Apprenticeship Manitoba

Manitoba

Computer Numerical Control (CNC) Machinist
Level 1

Rev. June 2008

Apprenticeship Manitoba

CNC Machinist

Unit: A1 Orientation: Structure and Scope of the Trade, and Workplace Environments

Level: One

Duration: 7 hours

Theory: 7 hours

Practical: 0 hours

Overview:

One sign that a CNC Machinist has mastered a task or technique is to be asked to share this knowledge. Jobsite skills-exchange has long been fundamental to machinist trade-learning. Even trade veterans rely on peers to refine their knowledge and skill.

The opportunity to benefit from this process, however, is shaped by complex factors that include jobsite practice and production deadlines. As adult trade-learners, CNC Machinist apprentices must use their eyes, ears, prior knowledge, and interpersonal skills to encourage journeypersons to teach as well as to supervise them. This requires understanding the trade's dynamics, as well as the roles and responsibilities, which order jobsite work-life. This unit profiles the trade's historical and modern significance, core tasks and skill requirements, as well as its job-ladders and long-term career options. It includes information about learning styles/strategies, stressing their application to apprenticeship and journey-level trade education. The unit also introduces the concept of skills stewardship, stressing the obligation that apprentices incur to help convey what their own journeypersons teach them to those who in turn follow them into the trade.

A sound grasp of the roles, workplace relationships, and possibilities introduced in this unit is part of 'learning to learn' in the apprenticeship system. Senior apprentices are later offered information about learning to *teach* in this system – a central and time-honoured foundation of CNC Machinist journeywork.

This unit of instruction is designed to introduce safety and health requirements with respect to workplace environments, ergonomic design and environmental concerns such as hazardous waste management, spills and potential environmental/human exposures. This unit will further develop the skills and knowledge to ensure compliance in managing a workplace environment. Material covered includes: industrial hygiene practices such as noise, air quality and lighting; ergonomic practices such as definition, repetitive strain injuries (RSI), ideal body positioning, lighting (age/task) and vibration human factors (stress/fatigue. etc); and environmental management such as inventory control, specific hazards related to controlled products and the CNC machine and waste management.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe structure and scope of the modern CNC Machinist trade.	**20%**

a. Historical background, including apprentice experience

b. Structure/scope of the trade
- International and national characteristics
- Characteristics and practice of the trade in Manitoba
- Trade organizations

c. Opportunities and career ladders
- Generalists and specialists
- Team leaders and other immediate supervisors

- Geographic mobility
- Job hierarchies and innovations

2. Describe Manitoba's CNC Machinist Apprenticeship Program. 20%

a. Concept and significance of skills stewardship
   - To the trade
   - To apprentices
   - To journeypersons
   - To employers
   - To the community

b. Practical Training (on-the-job)
   - Roles/responsibilities of employer and journeyperson(s)
   - Roles responsibilities of Apprenticeship Training Coordinator (ATC)
   - Roles/responsibilities of apprentice(s), including Practical Training Record Book (PTRB) documentation

c. Technical Training (in-school)
   - Role/responsibilities of instructors (including 'Related'-area faculty)
   - Role/responsibilities of apprentice(s)

d. Attendance requirements

e. Progression requirements

f. Reporting of Grades

g. Trade Regulation and its significance

h. Policies (e.g. re: personal conduct, "missed" units, fees, harassment, etc.)
   - Apprenticeship Branch
   - Training Provider (College)

3. **Explain special challenges and opportunities re: apprenticeship training. 20%**

a. Adapting personal learning goals to program contexts
   - Characteristics and 'domains' (types) of adult learning
   - Description/recognition of learning and teaching styles
   - Work culture (incl. work-crew hierarchy), interpersonal skills, and trade-learning
   - Integrating Technical Training and Practical Training content
   - Possibilities and perils of peer-learning
   - Budgeting and other necessary personal arrangements
   - Handling common varieties of stress at work and in school

b. On-the-job challenges/opportunities
   - Description/recognition of jobsite teaching styles/roles
   - Communicating with journeypersons and employers
   - Coverage/documentation of formally prescribed tasks and subtasks (PTRB)
   - Personal record of achievements/needs: the Trade Learning Journal option
   - Getting help and fixing mistakes

