the classroom, it may be possible to arrange a tour of a machine shop to see the operation performed. Save scrap pieces of aluminum and have students begin broaching on aluminum because it is softer. Encourage students to bring old pulleys from home to broach keyways into.

Module 23A: Introduction to the Milling Machine (Core)

Suggested time: 5-10 hours **Level:** Intermediate
Prerequisite: Modules 1 and 2

Foundational Objectives
- To be able to use and understand the terminology related to machining in context.
- To develop proficiency in the safe use of hand and machine tools.

Common Essential Learnings Foundational Objectives
- To learn and use the language and terms of the machining trade as they apply to milling machines. (COM)
- To learn the skills necessary to do milling safely. (TL)

	Learning Objectives	Notes
23.1	To distinguish between the various types of milling machines. (COM)	Have the students collect data on different types of milling machines and the operations that they can perform.
23.2	To describe the operation of milling machines. (COM)	This should be a detailed description of the different operations that are possible for a variety of mill types. The students might also research the four methods of control that include manual, semi-automatic, automatic, and CNC milling machines. The last two being the types of mills found in industry when large scale project production is done.
23.3	To list the safety considerations for milling machines.	In addition to the standard safety practices that are to be followed for all machining operations, have the students add other safety considerations that could apply to the milling procedure.
23.4	To list the main components of milling machines and their operating relationship.	The different types of milling machines have similar components assembled in different configurations. Have the students describe the similarities and differences and their effect on the tool's operation.

Module 23B: Milling Machine Cutters (Optional)

Suggested time: 3-5 hours **Level:** Intermediate
Prerequisite: Module 23A

	Learning Objectives	Notes
23.5	To describe various types of milling cutters. (COM)	Have students identify the two main types of cutters and how cutters are classified. It is important that students learn the terminology for the various styles of cutters for the two types.
23.6	To select the proper cutter for the job to be done. (CCT)	The selection of the cutter will depend on the material being cut and the type of milling operation that is being carried out, as well as the type of milling machine that is used for the work operation. The following should be considered when a cutter is being selected: • face milling and peripheral milling • solid or insert tooth cutter • milling cutter classification • milling cutter material • end, face or arbor mill cutters • miscellaneous milling cutters • care of milling cutters • methods of milling • safe handling and storage of milling cutters.
23.7	To list the rules and formulas used to determine cutter speeds and feeds. (NUM)	Students will need to apply a variety of formulas in order to correctly set up the milling machine for the various types of material that they may be working with to complete their assignments. Have the students prepare a table of the information they will need and then laminate it to keep it clean, legible, and close at hand when they are working.
23.8	To calculate cutting speeds and feeds. (NUM)	Have the students list the points to consider when selecting a feed and cutting speed for different materials, and draw conclusions from their research. The students will need to be reminded about the importance of the calculations that are necessary to do this type of operation successfully.
23.9	To identify milling methods. (CCT)	Have the students list the advantages and disadvantages of each milling method, conventional (up-milling) and climb (down-milling).

Module 23C: Setting a Milling Machine (Optional)

Suggested time: 3-5 hours **Level:** Advanced
Prerequisite: Module 19B

	Learning Objectives	Notes
23.10	To install a variety of cutters appropriate for different types of milling machines. (IL)	Have the students identify the three main types of arbor styles used and their characteristics. The students can demonstrate how to mount cutters on different arbors and locate the cutter on the arbor by the use of spacing collars. Remind students of the need to keep the work area clean as a maintenance procedure and to prevent damage to equipment. It is also important to remember to protect the cutter and the operator's hands when installing and removing cutters and holding devices from the machines**.** Students should establish a routine for storage and care of cutters and driving devices.
23.11	To demonstrate the use of collets.	The students can do end milling operations using spring collets and a collet chuck (if needed).
23.12	To understand the need for different cutting speeds and feeds. (CCT)	The students could collect a sample of different metals and rank them to determine which materials are soft and which are harder, and then decide on a slow or fast cutting speed.
23.13	To calculate cutting speeds and feed rates for a variety of materials. (NUM)	It is important for students to recognize the need for careful calculations when they are doing machine tool operations. The type of cutter will have a bearing on the cutter speed and the feed rate for a particular operation such as, a rough cut or a finishing cut. There are a variety of calculations and formulas that students will need to be familiar with to determine correct feeds and speeds.

	Learning Objectives	Notes
23.14	To select a cutting fluid appropriate for different cutting operations. (TL)	The material being worked determines the choice of cutting fluid. Have students list the reasons for using cutting fluid and prepare a chart or a poster of the fluids needed for cutting different materials. (COM)
23.15	To understand the application of different work-holding attachments. (CCT)	Have the students collect examples of different work holding devices, both manually and automatically controlled. Examples should include: • flanged vise • swivel vise • universal vise • rotary table • dividing head (set-up and use) • indexing table • magnetic chuck. Have the students list the advantages and disadvantages of the various types of work-holding devices. Review cutting speeds and feeds and safety procedures to be followed when handling heavy work-holding attachments.

Module 24: Operating a Vertical Milling Machine (Core)

Suggested time: 10-15 hours **Level:** Advanced
Prerequisite: Module 23C

Foundational Objectives
- To understand the properties and uses of different materials used in machining.
- To be able to use and understand the terminology related to machining in context.
- To be able to produce parts to meet given specifications.
- To develop proficiency in the safe use of hand and machine tools.

Common Essential Learnings Foundational Objectives
- To use the technical terminology specific to the machining trade. (COM)
- To work in a safe and careful manner. (PSVS)

	Learning Objectives	Notes
24.1	To describe how a vertical milling machine operates. (COM)	Have students identify and/or demonstrate the following: • Name the various parts and operations of the vertical milling machine. • Explain the different types cutters used with vertical milling machines. • Describe the maintenance and care of a milling machine.
24.2	To point out safety precautions that must be observed when operating a milling machine. (COM)	The students can identify areas on the mill where safety concerns need to be recognized.
24.3	To set up and safely operate a vertical milling machine. (TL)	The students could do demonstrations in pairs. One student demonstrates while the other marks a checklist of important points that need to learned about the vertical milling machine operation. Then have the students reverse their roles. Points to include in the checklist include: • methods employed to mount cutters • methods used to align a vise • how to align a vise with a dial indicator • mounting the project work in a vise.

24.4	To perform various operations on a vertical milling machine. (IL)	The selected project for the students should include the following operations:
		• squaring stock with a vertical milling machine
		• machining angular surfaces
		• positioning a cutter to mill a keyway or slot
		  ▪ how to position a cutter using a paper strip
		  ▪ how to position a side cutter to mill a slot in flat stock
		  ▪ how to position a side cutter to mill a slot or keyway in round stock.
		
		Have the students demonstrate the following:
		• how to use a wiggler
		• how to use an edge finder
		• boring with a vertical milling machine.

Module 25: Operating a Horizontal Milling Machine (Optional)

Suggested time: 10-15 hours **Level:** Advanced
Prerequisite: Module 23C

Foundational Objectives
- To develop proficiency in the safe use of hand and machine tools.
- To gain an overview of the different machining processes.
- To be able to produce parts to meet given specifications.
- To increase self-esteem from success with the equipment, materials, and techniques used.

Common Essential Learnings Foundational Objectives
- To use the technical terminology specific to the machining trade. (COM)
- To work in a safe and careful manner. (PSVS)

	Learning Objectives	Notes
25.1	To describe how a horizontal milling machine operates. (COM)	Have students identify and/or demonstrate the following: • Name the various parts and operations of the horizontal milling machine. • Identify different types of cutters used with horizontal milling machines and their applications. • Mainten and care for a milling machine.
25.2	To point out safety precautions that must be observed when operating a milling machine. (COM)	The students should identify areas on the mill where safety concerns need to be recognized and describe methods to ensure safe operations.

25.3	To select milling cutters appropriate for the required cut. (TL)	Have the students prepare a chart of the various cutters and the type of cut that they will perform on a horizontal mill. The list of cutters could include the following common types:
		• plain (slab)
		• side milling
		• angle
		• metal slitting
		• formed
		  ▪ concave
		  ▪ convex
		  ▪ corner rounding
		  ▪ gear.

25.4	To set up and safely operate a horizontal milling machine. (TL)	Have the students discuss and demonstrate the sequence of steps used to prepare for horizontal milling operations including: • milling flat surfaces using plain (straight tooth cutters) and slab (helical tooth cutters) cutting mills • how to position a side cutter to mill a slot in flat stock • how to position a side cutter to mill a slot or keyway in round stock • selecting cutting speeds and feeds.

	Learning Objectives	Notes
25.5	To perform various milling operations on a horizontal milling machine. (IL)	The students should select a project that involves as many of the following operations as can be incorporated: • flat milling • face and side milling • straddle and gang milling • slitting and slotting operations. Have the students review methods to determine cutting speeds and feeds.
25.6	To perform drilling operations on a horizontal milling machine. (IL)	Have the students demonstrate drilling on a horizontal milling machine using different drill holding attachments.
25.7	To perform boring operations on a horizontal milling machine. (IL)	Have the students correctly align an existing drilled hole using a dial indicator gauge and a boring bar. If possible, arrange a tour of an automotive engine re-building business to see a practical application for boring operations.

Module 26: Gear Cutting Operations (Optional)

Suggested time: 5-10 hours **Level:** Advanced
Prerequisite: Module 23C

Foundational Objectives
- To develop proficiency in the safe use of hand and machine tools.
- To handle, use and dispose of materials safely.
- To be able to use and understand the terminology related to machining in context.
- To be able to produce parts to meet given specifications.

