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MECHANICAL MANUFACTURING

NUMERICAL CONTROL MACHINE TOOL OPERATION

PROGRAM OF STUDY
5724

VOCATIONAL and TECHNICAL EDUCATION

Québec

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The *Numerical Control Machine Tool Operation* program leads to the Attestation of Vocation Specialization (AVS) and prepares the student to practise the trade of *machinist*.

Direction générale de la formation professionnelle et technique

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INTRODUCTION

The *Numerical Control Machine Tool Operation* program is based on a framework for developing vocational education programs that calls for the participation of experts from the employment and the education sectors.

The program of study is developed in terms of competencies, expressed as objectives. These objectives are divided into modules. Various factors were kept in mind in developing the program: training needs, the job situation, purposes, goals, and strategies and means used to attain objectives.

The program sets out and structures the competencies that students from the youth and adult sectors must acquire in order to obtain an Attestation of Vocational Specialization. It also provides the basis for organizing courses, planning teaching strategies, and preparing instructional and evaluation materials.

The program is divided into 13 modules and its total duration is 885 hours, including 570 hours spent on the specific competencies required to practise the trade and 315 hours on general competencies. However, there is a core content common to this program (AVS 5724) and the *Machining Techniques* program (DVS 5723), which includes basic training in the use of numerical control machine tools. Consequently, students who have obtained their Diploma of Vocational Studies (DVS) and now wish to specialize in numerical control machine tool operation can obtain recognition for competencies already acquired. In such cases, the specialized training is divided into five modules and its total duration is reduced to 420 hours, including 330 hours spent on the specific competencies and 90 hours on general competencies.

The modules vary in length from 15 to 120 hours (multiples of 15). The total duration includes time allocated not only for teaching but also for evaluation and remedial work.

The document contains two parts. Part I is of general interest and provides an overview of the training plan in five chapters. It includes a synoptic table of basic information about the modules, a description of the program training goals, the competencies to be developed and the general objectives, and an explanation of operational objectives. Part II is designed primarily for those directly involved in implementing the program. It contains a description of the operational objectives of each module. It also contains suggestions on the instructional approach and related content for each module in the program. The suggestions are intended for users of the program and are provided for informational purposes only.

In keeping with this broad approach, two accompanying documents will be provided: an evaluation guide and a planning guide.

HARMONIZATION

Numerical Control Machine Tool Operation (5724) is a vocational education program in the *Mechanical Manufacturing* sector. It was designed and developed as part of a project to harmonize the different programs in this sector, including *Mechanical Engineering Technology* and *Aircraft Manufacturing Technology* at the college level, as well as *Industrial Drafting* and *Machining Techniques* at the secondary level.

The different programs were harmonized with a view to achieving continuity between vocational and technical education. The main objective of harmonization is to encourage students to pursue their studies by optimizing their efforts, whether they are returning to school after a period of absence or taking a new career direction. Harmonization makes it possible to move from one program to another or from one level of instruction to another without repeating the same courses.

Tables of equivalents have been designed to show the relationships among the different programs that have undergone harmonization. These tables appear in the following pages.

Equivalences between programs can be of different types. Some competencies are common to several programs of study. Their content is therefore identical, and they bear the same code in all programs in a given level of instruction. Some competencies correspond to several competencies in another program or may be deemed equivalent to a competency in another program by the development team despite the fact that they are not identical. The tables in the following pages illustrate this information. For all other cases, the educational institution is responsible for evaluating and recognizing the prior learning of its students.

The following tables concern all programs involved in the harmonization process. The left-hand column contains the codes and statements of competency of the program in question. The other columns contain the codes of the equivalent competencies in the other programs. Thus, students who have acquired one or more competencies in the program in question will receive recognition for the equivalent competencies in another program if they pursue their studies in that program.

Students who have attained one or more of the competencies of the *Numerical Control Machine Tool Operation* (5724) program will receive recognition for corresponding competencies in one of the programs below, if they pursue their studies in that program.

Table 1 – Equivalents for the *Numerical Control Machine Tool Operation* program

FROM →		TO			
NUMERICAL CONTROL MACHINE TOOL OPERATION (AVS) 5724		**Industrial Drafting (DVS) 5725**	**Mechanical Engineering Technology (DEC) 241.A0**	**Machining Techniques (DVS)[1] 5723**	**Aircraft Manufacturing Technology (DEC) 280.B0**
872 011	Determine their suitability for the trade and the training process			872 011	
872 292	Interpret complex drawings related to numerical control machine tool operation				
872 303	Solve mathematical problems related to numerical control machining			872 182	
872 194	Program a numerical control lathe manually		0133	872 194	011Z
872 214	Program a machining centre manually		012W	872 214	
872 314	Do automatic programming		0135		
872 206	Machine simple parts on a numerical control lathe		012V	872 206	
872 226	Machine simple parts using a machining centre			837 226	
872 328	Perform complex machining operations on a numerical control lathe				
872 338	Perform complex machining operations using a machining centre				
872 153	Adapt to new types of work organization	872 153	012X	872 153	0127
872 346	Mass-produce parts using numerical control machine tools				
872 354	Enter the workforce			872 286	

1. The *Numerical Control Machine Tool Operation* program leads to an Attestation of Vocational Specialization. Students wishing to enrol in this program must have a Diploma of Vocational Studies in *Machining Techniques* or the equivalent scholastic or experiential learning. It is inconceivable that a student study the specialty before enrolling in the basic program. The equivalents in this table are intended merely to indicate the competencies for which a student having obtained a DVS and enrolled in the AVS program would receive recognition.

Students who have attained one or more of the competencies of the *Machining Techniques* (5723) program will receive recognition for corresponding competencies in one of the programs below, if they pursue their studies in that program.

Table 2 – Equivalents for the *Machining Techniques* program

FROM → TO					
MACHINING TECHNIQUES (DVS) 5723		**Industrial Drafting (DVS) 5725**	**Mechanical Engineering Technology (DEC) 241.A0**	**Numerical Control Machine Tool Operation (AVS) 5724**	**Aircraft Manufacturing Technology (DEC) 280.B0**
872 011	Determine their suitability for the trade and the training process			872 011	
872 024	Solve mathematical problems related to conventional machining				
872 035	Interpret technical drawings	872 035	012F		
872 041	Avoid occupational health and safety risks				
872 054	Take and interpret measurements	872 054	012P		
872 066	Do shop work				
872 072	Interpret technical information related to materials and manufacturing processes				
872 083	Sketch objects		012G		011S
872 096	Perform external cylindrical turning operations		012Q		
872 105	Perform boring operations				
872 125	Cut threads on a lathe				
872 118	Perform longitudinal and transverse machining operations on a milling machine		012R		
872 133	Perform drilling and reaming operations on a milling machine				
872 178	Perform angular and circular milling operations on a milling machine				
872 144	Surface grinding				
872 153	Adapt to new types of work organization	872 153	012X	872 153	0127
872 162	Become familiar with the workplace				
872 182	Solve mathematical problems related to numerical control machining			872 303	
872 194	Program a numerical control lathe manually		0133	872 194	
872 214	Program a machining centre manually		012W	872 214	
872 206	Machine simple parts on a numerical control lathe		012V	872 206	
872 226	Machine simple parts using a machining centre			872 226	
872 238	Perform complex turning operations				
872 248	Perform complex milling operations				
872 255	Mass-produce parts using conventional machining techniques (optional)				
872 265	Perform machining operations using a boring machine (optional)				
872 271	Explore the possibility of starting their own business				
872 286	Enter the workforce			872 354	

Students who have attained one or more of the competencies of the *Industrial Drafting* (5725) program will receive recognition for corresponding competencies in one of the programs below, if they pursue their studies in that program.

Table 3 – Equivalents for the *Industrial Drafting* program

FROM →		TO			
INDUSTRIAL DRAFTING DVS 5725		**Mechanical Engineering Technology (DEC) 241.A0**	**Machining Techniques (DVS) 5723**	**Numerical Control Machine Tool Operation (AVS) 5724**	**Aircraft Manufacturing Technology (DEC) 280.B0**
872 311	Determine their suitability for the trade and the training process				
872 324	Solve problems related to industrial drafting				
872 035	Interpret technical drawings	012F	872 035		
872 335	Produce sketches	012G	872 083		011U
872 356	Produce detail drawings of mechanical components	012N			
872 395	Produce assembly drawings	012U			
872 345	Work at a computerized work station	012M			
872 364	Illustrate fasteners				
872 373	Illustrate the arrangement and movement of the components of a mechanism				
872 386	Interpret technical information about materials and manufacturing processes		872 072		
872 407	Use the specialized functions of a computer-aided drafting program	013C			
872 054	Take and interpret measurements	012P	872 054		
872 414	Determine dimensional tolerances	012S			
872 421	Correct a drawing				
872 436	Illustrate power train systems				
872 446	Produce development drawings	013B			
872 456	Make a three-dimensional model of an object	013D			
872 466	Produce detail drawings of a mechanism				
872 476	Make piping and circuit diagrams				
872 482	Use job search or entrepreneurial techniques		872 271		
872 495	Produce drawings for a mechanical system				
872 507	Draw the housing of a machine				
872 153	Adapt to the new types of work organization	012X	872 153	872 153	0127
872 517	Design a simple technical object				
872 526	Enter the workforce				

Students who have attained one or more of the competencies of the *Mechanical Engineering Technology* (241.A0) program will receive recognition for corresponding competencies in one of the programs below, if they pursue their studies in that program.

Table 4 – Equivalents for the *Mechanical Engineering Technology* program

FROM →		TO			
MECHANICAL ENGINEERING TECHNOLOGY (DEC) 241.A0		**Industrial Drafting (DVS) 5725**	**Machining Techniques (DVS) 5723**	**Numerical Control Machine Tool Operation (AVS) 5724**	**Aircraft Manufacturing Technology (DEC) 280.B0**
012D	Analyze the occupation				
012E	Solve problems related to industrial mechanics	872 324	872 024		011Q
012F	Interpret technical drawings	872 035	872 035		
012G	Produce sketches	872 335	872 083		
012N	Produce detail drawings of mechanical components	872 356			011U
012U	Produce assembly drawings	872 395			
012H	Interpret technical information about materials and manufacturing processes	872 386	872 072		
012J	Analyze the internal and external forces exerted on a mechanical object				011W
012K	Plan the application of heat treatments				
012L	Do the engineering design of an object's fasteners				
012M	Use a computerized work station	872 345			
012P	Take and interpret measurements	872 054	872 054		
012S	Determine dimensional tolerances	872 414			011T
012T	Determine the geometric tolerances required for an assembly				
012Q	Operate a conventional lathe		872 096 872 105		011S
012R	Operate a conventional milling machine		872 118		
012V	Operate a numerical control machine tool		872 206 872 226	872 206 872 226	
012W	Program a machining centre manually		872 214	872 214	
0133	Program a numerical control lathe manually		872 194	872 194	011Z
0135	Do automatic programming			872 314	
012X	Adapt to the new types of work organization	872 153	872 153	872 153	0127
012Y	Establish the sequence of operations for manufacturing processes				0129
0134	Develop a process sheet				
012Z	Control the quality of products				
0130	Modify the design concept of the components of a piece of industrial equipment				
0131	Do the engineering design of the tools necessary for a manufacturing project				012A
0132	Watch for new technologies				
0136	Produce the tools necessary to carry out a manufacturing project				
0137	Plan the maintenance of a machine population				
0138	Maintain manufacturing machines				

FROM → TO					
MECHANICAL ENGINEERING TECHNOLOGY (DEC) 241.A0		**Industrial Drafting (DVS) 5725**	**Machining Techniques (DVS) 5723**	**Numerical Control Machine Tool Operation (AVS) 5724**	**Aircraft Manufacturing Technology (DEC) 280.B0**
0139	Organize the work for a medium production run				
013A	Coordinate a medium manufacturing run				
013B	Produce development drawings	872 446			
013C	Use the specialized functions of a computer-aided drawing program	872 407			
013D	Make a three-dimensional model of an object	872 456			
013E	Develop hydraulic and pneumatic circuits for industrial machines				
013F	Do the engineering design of an industrial piping system				
013G	Do the engineering design of an industrial system				
013H	Do the engineering design of machine housings				
013J	Develop basic automated circuits				
013K	Automate an industrial system				
013L	Coordinate a design project				

Students who have attained one or more of the competencies of the *Aircraft Manufacturing Technology* (280.B0) program will receive recognition for corresponding competencies in one of the programs below, if they pursue their studies in that program.