c. In-school opportunities/challenges
   - Personal arrangements that support in-school progress
   - "Baggage handling" – self-assessing potential impacts of previous school experience on current learning (favourable/unfavourable); resources
   - Techniques for note-taking, record-keeping, and review
   - Relations with instructors (including 'Related'-area faculty)
   - College resources (library, support services, etc.)
   - 'Missed Units' – policies re: supplemental, re-tests, make-up assignments, etc.
   - Personal arrangements that support in-school progress
   - "Baggage handling" – self-assessing potential impacts of previous school experience on current learning (favourable/unfavourable); resources
   - Techniques for note-taking, record-keeping, and review

- Relations with instructors (including 'Related'-area faculty)
- College resources (library, support services, etc.)
- 'Missed Units' – policies re: supplemental, re-tests, make-up assignments, etc.

4. **Identify safety and health requirements for CNC operators and workplace as they apply with emphasis on the following:** **20%**
   a. Definition of terms:
      - Ergonomics
      - Hazardous waste
      - Noise-induced hearing loss
      - RSI
   b. Content and purpose of the regulations that govern ergonomics, lighting, noise, air quality and waste management
   c. Specific workplace environmental rights and responsibilities of employees/employers
   d. Benefits of safe workplace environmental practices.
   e. Methods of planning for and implementing a safe work environment.

5. **Identify workplace environmental hazards and implement control measures:** **10%**
   a. Define the term: fugitive emissions. Typical fugitive emissions.
   b. Recognize situations when fugitive emissions may be hazardous and determine steps to take. Recognize short-term and long-term health hazards.
   c. Air quality testing, application and limitation.
   d. General ventilation and local exhaust ventilation- application and limitation.
   e. Identification of two basic kinds of respirators-application and limitation.
   f. Identify hazardous noise situations and understand health impacts.
   g. Noise testing.
   h. Noise control procedures and personal protective equipment (hearing).
   i. Other PPE.
   j. Staff training requirements in workplace environment.

6. **Identify Ergonomic issues and implement changes.** **10%**
   a. Causes of RSI
   b. Ideal body positioning-neutral postures.
   c. Description of proper and improper positioning when working with machines
   d. Explanation of the importance of identifying human factors (stress, fatigue) in the workplace.
   e. Explanation of issues relating to vibration.
   f. Impact and importance of lighting in the workplace.
   g. Simple ergonomic procedures and precautions related to material handling. Safe lifting.
   h. Definition and identification of various types of ergonomic control measures.

7. **Define and identify chemical disposal and other environmental issues.** **10%**
   a. Definition of terms - hazardous waste
   b. Regulatory requirements for hazardous waste disposal-legislation, manifests, training, storage.
   c. Other environmental, legislative requirements as pertains to emission controls, spill control reporting requirements and other.
   d. Common practices for disposal-hazardous waste and non-hazardous waste. Recycling, reduction, re-use.
   e. Managing chemical spill/release episodes.
   f. Definition, purpose and objectives of having an environmental management plan.

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Apprenticeship Manitoba

CNC Machinist

Unit: A2 Computer Storage Architecture and Requirements of Unique Programs, and Manufacturing Processes

Level: One

Duration: 35 hours

Theory: 0 hours

Practical: 35 hours

Overview:

This unit of instruction is designed to provide the CNC Machinist apprentice with the knowledge and understanding of trade-related computer skills. This unit of instruction is designed to introduce manufacturing processes, tooling, and production methods. Material covered includes: storage architecture, capacity to handle the requirements of unique programs, manufacturing processes, tooling and production methods.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe Computer Numerical Control and its components:	**50%**

a. Definition of Computer Numerical Control and its components
   - Machine control unit
   - NC machine