Common Essential Learnings Foundational Objectives
- To learn the terminology necessary to identify the parts of spur and bevel gears. (COM)
- To apply mathematical formulas to do required calculations to determine how to cut spur and bevel gears. (NUM)
- To work in a safe and careful manner. (PSVS)

	Learning Objectives	Notes
26.1	To use the terms for gear nomenclature in context. (COM)	Have the students identify to collect different types of gears and give examples of typical applications for each type. In order for students to do the calculations needed to create toothed gears, they need to learn the terminology that applies to the parts of the gear. (COM, NUM)
26.2	To make calculations and measurements for spur gears. (NUM)	Have the students discuss and demonstrate the following: • calculating the information necessary to cut a spur gear • how gear teeth measurement is checked. As an additional exercise, provide students with samples of spur gears and have them determine the calculations that were necessary in order to make the gear.
26.3	To cut a spur gear using the dividing head on a horizontal mill. (IL)	Before the students do the cutting operation, they should: • determine the correct gear cutter • center the gear cutter over the work • prepare the dividing head to cut the required number of teeth and review cutter alignment • perform the cutting and finishing operations.
26.4	To make calculations and measurements for a bevel gear. (NUM)	Discuss and demonstrate the following with the students before they undertake cutting their own bevel gear: • the difference between bevel and spur gears • the complexity of cutting a bevel gear with accuracy. Have the students discuss and demonstrate: • calculating the information necessary to cut a spur gear • how gear teeth measurement is checked. As an additional exercise, provide students with samples of spur gears and have them determine the calculations that were necessary in order to make the gear.

	Learning Objectives	Notes
26.5	To cut a bevel gear using the dividing head on a horizontal mill. (IL)	Before the students do the cutting operation, they should: • determine the correct gear cutter • center the gear cutter over the work • prepare the dividing head to cut the required number of teeth and review cutter alignment • perform the cutting and finishing operations.
26.6	To review safety precautions that must be observed when operating a milling machine. (PSVS)	Have the students demonstrate the necessary safety procedures to operate a milling machine before they proceed with the cutting procedure.

Module 27: Precision Grinding (Core)

Suggested time: 5-10 hours **Level:** Intermediate
Prerequisite: Modules 1, 2, and 11

Foundational Objectives
- To develop proficiency in the safe use of hand and machine tools.
- To identify and explain health and safety hazards in the workplace so that the potential for personal injury and damage to the equipment and the environment are minimized.
- To understand the properties and uses of different materials used in machining.

Common Essential Learnings Foundational Objectives
- To use the technical terminology specific to the machining trade. (COM)
- To work in a safe and careful manner. (PSVS)

	Learning Objectives	Notes
27.1	To explain the function of precision grinders.	The students might sketch and identify the general operating characteristics a precision grinder. Other topics to explore include: • the principles of precision grinding and why it is done • how different types (I, II, III) of surface grinders operate • how cylindrical grinders operate including centre, roll, centreless, internal cylinder, and tool and cutter types.
27.2	To use the grinding terminology in context. (COM)	Have students list the terms and definitions that apply to the grinder operations.
27.3	To identify and describe the various types of precision grinding machines. (TL)	Have the students identify the different operating characteristics of planer and rotary surface grinders.
27.4	To identify and select grinding wheels. (CCT)	Students will need to be able to identify grinding wheels by the specification numbers printed on them. Have students prepare a chart of the numbering system that illustrates what the numbers and symbols stand for on any grinding wheel. Have the students prepare a chart of various types, shapes, and applications for grinding wheels.
27.5	To inspect grinding wheels for safe operation. (TL)	Demonstrate to students the procedure for inspecting grinding wheels for possible defects or the need for dressing. Students might list the defects that they locate in various supplied samples of older grinding wheels that are no longer suitable for use.

	Learning Objectives	Notes
27.6	To prepare a grinder for operation. (IL)	Have the students select the proper grinding wheel for a particular application and follow the correct mounting procedure to put the grinder into service. Review how to check the soundness of the grinding wheel with the "ring test" before mounting it on the surface grinder. Have the students demonstrate the operating sequence for starting and stopping a surface grinder.
27.7	To dress and true a grinding wheel. (IL)	Have students prepare an instruction sheet to dress a grinding wheel, to true the surface, and to unload the abrasive or de-glaze the surface. This operation will be revisited as a student activity in the next module.
27.8	To recognize the safety hazards that precision grinding presents. (IL)	Students must be aware of the danger of material being projected out of the magnetic chuck, and, therefore, the importance of removing only small amounts of material with each pass of the surface grinder. The students should understand the danger of the grind wheel becoming jammed in the work and the possibility of the stone exploding.
27.9	To identify and select cutting fluids.	Have students identify: • why cutting fluids are required for most grinding operations • types of cutting fluids and their application method • how cutting fluids are applied • how swarf is removed from cutting fluid.

Module 28: Work Holding Devices and Surface Grinding (Optional)

Suggested time: 15-20 hours **Level:** Advanced
Prerequisite: Modules 1, 2, and 11

Foundational Objectives
- To develop proficiency in the safe use of hand and machine tools.
- To identify and explain health and safety hazards in the workplace so that the potential for personal injury and damage to the equipment and the environment are minimized.
- To be able to use and understand the terminology related to machining in context.

Common Essential Learnings Foundational Objectives
- To use the technical terminology specific to the machining trade. (COM)
- To work in a safe and careful manner. (PSVS)

	Learning Objectives	Notes
28.1	To identify various work-holding devices used for surface grinding. (TL)	Types of work-holding devices students could identify and describe used for surface grinding include: • magnetic chucks • electromagnetic chucks (demagnitizers) • universal vise • indexing head and clamps. The students might also list the advantages and disadvantages of each type of holder.
28.2	To select a work-holding device and safely operate a surface grinder. (PSVS)	Have the students select a work-holding device and justify their choice. Points for discussion with the students could include: • why a magnetic chuck is "ground-in" • why a piece of oiled paper is placed between the work and the magnetic chuck • how to use a paper strip to position the grinding wheel • grinding edges square and parallel with face sides • the proper way to clean the surface grinder.
28.3	To dress, balance, and true a grinding wheel. (IL)	Have students mount, balance, and dress a grinding wheel to true the surface or to unload the abrasive or de-glaze the surface.
28.4	To list safety rules related to precision grinding.	Have students produce a checklist to review before they begin to use the surface grinder. Laminate the checklist to keep it clean.
28.5	To perform a surface grinding sequence. (IL)	Students will need to practice the set-up procedure to ensure that they are working for the accuracy that surface grinding is intended to produce and not the removal of large amounts of material. The students could prepare a worksheet that sequences the method they intend to follow to carry out the surface grinding procedure.

Module 29: Additional Grinding Techniques (Optional)

Suggested time: 3-5 hours **Level:** Advanced
Prerequisites: Modules 1, 2, and 11

Foundational Objectives
- To gain an overview of the different machining processes.
- To be able to produce parts to meet given specifications.
- To be knowledgeable about the impact of new technologies in the machining industry.

Common Essential Learnings Foundational Objectives
- To operate machine tools in a safe manner. (PSVS)
- To use the technical terminology specific to the machining trade. (COM)

	Learning Objectives	Notes
29.1	To explain how tool and cutter grinders operate. (COM)	Have the students identify the uses for a tool and cutter grinder and describe how milling cutters are sharpened with a tool and cutter grinder. The students could discuss the following topics: • use of the tool and cutter grinder • selecting the proper wheel for the sharpening operation • using and adjusting tooth rest • sequence for grinding plain milling cutters • sequence for grinding cutters with helical teeth • how to grind end mills • how to grind form cutters • sharpening taps and reamers.
29.2	To safely operate a tool and cutter grinder.	Remind students that carbide tool steel and high speed steel (HSS) do not produce showers of sparks when they are being dressed. This can lead to the false assumption that too light a cut is being made. It is far better for the equipment to make several light cuts than to be too aggressive.
29.3	To explain how to operate a cylindrical grinder. (COM)	Have students review the following: • the principles of cylindrical grinding • the differences between traverse and plunge grinding • methods of holding and driving the work • machining procedure, setting cutting speeds and feeds, table movement and runoff.
29.4	To explain how internal grinding is done. (COM)	Demonstrate: • the principles of internal grinding • holding and driving the work • machining procedure; setting cutting speeds and feeds, grinder movement and runoff.
29.5	To perform cylindrical and internal grinding operations. (IL)	The project selected by the student could employ both cylindrical and internal grinding operations. A plan of how the grinding will be sequenced could be used to reinforce the necessity to be properly prepared before beginning work.

	Learning Objectives	Notes
29.6	To describe centreless grinding operations. (COM)	Have the students prepare sketches of the various centreless grinding operations including: • through feed grinding • infeed grinding • endfeed grinding • internal grinding. Tours might be arranged for students as the more specialized grinding machine operations may only be available through visitations to manufacturers.
29.7	To describe other methods of grinding. (COM)	Have students research additional types of grinding that are used in industry. These might include Computer Numerical Control (CNC), electrolytic, and belt grinding.

Module 30: Numerical Control (Optional)

Suggested time: 3-5 hours **Level:** Intermediate
Prerequisite: Module 1

Foundational Objectives
- To be knowledgeable about the impact of new technologies in the machining industry.
- To become aware of the variety of jobs and career opportunities in the machining trades.
- To gain an overview of the different machining processes.

Common Essential Learnings Foundational Objectives
- To understand the impact of technology on the area of machining and on society in general. (TL)
- To explore the evolution of technological innovations within areas of study with a focus on the benefits and limitations of the innovation itself. (TL)

	Learning Objectives	Notes
30.1	To describe numerical control. (COM)	Have the students discuss and understand with the following terminology: • Numerical Control (NC) and Computer Numerical Control (CNC) • The differences between Direct and Distributed Numerical Control • The Cartesian Coordinate System: Spindle motion of the machine tool determines which axis will be the z-axis. (NUM)
30.2	To distinguish between incremental and absolute positioning methods. (COM)	Have the students review the operations performed by each method and decide which is the preferred system of use and why.
30.3	To describe the actions of the three movement systems. (COM)	Have the students decide which three NC movement systems is best suited to NC machine operations and provide examples of each of the following: • point-to-point • straight-cut • contour (continuous path) ▪ circular interpolation ▪ mirror imaging.
30.4	To list the advantages of using numerical control (NC) tools. (CCT)	Have the students brainstorm ideas where NC would be used in industry. They might also predict what might be possible in the future using this technology. (TL) Have students explain the uses and reasons for having adaptive control (AC) on CNC machines.
30.5	To differentiate between programming systems for automated control of machine tools.	Have students decide whether a manual program or computer-aided program would be the best choice for a variety of NC operations. Then have students prepare a list of operations that might be performed for a given object or component from the rough-out to finish operations.
30.6	To understand programming terminology and language. (TL)	Have students collect information on the programming languages used by machine tool onboard computers for CNC work.