Table 5 – Equivalents for the *Aircraft Manufacturing Technology* program

FROM → TO					
AIRCRAFT MANUFACTURING TECHNOLOGY (DEC) 280.B0		**Industrial Drafting (DVS) 5725**	**Mechanical Engineering Technology (DEC) 241.A0**	**Machining Techniques (DVS) 5724**	**Numerical Control Machine Tool Operation (AVS) 5723**
011P	Analyze the occupation				
011Q	Do calculations related to aeronautics	872 324			
011R	Interpret technical drawings related to aeronautics	872 035	012F	872 035	
011S	Apply the potential of machining processes		012Q 012R		
011T	Ensure the conformity of the dimensional and geometric components of aircraft	872 414	012S 012T		
011U	Produce and modify sketches, technical drawings and models related to aeronautics	872 335 872 356 872 395	012G 012N 012U		
011V	Apply the potential of forming processes				
011W	Optimize the performance of the materials used in aeronautics		012K		
011X	Establish relationships between the operational characteristics of an aircraft and construction principles				
011Y	Design and modify a detail part of an aircraft component				
011Z	Produce and modify programs for numerical control machines		012W 0133 0135		872 194 872 214 872 314
0120	Apply the potential of the forming of composites				
0121	Establish relationships between the characteristics of aircraft systems and design and planning decisions				
0122	Apply the potential of assembly processes				
0123	Design and modify aircraft components				
0124	Find and process technical information				
0125	Develop concepts and procedures related to structural repair				
0126	Contribute to the optimization of the manufacturing process	872 153	012X	872 153	872 153
0127	Interact with colleagues in various work situations				
0128	Ensure quality control		012Z		
0129	Develop and modify process sheets		0134		
012A	Design and modify production tooling for aircraft components		0131		
012B	Develop and modify specifications				
012C	Design and modify the tools required to assemble aircraft components				

GLOSSARY

Program Training Goals
Statements that describe the educational aims of a program. These goals are the general goals of vocational education adapted to a specific trade or occupation.

Competency
A set of knowledge, skills, perceptions and attitudes that enable a person to correctly perform a work-related activity or task.

General Objectives
Instructional objectives that provide an orientation for leading the students to attain one or more related objectives.

Operational Objectives
Statements of the educational aims of a program in practical terms. They serve as the basis for teaching, learning and evaluation. In the competency-based approach, the educational aims are expressed as competencies to be developed.

Module of a Program
A component part of a program of study comprising an operational objective.

Credit
A unit used for expressing quantitatively the value of the modules in a program of study. One credit corresponds to 15 hours of training. Students must accumulate a set number of credits to graduate from a program.

PART I

1. SYNOPTIC TABLE

Number of modules: 13
Duration in hours: 885
Credits: 59

Numerical Control Machine Tool Operation
CODE: 5724

CODE	NO.	TITLE OF THE MODULE	HOURS	CREDITS*
872 011	1	The Trade and the Training Process	15	1
872 292	2	Interpreting Complex Drawings Related to Numerical Control	30	2
872 303	3	Mathematics Related to Numerical Control Machining	45	3
872 194	4	Manual Programming of a Numerical Control Lathe	60	4
872 206	5	Basic Machining on a Numerical Control Lathe	90	6
872 214	6	Manual Programming of a Machining Centre	60	4
872 226	7	Basic Machining using a Machining Centre	90	6
872 314	8	Automatic Programming	60	4
872 328	9	Complex Machining on a Numerical Control Lathe	120	8
872 338	10	Complex Machining using a Machining Centre	120	8
872 153	11	New Types of Work Organization	45	3
872 346	12	Mass Production	90	6
872 354	13	Entering the Workforce	60	4

* 15 hours = 1 credit

This program leads to an Attestation of Vocational Specialization in *Numerical Control Machine Tool Operation.*

2. PROGRAM TRAINING GOALS

The training goals of the *Numerical Control Machine Tool Operation* program are based on the general goals of vocational education and take into account the specific nature of the trade. These goals are:

1. To develop effectiveness in the practice of a trade.

- To teach students to perform numerical control machining tasks and activities correctly, at an acceptable level of competence for entry into the job market.
- To prepare students to perform satisfactorily on the job by fostering:
  - the intellectual skills needed to make informed judgments about the work and to make appropriate decisions;
  - the ability to plan and organize their work and time in accordance with deadlines;
  - the ability to solve mathematical problems related to machining operations on numerical control machine tools and the ability to do manual and automatic programming;
  - a sense of responsibility and a habit of self-inspection;
  - a constant concern for occupational health and safety;
  - attention to detail and precision;
  - the development of a sense of observation and spatial perception;
  - the ability to understand instructions;
  - the ability to communicate with colleagues and superiors and to work in a team;
  - the acquisition of a technical vocabulary in English and French.

2. To ensure integration into the job market.

- To familiarize students with the job market in general and the trade of machinist in particular.
- To familiarize students with new concepts in work organization.
- To familiarize students with their rights and responsibilities as workers.

3. To foster personal and occupational development.

- To help students improve their ability to adapt to change.
- To help students develop their autonomy so that they can find information and resource materials and become familiar with new technologies.
- To help students understand the principles underlying the techniques used.
- To help students develop the ability to perform more complex tasks.
- To help students develop the desire for excellence and the basic attitudes required for success.

4. **To ensure job mobility.**
    - To help students develop a positive attitude toward technological change, new situations and professional development.
    - To help students develop problem-solving skills.
    - To help students achieve the versatility required to function within work cells.

3. COMPETENCIES

The competencies to be developed in *Numerical Control Machine Tool Operation* are shown in the grid of learning focuses on the following page. The grid lists general and specific competencies as well as the major steps in the work process.

General competencies involve activities common to several tasks or situations. They cover, for example, the technological or scientific principles that the students must understand to practise the trade or occupation. Specific competencies focus on tasks and activities that are of direct use in the trade or occupation. The work process includes the most important steps in carrying out the tasks and activities of the trade or occupation.

The grid of learning focuses shows the relationship between the general competencies on the horizontal axis and the specific competencies on the vertical axis. The symbol ▲ indicates a correlation between a specific competency and a step in the work process. The symbol O indicates a correlation between a general and a specific competency. Shaded symbols indicate that these relationships have been taken into account in the formulation of objectives intended to develop specific competencies related to the trade or occupation.

The logic used in constructing the grid influences the course sequence. Generally speaking, this sequence follows a logical progression in terms of the complexity of the learning involved and the development of the students' autonomy. The vertical axis of the grid shows the competencies directly related to the practice of a specific trade or occupation. These competencies are arranged in a relatively fixed order; therefore, the modules should be taught, insofar as possible, in the order represented on the grid. This means that some modules are prerequisite to others, while other modules are taught concurrently.

GRID OF LEARNING FOCUSES IN **NUMERICAL CONTROL MACHINE TOOL OPERATION** — SPECIFIC COMPETENCIES (directly related to the practice of the specific occupation)		OPERATIONAL OBJECTIVES	DURATION (IN HOURS)	WORK PROCESS (major steps): Interpret drawings and technical manuals	Plan the work	Do programming	Do the work	Carry out quality control	Tidy up	Carry out standard equipment maintenance	GENERAL COMPETENCIES (related to technology, subjects, personal development, etc.): Determine their suitability for the trade and the training process	Interpret complex drawings related to numerical control machine tool operation	Solve mathematical problems related to numerical control machining	Program a numerical control lathe manually	Program a machining centre manually	Do automatic programming	Adapt to new types of work organization	TOTALS: NUMBER OF OBJECTIVES	TOTALS: DURATION (IN HOURS)
MODULES	**MODULES**										1	2	3	4	6	8	11		
	OPERATIONAL OBJECTIVES										S	B	B	B	B	B	B	7	
	DURATION (IN HOURS)										15	30	45	60	60	60	45		315
5	Machine simple parts on a numerical control lathe	B	90	▲	▲	▲	▲	▲	▲	▲	○	●	●	●			○		
7	Machine simple parts using a machining centre	B	90	▲	▲	▲	▲	▲	▲	▲	○	●	●		●		○		
9	Perform complex machining operations on a numerical control lathe	B	120	▲	▲	▲	▲	▲	▲	▲	○	●	●	●		●	○		
10	Perform complex machining operations using a machining centre	B	120	▲	▲	▲	▲	▲	▲	▲	○	●	●		●	●	○		
12	Mass-produce parts using numerical control machine tools	B	90	▲	▲	▲	▲	▲	▲	▲	○	●	●	●	●	●	●		
13	Enter the workforce	S	60	△	△	△	△	△	△	△	○	○	○	○	○	○	○		
NUMBER OF OBJECTIVES		6																13	
DURATION (IN HOURS)			570																885

S: Situational objectives
B: Behavioural objectives

△ Correlation between a step and a specific competency
▲ Correlation to be taught and evaluated

○ Correlation between a general and a specific competency
● Correlation to be taught and evaluated

4. GENERAL OBJECTIVES

The general objectives of the *Numerical Control Machine Tool Operation* program are presented below, along with the major statement of each corresponding operational objective.

To develop in the students the basic competencies required to carry out machining tasks.

- Interpret complex drawings related to numerical control machine tool operation.
- Solve mathematical problems related to numerical control machining.

To develop in the students the specific competencies required to perform programming tasks.

- Program a numerical control lathe manually.
- Program a machining centre manually.

To develop in the students the competencies required to perform machining tasks using numerical control machine tools.

- Machine simple parts on a numerical control lathe.
- Machine simple parts using a machining centre.
- Perform complex machining operations on a numerical control lathe.
- Perform complex machining operations using a machining centre.

To develop in the students the competencies required to participate actively in multidisciplinary teams within organizations.

- Adapt to new types of work organization.
- Mass-produce parts using numerical control machine tools.

To develop in the students the competencies required to integrate harmoniously into the school and work environments.

- Determine their suitability for the trade and the training process.
- Enter the workforce.

5. OPERATIONAL OBJECTIVES

5.1 DEFINITION

An operational objective is defined for each competency to be developed. Competencies are organized into an integrated training program designed to prepare students to practise the trade or occupation. This systematic organization of competencies produces better overall results than training by isolated objectives. More specifically, it fosters a smooth progression from one objective to the next, saves teaching time by eliminating needless repetition, and integrates and reinforces learning material.

Operational objectives are the main, compulsory teaching/learning targets and they are specifically evaluated for certification. There are two kinds of operational objectives: behavioural and situational.

- **A behavioural objective** is a relatively closed objective that describes the actions and results expected of the student by the end of a learning step. Evaluation is based on expected results.
- **A situational objective** is a relatively open-ended objective that outlines the major phases of a learning situation. It allows for output and results to vary from one student to another. Evaluation is based on the student's participation in the activities of the learning context.

5.2 HOW TO READ AN OPERATIONAL OBJECTIVE

A. How to Read a Behavioural Objective

Behavioural objectives consist of five components. The first two provide an overview of the objective:

- The **expected behaviour** states a competency in terms of the general behaviour that the students are expected to have acquired by the end of the module.
- The **conditions for performance evaluation** define what is necessary or permissible to the students during evaluation designed to verify whether or not they have attained the objective. This means that the conditions for evaluation are the same wherever and whenever the program is taught.

The last three components ensure that the objective is understood clearly and unequivocally:

- The **specifications of the expected behaviour** describe the essential elements of the competency in terms of specific behaviours.
- The **specific performance criteria** define the requirements for each of the specifications of behaviour. They ensure a more enlightened decision on the attainment of the objective.
- The **field of application** defines the limits of the objective, *where necessary*. It indicates cases where the objective applies to more than one task, occupation or field.

B. How to Read a Situational Objective

Situational objectives consist of six components:

- The **expected outcome** states a competency as an aim to be pursued throughout the course.

- The **specifications** outline the essential aspects of the competency and ensure a better understanding of the expected outcome.

- The **learning context** provides an outline of the learning situation designed to help the students develop the required competencies. It is normally divided into three phases of learning:
  - information
  - performance, practice or involvement
  - synthesis, integration and self-evaluation

- The **instructional guidelines** provide suggested ways and means of teaching the course to ensure that learning takes place. These guidelines may include general principles or specific procedures.

- The **participation criteria** describe the requirements the students must fulfil. They focus on how the students take part in the activities rather than on the results obtained. Participation criteria are normally provided for each phase of the learning context.

- The **field of application** defines the limits of the objective, *where necessary*. It indicates cases where the objective applies to more than one task, occupation or field.

Note: In this program, the objectives are also accompanied by suggestions concerning the instructional approach and related content applicable to the specifications of the expected behaviour, in the case of a behavioural objective, or to the phases of the learning context, in the case of a situational objective. Since this information was used to determine the competencies, it might be useful for those involved in the implementation of the program. It goes without saying that the suggestions and related content are provided for informational purposes only.

PART II

MODULE 1: THE TRADE AND THE TRAINING PROCESS		**CODE: 872 011 15 HOURS**
HARMONIZATION: **This module is equivalent to Module 1 of *Machining Techniques* (DVS).**		
Expected Outcome	**Instructional Guidelines**	**Suggested Approach**
Determine their suitability for the trade and the training process. *Specifications*: Be familiar with the nature of the trade. Understand the training plan. Confirm their career choice. Be aware of the impact of new management approaches in Québec businesses.	• Create a climate that helps the students to enter the job market. • Encourage the students to engage in discussions and express themselves. • Help the students acquire an accurate perception of the trade, especially with respect to the new types of work organization. • Provide the students with the means to assess their career choice honestly and objectively. • Organize field trips to companies that are representative of the work environment, visits to exhibitions, meetings with trade specialists, conferences, etc. • Make a selection of relevant literature available to the students. • Provide the students with an outline for their report and help them produce their documents.	• An observation checklist would make it easier to follow the students' progress in developing this competency.