b. Evolution of the NC/CNC machine

c. Integrated circuitry

d. Advantages of CNC compared to NC

e. Special requirements for utilizing CNC

f. CNC Machining Centres and Turning Centres

g. Other types of CNC equipment
   - CNC Plasma machines
   - CNC Spring Forming Machines
   - CNC Laser Cutting Machines
   - Vertical Machining Centres
   - Horizontal Machining Centres
   - Variable axes machining
   - CNC Press Brakes
   - CNC Punch Press

h. Components of CNC Machines

i. NC/CNC Controls

j. CRT Displays

k. CNC input and storage media
   - Flash cards
   - CD-ROM

2. **Identify manufacturing processes as they apply with emphasis on the following:** **20%**

a. Planning
- Set up sheets
- Operational instructions

3. **Identify tooling as it applies with emphasis on the following:** **10%**

Special cutters
RQ tombstones
Locating Clamping
Hydraulic Modular Fixturing
GD and T
Charting, SPC

4. **Identify production methods as they apply with emphasis on the following:** **10%**

a. Quality control and special processes
b. Quality assurance
c. Documentation
d. Statistical process control CMM
e. Quality control and special processes
f. Quality assurance

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Apprenticeship Manitoba

CNC Machinist

Unit: B1 Planning

Level: One
Duration: 35 hours
Theory: 20 hours
Practical: 15 hours

Overview:

This unit of instruction is designed to provide the CNC Machinist apprentice with the knowledge and understanding of trade-related computer skills. Material covered includes: Computer Numerical Control shop activities.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe Computer Numerical Control Shop Activities.	**100%**

a. Essential CNC Shop Activities
b. Part Drawing Study
c. Methodizing of Operations
d. Deciding on CNC Machine
e. Methods of Holding the Part During Machining
f. Machining Determination
g. Cutting Conditions
h. Writing a Part Programming Manuscript
i. Setup and Machining Documentation
j. Setup Procedure
k. Debugging the Program
l. Part Production

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Apprenticeship Manitoba

CNC Machinist

Unit: B2 Tooling

Level: One
Duration: 35 hours
Theory: 35 hours
Practical: 0 hours

Overview:

This unit of instruction is designed to provide the CNC Machinist apprentice with the knowledge and understanding of trade-related computer skills. This unit of instruction is designed to introduce manufacturing processes, tooling, and production methods. Material covered includes: storage architecture, capacity to handle the requirements of unique programs, manufacturing processes, tooling and production methods.

Objectives and Content: **Percent of Unit Mark (%)**

1. Describe CNC Machining Center Cutting Fundamentals. **50%**

a. CNC Machining Center Operation Types
- Drilling Operations
- Chamfer
- Countersink
- Spotface
- Counterbore
- Spot Drilling
- Spade Drilling
- Boring
- Reaming
- Tapping
- Face Milling
- End Milling
- Slot Milling

b. CNC Machining Center Hole Descriptions

c. CNC Machining Center Cutting Tools
- Clamping the Tools into the Machine Spindle
- Collet Holders
- CNC V-Flange Holder Description
- Drilling Tools
- Twist Drills
- Spot Drills and Center Drills
- Coolant-Fed Drills
- Spade Drills
- Carbide-Indexable Insert Drills
- Boring Bars

- Floating Reamer Holder
- Reamer
- Tap Holders
- Taps
- Shell Mill Holders
- Face Mills
- End Mill Holders
- End Mills
- Slot Mill Holders
- Milling Operation Description
- Climb Milling
- Conventional Milling

d. Components of CNC Machines
- Cutting Fluids (Coolant)
- Carbide Insert Features and Identification Number System
- Insert Identification and Grades
- Other Insert Cutting Materials
- Insert Nose Radius Selection
- Insert Geometry Selection

e. CNC Machining Center Application

2. Describe CNC Lathe Cutting Fundamentals. 50%

a. CNC Lathe Cutting Terms and Features
- RPM
- Feedrate
- Depth of Cut
- Chuck
- Jaws
- Lathe Cutting Terms and Features
- Turret
- Turn Tool
- Insert
- Metal Chip
- Chipbreaker
- Workpiece

b. CNC Turning Operations
- Facing
- Turning
- Taper Turning
- Chamfer
- Boring
- Taper Boring
- Counterboring
- Grooving
- OD Threading
- ID Threading
- Drilling
- Drilling with Carbide Indexable Insert Drills
- Spade Drilling
- Reaming
- Tapping
- Parting