Module 31: Automated Multi-machine Manufacturing (Optional)

Suggested time: 3-5 hours **Level:** Intermediate
Prerequisite: Modules 13A and 19A

Foundational Objectives
- To be knowledgeable about the impact of new technologies in the machining industry.
- To learn about the evolution of machine tools.

Common Essential Learnings Foundational Objective(s)
- To be knowledgeable about the impact of new technologies in the machining industry. (CCT, TL)

	Learning Objectives	Notes
31.1	To explain what automation means in the machining industry.	Have students define what the term automation means. List the advantages of using an automated manufacturing system. Ask students if an assembly line operation is a good example of automation and to give reasons or examples to justify their answers.
31.2	To describe several situations that would utilize automated production systems.	The students might brainstorm possible applications for flexible manufacturing systems (FMS) using computer numerical control and robotics to minimize the necessity for human involvement.
31.3	To explain how industrial robots are used.	Have the students define the functions performed by an industrial robot and describe some of the operations performed by industrial robots.
31.4	To explain how robotics are used in automated production systems.	Robotic applications are becoming more common and sophisticated. Have students brainstorm for applications where robots carry out tasks which may be unsafe for a human. If possible, visit an industrial site that uses robots as part of their manufacturing system. It may also be possible to build a robot from a kit to perform simple tasks as an example of possible applications that parallel the work of industrial robots.

Module 32: Quality Control (Optional)

Suggested time: 3-5 hours **Level:** Intermediate
Prerequisite: None

Foundational Objectives
- To be knowledgeable about the impact of new technologies in the machining industry.
- To learn about the evolution of machine tools.

Common Essential Learnings Foundational Objective(s)
- To be aware of the motives, interests, knowledge base, and justification for their own position and that of others. (CCT)

	Learning Objectives	Notes
32.1	To explain why quality control is such an important issue in the manufacturing process. (COM)	Have the students discuss quality control as a preventive measure in the manufacturing process. Discuss: • measuring techniques • the coordinated measuring machine and its capability • other quality control techniques.
32.2	To identify the difference between destructive and non-destructive testing. (CCT)	The two basic types of quality control are destructive and non-destructive testing. The students could identify situations where each method of testing is used to evaluate a product.
32.3	To describe some methods of performing non-destructive tests.	Common methods of non-destructive testing include visual inspection, accurate measurement, and weighing. Have students identify specialized tools used to assist these inspection methods. Other types of inspections might include the following inspection methods: • radiographic (X-ray) • magnetic particle • fluorescent penetrant • ultrasonic • laser measurement • electrical eddy-current.
32.4	To demonstrate methods of destructive testing.	Have the students demonstrate different methods of destructive testing and discuss what the results demonstrate about the quality of the product. The students could also list situations where destructive testing is used extensively in industry. The most evident is in the automotive industry when vehicles are crashed to verify safety features.

Module 33: Electro-machining Processes (Optional)

Suggested time: 2-4 hours **Level:** Intermediate
Prerequisite: None

Foundational Objectives
- To gain an overview of the different machining processes.
- To be knowledgeable about the impact of new technologies in the machining industry.

Common Essential Learnings Foundational Objective(s)
- To understand the evolving role of a machinist. (TL)

	Learning Objectives	Notes
33.1	To explain the advantages and disadvantages of the electro-machining processes.	Have the students identify the components of an electrical discharge machine. Have students describe the operating process of electro-machining and list the advantages of electro-machining compared to traditional machining.
33.2	To describe the types of electrical discharge machining (EDM). (COM)	Have the students prepare a diagram, label it and explain the process and operation of the components of the two types of EDMs. Have students provide examples of EDM applications.
33.3	To describe electrical discharge wire cutting. (COM)	Have the students compare the wire cutting (EDWC) process to band machining. An illustrative example of the process could be to use a wire saw to cut through a thin piece of wood or styrofoam.
33.4	To describe the process of forming parts using electrochemical machining (ECM).	Have the students describe the process of electrochemical machining (ECM) and then list the advantages of ECM.

Module 34: Non-traditional Machining Techniques (Optional)

Suggested time: 2-4 hours **Level:** Intermediate
Prerequisite: None

Foundational Objectives
- To be knowledgeable about the impact of new technologies in the machining industry.
- To be able to use and understand the terminology related to machining in context.

Common Essential Learnings Foundational Objectives
- To acquire knowledge about non-traditional machining methods. (TL)
- To develop independence regarding planning, monitoring, and evaluating of learning experiences. (IL)

	Learning Objectives	Notes
34.1	To differentiate between non-traditional machining techniques and traditional machining methods. (CCT)	Have the students research both methods of machining. They could prepare a list, and compare the advantages and disadvantages of each method.
34.2	To describe the processes common to non-traditional machining. (COM)	The four major groups of non-traditional machining include: • mechanical energy machining • electrical energy machining • thermal energy machining • chemical energy machining. Have the students list the different processes that are members of each of the above major groups. Many of these processes are known by acronyms. Have the students list the acronyms that apply to each group and identify them. Have students collect other examples of new processes that have not yet reached wide industry acceptance.
34.3	To understand electrical energy machining processes.	Have the students collect examples of industrial situations that use this machining technique. Each process will do some operations better than another process. Provide examples of the benefits that the electrical energy machining process has over the other three major types. This process includes the following electrochemical (EC) operations: • ECD – deburring • ECG – grinding • ECM – machining • ECH – honing • ECP – polishing • ECT – turning. For additional information, refer to Module 32.

	Learning Objectives	Notes
34.4	To describe other non-traditional methods of machining. (COM)	Have the students work in groups each researching a different type of machining process. Include the following types: • hydrodynamic machining – water-jet cutting • ultrasonic machining • electron Beam (EBM) machining • laser Beam – cutting. If possible, arrange tours of facilities which use these techniques.

Module 35: Other Machining Processes (Optional)

Suggested time: 2-4 hours **Level:** Intermediate
Prerequisite: Modules 1 to 20

Foundational Objectives
- To understand the properties and uses of different materials used in machining.
- To be knowledgeable about the impact of new technologies in the machining industry.

Common Essential Learnings Foundational Objectives
- To acquire knowledge about non-traditional machining methods. (TL)
- To develop independence regarding planning, monitoring, and evaluating of learning experiences. (IL)

	Learning Objectives	Notes
35.1	To discuss characteristics of various plastics that must be considered before machining.	Have the students discuss the various types of plastics and their machining characteristics. Have the students discuss why some plastics but not others must be annealed.
35.2	To describe the safety issues that must be considered before machining plastics.	Have students brainstorm a list of the possible hazards associated with machining plastics. When machining plastics, the build up of heat is a concern. Have the students discuss methods to prevent heat build up when machining plastics.
35.3	To sharpen cutting tools to machine plastics.	Sharpening cutting tools used for machining plastics is different than the procedures used for machining metals. Have students compare the two materials and the sharpening characteristics of tools for different types of plastics and metals. Have students prepare a display of tools sharpened for metal cutting compared to others sharpened for plastic cutting.
35.4	To describe various forms of chipless machining operations. (COM)	Have the students describe the five basic operations required for the cold heading technique and how it is put to use for making bolts, nuts, screws, and other fasteners. Have students explain how the Intraform® process differs from other chipless machining techniques.
35.5	To describe the powder metallurgy (P/M) process.	The students could prepare a poster showing the steps involved in the P/M process used to create objects. Process terms including briquetting, sintering, forging and coining should be included. Have students collect examples of parts or components manufactured using the powder metallurgy process.

	Learning Objectives	Notes
35.6	To describe high-energy-rate forming (HERF).	Have the students explain the differences between HERF and conventional metal forming techniques.
35.7	To describe various types of HERF.	Have the students describe the actions of: • explosive forming – stand-off and contact operations • electromagnetic forming • electrohydraulic forming • pneumatic-mechanical forming. Then have students compare the advantages and disadvantages of various HERF techniques.
35.8	To explain how the science of cryogenics is playing a role in the machining industry.	Have students list uses for cyrogenics in machining. Develop an experiment to illustrate the effect of using cold to fit parts together that would not fit if cold was not used.

Module 36A, B, C: Machining Project Options (Optional)

Suggested time: 20-35 hours **Level:** Introductory/Intermediate/Advanced
Prerequisite: Modules 1, 3, and 4

Foundational Objectives
- To increase self-esteem from success with the equipment, materials, and techniques used.
- To develop proficiency in the safe use of hand and machine tools.
- To gain an overview of the different machining processes.

Common Essential Learnings Foundational Objectives
- To measure, cut and assemble materials as required by instructions. (TL, NUM)
- To work on in-depth processes of their choice. (PSVS)
- To take pride in the completed project. (PSVS)

	Learning Objectives	Notes
36.1	To read and understand technical drawings. (CCT, NUM)	Have students explain what the plan they are working from tells them to do in a sequence that will produce the desired product. For additional information about reading technical drawings, see Module 3. More information is also available in the *Drafting and Computer-Aided Design 10, 20, 30 Curriculum Guide.*
36.2	To measure and cut selected metal material. (NUM)	Students need to be familiar with imperial and metric measurements. Students should measure twice and cut once. (TL) Review the necessary math skills from the Geometry-Measurement strand of the Mathematics curriculum, grades 6-9, (perimeter, area, volume, and circumference) available at the Saskatchewan Learning website.
36.3	To use hand tools and machine tools in a safe and productive manner. (TL)	The project(s) at the introductory level should focus on the use of hand tools to complete the project. Continually monitor student work habits emphasizing safe, careful work. Ensure that students wear protective safety equipment when working in the shop. As a means to evaluate knowledge of large machine operation, have students do presentations on the proper and safe use of machine tools for other members in the class who are to provide feedback (which would also be evaluated). If each student is required to make a presentation, the importance of careful use of large machines like lathes, saws, and milling machines will be reinforced. There is a selection of projects in Appendix E suited to student use with access to a lathe.