Learning Context	Participation Criteria	Suggested Related Content
PHASE 1: **Information on the Trade**	- Gather information on most of the topics to be dealt with. - Express their views on the trade at a group meeting, relating them to the information they have gathered.	
• Learning about the types of companies that employ machinists and about the different types of work organization.		• Size of the company, sector of economic activity, type of clientele, type of production, manufacturing processes and use of new types of equipment • Types of management and work organization, in accordance with current standards • Other possibilities
• Describing factory production and the different jobs involved.		• Stages in the production process: - research into new processes - design and drawing of products - design of transformation methods or processes - optimization of production - training of personnel - planning - performance of transformation or manufacturing processes - inspection (planning and testing) - planning and performance of equipment maintenance - application of management techniques • Distribution of stages among jobs involved

Learning Context	Participation Criteria	Suggested Related Content
• Learning about the nature of the job.		• Reference to Chapter 1 of the job situation analysis report. • Position of machining in the company's organizational chart • Specific requirements of the job • Determination of duties and responsibilities of workers • Their role in various work teams • Participation in the optimization of production • Other
• Examining trade-related tasks and operations.		• Reference to Chapter 2 of the job situation analysis report
• Examining the skills and behaviours needed to practise the trade.		• Reference to Chapter 3 of the job situation analysis report
• Presenting the information gathered and discussing their views on the trade (i.e. advantages, disadvantages, requirements) at a group meeting		• Rules governing group discussion • Attitudes and behaviours: respect, politeness, attentiveness • Knowledge, skills and aptitudes required to practise the trade • Definition of their preferences and interest with respect to numerical control machine tool operation • Observations concerning the introduction of leading-edge technology, more productive materials and new management methods

Learning Context	Participation Criteria	Suggested Related Content
PHASE 2: **Information on Training and Participation in the Training Process**	- Carefully study the written material provided. - Express their views on the program of study at a group meeting.	
• Learning about the program of study and the training process.		• Examination of the program of study, especially the synoptic table, the program training goals and general objectives, and the objectives and standards • Information on evaluation, certification of studies and course structure
• Discussing the relevance of the program given the work situation.		• Comparisons between the job situation analysis report and the competencies included in the program
• Sharing their initial reactions to the specialized trade and the training program.		• Verification of opportunities afforded by technological development, new types of work organization, new materials, etc.
• Learning about the concept of techno-watch and further training.		• Upgrading to keep pace with technological development • Adaptation to new management approaches • Career progress • Change of career direction • Development of trade-related knowledge, personal culture, etc. • Examination of opportunities afforded by further training

Learning Context	Participation Criteria	Suggested Related Content
PHASE 3: **Evaluation and Confirmation of Their Career Choice** • Producing a report in which they: - state their preferences, aptitudes and interest with respect to the trade - assess their career choice by comparing the different aspects and requirements of the trade with their own preferences, aptitudes and interests	- Write a report that: - sums up their preferences, aptitudes and interests - explains clearly how they arrived at their career choice	• Parts of a report • Items to include • Production of the report using the outline provided by the instructor • Neatness, clarity and concision

MODULE 2: INTERPRETING COMPLEX DRAWINGS		CODE: 872 292 30 HOURS
Expected Behaviour	**Conditions for Performance Evaluation**	**Suggested Approach**
Interpret complex drawings related to numerical control machine tool operation.	• Given: - complex detail and assembly drawings and illustrations in metric and imperial units of measurement of mechanical parts, machining templates and machine tool accessories - instructions - technical documentation in French and English - tables - course notes - standards for fits, surface finishing and tolerances	• Have the students read technical drawings in both the metric and the imperial systems of measurement. • Demand serious, careful work. • Provide students with individualized support. • Select drawings that will be used for specific competencies. • Help the students develop spatial perception by having them read examples of descriptive geometry. • Accustom the students to consulting drawings that use English and French terminology.

Specifications	Performance Criteria	Suggested Related Content
1. Visualize a complete part.	1.1 Accurate differentiation among the types of projections: - American and European orthographic projections - axonometric projections 1.2 Proper identification of views and sections 1.3 Accurate interpretation of lines and hatching lines 1.4 Accurate identification of part on assembly drawing 1.5 Accurate observations of the shape of the part, its position and its function in the whole 1.6 Proper drawing of symmetry of illustrated part	• Thickness and characteristics of lines in accordance with ANSI and CSA standards: - contour lines and visible lines - contour lines and hidden lines - hatching lines - centre line - extension, dimension and reference lines - sectional plan - short and long break lines - phantom lines • The six orthographic projection views • Relative position of views • American and European projection methods • Full, partial, broken-out, rib, half and broken sections on parallel and sectional plans • Cut-away view of threads • Revolved and removed sections • Conventional breaks • Standard hatching lines for the materials used • Conventions for using hatching lines in an assembly • Section views in accordance with CSA and ANSI standards • Auxiliary views: depth dimensions, front view, top view • Auxiliary half-views • Local, partial and broken-out views • Representation of: - intersections and tangencies - holes - fillets and edges - rough and machined surfaces - fictitious edges - threading

Specifications	Performance Criteria	Suggested Related Content
2. Interpret the dimensioning of a complex part.	2.1 Thorough identification of information needed for the job: - dimensions - dimensions with tolerances - form and positioning tolerances, and runout - nomenclature of threads - fit tolerances 2.2 Determination of value of: - dimensions - dimensions with tolerances - form tolerances - positioning tolerances - runout - size and location dimensions 2.3 Relevant associations between the dimensions and the surfaces of various views	• Extension line • Dimension line • Standardized dimensioning • Dimensions with tolerances: reference dimension, basic dimension, minimum dimension, maximum dimension and maximum and minimum limits • Coordinate dimensioning, parallel dimensioning, superimposed running dimensioning • Special dimensioning cases: - framed dimensions - equidistant elements - oblique extension lines - dimensioning of a chord, arc or angle - not-to-scale dimensions - local surface treatment • Dimensional tolerances of smooth parts in accordance with international and American standards • Standardized fits: - clearance fit - transition fit - interference fit • Special dimensional tolerance cases: - angular tolerances - symmetrical limit tolerances - limit dimension tolerances - single limit tolerances - maximum material tolerances • Surface roughness symbols: - surface with function - direction of stria - machining allowance • Form tolerances: straightness, flatness, circularity, cylindricity, surface and all lines

Specifications	Performance Criteria	Suggested Related Content
		• Positioning tolerances: location, parallelism, perpendicularity, coaxiality, symmetry and angularity • Circular and total runout • Symbols • Modifying symbols • Reference surfaces
3. Find complementary information in drawings of complex parts.	3.1 Proper identification of information in: - title block - list of terms used - annotations 3.2 Thorough identification of information needed for complex machining on numerical control machine tools 3.3 Accurate interpretation of symbols, codes and abbreviations, and of English and French technical terminology	• Scale, symbols and abbreviations • Review of material codes according to different standards • Review of main material forms and dimensions • Review of different surface treatments and processes • Updating indices • Standards and conventions
4. Determine the function of the components of a complex assembly.	4.1 Thorough identification of the components of an assembly in a complex assembly drawing 4.2 Recognition of the characteristics of the components 4.3 Recognition of the function of each component of the assembly and its relationship with the other components 4.4 Complete review of the dimensional, geometric and surface finish tolerances of parts and relationships with the various components 4.5 Partial or complete sketch of parts in accordance with the review	• Functions: permanent or temporary installation, fastening, transformation of motion, power transmission, leakproofing, stops, etc. • Techniques for manufacturing parts of the various components • Method of using component tables • Diagrammatic, symbolic and simplified views • Principles underlying assembly • Assembly elements • Machine parts • Seals • Bushings and bearings • Principles underlying power transmission • Principles underlying the transformation of motion • Standardized phantom lines

MODULE 3: MATHEMATICS RELATED TO NUMERICAL CONTROL MACHINING		CODE: 872 303 45 HOURS
HARMONIZATION: **This module is equivalent to Module 18 of *Machining Techniques* (DVS).**		
Expected Behaviour	**Conditions for Performance Evaluation**	**Suggested Approach**
Solve mathematical problems related to numerical control machining.	• Given: - drawings of workpieces to be machined on numerical control machine tools, in metric and imperial units of measurement - instructions - the necessary technical documentation and course notes - a scientific calculator	• Have the students solve problems in both the metric and imperial systems of measurement. • Demand serious, careful work. • Provide students with individualized support. • Spend the first few hours revising basic operations, the rule of three and formula transformation. • Review the methods of solving right-angle and other types of triangles. • Help the students develop competencies in trigonometry, analytic geometry and problem solving. • Integrate the learning from this module into the manual programming of machining projects.

Specifications	Performance Criteria	Suggested Related Content
1. From the drawings, obtain the information required to calculate the coordinates needed for programming.	1.1 Accurate calculation of: - dimensions - dimensional tolerances 1.2 Appropriate identification of information from the list of terms used, title block and annotations 1.3 Accurate identification of reference surfaces 1.4 Accurate interpretation of: - symbols, codes and abbreviations - English and French technical terminology 1.5 Complete review of the geometric forms used for calculating coordinates	• Items to be located in the drawings: - dimensions - tolerance limits, including fit tolerances - annotations - title block - symbols • Units expressed as decimals and fractions
2. Do calculations related to dimensions.	2.1 Thorough identification of tolerance limits in tables 2.2 Proper choice of formulae 2.3 Accurate calculation of missing and average dimensions: - lengths - diameters - radii - angles	• Method of consulting tables and nomographs • Items to be found in reference tables and technical manuals: values related to programming and quality control • Dimensional tolerances in accordance with international and American standards • Method of calculating missing and average dimensions • Metric and imperial systems of measurement • Use of a scientific calculator
3. Analyze the geometrical configuration of workpieces to be machined on numerical control machine tools.	3.1 Accurate breakdown of shape of workpiece into geometric elements 3.2 Relevance of geometric elements to the calculation of coordinates 3.3 Neatness and clarity of elements represented	• Method of constructing geometric figures: parallel lines, perpendicular lines, tangents, secants, medians, bisectors, height, rectangles, squares, parallelograms, trapezoids, rhomboids, regular and irregular polygons, circles and arcs • Method of breaking down geometric figures • Advanced concepts of analytic geometry

Specifications	Performance Criteria	Suggested Related Content
4. Calculate the rectangular and polar coordinates needed to program numerical control machine tools.	4.1 Proper choice of elements to be calculated 4.2 Proper application of: - formula - Pythagorean theorem - trigonometric functions - law of sines and cosines 4.3 Accurate transformation of formula 4.4 Accurate calculation of points of intersection, connection and tangency for: - absolute programming - incremental programming - mixed programming 4.5 Accurate calculation of the centres of arcs 4.6 Use of signs in accordance with the different quadrants 4.7 Accurate conversions of rectangular and polar coordinates 4.8 Observance of problem-solving process	• System of axes for the different numerical control machine tools: lathes, horizontal and vertical milling machines • Terminology related to the Cartesian coordinate system: axes, origin, abscissa, ordinate, sign, rectangular and polar coordinates, etc. • Degree of precision in accordance with the capacity of the controllers for different numerical control machine tools • Solution of right-angle triangles: Pythagorean theorem and trigonometric functions • Solution of other types of triangles: law of sines and cosines • Technique of solving a triangle by breaking it down into right-angle triangles • Application and transformation of formulae • Synaptic table of solution of right-angle and other types of triangles • Solution of problems requiring analysis and reasoning • Analytic geometry formulae: line, diameter, radius, tangent, circumference, arc, arrow and secant • Method of calculating points of intersection, connection and tangency of different geometric shapes: line segments and arcs • Method of calculating radius compensation • Method of calculating the centre of radii of arcs constituting the shape to be created • Metric and imperial systems of measurement • Use of a scientific calculator

Specifications	Performance Criteria	Suggested Related Content
5. Calculate machining parameters.	5.1 Accurate summary of information relating to machining parameters in the tables 5.2 Appropriate use of nomographs 5.3 Proper choice of formulae 5.4 Correct application of formulae 5.5 Accurate calculations	• Method of consulting tables and nomographs • Items to be found in reference tables and technical manuals: machining parameters and formulae, and values related to machining and quality control • Machining parameters: cutting speed, rpm, advance speed and cutting depth • Definition of formulae elements • Basic formulae for the calculation of machining parameters • Calculation of surfaces and volumes • Material removal volume per minute • Rule of three calculation method • Formula application and transformation • Application of the method of calculating sets of pullies and cogs as an enrichment activity • Units expressed as decimals and fractions • Metric and imperial systems of measurement • Use of a scientific calculator
6. Convert between the metric and imperial systems of measurement.	6.1 Correct use of conversion tables 6.2 Proper choice of formulae 6.3 Appropriate application of conversion formulae 6.4 Accurate calculations	• Units expressed as decimals and fractions • Units of length, mass and volume • Conversion factors and tables • Metric and imperial systems of measurement • Use of a scientific calculator

MODULE 4: MANUAL PROGRAMMING OF A NUMERICAL CONTROL LATHE CODE: 872 194 60 HOURS

HARMONIZATION:
This module is equivalent to Module 19 of *Machining Techniques* (DVS) and competency 0133 of *Mechanical Engineering Technology* (DEC).
The content of modules 4, 6 and 8 of this program is equivalent to competency 011Z of *Aircraft Manufacturing Technology* (DEC).