	Learning Objectives	Notes
36.4	To take pride in completed project(s). (IL, PSVS)	Have students check their work frequently and give attention to detail such as being square, proper fit and finish, etc. before assembly. Provide assistance as necessary to ensure a satisfactory product. Do not allow students to take an inferior product home. Work with the student to bring the work up to an acceptable standard Display student projects in school display cases whenever possible. Ask students to evaluate their project(s) and state what they would change if they were to make the project again.

Module 36B: Metal Projects (Optional)

Suggested time: 20-35 hours
Level: Intermediate
Prerequisite: Module 36A

Review or repeat objectives from Module 36A as required before proceeding with the Intermediate level project work.

Module 36C: Metal Projects (Optional)

Suggested time: 20-35 hours
Level: Advanced
Prerequisite: Module 36B

Review or repeat objectives from Module 36A as required before proceeding with the Advanced level project work.

Module 37A, B, C: Work Study Preparation and Follow-up Activities (Optional)

Note: Module 37 Work Study Preparation and Follow-up Activities is 5 - 10 hours. If students have participated in a work study module in a previous Practical and Applied Arts course, a review of this module is still required but less time may be needed.

Suggested time: 5-10 hours **Level:** Introductory/Intermediate/Advanced
Prerequisite: None

Module Overview
Students will prepare for work study in the community. Expectations for the student, the teacher, and the employer should be discussed. During follow-up, students will reflect on work study experiences.

Foundational Objectives
- To develop workplace skills, knowledge, and attitudes in the machining industry that may lead to successful employment.
- To understand how skills acquired in school may transfer to the workplace.

Common Essential Learnings Foundational Objective(s)
- To demonstrate skills and attitudes that contribute to the development of positive human relationships. (IL, PSVS)

	Learning Objectives	Notes
37.1	To be aware of the expectations of each of the partners in the work study component.	In order to establish a successful working relationship with all of the partners involved in the workplace, it is important to define the expectations of each partner. For a list of roles and responsibilities of the business, personnel, manager, teacher monitor, school, parent, and student, see the Work Study Guidelines for the Practical and Applied Arts included in the *Practical and Applied Arts Handbook*.
37.2	To determine the factors that may affect the student's contribution in the workplace. (CCT)	Brainstorm a list of factors that may affect the student's contribution in the workplace, then verify through experience. The list may include previous work experience, volunteer work, teamwork activities and extra-curricular participation within the school.
37.3	To build good communication skills for the workplace. (COM, PSVS)	Discuss verbal and non-verbal communication. List some ways in which negative and positive non-verbal communication may be displayed. Encourage students to role play ways of demonstrating effective techniques of verbal communication on the job when giving or receiving instructions and resolving conflict. Use case studies and divide the students into groups to role play how effective communication may be used to resolve conflict on the job. Emphasize the Employability Skills (from the Conference Board of Canada) and compare them to the Common Essential Learnings of Saskatchewan's Core Curriculum. Make the direct link between skill development in this course and the needs of employers. Development of skills and documentation of the skills leads to employment using those skills.

Learning Objectives		Notes
37.4	To develop a résumé that may be forwarded to a potential employer.	The student will develop a résumé using the correct format. (IL) The résumé may be used to introduce the student to the employer of a workplace site prior to an interview. Teachers are encouraged to work with other staff members to ensure résumé preparation is taught. Résumé writing is covered in *English Language Arts 20 and A30*, *Information Processing 10, 20, 30* and *Career and Work Exploration 10, 20, A30, B30* curriculum guides. Students should save the résumé and update it as changes need to be made and references are added. Skills that have been developed can also be added to the updated résumé. Students should develop their résumés and update them during the course, as work placement references are accumulated. A discussion with students about the benefits of a portfolio of sample work is appropriate at this time. A personal website that highlights the student's skills and training might be created and referred to in the résumé. If students have already completed a résumé and cover letter in another course, the teacher may do a review and encourage students to update their information. Each student should submit a résumé for teacher approval prior to going to an interview or directly to the workplace.
37.5	To create a student guide in preparation for an interview.	Through a classroom discussion or in groups, students should compile a "guide" for job interviews. After the students formulate their guide, the teacher may prompt them for missing items. Outline and describe the three stages of an interview. Point out to the students at what stage of the interview each of the guidelines previously discussed will be used. The **greeting** involves an introduction between the student and employer. Discuss or demonstrate how this should be done. The **exchange** is the longest part of the interview where the employer asks a series of questions and engages in a dialogue with the student about information on the résumé and other matters relating to the job. A student's portfolio may be examined by the employer as part of the exchange. The **parting** provides closure to the interview and may be just as important as the greeting. Explain how this may be done. Provide the students with a list of questions frequently asked by employers or ask students to make a list. Students may role play the stages of the interview.

	Learning Objectives	Notes
37.6	To discuss the post interview.	After the student has completed the interview with the employer, do a follow-up activity. Review the interview with the student using the three stages above as points for discussion.
37.7	To develop a procedural guide for the work site.	Discuss the following work site items with students: • transportation • hours of work • absence and tardiness • procedures for conflict resolution • role of the student, teacher, and workplace supervisor • dress code • job description • school and employer expectations.
37.8	To relate feedback from the work placement.	Students provide feedback about work placement including: location, type of business, duties, most rewarding experience, and most difficult situation and how they handled it. It is recommended that each student send a thank-you note or card to the employer upon the completion of each work placement. If more than one placement has been made in the course, follow-up activities must be completed after each placement. Ensure that students understand these guidelines by asking students to describe each of these items. Look for opportunities to introduce and reinforce ideas about Labour Standards, Occupational Health and Safety, and WHMIS. Use the *Career and Work Exploration 10, 20, A30, B30 Curriculum Guide*, the *Practical and Applied Arts Handbook*, the Saskatchewan Labour website, and other recommended resources in the accompanying bibliography.

Module 38A, B, C: Work Study (Optional)

Suggested time: 25-50 hours **Level:** Introductory/Intermediate/Advanced
Prerequisite: Module 32

Foundational Objectives
- To provide students with experience in the machining industry that will enable them to make informed career decisions.
- To integrate classroom learning with work-based learning.

Common Essential Learnings Foundational Objectives
- To engage in a work study experience and develop entry level workplace skills that may lead to sustainable employment. (PSVS)
- To expand career research beyond the classroom setting. (IL)

For more information about implementing work study in schools, see the Work Study Guidelines for the Practical and Applied Arts included in the *Practical and Applied Arts Handbook*. Teachers need to use or design appropriate learning objectives for this module (e.g., to demonstrate ability to follow a "Training Plan"). The training plan for the student should be designed to relate to the objectives of the course modules chosen in collaboration with the cooperating employer.

Consult Saskatchewan Labour for content about Labour Standards, Occupational Health and Safety, and WHMIS.

Module 88: Apprenticeship in Saskatchewan (Optional)

Suggested time: 2-5 hours **Level:** Introductory
Prerequisite: None

Module Overview

Students will be introduced to the apprenticeship and trade certification process and the role of the Saskatchewan Apprenticeship and Trade Certification Commission. Students will also explore a variety of opportunities that apprenticeship offers, and the relationship between Secondary Level and apprenticeship training.

This module is available for all Practical and Applied Arts curricula related to a designated trade, but should be taught from the perspective of the specific trade involved. In this case, the perspective reflects the trade of machining.

Foundational Objective
- To create an awareness of apprenticeship programs and opportunities in Saskatchewan.

Common Essential Learnings Foundational Objectives
- To broaden students' understanding of the apprenticeship program and the role it plays in the trade industries. (CCT)
- To examine particular trade opportunities that are appropriate for themselves. (IL, PSVS)

Learning Objectives	Notes
88.1 To understand and describe the process and benefits of apprenticeship.	Students should recognize that apprenticeship is a process of training and certifying workers in specific trades. Students could perform research to determine which trades are designated in Saskatchewan and how those compare to those in other provinces. Students should brainstorm reasons why a person would become an apprentice. Alternatively, they could interview journeypersons or apprentices to find out what they feel the advantages of the apprenticeship program were for them. Students should be able to describe the difference between a provincial certification and the Interprovincial Standards "Red Seal" program.
88.2 To understand and use the appropriate terminology related to apprenticeship.	Students should be able to use a wide variety of terms appropriately including, but not limited to, the following: • journeyperson • indenture • joint training committee • pre-employment training • designated trade and sub-trade • advanced standing.

Learning Objectives	Notes
88.3 To determine the steps involved in becoming an apprentice.	Students need to be aware that the applicant must be working in the trade, must sign a formal contract with the employer and the Saskatchewan Apprenticeship and Trade Certification Commission, and must be prepared to attend technical training, typically once per year. Students could interview a journeyperson or an apprentice to learn about their experience.
88.4 To determine the relationship between the ATCC and the various trade boards.	Students should be aware of how a trade board becomes established and how a trade becomes designated in Saskatchewan. Each student could contact a trade board and find out the role it plays in the apprenticeship process. They should also determine the relationship between the trade board and the ATCC. Students could share and compare their findings with other students in the class.
88.5 To develop an understanding of the programs available to help make the transition from Secondary Level to apprenticeship.	Students should be aware of the recognition of time that is available. Students should also be aware of the opportunity for challenging the Level I examination in a given trade, providing certain conditions are met.
88.6 To determine the length of apprenticeship and the annual training required in a particular trade that may be of interest to the student.	Students should explore the requirements of one or more specific trades including years and hours required, location of annual training, and the duration of annual training. Students could also explore employability and expected wages for those trades. They could share their findings with the rest of the class.
88.7 To explore the qualities of a successful apprentice.	Students could interview employers to determine personal characteristics that will help make an apprentice in a particular trade successful. Students could also brainstorm a list of qualities and discuss them. With these qualities in mind, the students could perform a peer or self-assessment to gauge their own suitability for a career in that trade.