Expected Behaviour	Conditions for Performance Evaluation	Suggested Approach
Program a numerical control lathe manually.	• Given: - drawings of simple parts to be machined, in metric or imperial units of measurement - process sheets - instructions - industrial numerical control lathes or a microcomputer with a text editor and communications software - a scientific calculator • Using various reference materials, such as: - *Machinery's Handbook* - tables and nomographs - technical manuals - tool catalogues - programming manuals • Following occupational health and safety rules	• Have the students write programs in both the metric and imperial systems of measurement. • Demand serious, careful work. • Provide students with individualized support. • Mounting techniques and cutting technology will be dealt with in subsequent modules. • In order to better integrate the learning in manual programming, this competency should be taught concurrently with the competency *Machine simple parts on a numerical control lathe*.

Specifications	Performance Criteria	Suggested Related Content
1. Identify, in the drawings, process sheet and manuals, the information needed to program a lathe.	1.1 Thorough identification of information needed for the job 1.2 Accurate interpretation of information 1.3 Accurate identification of reference surfaces 1.4 Accurate English and French terminology	• Dimensions (length, diameter, radius, angle, etc.) • Tolerance limits: - international standards - American standards • Dimensional, form and positioning tolerances • Surface finishes • Basic symbols and symbols specific to numerical control • Reference surfaces and surfaces to be machined • Conventional and absolute dimensioning • Characteristics of lathe (e.g. capacity) • Productivity and quality resulting from the sequence of operations • Cutting tools and tool holders specific to numerical control lathes
2. Write the program.	2.1 Proper choice of zero position of workpiece 2.2 Accurate calculation of rectangular and polar coordinates, as needed 2.3 Determination of position of beginning and end of toolpath 2.4 Structured development of program 2.5 Accurate insertion of machining parameters specific to turning: - cutting speed in units per minute - feed rate in units per revolution 2.6 Conformity with process sheet 2.7 Observance of programming syntax	• Systems of axes specific to numerical control lathes • Incremental and absolute methods • Methods of calculating average dimensions • Programming design: - position of tool at each point of intersection - zero position - toolpath • Metric and imperial systems of measurement • Preparatory, miscellaneous and information functions • Machining cycles • Cutter compensation • Translation of toolpaths into machine language • Other

Specifications	Performance Criteria	Suggested Related Content
3. Edit the program using: - a microcomputer - the machine tool controller	3.1 Observance of procedure, in accordance with the material used: - data entry - data archiving - data transmission 3.2 Inclusion of all program data 3.3 Accurate data entered	• Editing method using a microcomputer with a text editor • Editing method using the machine tool controller • Methods of archiving data: - hard disk - diskette - cassette - tape - other • Method of transmitting data using different media
4. Validate the program.	4.1 Conformity of program with drawing and instructions 4.2 Detailed simulation of toolpaths: - graphic simulation - no-load test 4.3 Detection of programming errors 4.4 Appropriate corrections made 4.5 Observance of archiving method 4.6 Observance of time limits at all steps in the programming process	• Method of graphic simulation • Method of no-load test of program on machine tool controller without graphic simulator • Problem-solving methods • Common errors

MODULE 5: BASIC MACHINING ON A NUMERICAL CONTROL LATHE CODE: 872 206 90 HOURS

HARMONIZATION:
This module is equivalent to Module 20 of *Machining Techniques* (DVS). The content of Modules 5 and 7 of this program is equivalent to competency 012V of *Mechanical Engineering Technology* (DEC).

Expected Behaviour	Conditions for Performance Evaluation	Suggested Approach
Machine simple parts on a numerical control lathe.	• Given: - drawings of parts requiring external turning only, in metric or imperial units of measurement - instructions - materials with a high machinability rating - industrial numerical control lathes (programming could also be done using a microcomputer with a text editor and communications software) - conventional carbide and new types of cutting tools - testing instruments and apparatus (including a three-dimensional measuring machine) - a scientific calculator • Using various reference materials, such as: - *Machinery's Handbook* - tables and nomographs - technical manuals - tool catalogues - programming manuals • Following occupational health and safety rules	• Have the students write programs in both the metric and imperial systems of measurement. • Demand serious, careful work. • Provide students with individualized support. • Devote 10 percent of teaching time to mounting methods and cutting tools used on numerical control lathes. • Perform manual operations on the numerical control lathe at the very beginning of the module. • Machine the first part using a program written by the instructor. • Set up the process sheet, installations and programming for mass production. • At this stage of the program, use drawings with a minimum of geometric tolerances. • Projects should gradually increase in complexity. • In order to better integrate the learning in basic machining, this competency should be taught concurrently with the competency *Program a numerical control lathe manually*. • Use both incremental and absolute programming methods. • Apply concepts of self-inspection to numerical control.

Specifications	Performance Criteria	Suggested Related Content
1. Identify, in the drawings and manuals, the information needed to machine a part on a numerical control lathe.	1.1 Thorough identification of information needed for the job 1.2 Accurate interpretation of information 1.3 Accurate identification of reference surfaces 1.4 Accurate English and French terminology	• Characteristics of numerical control lathes • Productivity and quality resulting from the sequence of operations • Types of installation in accordance with the machining operation and the shape of the workpiece • Characteristics of a proper installation • Safety rules related to installation • Cutting tools and tool holders specific to numerical control lathes • Machining conditions: - a minimum of chips - wear and useful life of tools - required power - other • Application of cutting fluids • Awareness of the physical phenomena that occur during machining: - bending - vibration (resonance) • Calculation of machining parameters in accordance with information in tool manufacturers' catalogues • Use of tables and nomographs • Direct and indirect measuring instruments • Testing apparatus • Mounting accessories specific to numerical control lathes • Quality of surface finish in accordance with feed and type of tool

Specifications	Performance Criteria	Suggested Related Content
2. Develop the process sheet.	2.1 Determination of a logical sequence of turning operations 2.2 Choice of lathe in accordance with: - its capacity - the turning operations required 2.3 Choice of installation methods in accordance with: - the material to be machined - the turning operations required - the machining precision required 2.4 Proper identification of support and clamping points 2.5 Choice of cutting tools and mounting methods in accordance with: - their machining capacity - the material to be machined - the turning operations required - the capacity of the lathe - the surface finishes - the optimization of the process 2.6 Proper choice of testing instruments and apparatus 2.7 Verification of availability of lathe, accessories, cutting tools, measuring instruments and testing apparatus 2.8 Determination of machining parameters 2.9 Careful sketch of workpiece in machining position	• Systems of axes specific to numerical control lathes: - system of machine axes - system of axes of the workpiece • Incremental and absolute methods • Programming design: - position of tool at each point of intersection - zero position of workpiece - toolpaths • Metric and imperial systems of measurement • Use of a scientific calculator • Preparatory, miscellaneous and information functions • Machining cycles • Cutter compensation • Editing using a microcomputer with a text editor or the machine tool controller • Method of archiving data • Transmission of data using different media

Specifications	Performance Criteria	Suggested Related Content
3. Program the numerical control lathe.	3.1 Accurate calculation of rectangular and polar coordinates 3.2 Proper choice of zero position of workpiece 3.3 Determination of toolpaths 3.4 Proper translation of toolpaths into machine language 3.5 Conformity with process sheet 3.6 Proper editing of program: - using a computer - using the machine tool controller 3.7 Thorough verification of inclusion and accuracy of program data	
4. Mount the workpiece on the numerical control lathe.	4.1 Visual and manual inspection of machine tool and mounting accessories 4.2 Appropriate corrections made 4.3 Proper installation of mounting accessories on machine tool 4.4 Proper positioning and alignment of workpiece 4.5 Safe installation of workpiece on numerical control lathe	• Characteristics of a proper installation • Handling of workpiece and mounting accessories • Condition and maintenance of accessories • Alignment of: – tailstock – lathe spindle – turret • Method of mounting accessories • Position and orientation of workpiece • Clamping technique and effect on workpiece • Hydraulic pressure of chuck, tailstock and tailstock spindle in accordance with the dimensions and rpm of the workpiece • Soft-jaw and hard-jaw chucks • Machining of soft jaws • Other

Specifications	Performance Criteria	Suggested Related Content
5. Prepare the numerical control lathe.	5.1 Visual and manual inspection of accessories and cutting tools 5.2 Appropriate corrections made 5.3 Proper installation of cutting tools 5.4 Proper adjustment of tool offset, feed, cutting speed and spray nozzles	• Cutting tool problems • Observance of tool positions, in accordance with programming • Methods of adjusting the spray nozzles • Reading of cutting tool offsets on: - the machine tool - a pre-set tooling bench • Method of inputting tool offsets using: - the machine tool controller - the program • Determination of type of tool tip • Size of tool corner radius • Adjustment of rapid and machining feed rate as a percentage • Adjustment of rpm as a percentage • Safety devices on the machine tool: - axis lock - spindle lock - emergency stop
6. Validate the program.	6.1 Simulation of toolpaths in accordance with the capacity of the numerical control lathe: - graphic simulation - semi-automatic no-load test - automatic no-load test 6.2 Recognition of the causes of machining incidents when machining the first part 6.3 Verification of conformity of first part with drawing and instructions 6.4 Appropriate corrections made to: - the program - the tool offset	• Graphic simulation of toolpaths • No-load test • Semi-automatic (block by block) and automatic modes • Problem-solving methods • Machining of first part in semi-automatic mode • Adjustment, as needed, of machining parameters after the first part • Adjustment, as needed, of tool offsets after the first part • Problem-solving methods • Common errors

Specifications	Performance Criteria	Suggested Related Content
7. Perform external turning operations, such as: - roughing and finishing - facing - parallel turning - grooving - threading - taper turning - chamfering	7.1 Safe start-up of numerical control lathe in automatic mode 7.2 Constant supervision of operations 7.3 Frequent verification of condition of cutting tools and conformity of machined parts 7.4 Appropriate corrections made to: - the machining process - the process sheet 7.5 Confirmation of validity of corrections with the appropriate person 7.6 Proper use of cutting fluids 7.7 Careful deburring and cleaning of parts 7.8 Observance of time limits at all stages of the task 7.9 Observance of health and safety rules specific to numerical control lathes	• Techniques for performing the different external turning operations • Observance of procedure for starting up the lathe • Observance of dimensional and geometric tolerances • Detection of abnormal noises • Awareness of wear of cutting tools • Replacement of cutting tools during production • Cleaning and deburring methods • Risk of injury • Preventive measures
8. Control the quality of the machined part.	8.1 Conformity of part with requirements 8.2 Proper use of: - measuring instruments and devices - three-dimensional measuring machine 8.3 Proper presentation of results in reports 8.4 Careful cleaning and storage of measuring devices and instruments	• Direct and indirect measuring instruments • Calibration methods • Specific installations for inspection • Optical comparator • Roughness tester • Other necessary measuring instruments or devices • Inspection sheets and reports

Specifications	Performance Criteria	Suggested Related Content
9. Perform daily maintenance on the machine tool, tools and accessories.	9.1 Proper cleaning and storage of the machine tool, tools and accessories, and proper cleaning of work area 9.2 Careful inspection of condition and level of cutting fluid, lubricating oil and hydraulic oil 9.3 Appropriate corrections made 9.4 Appropriate reporting of abnormalities 9.5 Observance of health and safety rules 9.6 Disposal of hazardous and toxic waste in conformity with regulations	• Methods of cleaning machine tools • Storage methods • Types of soluble oils • Treatment or replacement of substandard soluble oils • Health risks associated with contaminated coolants • Types of lubricating oils • Types of hydraulic oils • Types of greases • Detection of abnormal noises • Detection of abnormal vibrations

MODULE 6: MANUAL PROGRAMMING OF A MACHINING CENTRE CODE: 872 214 60 HOURS

HARMONIZATION:
This module is equivalent to Module 21 of *Machining Techniques* (DVS) and competency 012W of *Mechanical Engineering Technology* (DEC).
The content of Modules 4, 6 and 8 of this program is equivalent to competency 011Z of *Aircraft Manufacturing Technology* (DEC).

Expected Behaviour	Conditions for Performance Evaluation	Suggested Approach
Program a machining centre manually.	• Given: - drawings of simple parts to be machined in metric or imperial units of measurement - process sheets - instructions - industrial numerical control machining centres or milling machines or a microcomputer with a text editor and communications software - a scientific calculator • Using various reference materials, such as: - *Machinery's Handbook* - tables and nomographs - technical manuals - tool catalogues - programming manuals • Following occupational health and safety rules	• Have the students write programs in both the metric and the imperial systems of measurement. • Demand serious, careful work. • Provide students with individualized support. • Mounting techniques and cutting technology will be dealt with in more detail in subsequent modules. • In order to better integrate the learning in manual programming, this module should be taught concurrently with the competency *Machine simple parts using a machining centre*.

Specifications	Performance Criteria	Suggested Related Content
1. Identify, in the drawings, process sheet and manuals, the information needed to program a machining centre.	1.1 Thorough identification of information needed for the job 1.2 Accurate interpretation of information 1.3 Accurate identification of reference surfaces 1.4 Accurate English and French terminology	• Dimensions (length, diameter, radius, angle, etc.) - international standards - American standards - dimensional, form and positioning tolerances • Tolerance limits: • Surface finishes • Basic symbols and symbols specific to numerical control • Reference surfaces and surfaces to be machined • Conventional and absolute dimensioning • Characteristics of a numerical control machining centre or milling machine (e.g. capacity) • Productivity and quality resulting from the sequence of operations
2. Write the program.	2.1 Proper choice of zero position of workpiece 2.2 Accurate calculation of rectangular and polar coordinates, as needed 2.3 Determination of position of beginning and end of toolpath 2.4 Structured development of program 2.5 Accurate insertion of machining parameters: - rpm - feed rate in units per minute 2.6 Conformity with process sheet 2.7 Observance of programming syntax	• Systems of axes specific to numerical control machining centres or milling machines • Incremental and absolute methods • Method of calculating average dimensions • Programming design: - position of tool at each point of intersection - zero position - toolpaths • Metric and imperial systems of measurement • Preparatory, miscellaneous and information functions • Machining cycles • Cutter compensation • Translation of toolpaths into machine language • Other

Specifications	Performance Criteria	Suggested Related Content
3. Edit the program using: - a microcomputer - the machine tool controller	3.1 Observance of procedure according to equipment used: - data entry - data archiving - data transmission 3.2 Inclusion of all program data 3.3 Accurate data entered	• Editing method using a microcomputer with a text editor • Editing method using the machine tool controller • Method of archiving data: - hard disk - diskette - cassette - tape - other • Method of transmitting data using different media
4. Validate the program.	4.1 Conformity of program with drawing and instructions 4.2 Detailed simulation of toolpaths: - graphic simulation - no-load test 4.3 Detection of programming errors 4.4 Appropriate corrections made 4.5 Observance of archiving method 4.6 Observance of time limits at every stage of the programming process	• Method of graphic simulation • Method of no-load testing of program on machine tool controller without graphic simulator • Problem-solving methods • Common errors

MODULE 7: BASIC MACHINING USING A MACHINING CENTRE **CODE: 872 226 90 HOURS**

HARMONIZATION:
This module is equivalent to Module 22 of *Machining Techniques* (DVS). The content of Modules 5 and 7 of this program is equivalent to competency 012V of *Mechanical Engineering Technology* (DEC).

Expected Behaviour	Conditions for Performance Evaluation	Suggested Approach
Machine simple parts using a machining centre.	• Given: - drawings of parts requiring machining operations on a milling machine, in metric and imperial units of measurement - instructions - materials with a high machinability rating - industrial numerical control machining centres or milling machines (programming could also be done using a microcomputer with a text editor and communications software) - conventional carbide and new types of cutting tools - testing instruments and apparatus (including a three-dimensional measuring machine) - a scientific calculator • Using various reference materials, such as: - *Machinery's Handbook* - tables and nomographs - technical manuals - tool catalogues - programming manuals • Following occupational health and safety rules	• Have the students write programs in both the metric and imperial systems of measurement. • Demand serious, careful work. • Provide students with individualized support. • Devote 10 percent of teaching time to mounting methods and cutting tools used on numerical control milling machines and machining centres. • Perform manual operations on the numerical control milling machine or machining centre at the very beginning of the module. • Machine the first part using a program written by the instructor. • Set up the process sheet, installations and programming for mass production. • At this stage of the program, use drawings with a minimum of geometric tolerances. • Projects should gradually increase in complexity. • In order to better integrate the learning in basic machining, this competency should be taught concurrently with the competency *Program a machining centre manually*. • Use both incremental and absolute programming methods. • Apply concepts of self-inspection to numerical control.

Specifications	Performance Criteria	Suggested Related Content
1. Identify, in the drawings and manuals, the information needed to machine parts using a machining centre.	1.1 Thorough identification of information needed for the job 1.2 Accurate interpretation of information 1.3 Accurate identification of reference surfaces 1.4 Accurate English and French terminology	• Dimensions (length, diameter, radius, angle, etc.) • Tolerance limits: - international standards - American standards • Dimensional, form and positioning tolerances • Surface finishes • Basic symbols and symbols specific to numerical control • Reference surfaces and surfaces to be machined • Conventional and absolute dimensioning • Annotations • Consultation of reference tables

Specifications	Performance Criteria	Suggested Related Content
2. Develop the process sheet.	2.1 Determination of logical sequence of machining operations 2.2 Selection of machine tool in accordance with: - its capacity - the machining operations required 2.3 Choice of mounting methods in accordance with: - the material to be machined - the machining operations required - the machining precision required 2.4 Proper identification of support and clamping points 2.5 Choice of cutting tools and mounting methods in accordance with: - their machining capacity - the material to be machined - the machining operations required - the capacity of the machine tool - the surface finishes - the optimization of the process 2.6 Proper choice of testing instruments and apparatus 2.7 Verification of availability of machine tool, accessories, cutting tools, measuring instruments and testing apparatus 2.8 Determination of machining parameters 2.9 Careful sketch of workpiece in machining position	• Characteristics of numerical control milling machines and machining centres • Productivity and quality resulting from the sequence of operations • Types of installation in accordance with the machining operation and the shape of the workpiece • Characteristics of a proper installation • Safety rules related to installation • Cutting tools and tool holders specific to numerical control milling machines and machining centres • Machining conditions: - minimum of chips - wear and useful life of tools - necessary power - other • Application of cutting fluids • Awareness of physical phenomena that occur during machining: - bending - vibration (resonance) • Calculation of machining parameters in accordance with the information in the manufacturers' tool catalogues • Use of tables and nomographs • Direct and indirect measuring instruments • Testing apparatus • Mounting accessories specific to numerical control milling machines and machining centres • Quality of surface finish in accordance with feed and type of tool

Specifications	Performance Criteria	Suggested Related Content
3. Program the machining centre.	3.1 Accurate calculation of rectangular and polar coordinates 3.2 Proper choice of zero position of workpiece 3.3 Determination of toolpaths 3.4 Proper translation of toolpaths into machine language 3.5 Conformity with process sheet 3.6 Proper editing of program using: - a computer - the machining centre controller 3.7 Thorough verification of inclusion and accuracy of program data	• Systems of axes specific to numerical control milling machines: - system of machine axes - system of axes of the workpiece • Incremental and absolute methods • Program design: - position of tool at each point of intersection - zero position of workpiece - toolpaths • Metric and imperial systems of measurement • Use of a scientific calculator • Preparatory, miscellaneous and information functions • Machining cycles • Cutter compensation • Editing using a microcomputer with a text editor or the machine tool controller • Method of archiving data • Transmission of data using different media
4. Mount the workpiece on the machining centre.	4.1 Visual and manual inspection of machine tool and mounting accessories 4.2 Appropriate corrections made 4.3 Proper installation of mounting accessories on machining centre 4.4 Proper positioning and alignment of workpiece 4.5 Safe installation of workpiece on machining centre	• Characteristics of a proper installation • Handling of workpiece and mounting accessories • Condition and maintenance of accessories • Alignment of: - vice - jig - workpiece • Method of mounting accessories • Position and orientation of workpiece • Clamping technique and effect on workpiece • Other

Specifications	Performance Criteria	Suggested Related Content
5. Prepare the machining centre.	5.1 Visual and manual inspection of accessories and cutting tools 5.2 Appropriate corrections made 5.3 Proper installation of cutting tools 5.4 Proper adjustment of tool offsets, feed rates, cutting speeds and spray nozzles	• Cutting tool problems • Methods of adjusting the spray nozzles • Reading of cutting tool offsets on: - the machine tool - a pre-set tooling bench • Method of inputting tool offsets using: - the machine tool controller - the program • Method of determining the zero position of the workpiece • Size of tool corner radius for roughing and finishing • Adjustment of rapid and machining feed rate as a percentage • Adjustment of rpm as a percentage • Safety devices on the machine tool: - axis lock - spindle lock - emergency stop
6. Validate the program.	6.1 Proper simulation of toolpaths in accordance with the capacity of the machining centre: - graphic simulation - semi-automatic no-load test - automatic no-load test 6.2 Recognition of the causes of incidents during machining of the first part 6.3 Verification of conformity of first part with drawing and instructions 6.4 Appropriate corrections made to: - the program - the tool offset	• Graphic simulation of toolpaths • No-load test • Semi-automatic (block by block) and automatic modes • Problem-solving methods • Machining of first part in semi-automatic mode • Adjustment, as needed, of machining parameters after the first part • Adjustment, as needed, of tool offsets after the first part • Problem-solving methods • Common errors

Specifications	Performance Criteria	Suggested Related Content
7. Perform machining operations using the machining centre, such as: - contouring - face milling - centre drilling - drilling - reaming - spot-facing - grooving - pocket-milling - tapping	7.1 Safe start-up of machining centre in automatic mode 7.2 Constant supervision of operations 7.3 Frequent verification of condition of cutting tools and conformity of machined parts 7.4 Appropriate corrections made to: - the machining process - the process sheet 7.5 Confirmation of validity of corrections with the appropriate person 7.6 Proper use of cutting fluids 7.7 Careful deburring and cleaning of parts 7.8 Observance of time limits at every stage of the process 7.9 Observance of health and safety rules specific to machining centres	• Techniques for performing the different machining operations on a numerical control milling machine or machining centre • Straight and curved contouring • Circular and rectangular recesses • Observance of procedure for starting up the machine tool • Observance of dimensional and geometric tolerances • Detection of abnormal noises • Awareness of wear of cutting tools • Replacement of cutting tools during production • Cleaning and deburring methods • Risk of injury • Preventive measures
8. Control the quality of the machined part.	8.1 Conformity of part with requirements 8.2 Proper use of: - measuring instruments and devices - three-dimensional measuring machine 8.3 Proper presentation of results in reports 8.4 Careful cleaning and storage of measuring devices and instruments	• Direct and indirect measuring instruments • Calibration methods • Specific installations for inspection • Optical comparator • Roughness tester • Other necessary measuring instruments or devices • Inspection sheets and reports

Specifications	Performance Criteria	Suggested Related Content
9. Perform daily maintenance on the machining centre, tools and accessories.	9.1 Proper cleaning and storage of the machine tool, tools and accessories, and proper cleaning of work area 9.2 Careful inspection of condition and levels of cutting fluid, lubricating oil and hydraulic oil 9.3 Appropriate corrections made 9.4 Appropriate reporting of abnormalities 9.5 Observance of health and safety rules 9.6 Disposal of hazardous and toxic waste in conformity with regulations	• Methods of cleaning machine tools • Storage methods • Types of soluble oils • Treatment or replacement of substandard soluble oils • Health risks of contaminated coolants • Types of lubricating oils • Types of hydraulic oils • Types of greases • Detection of abnormal noises • Detection of abnormal vibrations

MODULE 8: AUTOMATIC PROGRAMMING **CODE: 872 314 60 HOURS**

HARMONIZATION:
This module is equivalent to competency 0135 of *Mechanical Engineering Technology* (DEC). The content of modules 4, 6 and 8 of this program is equivalent to competency 011Z of *Aircraft Manufacturing Technology* (DEC).