Module 99A, B, C: Extended Study (Optional)

Note: The extended study module may be used only once in each 100 hour course. It is important to record the title of the extended study module on the recordkeeping chart. Record 99A for the first extended study module offered in the course series, 99B for the second offering, and 99C for the third.

Suggested time: 5-20 hours **Level:** Introductory/Intermediate/Advanced
Prerequisite: None

Evolving societal and personal needs of society, advances in technology and demands to solve current problems require a flexible curriculum that can accommodate new ways and means to support learning in the future. The extended study module is designed to provide schools with an opportunity to meet current and future demands that are not provided within current modules in the renewed PAA curriculum.

The flexibility of this module allows a school/school division to design **one new module per credit to complement or extend the study of pure, core and optional modules** configured to meet the specific needs of students or the community. The extended study module is designed to extend the content of the pure courses and to offer survey course modules beyond the scope of the available selection of PAA modules.

The list of possibilities for topics of study or projects for the extended study module approach is as varied as the imagination of those involved in using the module. These optional extended study module guidelines should be used to strengthen the knowledge, skills, and processes advocated in the PAA curriculum and to address particular student needs and interests.

For more information on the guidelines for the Extended Study module see the *Practical and Applied Arts Handbook*.

References

Note: A complete list of resources providing annotations and ordering information is available in the bibliography.

Apprenticeship and Trade Certification Commission. (2003). *High school to apprenticeship: Linking to the future. A handbook for high school administrators and student counsellors*. Regina, SK: Author.

Hache, L., Redekopp, D. E., and Jarvis, P. S. (1998). *Blueprint for life/work designs*. National Life/Work Centre.

Kibbe, R., Neely, J., Meyer, R., and White, W. (1999). *Machine tool practices*. (6th Ed.). Columbus, OH: Prentice Hall.

Krar, S., Rapisarda, M. and Check, A. (1998). *Machine tool and manufacturing technology*. Albany, NY: Delmar Publishers.

Saskatchewan Education. (1988). *Understanding the common essential learnings: A handbook for teachers*. Regina, SK: Author.

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Saskatchewan Learning. (2003). *Career and work exploration 10, 20, A30, B30 curriculum guide. A practical and applied art*. Regina, SK: Author.

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Appendix A: Determining a Trade Pathway for Students

During the renewal of the Practical and Applied Arts (PAA), Saskatchewan Learning has signed an articulation agreement for Machining with the Apprenticeship and Trade Certification Commission (ATCC), and the Saskatchewan Institute of Applied Science and Technology (SIAST).

School divisions should be aware that although Machining content requires a certain level of maturity, some modules are recommended for Middle Level grades 7-9. These modules are listed in the *Practical and Applied Arts Handbook*.

Pure courses, one hundred hours long, are available beginning at the grade 10 level. Students may take Machining with no intent to pursue the Machining apprenticeship route.

Articulation

Saskatchewan Learning, in consultation with the PAA Reference Committee, has agreed to develop adequate hours of provincial curriculum in the designated trade areas, that, combined with limited practical experience, will meet the Level I requirements (or their equivalent), as outlined by the Apprenticeship and Trade Certification Commission (ATCC). Articulation agreements have been established to accommodate students who have met the Level I requirements and who have followed the procedures specified by the ATCC's *High School to Apprenticeship: A Link to the Future (2003)*. Such students may challenge the Level I trade exam and, if successful, receive Level I technical training credit and verifiable time credit in Apprenticeship. Verifiable time credit refers to: time accrued under the supervision of a journeyperson, a course taught by a teacher holding a journey status in the designated trade, or a course taught by a teacher who has taken an approved certification course.

Training plans included in Appendix C have been designed to provide direction for Level I skill development in the classroom and in the workplace.

School divisions or schools seeking to register students who wish to challenge the Machining Level I exam, must meet the following criteria:

- Review and understand procedures outlined in *High School to Apprenticeship: A Link to the Future* (2003). (Apprenticeship Work Placement Program, Apprenticeship Recognition for Practical and Applied Arts Courses, Additional Practical and Applied Arts Courses in the Designated Trades)

- The Level I theory identified below as required modules in Machining must be covered thoroughly by the journey status or certified teacher and students.

- Practical experiences must be offered in the school setting or through the optional work study modules used in partnership with local businesses and journeypersons.

- Only a teacher who is a **journeyperson** or who has completed an **approved certification course in the designated trade** may recommend students for a Level I challenge exam. This will ensure that the teacher has the necessary background skills to evaluate Level I theory and practice in the school.

- Time credit is granted when time is accrued under a journeyperson or when the course is taught by a teacher who either holds journey status in the designated trade or who has taken an approved certification course in the designated trade.

- **Accreditation courses, approved by the ATCC and Saskatchewan Learning, are delivered by SIAST through the STF Summer Short Course mechanism.**

- Only those students who have successfully completed the Level I content in the Secondary Level courses and whose marks have been submitted to Saskatchewan Learning student records may challenge the Level I exam. Students without aspirations of pursuing further training in the trade should not consider this route. To be successful, students challenging the Level I apprenticeship theory exam must attain a mark of 70%. The Level I exam may not replace any portion of the evaluation for Secondary Level credit.

- Certified teachers are responsible for assigning a mark for submission to Student Records for Secondary Level students.

- The students must successfully complete all the courses in the series before challenging the Level I exam and should be nearing completion of the last course in the series when they indicate their intent to challenge the Level I exam.

- The school division or school must notify ATCC at least two months prior to the writing of the Level I exam, stating their intention to recommend a student or students. Verification of the marks for the completed course (official transcript), a statement of preliminary marks for courses underway if applicable, and the examination fee must be submitted for each student eligible to write. Registration for the Level I exam is managed by ATCC.

- The ATCC will administer the Level I exams to Secondary Level students during the January and June Departmental Examination writing sessions. ATCC will evaluate the exams, record the results and notify the student(s) of results at school. The dates for the writing sessions are established annually and published in the *Registrar's Handbook for School Administrators* that is distributed to the schools. (Available from Student Records at Saskatchewan Learning).

- Saskatchewan Learning will distribute information to inform schools of changes to the Level I apprenticeship requirements in the trade.

- Successful students will receive Level I technical training credit and verifiable time credit in Apprenticeship.

- Advanced standing in the Machining program at SIAST will be awarded to students who are successful in the challenge of the Level I exam and/or who have completed verifiable time credit for Level I in the designated trade.

- Upon registration in the trade, a Secondary Level student who was unsuccessful in the Level I challenge will not receive credit for Level I theory, but will receive time credit recognition for time spent in practical experience under the supervision of a journeyperson. This must be documented in a letter (on a Form 6) signed by the supervising journeyperson.

For more information about trade articulation, see the *High School to Apprenticeship: A Link to the Future (2003)* document distributed by ATCC.

- The following Saskatchewan Learning PAA Machining modules must be successfully completed in order to meet the Level I requirements in the trade:

MODULE	TITLE
MACH01	Introduction to Machining (Core)
MACH2A,B,C	Safety (Core)
MACH03	Using Technical Drawings (Core)
MACH04A	Simple Measurement (Core)
MACH04B	Adjustable Measurement Tools (Core)
MACH04C	Measuring with Gauges (Core)
MACH05	Layout Work (Core)
MACH06	Hand Tools (Core)
MACH07	Fasteners (Core)
MACH09	Cutting Fluids (Optional)
MACH10	Drills and Drilling Machines (Core)
MACH11	Offhand Grinding (Core)
MACH12	Saws and Cutoff Machines (Core)
MACH13	Metal Characteristics (Optional)
MACH17A	The Lathe, Introduction (Core)
MACH17B	Lathe Cutting Tools (Core)
MACH17C	Cutting Speeds and Feeds on the Lathe (Core)
MACH17D	Mounting Work Between Centres on the Lathe (Optional)
MACH17E	Turning Between Centres on the Lathe (Optional)
MACH17F	Lathe Chucks (Optional)
MACH18	Cutting Tapers on the Lathe (Optional)
MACH19	Cutting Screw Threads on the Lathe (Core)
MACH20	Additional Lathe Operations (Optional)
MACH23A	Introduction to the Milling Machine (Core)
MACH23B	Milling Machine Cutters (Optional)
MACH23C	Setting a Milling Machine (Optional)
MACH24	Operating a Vertical Milling Machine (Core)
DRAF03	Sketching and Freehand Drawing Fundamentals (Optional)
DRAF31	Reading Technical Drawings (Blueprints) (Optional)

The modules above in the Machining curriculum have been identified as core modules required for a Level I exam challenge. The content in these modules is similar enough to be considered as equal with the SIAST modules that follow:

MACH-190	Lathe
TOOL-192	Benchwork/Measure
MACH-192	Cutoff Saws, Material ID, Pedestal Grinder, Cutting Fluids
MACH-193	Drilling Machines
DRFT-188	Technical Drawing and Blueprint Reading
ME-181	Safety and Basic Shop Mechanics
MACH-189	Milling
MATH-290	Mathematics

SAMPLE FORM – Obtain full document from address below

Saskatchewan Apprenticeship and Trade Certification Commission

2140 Hamilton Street
Regina, Saskatchewan
S4P 3V7

Tel (306) 787-2444
Fax (306) 787-5105

Form 6

Verification of Trade Experience Letter

This letter is to verify the type of work a person performs in a specific trade.

Use one verification letter per employer.