Expected Behaviour	Conditions for Performance Evaluation	Suggested Approach
Do automatic programming.	• Given: - drawings of parts to be machined and requiring automatic programming, in metric or imperial units of measurement - process sheets - instructions For geometric surfaces of average complexity requiring programming of two turning axes and two and a half milling axes. • Given: - a microcomputer or machine tool controller and a conversational programming language - appropriate computer-aided manufacturing software - a scientific calculator • Using various reference materials, such as: - *Machinery's Handbook* - tables and nomographs - technical manuals - tool catalogues - programming manuals • Following occupational health and safety rules	• Have the students write programs in both the metric and imperial systems of measurement. • Demand serious, careful work. • Provide students with individualized support. • Devote 20 percent of teaching time to geometric construction methods using computer-aided manufacturing software. • Remind students of the importance of using appropriate machining parameters. • In order to better integrate the learning in automatic programming, this competency should be taught concurrently with the competencies *Perform complex machining operations on a numerical control lathe* and *Perform complex machining operations using a machining centre.*

Specifications	Performance Criteria	Suggested Related Content
1. Identify, in the drawings, process sheet and manuals, the information needed to program a numerical control lathe and mill automatically.	1.1 Thorough identification of information needed for the job 1.2 Accurate interpretation of information 1.3 Accurate identification of reference surfaces 1.4 Accurate English and French terminology	• Dimensions (length, diameter, radius, angle, etc.) • Tolerance limits: - international standards - American standards • Dimensional, form and positioning tolerances • Surface finishes • Basic symbols and symbols specific to numerical control • Incremental and absolute dimensioning • Annotations • Reference surfaces and surfaces to be machined
2. Establish the geometric elements needed to machine a part.	2.1 Proper choice of zero position 2.2 Accurate calculation of rectangular and polar coordinates for the construction of geometric elements 2.3 Appropriate use of the software's geometric construction commands 2.4 Determination of position of beginning and end of toolpath 2.5 Representation of workpiece geometry in accordance with drawing rules 2.6 Simplified representation of the elements used to support, mount and clamp the workpiece 2.7 Saving of the geometry 2.8 Correct use of computer equipment	• Systems of axes specific to numerical control machine tools • Incremental and absolute methods • Calculation of average dimensions • Software-aided geometric construction methods: points, perpendicular, parallel and polar lines, circles, arcs, other regular shapes, intersections of straight lines, intersections of straight lines and circles, intersections of circles, etc. • Automatic calculation of points of tangency • Methods of using computer equipment

Specifications	Performance Criteria	Suggested Related Content
3. Import a drawing to the screen.	3.1 Proper choice of zero position 3.2 Appropriate use of the software's geometric construction commands 3.3 Determination of position of beginning and end of toolpath 3.4 Simplified representation of the elements used to support, mount and clamp the workpiece 3.5 Saving of geometry 3.6 Correct use of computer equipment 3.7 Compliance with importing method	• Characteristics of various graphic formats: DXF, CAD and IGES • Importing methods • Methods of correcting the zero position of an imported drawing: tweaking, rotation and correction of scale factor • Methods of transforming imported drawings into machining geometry
4. Establish the toolpaths needed to machine a part.	4.1 Complete introduction to the characteristics of cutting tools 4.2 Determination of appropriate toolpath for each operation 4.3 Use of appropriate commands to enter data 4.4 Entry of accurate machining parameters and data on tools 4.5 Compliance with process sheet 4.6 Detailed simulation of toolpaths 4.7 Detection of programming errors 4.8 Appropriate corrections made 4.9 Appropriate saving of: - the list of tool characteristics - the toolpaths	• Relationship between geometric elements and tool movement commands • Methods of describing cutting tools using the software • Machining cycles available in the software, for turning and milling • Tool compensation methods • Automatic calculation of cutting tool offset and of the number and depth of cuts • Toolpath simulation method

Specifications	Performance Criteria	Suggested Related Content
5. Translate the program into machine code.	5.1 Appropriate choice of postprocessor for the machine tool controller 5.2 Correct translation of toolpaths into machine language 5.3 Compliance with required procedure 5.4 Careful verification of the inclusion and accuracy of program data using a text editor 5.5 Detailed simulation of program in machine code 5.6 Appropriate corrections made	• Method of operating and using a postprocessor • Methods of verifying a program generated in machine code • Common errors • Method of simulating a program in machine code • Editing a postprocessor as an enrichment activity
6. Transfer the program to the machine tool.	6.1 Methodical transfer of data to the machine tool 6.2 Conformity of the transferred data with the program 6.3 Observance of archiving method: - saving of data - printing of documents 6.4 Observance of time limit for the programming process	• Program transfer software • Archiving methods • Method of using a printer • Comparison of different automatic programming systems as an enrichment activity

MODULE 9: COMPLEX MACHINING ON A NUMERICAL CONTROL LATHE	CODE: 872 328	120 HOURS
Expected Behaviour	**Conditions for Performance Evaluation**	**Suggested Approach**
Perform complex machining operations on a numerical control lathe.	• Given: - drawings of parts requiring at least five boring and external turning operations and a high level of precision, in metric and imperial units of measurement - instructions - materials with a low machinability rating, such as stainless steel, high alloy steels, etc. - materials of different kinds, such as polymers, composites, etc. - industrial numerical control lathes and their mounting accessories - conventional carbide and new types of cutting tools for materials with specific machining problems - testing instruments and apparatus, including a three-dimensional measuring machine - a microcomputer - a machine tool controller and a conversational programming method - computer-aided manufacturing software - a text editor - communications software - a scientific calculator • Using various reference materials, such as: - *Machinery's Handbook* - tables and nomographs - technical manuals - tool catalogues - programming manuals • Following occupational health and safety rules	• Have the students write programs in both the metric and imperial systems of measurement. • Demand serious, careful work. • Provide students with individualized support. • Allow each student to machine a set of soft jaws. • Machine parts requiring between five and eight operations. • Set up the process sheet, installations and programming for mass production. • Use ready-structured programs containing minor errors. • Consult tool manufacturers and retailers for up-to-date information on rapid mounting and offset systems for cutting tools. • Use modular tooling. • Use continuous bar feed techniques. • At this stage of the program, use drawings with more geometric tolerances and tighter dimensional tolerances. • Projects should gradually increase in complexity. • Help the students develop greater independence in the work planning process. • In order to better integrate the learning in complex machining, this competency should be taught concurrently with the competency *Do automatic programming.* • To make optimal use of the available machine tools, this module should be taught concurrently with Module 10, *Complex machining using a machining centre.* • Apply concepts of self-inspection to numerical control.

Specifications	Performance Criteria	Suggested Related Content
1. Identify, in the drawings and manuals, the information needed for complex machining on a numerical control lathe.	1.1 Thorough identification of information needed for the job 1.2 Accurate interpretation of information 1.3 Accurate identification of reference surfaces 1.4 Accurate English and French terminology	• Dimensions (length, diameter, radius, angle, etc.) • Tolerance limits: international and American standards • Dimensional, form and positioning tolerances • Surface finishes • Basic symbols and symbols specific to numerical control • Reference surfaces and surfaces to be machined • Conventional and absolute dimensioning • Annotations • Use of reference tables

Specifications	Performance Criteria	Suggested Related Content
2. Develop the process sheet.	2.1 Determination of a logical sequence of turning operations 2.2 Choice of lathe in accordance with: - its capacity - the turning operations required 2.3 Choice of installation methods in accordance with: - the physical constraints of the material to be machined - boring and external turning operations - a high level of machining precision 2.4 Proper identification of support and clamping points 2.5 Choice of cutting tools and mounting methods in accordance with: - machining complexity - materials with specific physical constraints - boring and external turning operations - the capacity of the lathe - difficult surface finishes - the optimization of the process 2.6 Proper choice of testing instruments and apparatus to achieve a high level of dimensional and geometric precision 2.7 Verification of availability of lathe, accessories, cutting tools, measuring instruments and testing apparatus 2.8 Determination of machining parameters for materials with specific machining difficulties 2.9 Careful sketch of workpiece in machining position	• Preparation of process sheet for mass-production of at least three workpieces • Characteristics of numerical control lathes • Productivity and quality resulting from the sequence of operations • Types of installation in accordance with the machining operation and the shape of the workpiece • Physical constraints of materials: fragile parts, parts with thin walls, parts with low machinability rating, etc. • Characteristics of a proper installation • Safety rules applicable to installation • Cutting tools and holders specific to numerical control lathes • Grades and geometry of chip breaker for materials with specific physical constraints • Surface finishes for different applications: bearings, spindles, bearing races, oil seals, etc. • Machining conditions: minimum amount of chips, wear and useful life of tools, required power, etc. • Introduction of finishing inserts to reduce cylinder grinding operations • Application of cutting fluids • Awareness of physical phenomena that occur during machining • Calculation of machining parameters in accordance with information in tool manufacturers' catalogues • Use of tables and nomographs • Direct and indirect measuring instruments • Testing apparatus • Installation of accessories specific to numerical control lathes • Quality of surface finish in accordance with feed and type of tool

Specifications	Performance Criteria	Suggested Related Content
3. Program the numerical control lathe automatically.	3.1 Thorough identification of the geometry needed for on-screen machining on a computer or machine tool in conversational mode 3.2 Importing of drawings to a computer screen, where necessary 3.3 Determination of toolpaths on screen 3.4 Conformity with process sheet 3.5 Proper translation of toolpaths into machine language 3.6 Appropriate transfer of program to machine tool 3.7 Thorough verification of inclusion and accuracy of program data	• Systems of axes specific to numerical control lathes • Incremental and absolute methods • International and American systems • Use of a scientific calculator • Use of subprograms • Tool compensation methods in automatic programming • Reference: points 2 to 5 inclusively of Module 8, *Automatic Programming* • Programming method designed to reduce deburring to a minimum
4. Mount the workpiece on the numerical control lathe.	4.1 Visual and manual inspection of machine tool and mounting accessories 4.2 Appropriate corrections made 4.3 Proper installation of mounting accessories on machine tool by type of mounting: - hard jaws - soft jaws - mobile centres 4.4 Proper positioning and alignment of workpiece according to its dimensional and geometric constraints 4.5 Safe installation of workpiece on numerical control lathe according to its physical constraints	• Characteristics of a proper installation • Handling of workpiece and mounting accessories • Condition and maintenance of accessories • Alignment of: – tailstock – lathe spindle – turret • Method of mounting accessories • Position and orientation of workpiece • Clamping technique and effect on workpiece • Hydraulic pressure of chuck, tailstock and tailstock spindle in accordance with the dimensions and rpm of the workpiece • Soft-jaw and hard-jaw chucks • Machining of soft jaws • Other

Specifications	Performance Criteria	Suggested Related Content
5. Prepare the numerical control lathe.	5.1 Visual and manual inspection of accessories and cutting tools 5.2 Appropriate corrections made 5.3 Proper installation of cutting tools 5.4 Proper adjustment of tool offset, feed, cutting speed and spray nozzles	• Cutting tool problems • Observance of tool positions, in accordance with programming • Methods of adjusting the spray nozzles • Reading of cutting tool offsets on: - the machine tool - a pre-set tooling bench • Method of inputting tool offsets using: - the machine tool controller - the program • Determination of type of tool tip • Size of tool corner radius • Adjustment of rapid and machining feed rate as a percentage • Adjustment of rpm as a percentage • Safety devices on the machine tool: - axis lock - spindle lock - emergency stop
6. Validate the program.	6.1 Simulation of toolpaths in accordance with the capacity of the numerical control lathe: - graphic simulation - semi-automatic no-load test - automatic no-load test 6.2 Appropriate adjustment of zero position of workpiece 6.3 Recognition of the causes of machining incidents when machining the first part 6.4 Verification of conformity of first part with drawing and instructions 6.5 Appropriate corrections made to: - the program - the tool offset	• Graphic simulation of toolpaths • No-load test • Semi-automatic (block by block) and automatic modes • Machining of first part in semi-automatic mode • Adjustment, as needed, of machining parameters after the first part • Adjustment, as needed, of tool offsets after the first part • Problem-solving methods • Common errors

Specifications	Performance Criteria	Suggested Related Content
7. Perform external turning and boring operations, such as: - back boring - chamfering - parallel turning - facing - roughing and finishing - grooving - high-performance drilling - surface and conventional grooving - reworking on the lathe - taper turning - external turning and boring of irregular shapes - parting - machining of grooves and clearances	7.1 Safe start-up of numerical control lathe in automatic mode 7.2 Constant supervision of external turning and boring operations 7.3 Frequent verification of condition of cutting tools and conformity of machined parts 7.4 Appropriate corrections made to: - the machining process - the process sheet 7.5 Confirmation of validity of corrections with the appropriate person 7.6 Proper use of cutting fluids 7.7 Careful deburring and cleaning of parts 7.8 Observance of time limits at every stage of the process 7.9 Observance of health and safety rules specific to numerical control lathes	• Techniques for performing the different external turning and boring operations • Observance of procedure for starting up the lathe • Observance of dimensional and geometric tolerances • Detection of abnormal noises • Awareness of problems caused by machining materials with a low machinability rating • Replacement of cutting tools during production • Use of a wider variety of cutting tools • Use of high-performance drills • Cleaning and deburring methods • Risk of injury • Preventive measures
8. Control the quality of the machined part.		• Direct and indirect measuring instruments • Calibration methods • Specific installations for inspection • Optical comparator • Roughness tester • Other necessary measuring instruments or devices • Inspection sheets and reports

Specifications	Performance Criteria	Suggested Related Content
9. Perform daily maintenance on the machine tool, tools and accessories.	9.1 Proper cleaning and storage of the machine tool, tools and accessories, and proper cleaning of work area 9.2 Careful inspection of condition and levels of cutting fluid, lubricating oil and hydraulic oil 9.3 Appropriate corrections made 9.4 Lubrication by hand at the appropriate points 9.5 Appropriate reporting of abnormalities 9.6 Observance of health and safety rules 9.7 Disposal of hazardous and toxic waste in conformity with regulations	• Methods of cleaning machine tools • Storage methods • Methods of lubricating machine tools • Types of soluble oils • Treatment or replacement of substandard soluble oils • Health risks associated with contaminated coolants • Types of lubricating oils • Types of hydraulic oils • Types of greases • Detection of abnormal noises • Detection of abnormal vibrations • Enrichment activity: elementary repairs, e.g. detecting and correcting simple problems related to sensors, pneumatic jacks and fuses in low-voltage circuits, under the supervision of the instructor