Social Insurance Number _____

Please check one of the following:

- ☐ New Apprenticeship Contract (must be accompanied by Form 1)
- ☐ Placement on Apprenticeship File (updating hours)
- ☐ Examination (must be accompanied by Form 2)
- ☐ Request for Journeyperson Certificate (must be accompanied by Form 3)
- ☐ Entry into Upgrading Course (must be accompanied by Form 4)

Trade _____

Name of Apprentice/Tradesperson (last/first) _____

Address _____

City/Town _____

Postal Code _____ **Telephone** _____

Company Stamp If Available

Name of Company (Employer) for Which Trade Experience is Being Verified

_____

Address _____ **Telephone** _____

City/Town _____ **Postal Code** _____ .

Period of Employment From _____ (D/M/Y) to _____ (D/M/Y)

Please refer to Period of Employment instructions on reverse.

.

Work Performed At _____ (City/Town)

Document only the time spent actually working the trade, using the tools of the trade.
Please refer to Trade Experience instructions on reverse.

Description of Work Performed	Trade Experience in Hours
Total Hours	

FOR COMMISSION USE ONLY
Time Assessed _____ Hours Date _____ Assessed by _____

If the work was supervised by a Journeyperson:

Name of Journeyperson _____ Certificate # _____ Trade _____

Signed this _____ day of _____ 200__

_____
Signature of Witness*

_____
Name of Witness (Please Print)

Address _____

Telephone _____

*The witness may not be the subject (apprentice or tradesperson applying) of this letter.

_____
Signature of Appropriate Person*

_____
Name of Appropriate Person (Please Print)

Position _____

Address _____

Telephone _____

*An Appropriate Person: employer, employer's representative or journeyperson supervising the work

Instructions

a) Period of Employment**: When you submit the** *first* **Form 6, the period of employment** *starts with the day you started with the employer and ends with the day you fill out the form*. **The period of employment on the *second*, Form 6 you submit starts the day after the day listed on the first Form 6 and ends the day you fill out the form.**

Example: **First Form 6: 15/01/99 to 15/06/00**
Second Form 6: 16/06/00 to 30/12/00

b) Trade Experience in Hours:
Refers to the number of hours you worked in the period of employment.

Example:

Description of Work Performed	**Trade Experience in Hours**
Gears Transmissions	40 hours 75 hours
Total Hours	115 hours

Affidavit for Verification of Trade Time

An Affidavit is to be used only when confirming trade time in the following instances:

a) a business is no longer in existence;
b) self-employment. (Attach copy of business license or letter from: town clerk, municipal secretary, or person in authority in the community acknowledging that during the period in question, the tradesperson was known to be an owner/operator of a business.)

Before proceeding, please ensure that the reverse side of this form is fully completed.

Canada
Province of Saskatchewan

To Wit:

In the matter of the verification of trade time in the _____

trade, I _____ of _____
Address/ Postal Code

_____

do solemnly declare that said verification of trade time as stated on the reverse side of this document is accurate and I make this solemn declaration conscientiously believing it to be true and knowing that it is of the same force and effect as if made under oath and by virtue of the *Canada Evidence Act*.

Declared before me at the

_____ of
City/Town

_____ in

the Province of Saskatchewan

this _____ day

of _____ A.D., 200_.

_____
Signature of Tradesperson

_____
Commissioner of Oaths in and
For the Province of Saskatchewan
My Commission expires:

Appendix B: Recordkeeping Charts for Suggested Courses

Machining 10

Student Name _____

Student Number _____

Module Code	Module	Hours	Date	Teacher Initial
MACH01	Module 1: Introduction to Machining (Core)			
MACH02A	Module 2A: Safety (Core)			
MACH03	Module 3: Using Technical Drawings (Core)			
DRAF03	Module 3: Sketching and Freehand Drawing Fundamentals (Optional)			
MACH04A	Module 4A: Simple Measurement (Core)			
MACH05	Module 5: Layout Work (Core)			
MACH06	Module 6: Hand Tools (Core)			
MACH07	Module 7: Fasteners (Core)			
MACH08	Module 8: Jigs and Fixtures (Optional)			
MACH09	Module 9: Cutting Fluids (Optional)			
MACH10	Module 10: Drills and Drilling Machines (Core)			
MACH11	Module 11: Offhand Grinding (Core)			
MACH12	Module 12: Saws and Cutoff Machines (Core)			
MACH13	Module 13: Metal Characteristics (Optional)			
MACH14	Module 14: Heat Treatment of Metals (Core)			
MACH15	Module 15: Metal Finishing (Optional)			
MACH16	Module 16: Career Opportunities (Core)			
MACH36A	Module 36A: Machining Project Options (Optional)			
MACH37A	Module 37A: Work Study Preparation and Follow-up Activities (Optional)			
MACH38A	Module 38A: Work Study (Optional)			
MACH99A	Module 99A: Extended Study (Optional)			

Note: When the Extended Study, Work Study Preparation and Follow-up Activities, and Work Study modules are studied for the first time, record the module number and the letter A (Extended Study Module 99A). If the module is used at another level, the module is recorded using the letter B (Extended Study Module 99B).

All recordkeeping charts should be copied on school letterhead.

Machining 20

Student Name _____

Student Number _____

Module Code	Module	Hours	Date	Teacher Initial
MACH02B	Module 2B: Safety (Core)			
MACH04B	Module 4B: Adjustable Measuring Tools (Core)			
MACH17A	Module 17A: The Lathe, Introduction (Core)			
MACH17B	Module 17B: Lathe Cutting Tools (Core)			
MACH17C	Module 17C: Cutting Speeds and Feeds on the Lathe (Core)			
MACH18	Module 18: Cutting Tapers on the Lathe (Optional)			
MACH20	Module 20: Additional Lathe Operations (Optional)			
MACH21	Module 21: Band Machining (Core)			
MACH22	Module 22: Broaching Operations (Core)			
MACH23A	Module 23A: Introduction to the Milling Machine (Core)			
MACH23B	Module 23B: Milling Machine Cutters (Optional)			
MACH27	Module 27: Precision Grinding (Core)			
MACH30	Module 30: Numerical Control (Optional)			
MACH31	Module 31: Automated Multi-machine Manufacturing (Optional)			
MACH32	Module 32: Quality Control (Optional)			
MACH33	Module 33: Electro-machining Processes (Optional)			
MACH34	Module 34: Non-traditional Machining Techniques (Optional)			
MACH35	Module 35: Other Machining Processes (Optional)			
MACH36B	Module 36B: Machining Project Options (Optional)			
MACH37B	Module 37B: Work Study Preparation and Follow-up Activities (Optional)			
MACH38B	Module 38B: Work Study (Optional)			
MACH99B	Module 99B: Extended Study (Optional)			

Note: When the Extended Study, Work Study Preparation and Follow-up Activities and Work Study modules are studied for the first time, record the module number and the letter A (Extended Study Module 99A). If the module is used at another level, the module is recorded using the letter B (Extended Study Module 99B).

All recordkeeping charts should be copied on school letterhead.

Machining 30

Student Name _____

Student Number _____

Module Code	Module	Hours	Date	Teacher Initial
MACH02C	Module 2C: Safety (Core)			
MACH04C	Module 4C: Measuring with Gauges (Core)			
MACH17D	Module 17D: Mounting Work Between Centres on the Lathe (Optional)			
MACH17E	Module 17E: Turning Between Centres on the Lathe (Core)			
MACH17F	Module 17F: Lathe Chucks (Optional)			
MACH19	Module 19: Cutting Screw Threads on the Lathe (Core)			
MACH20	Module 20: Additional Lathe Operations (Optional)			
MACH22	Module 22: Broaching Operations (Core)			
MACH23C	Module 23C: Setting a Milling Machine (Optional)			
MACH24	Module 24: Operating a Vertical Milling Machine (Core)			
MACH25	Module 25: Operating a Horizontal Milling Machine (Optional)			
MACH26	Module 26: Gear Cutting Operations (Optional)			
MACH28	Module 28: Work Holding Devices and Surface Grinding (Optional)			
MACH29	Module 29: Additional Grinding Techniques (Optional)			
MACH36C	Module 36C: Machining Project Options (Optional)			
MACH37C	Module 37C: Work Study Preparation and Follow-up Activities (Optional)			
MACH38C	Module 38C: Work Study (Optional)			
MACH88	Module 88: Apprenticeship in Saskatchewan (Optional)			
MACH99C	Module 99C: Extended Study (Optional)			

Note: When the Extended Study, Work Study Preparation and Follow-up Activities, and Work Study modules are studied for the first time, record the module number and the letter A (Extended Study Module 99A). If the module is used at another level, the module is recorded using the letter B (Extended Study Module 99B).

All recordkeeping charts should be copied on school letterhead.

Appendix C: Sample Training Plan Checklists
Machining 10

Recordkeeping documents should be copied on school letterhead.

Student's name (print)_____

Workplace name (print)_____

Assessor's name and qualification (print)_____

Module Component	Observed	Assisted	Demonstrated	Checked by
Module 1: Introduction to Machining: *To understand the evolution of metal working hand and machine tools.*				
Module 2A: Safety: *To handle and care for hand tools in a safe and responsible manner.*				
Module 3: Using Technical Drawings: *To read and understand technical drawings used by machinists.*				
Module 4A: Simple Measurement: T*o be able to measure accurately with a steel rule and a protractor.*				
Module 5: Layout Work: *To use layout tools accurately.*				
Module 6: Hand Tools: T*o use hand tools to complete work assignments.*				
Module 7: Fasteners: T*o identify, select and use a variety of fasteners.*				
Module 8: Jigs and Fixtures: *To identify a variety of jigs and fixtures and applications for them.*				
Module 9: Cutting Fluids: *To identify different types of cutting fluids and their application.*				
Module 10: Drills and Drilling Machines: *To select and safely use drilling machines with a twist drill.*				
Module 11: Offhand Grinding: *To identify different grinding wheels and use them in a safe manner.*				
Module 12: Saws and Cutoff Machines: *To select the proper cutting blade for different applications and perform cutting operations in a safe fashion.*				
Module 13: Metal Characteristics: *To identify different types of metals and their properties.*				
Module 14: Heat Treatment of Metals: *To describe and perform different types and methods of heat treating metals.*				

Machining 20

Recordkeeping documents should be copied on school letterhead.