MODULE 10: COMPLEX MACHINING USING A MACHINING CENTRE		CODE: 872 338 120 HOURS
Expected Behaviour	**Conditions for Performance Evaluation**	**Suggested Approach**
Perform complex machining operations using a machining centre.	• Given: - drawings of parts requiring at least five high precision milling operations, in metric or imperial units of measurement - instructions - materials with a low machinability rating, such as stainless steel, high alloy steels, etc. - materials of different kinds, such as polymers, composites, etc. - industrial machining centres and numerical control milling machines and their mounting accessories - conventional carbide and new types of high performance cutting tools for materials with specific machining problems - testing instruments and apparatus, including a three-dimensional measuring machine - a microcomputer or a machine tool controller and a conversational programming method - computer-aided manufacturing software - a text editor - communications software - a scientific calculator • Using various reference materials, such as: - *Machinery's Handbook* - tables and nomographs - technical manuals - tool catalogues - programming manuals • Following occupational health and safety rules	• Have the students write programs in both the metric and imperial systems of measurement. • Demand serious, careful work. • Provide students with individualized support. • Allow each student to machine a set of contour clamps or a simple jig. • Machine parts requiring between 5 and 8 operations. • Set up the process sheet, installations and programming for mass production. • Use ready-structured programs containing minor errors. • Consult tool producers and retailers for up-to-date information on rapid mounting and offset systems for cutting tools. • Use modular tooling. • Use rapid installation techniques. • Use continuous bar feed techniques. • At this stage of the program, use drawings with more geometric tolerances and tighter dimensional tolerances. • Projects should gradually increase in complexity. • Develop greater independence in the work planning process. • To favour the integration of this competency, teach it concurrently with the competency *Do automatic programming.* • To make optimal use of the available machine tools, this module should be taught concurrently with Module 10, *Complex machining operations on a numerical control lathe.* • Develop 3 to 4-axis milling skills as an enrichment activity. (This activity may meet regional needs). • Apply concepts of self-inspection to numerical control.

Specifications	Performance Criteria	Suggested Related Content
1. Identify, in the drawings and manuals, the information needed for complex machining using a machining centre.	1.1 Thorough identification of information needed for the job 1.2 Accurate interpretation of information 1.3 Accurate identification of reference surfaces 1.4 Accurate English and French terminology	• Dimensions (length, diameter, radius, angle, etc.) • Tolerance limits: international and American standards • Dimensional, form and positioning tolerances • Surface finishes • Basic symbols and symbols specific to numerical control • Reference surfaces and surfaces to be machined • Conventional and absolute dimensioning • Annotations • Use of reference tables

Specifications	Performance Criteria	Suggested Related Content
2. Develop the process sheet.	2.1 Determination of a logical sequence of operations 2.2 Choice of machine tool in accordance with: - its capacity - the machining operations required 2.3 Choice of installation methods in accordance with: - the physical constraints of the material to be machined - complex milling operations - a high level of machining precision 2.4 Choice of cutting tools and mounting methods in accordance with: - machining complexity - materials with specific physical constraints - the capacity of the machine tool - difficult surface finishes - the optimization of the process 2.5 Proper choice of testing instruments and apparatus to achieve a high level of dimensional and geometric precision 2.6 Verification of availability of machine tool, accessories, cutting tools, measuring instruments and testing apparatus for complex machining 2.7 Determination of machining parameters for materials with specific machining difficulties 2.8 Careful sketch of workpiece in machining position	• Preparation of process sheet for mass-production of at least three workpieces • Characteristics of machining centres and numerical control milling machines • Productivity and quality resulting from the sequence of operations • Types of installation in accordance with the machining operation and the shape of the workpiece • Physical constraints of materials: fragile parts, parts with thin walls, parts with irregular contours, parts with low machinability rating, etc. • Characteristics of a proper installation • Safety rules applicable to installation • Cutting tools and holders specific to machining centres and numerical control milling machines • Grades and geometry of chip breaker for materials with specific physical constraints • Surface finishes for different applications: mechanical slides, sealed bearings, sealing surface, etc. • Machining conditions: minimum amount of chips, wear and useful life of tools, required power, etc. • Introduction of finishing inserts to reduce flat surface grinding operations • Application of cutting fluids • Awareness of physical phenomena that occur during machining (bending, vibration or resonance) • Calculation of machining parameters in accordance with information in tool manufacturers' catalogues • Use of tables and nomographs • Direct and indirect measuring Installation accessories specific to numerical control milling machines • Quality of surface finish in accordance with feed and type of tool instruments • Testing apparatus

Specifications	Performance Criteria	Suggested Related Content
3. Program the machining centre automatically.	3.1 Thorough identification of the geometry needed for on-screen machining on a computer or machine tool in conversational mode 3.2 Proper importing of a drawing to a computer screen, where necessary 3.3 Determination of toolpaths on screen 3.4 Conformity with process sheet 3.5 Proper translation of toolpaths into machine language 3.6 Appropriate transfer of program to machine tool 3.7 Thorough verification of inclusion and accuracy of program data	• Systems of axes specific to machining centres and numerical control milling machines • Incremental and absolute methods • International and American systems • Use of a scientific calculator • Use of subprograms • Tool compensation methods in automatic programming • Reference: points 2 to 5 inclusively of Module 8, *Automatic Programming* • Programming method designed to reduce deburring to a minimum
4. Mount the workpiece on the machining centre.	4.1 Visual and manual inspection of machine tool and mounting accessories 4.2 Appropriate corrections made 4.3 Proper installation of mounting accessories on machine tool by type of mounting: - hard-jaw vice - contour-jaw vice - jig - other rapid mounting systems 4.4 Proper positioning and alignment of workpiece according to its dimensional and geometric constraints 4.5 Safe installation of workpiece on the machining centre according to its physical constraints 4.6 Observance of time limits at each step	• Characteristics of a proper installation • Handling of workpiece and mounting accessories • Condition and maintenance of accessories • Alignment and positioning of: – the vice or vices – the jig – the 3-jaw or flexible collar chuck – the workpiece • Method of mounting accessories • Position and orientation of workpiece • Clamping technique and effect on workpiece • Soft-jaw and contour-jaw vices • Machining of contour jaws • Other

Specifications	Performance Criteria	Suggested Related Content
5. Prepare the machining centre.	5.1 Visual and manual inspection of accessories and cutting tools 5.2 Appropriate corrections made 5.3 Proper installation of cutting tools 5.4 Proper adjustment of tool offset, feed, rpm and spray nozzles 5.5 Observance of time limits for the entire process	• Cutting tool problems • Observance of tool positions, in accordance with programming • Methods of adjusting the spray nozzles • Reading of cutting tool offsets on: - the machine tool - a pre-set tooling bench • Method of inputting tool offsets using: - the machine tool controller - the program • Adjustment of rapid and machining feed rate as a percentage • Adjustment of rpm as a percentage • Safety devices on the machine tool: - axis lock - spindle lock - emergency stop

Specifications	Performance Criteria	Suggested Related Content
6. Validate the program.	6.1 Simulation of toolpaths in accordance with the capacity of the numerical control lathe: - graphic simulation - semi-automatic no-load test - automatic no-load test 6.2 Appropriate adjustment of zero position of workpiece 6.3 Recognition of the causes of machining incidents when machining the first part 6.4 Verification of conformity of first part with drawing and instructions 6.5 Appropriate corrections made to: - the program - the tool offset 6.6 Observance of time limits	• Graphic simulation of toolpaths • No-load test • Semi-automatic (block by block) and automatic modes • Machining of first part in semi-automatic mode • Adjustment, as needed, of machining parameters after the first part • Adjustment, as needed, of tool offsets after the first part • Problem-solving methods • Common errors

Specifications	Performance Criteria	Suggested Related Content
7. Perform complex machining operations using a machining centre, such as: - boring with adjustable boring bar and boring head - back boring - centre drilling - chamfering of sharp edges - contouring of irregular shapes - roughing and finishing - threading - spot-facing - high-performance drilling - grooving - reworking on the milling machine - face milling - tapping - pocket milling of irregular shapes with islands - machining of fillets and radii	7.1 Safe start-up of machining centre in automatic mode 7.2 Constant supervision of machining operations 7.3 Frequent verification of condition of cutting tools and conformity of machined parts 7.4 Appropriate corrections made to: - the machining process - the process sheet 7.5 Confirmation of validity of corrections with the appropriate person 7.6 Proper use of cutting fluids 7.7 Careful deburring and cleaning of parts 7.8 Observance of time limits 7.9 Observance of health and safety rules specific to machining centres	• Techniques for performing the different complex milling operations • Observance of procedure for starting up the machining centre or numerical control milling machine • Observance of dimensional and geometric tolerances • Detection of abnormal noises • Awareness of problems caused by machining of materials with a low machinability rating • Replacement of cutting tools during production • Use of a wider variety of cutting tools • Use of high-performance drills • Cleaning and deburring methods • Risk of injury • Preventive measures
8. Control the quality of the machined part.		• Direct and indirect measuring instruments • Calibration methods • Specific installations for inspection • Optical comparator • Roughness tester • Other necessary measuring instruments or devices • Inspection sheets and reports

Specifications	Performance Criteria	Suggested Related Content
9. Perform daily maintenance on the machine tool, tools and accessories.	9.1 Proper cleaning and storage of the machine tool, tools and accessories, and proper cleaning of work area 9.2 Careful inspection of condition and levels of cutting fluid, lubricating oil and hydraulic oil 9.3 Appropriate corrections made 9.4 Lubrication by hand at the appropriate points 9.5 Appropriate reporting of abnormalities 9.6 Observance of health and safety rules 9.7 Disposal of hazardous and toxic waste in conformity with regulations	• Methods of cleaning machine tools • Storage methods • Methods of lubricating machine tools • Types of soluble oils • Treatment or replacement of substandard soluble oils • Health risks associated with contaminated coolants • Types of lubricating oils • Types of hydraulic oils • Types of greases • Detection of abnormal noises • Detection of abnormal vibrations • Enrichment activity: elementary repairs, e.g. detecting and correcting simple problems related to sensors, pneumatic jacks and fuses in low-voltage circuits, under the supervision of the instructor

MODULE 11: NEW TYPES OF WORK ORGANIZATION		**CODE: 872 153 45 HOURS**
HARMONIZATION: **This module is equivalent to Module 15 of *Machining Techniques* (DVS), Module 23 of *Industrial Drafting* (DVS), competency 012X of *Mechanical Engineering Technology* (DEC) and competency 0127 of *Aircraft Manufacturing Technology* (DEC).**		
Expected Behaviour	**Conditions for Performance Evaluation**	**Suggested Approach**
Adapt to new types of work organization.	• Working in a team • Given complete information on the operation of a manufacturing company • Using relevant documentation • In an atmosphere of respect and openness	

Specifications	Performance Criteria	Suggested Related Content
1. Recognize the production management approaches of the company and their effects on the type of work organization.	1.1 Recognition of the company's management philosophy, particularly taylorism and added value 1.2 Proper description of preferred type of structural organization: - hierarchical organization - semi-autonomous teams - autonomous teams 1.3 Recognition of the company's production process 1.4 Appreciation of the effects of management approaches on production and on the evolution of tasks in the company	
2. Recognize the means used to promote the continual improvement of productivity.	2.1 Accurate differentiation among the instruments or techniques used in the company 2.2 Relevant associations between the means used and the company's ability to meet the requirements of the new economy, such as: - improvement of the time required to respond to market needs - economies of scale - elimination of waste 2.3 Recognition of the contribution of personnel to the improvement of productivity	

Specifications	Performance Criteria	Suggested Related Content
3. Communicate verbally with colleagues.	3.1 Choice of types of questions required to obtain relevant information 3.2 Proper reformulation of areas of agreement and disagreement in a discussion 3.3 Proper reformulation and reflection of message 3.4 Constructive and accurate feedback to: - encourage improvement in behaviour - recognize and encourage the contribution of colleagues 3.5 Relevant and persuasive expression of their point of view 3.6 Understanding of controversial comments 3.7 Use of an effective approach to deal with emotional behaviour	• Communication process • Obstacles to communication • Role of perception and defence mechanisms • Facilitating attitudes • Types of questions • Reformulation • Reflection • Summary of discussions • Personal feedback based on experience • Reaction to emotional behaviour • Arguments supporting an opinion
4. Solve problems related to work organization.	4.1 Choice of tools and techniques in accordance with the complexity of the problem to be solved 4.2 Clear description of the problem 4.3 Determination of the causes and consequences of the problem 4.4 Choice of best solution in accordance with established criteria 4.5 Realistic plan of action 4.6 Follow-up mechanisms clearly defined and scheduled	• Advantages of using a problem-solving process • Simple process • Modern tools and techniques

Specifications	Performance Criteria	Suggested Related Content
5. Work in a multidisciplinary team.	5.1 Determination of the goals of the team and the results to be attained in accordance with the company's mission and values 5.2 Consensus on team rules 5.3 Determination of the responsibilities of each team member 5.4 Proper planning of work 5.5 Consensus decision making 5.6 Recognition of style of participation of team members 5.7 Description of favourable and unfavourable factors for each stage of the work	• Bases of an effective work team • Cooperation as opposed to competition • Roles within the team • Team rules • Styles of participation • Planning stages • Consensus decision-making process • Stages in the growth of a work team

MODULE 12: MASS PRODUCTION		CODE: 872 346 90 HOURS
Expected Behaviour	**Conditions for Performance Evaluation**	**Suggested Approach**
Mass-produce parts using numerical control machine tools.	• Working in a team under supervision • Given: - assembly and detail drawings in metric and imperial units of measurement - process sheets - instructions - different types of materials - numerical control machine tools and their accessories (conventional machine tools may be used on occasion) - conventional and new types of carbide tools or form tools - electronic and conventional testing instruments and apparatus, including a three-dimensional measuring machine, statistical calculators or computers and software - a microcomputer or a machine tool controller and a conversational programming method - computer-aided manufacturing software - a text editor - communications software - products - a scientific calculator - a stock system • Using various reference materials, such as: - *Machinery's Handbook* - tables and nomographs - technical manuals - tool catalogues • In an environment allowing for mass production • Following health and safety rules	• The instructor should divide the group into teams and assign tasks. • The students will be responsible for the distribution of tasks within their own teams. • The students will be responsible for managing their own team's material. • Set up the process sheet, installations and programming for mass production. • Use ready-structured programs containing minor errors. • Use modular tooling. • Use rapid mounting techniques. • The students should have equal access to numerical control lathes and milling machines. • Carry out pre-machining operations on conventional machine tools. • Devote around 20 percent of teaching time to concepts of statistical quality control. • Review geometric tolerances and tolerance control methods. • Apply basic ISO-9000 principles to workshop operations. • Develop the concepts of communication and new work organizations learned in previous modules.