Student's name (print)_____

Workplace name (print)_____

Assessor's name and qualification (print)_____

Module Component	Observed	Assisted	Demonstrated	Checked by
Module 2B: Safety: *To handle and care for hand tools in a safe and responsible manner.*				
Module 4B: Adjustable Measuring Tools: *To measure accurately with a micrometer and a vernier caliper.*				
Module 17A: The Lathe, Introduction: *To identify the parts of the lathe and the safe operation of the lathe.*				
Module 17B: Lathe Cutting Tools: *To identify, sharpen and safely use a variety of lathe cutting tools.*				
Module 17C: Cutting Speeds and Feeds on the Lathe: *To calculate lathe speeds and feeds for a given material.*				
Module 18: Cutting Tapers on the Lathe: *To set up and operate a lathe to cut a taper.*				
Module 21: Band Machining: *To use a banding machine to perform a variety of cutting, filing and polishing.*				
Module 23A: Introduction to the Milling Machine: *To describe the safety requirements and the various parts and their operational relationship on a milling machine.*				
Module 23B: Milling Machine Cutters: *To describe various types of cutters and make appropriate selections for milling feeds and speeds.*				
Module 27: Precision Grinding: *To identify and select the correct grinder and grinding wheel, dress and true the wheel and operate in a safe manner.*				
Module 30: Numerical control: *To demonstrate an understanding of the operation of numerical control operations.*				

Module Component	Observed	Assisted	Demonstrated	Checked by
Module 31: Automated Multi-machine Manufacturing: *To demonstrate an appreciation for the importance and need for automated production systems.*				
Module 32: Quality Control: *To understand the methods of checking for quality controls, both destructive and non-destructive (measuring, visual etc.) testing.*				
Module 33: Electro-machining Processes: *To explain the operating characteristics of electro-machining.*				
Module 34: Non-traditional Machining Techniques: *To differentiate between traditional and nontraditional machining techniques.*				
Module 35: Other Machining Processes: *To be aware of the other possibilities for machining methods.*				

Machining 30

Recordkeeping documents should be copied on school letterhead.

Student's name (print)_____

Workplace name (print)_____

Assessor's name and qualification (print)_____

Module Component	Observed	Assisted	Demonstrated	Checked by
Module 2C: Safety: *To handle and care for hand tools in a safe and responsible manner.*				
Module 4C: Measuring with Gauges: *To be able to use dial indicator measuring gauges.*				
Module 17D: Mounting Work Between Centres on the Lathe: *To safely and correctly mount work to be turned between centres on a lathe.*				
Module 17E: Turning Between Centres on the Lathe: *To rough and finish turn materials between centres on the lathes to plan specifications.*				
Module 17F: Lathe Chucks: *To select and mount different types of turning chucks on the lathe*				
Module 19: Cutting Screw Threads on the Lathe: *To differentiate among different screw thread styles and demonstrate the method used to cut screw threads internally and externally.*				
Module 20: Additional Lathe Operations: *To perform a variety of lathe operations including: setup and use of work holding devices, drilling, reaming, and grinding.*				
Module 22: Broaching Operations: *To demonstrate and explain how to broach a keyway.*				
Module 23C: Setting a Milling Machine: *To select the proper cutter and determine cutting speeds and feed,s and the use of work holding devices.*				
Module 24: Operating a Vertical Milling Machine: *To demonstrate the safe use of a vertical milling machine.*				
Module 25: Operating a Horizontal Milling Machine: *To demonstrate the safe use of a vertical milling machine.*				

Module Component	Observed	Assisted	Demonstrated	Checked by
Module 28: Work Holding Devices and Surface Grinding: *To safely perform the grinding operations using work holding devices.*				
Module 29: Additional Grinding Techniques: *To safely operate a grinder to perform internal and cylindrical grinding.*				

Appendix D: Career Research Interview Questions

Adapted from *Business Education A Curriculum Guide for the Secondary Level Accounting 10, 20, 30* (Saskatchewan Education 1992).

Interview someone who currently works in this occupation.

The assignment may be completed independently, in pairs, in small groups or by whichever method is chosen by the student(s) and teacher. The teacher should encourage students to use a variety of resources to gather information about the career that they are researching. The student may use letters, the Internet, the telephone, or a personal interview to gather information.

After the students have discussed different career paths, students may prepare a short journal writing explaining why they are interested in the occupational area that they are about to investigate.

Students may develop a list of questions to collect the information they require in order to understand more about the career cluster or occupation chosen.

The following list of questions may be included in the students' interview project.

1. What is your job title?

2. What are the normal duties on your job?

3. What are some of the things that you enjoy about your job?

4. Are there any things about your job that you dislike? What are those things?

5. Does your company have a dress code for employees? What is considered suitable?

6. How often is working overtime required in your job?

7. Do you have to work nights or weekends?

8. What aptitudes and abilities are needed to succeed in your occupation?

9. What are the post-secondary education and training requirements to enter and advance in your career?

10. Can you give an approximate starting salary for someone just starting out in your occupation? How much does the average person earn after five years? After ten years? What types of employee benefits, such as sick leave or dental plans, do workers in your career usually receive?

11. Do you think the demand for workers in your career will increase or decrease over the next five years? Why?

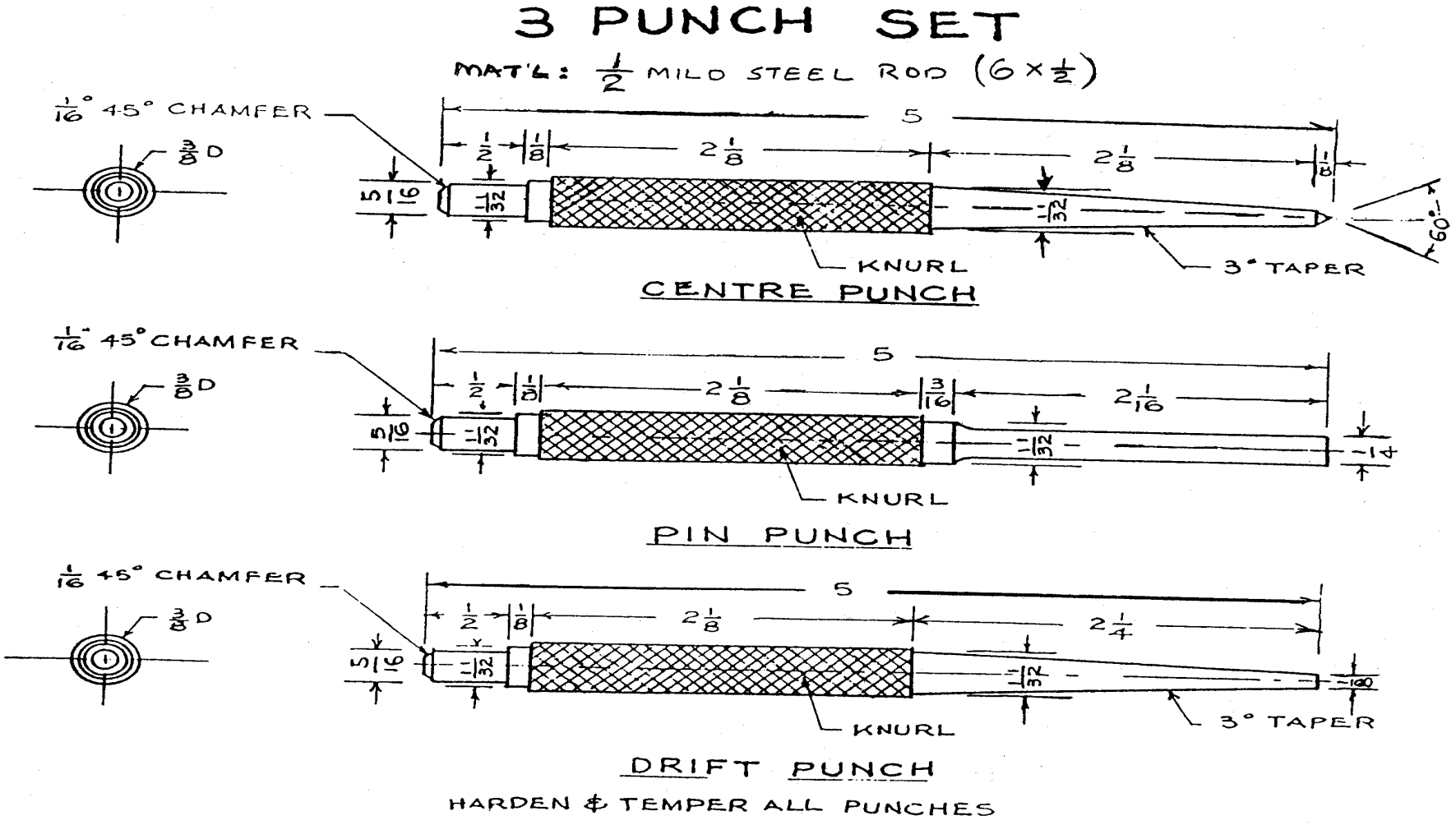
12. What changes have you seen over the past 5-10 years in this occupation?

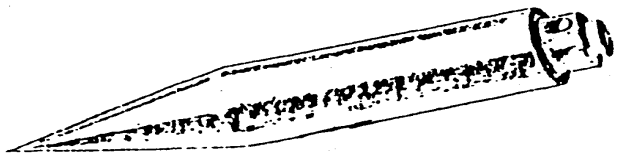
13. What are the advantages and disadvantages of entering and being in your occupation?

14. Is there any advice you would give to a young person making career decisions?

After the interview session, students may summarize the information they received and draw a conclusion as to whether they would like to learn more about this occupation.

Appendix E: Project Plans

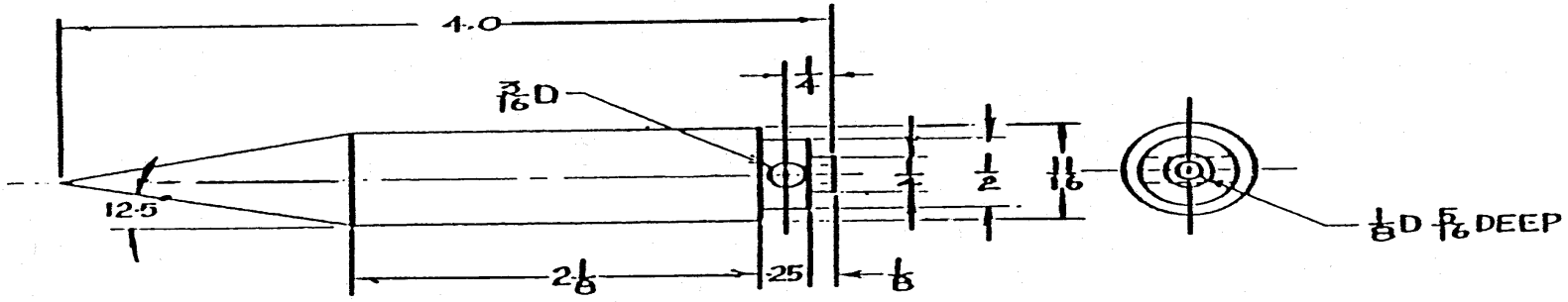


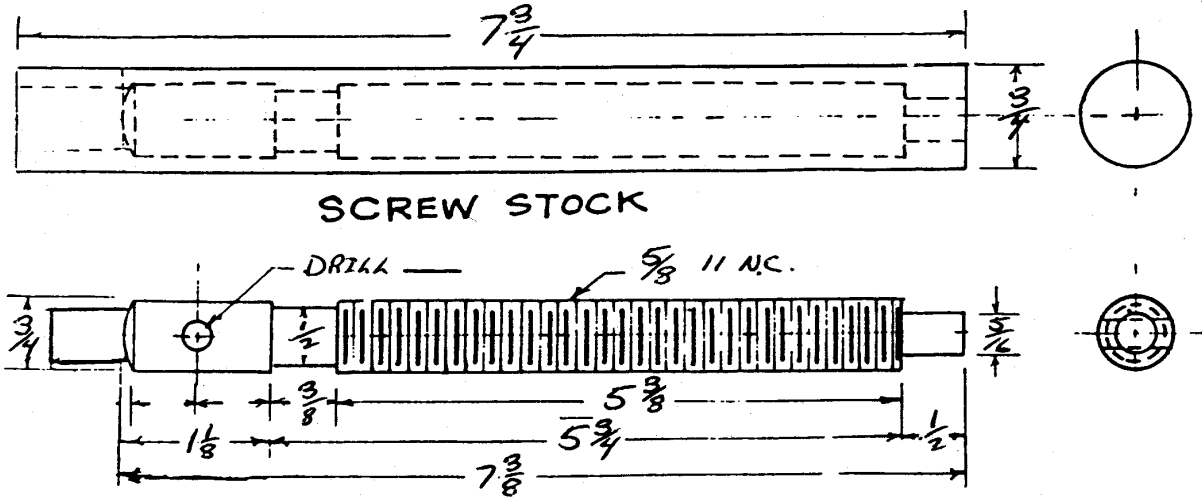


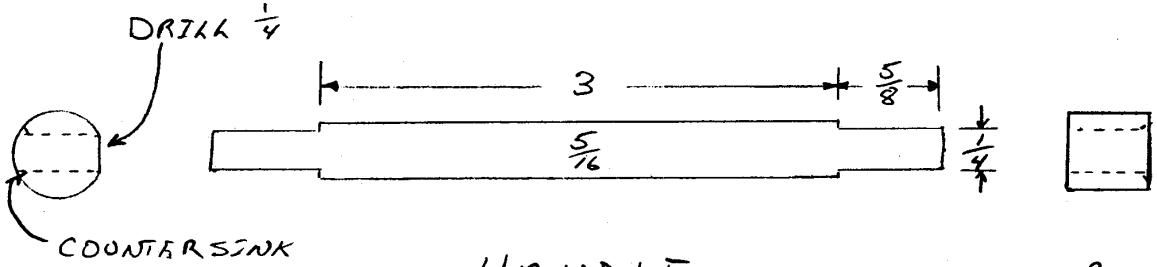
BRASS PLUMB BOB

THE BRASS PLUMB BOB IS A GOOD BEGINNING PROJECT FOR MACHINE SHOP. TO MAKE THIS PROJECT FROM BRASS ROD, REQUIRES TURNING, FACING, TAPER TURNING, DRILLING AND POLISHING.

_____ LONG $\frac{3}{4}$" DIA. COLD ROLLED STEEL.







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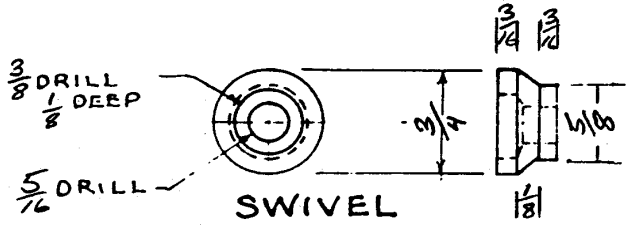

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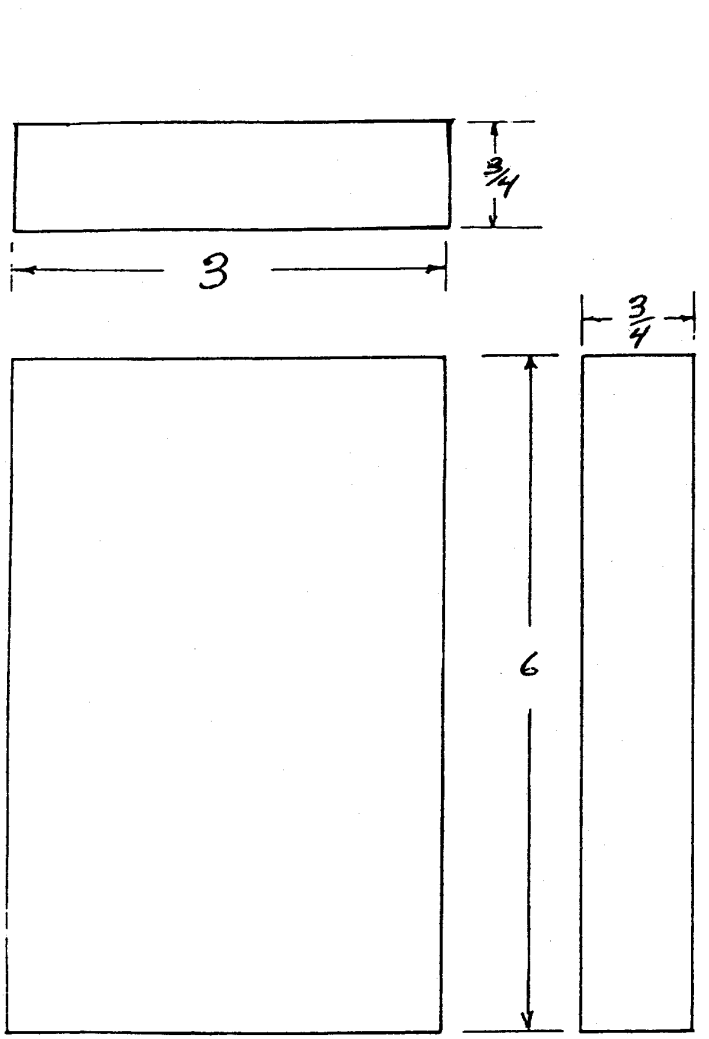

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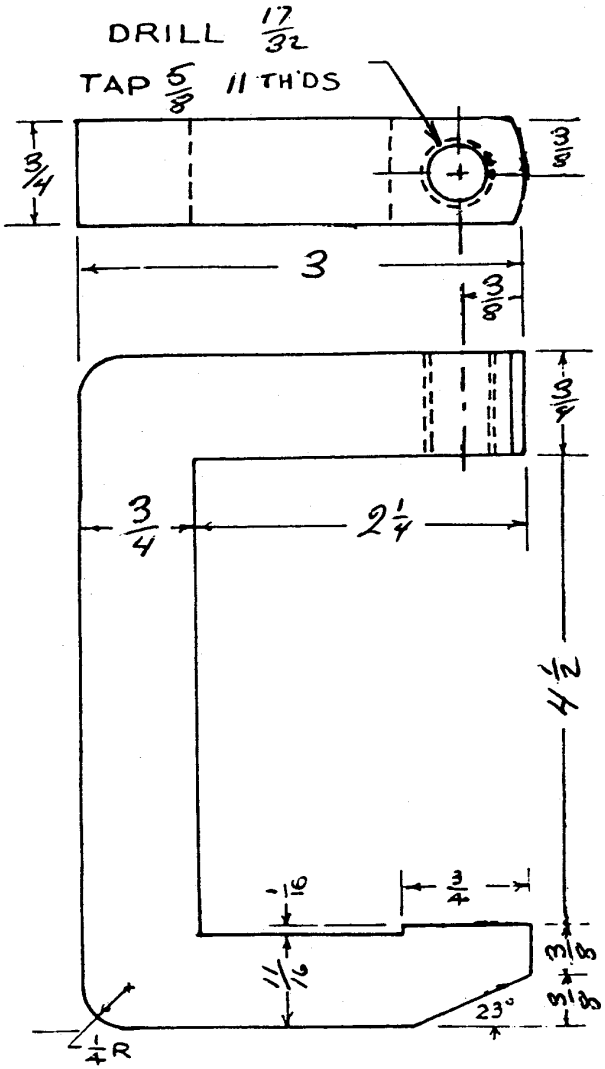

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