Specifications	Performance Criteria	Suggested Related Content
1. Find out about the mass-production project.	1.1 Thorough collection of information about mass production 1.2 Recognition of the components of the object to be made and their characteristics 1.3 Proper choice of drawings and process sheets for each part of the object 1.4 Recognition of the machining operations required to carry out the mass-production project	• Collection and study of documentation on the mass-production project
2. Organize the work team.	2.1 Consensus on team rules 2.2 Proper distribution of machining operations among the work stations, in accordance with the types of processes and optimization of performance 2.3 Efficient sharing of tasks 2.4 Accurate report of decisions made presented to those responsible for production	• Review and application of principles of communication and problem solving related to the organization of work as such, as well as to work in a multidisciplinary team
3. Identify, in the drawings, process sheets and manuals, the information needed to produce parts.	3.1 Thorough identification of information needed for the job 3.2 Accurate interpretation of information 3.3 Accurate identification of reference surfaces 3.4 Accurate English and French terminology	• Detail drawings in metric and imperial units of measurement • Symbols • Codes • Materials • Dimensioning • Characteristics of machine tools • Mounting accessories specific to machine tools • Productivity and quality resulting from the sequence of operations • Types of installation in accordance with the machining operation and the shape of the workpiece • Physical constraints of materials

Specifications	Performance Criteria	Suggested Related Content
4. Program the numerical control machine tool automatically.	4.1 Thorough identification of the geometry needed for machining 4.2 Importing of drawings to a computer screen, where necessary 4.3 Determination of toolpaths 4.4 Conformity with process sheet 4.5 Proper translation of toolpaths into machine language 4.6 Appropriate transfer of program to machine tool 4.7 Thorough verification of inclusion and accuracy of program data 4.8 Accurate account of time required for programming	• Systems of axes specific to the different numerical control machine tools • Incremental and absolute methods • International and American systems • Use of a scientific calculator • Use of subprograms • Tool compensation methods in automatic programming • Reference: points 2 to 5 inclusively of Module 8, *Automatic Programming* • Programming method designed to reduce deburring to a minimum

Specifications	Performance Criteria	Suggested Related Content
5. Organize the work stations.	5.1 Verification of availability of materials 5.2 Conformity with process sheets 5.3 Visual and manual inspection of machine tools, tools, accessories, instruments and testing apparatus 5.4 Appropriate corrections made 5.5 Proper installation of tools and accessories 5.6 Safe installation of workpieces on machine tools 5.7 Proper adjustment of machines 5.8 Observance of health and safety rules 5.9 Accurate account of time required for preparation	• Method of reorganizing work stations according to production • Flexible cells • Characteristics of proper mounting • Handling of workpiece and mounting accessories • Condition and maintenance of accessories • Alignment and positioning of machine tool, mounting accessories and workpiece • Method of mounting accessories • Position and orientation of workpiece • Clamping technique and effect on workpiece • Cutting tool problems • Observance of tool positions, in accordance with programming • Methods of adjusting the spray nozzles • Reading of cutting tool offsets on the machine tool and on a tooling bench • Method of inputting tool offsets using the machine tool controller and the program • Adjustment of rapid and machining feed rate as a percentage • Adjustment of rpm as a percentage • Safety devices on the machine tool: axis lock and spindle lock • Emergency stop

Specifications	Performance Criteria	Suggested Related Content
6. Produce the first parts.	6.1 Appropriate simulation of toolpaths 6.2 Appropriate adjustment of zero position of workpiece 6.3 Observance of techniques 6.4 Safe use of machine tools 6.5 Recognition of the causes of machining incidents 6.6 Complete verification of conformity of first parts with drawings and instructions 6.7 Relevance of decisions made by the team with respect to corrective measures 6.8 Appropriate corrections made: - to the program - to the tool offset 6.9 Accurate account of time required for the production of the first parts	• Graphic simulation of toolpaths in accordance with the possibilities offered by the numerical control machine tool controller • No-load test • Semi-automatic (block by block) and automatic modes • Machining of first part in semi-automatic mode • Adjustment, as needed, of tool offsets after the first part • Problem-solving methods • Common errors
7. Perform the machining operations required for mass production.	7.1 Safe use of machine tools 7.2 Constant supervision of operations 7.3 Frequent inspection of cutting tools and machined parts 7.4 Appropriate corrections made 7.5 Complete list of machining incidents 7.6 Proper use of cutting fluids 7.7 Careful deburring and cleaning of parts 7.8 Accurate account of time required for each stage of production	• Techniques for performing the different machining operations • Observance of procedure for starting up numerical control and conventional machine tools • Observance of dimensional and geometric tolerances • Detection of abnormal noises • Awareness of problems caused by machining of materials with a low machinability rating • Replacement of cutting tools during machining • Use of high-performance drills • Cleaning and deburring methods • Risk of injury • Preventive measures

Specifications	Performance Criteria	Suggested Related Content
8. Perform statistical quality control tasks.	8.1 Methodical application of a sampling plan 8.2 Proper choice of testing instruments and apparatus 8.3 Verification of conformity of parts with requirements 8.4 Proper use of method of transferring data onto a computer medium 8.5 Brief interpretation of results 8.6 Careful cleaning and storage of testing instruments and apparatus	• Role of statistical quality control in the production process • Role of the machinist in quality control • Terminology related to statistical quality control • Statistical control chart • On-screen display or printing • Better perception of surface flaws and irregularities: undulation, roughness, scratches, cracks, pitting, ridges and depressions • Causes of dispersion of measurements: variation of measurements due to tool wear, incorrect tool replacement interval, incorrect cutting parameters, poor mounting, poor condition of machine tool, quality criteria in excess of the capacity of the machine tool and the thermal expansion of parts • Use of clean and efficient testing instruments and apparatus in the production process: digital instruments, direct instruments, comparators, callipers, gauge blocks, roughness tester, three-dimensional measuring machine, etc. • Accuracy class of instruments • Inspection sheets and reports

Specifications	Performance Criteria	Suggested Related Content
9. Suggest methods for continuous improvement.	9.1 Appropriate timing 9.2 Clear description of production problems 9.3 Determination of causes 9.4 Common definition of team productivity and quality objectives 9.5 Relevant, realistic suggestions 9.6 Consensus on solution	• Problem solving • Comments or recommendations after consultation of statistical reports and time sheets • Process of decision making by consensus
10. Perform regular maintenance on the machine tools, accessories and cutting tools.	10.1 Proper cleaning and storage of the machine tools, tools and accessories, and proper cleaning of work area 10.2 Careful inspection of the condition and levels of cutting fluid, lubricating oil and hydraulic oil 10.3 Appropriate corrections made 10.4 Lubrication by hand at the appropriate points 10.5 Appropriate reporting of abnormalities 10.6 Observance of health and safety rules 10.7 Disposal of hazardous and toxic waste in conformity with regulations	• Methods of cleaning machine tools • Lubrication methods • Types of lubricants: soluble oils, lubricating oils, hydraulic oils and greases • Lubrication points • Treatment or replacement of substandard soluble oils • Health risks associated with contaminated coolants • Disposal of used oil • Detection of abnormal vibrations and noises • Criteria related to cleanliness

MODULE 13: ENTERING THE WORKFORCE		CODE: 872 354 60 HOURS
HARMONIZATION: **This module is equivalent to Module 28 of *Machining Techniques* (DVS).**		
Expected Outcome	**Instructional Guidelines**	**Suggested Approach**
Enter the workforce. *Specifications*: Find a practicum position. Observe and perform trade-related tasks in the workplace. Communicate with the work team. Evaluate their training with respect to their observations during the practicum.	• Provide the students with the necessary means and assistance to find a practicum position. • Maintain close ties between the school and the company. • Make sure that the trainees receive the support and supervision of a responsible person in the company. • Ensure the regular support and supervision of students and intervene only in the case of difficulties. • Make sure that the company respects the conditions required for the students to attain the objectives of the practicum. • Encourage the students to engage in discussions and express themselves. • Provide the students with an outline for the report.	

Learning Context	Participation Criteria	Suggested Related Content
PHASE 1: **Search for a Practicum Position**	- List in order of priority possible practicum positions that meet their selection criteria. - Meet with a representative of the company in order to obtain a practicum position.	
• Learning about the practicum and the related procedures.		• Objectives of the practicum • Duration • Instructional guidelines • Participation criteria
• Defining their expectations and needs with respect to the practicum.		• Personal and occupational goals and objectives • Criteria for selecting the company, such as: - size and location - type of production - structure - quality of working relations - possibility of attaining the objectives of the practicum - other • Criteria meeting expectations
• Finding companies likely to meet their expectations and needs.		• Various sources: - banks of companies - telephone books - employment centres - want ads - list of companies that have accepted trainees in the past and related experiences - instructor's assistance - other • Classification of companies by type of product or process

Learning Context	Participation Criteria	Suggested Related Content
• Obtaining a practicum position.		• Introduction by mail, telephone or visit • Agreement on practicum procedure • Presentation to employer of the list of tasks required to pass the practicum • Confirmation of practicum • Demonstration of determination, openness, a positive attitude, availability, etc.
• Ensuring that the practicum procedure is within regulations.		• Elements to confirm: - insurance - registration of trainee with the CSST - agreements with unions - responsibilities of parties - other • Agreements on supervision (by the company and the instructor)
PHASE 2: **Performance of Activities in the Workplace**	- Follow company rules regarding activities, work schedules and professional ethics. - Write a practicum report on the activities performed. - Demonstrate interest throughout the activity.	
• Performing various trade-related tasks or participating in their performance.		• Active participation in tasks • Observance of health and safety rules • Observance of company rules and regulations: order, schedules, attendance, movements in the shop and clothing • Behaviour: attentiveness, respect, tact, discretion, concern for excellence, demonstration of interest in all new work experiences, etc.

Learning Context	Participation Criteria	Suggested Related Content
• Communicating with members of the work team and those responsible for the practicum.		• Search for information (desire to learn) • Transmission of information • Positive, open attitude • Acceptance of advice and comments • Feedback • Verification of satisfaction of the person responsible for the practicum • Other
• Producing a report on the tasks and operations performed during the practicum.		• Content of the practicum report: - general information on the location and date of the practicum and on those responsible in the company and the school - description of tasks performed - machining processes performed: new types of equipment used, new tools used, etc. - problems that occurred and solutions that were applied - comments on the practicum procedure - appreciation of tasks - new elements or elements different from those presented at school - other • Daily report

Learning Context	Participation Criteria	Suggested Related Content
PHASE 3: **Evaluation of the Practicum and of the Training Received**	- Participate in discussions on their experience and on the tasks and operations performed during the practicum. - Emphasize the strong and weak points of the training received.	
• Sharing opinions with other students on their experience and on the tasks and operations performed in the workplace.		• Presentation of the main elements of their report in a group discussion
• Assessing the relevance of their training with respect to the requirements of the workplace.		• List of aspects of the trade that correspond to the training received and those that do not • Comparison of their perception of the trade before and after the practicum: - workplace - occupational practices - equipment - other
• Stating the specific and complementary training needs in machining techniques.		• Extension courses • Specialization courses • Further training

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