c. CNC Lathe Cutting Tools
   - OD Cutting Tools
   - OD Toolholder Insert Geometry Shapes and Features
   - Insert Toolholder Rake Angle Descriptions
   - ID Cutting Tools
   - Twist Drills
   - Center Drills
   - Carbide Indexable Insert Drills
   - Carbide-Tipped Coolant-Fed Drills
   - Spade Drills
   - Boring Bars
   - Reamers
   - Taps

d. Carbide Insert Technology
   - Insert Identification and Grades
   - Insert Nose Radius Selection
   - Insert Geometry Selection
   - Other Insert Cutting Materials
   - Cutting Tool Pressure
   - Cutting Fluids (Coolant)

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Apprenticeship Manitoba

CNC Machinist

Unit: B3 Production Methods

Level: One

Duration: 35 hours

Theory: 20 hours

Practical: 15 hours

Overview:

This unit of instruction is designed to provide the CNC Machinist apprentice with the knowledge and understanding of trade-related computer skills. Material covered includes: CNC fundamentals, CNC machining center control and operation, CNC lathe control and operation and CNC technical data.

Objectives and Content:	**Percent of Unit Mark (%)**

1. Describe CNC Machine Fundamentals. **25%**

a. CNC Machine Center Components:
- CNC Control
- CRT Display
- Frame
- Headstock
- Spindle/Tool Taper
- Table/Pallet
- Tool Magazine
- Automatic Tool Change Arm
- Ways and Way Covers
- Way Lube System
- Electrical Control Panel
- Servodrive Motors
- Ball Screw
- Open-Loop System
- Closed-Loop System
- Point-to-Point and Continuous Path
- Input Media
- CNC Machine Options
- Spindle Speed
- Tool Setter

b. Cartesian Coordinate System:
- Absolute and Incremental Programs
- VMC Cartesian Coordinate System
- HMC Cartesian Coordinate System
- Rotary Cartesian Coordinate System

- Cartesian Quadrants

c. Absolute Versus Incremental Worksheet
d. CNC Machining Center Program Format
e. CNC Machining Center Command Codes:
   - Letter Address Commands

2. CNC Machining Center Control and Operation. 25%

c. CNC Machining Center Cutting Tools
   - Clamping the Tools into the Machine Spindle
   - Collet Holders
   - CNC V-Flange Holder Description
   - Drilling Tools
   - Twist Drills
   - Spot Drills and Center Drills
   - Coolant-Fed Drills
   - Spade Drills
   - Carbide-Indexable Insert Drills
   - Boring Bars
   - Floating Reamer Holder
   - Reamer
   - Tap Holders
   - Taps
   - Shell Mill Holders
   - Face Mills
   - End Mill Holders
   - End Mills
   - Slot Mill Holders
   - Milling Operation Description
   - Climb Milling
   - Conventional Milling

d. Components of CNC Machines
   - Cutting Fluids (Coolant)
   - Carbide Insert Features and Identification Number System
   - Insert Identification and Grades
   - Other Insert Cutting Materials
   - Insert Nose Radius Selection
   - Insert Geometry Selection

e. CNC Machining Center Application

2. Describe CNC Lathe Cutting Fundamentals. 25%

a. CNC Machining Center CRT and Keypad Panel Functions:
   - CRT and Keypad Descriptions

b. CNC Machining Center Operation Panel Functions:
   - Mode Selections
   - Feed Hold, Dry Run, Single Block, and Optional Block Skip
   - Feed Hold Button
   - Dry Run
   - Single Block
   - Optional Block Skip
   - Feedrate, Spindle Speed, and Rapid Traverse Overrides

c. CNC Machining Center Workholding:
   - Locating Fundamentals

- CNC Fixture
- Methods of Holding the Part during Machining
- Workholding Devices
- Fixtures
- Modular Fixtures
- Tombstone Fixtures
- Clamping Hints
- Pin Locators and Bushings
- Workholding Methods

d. CNC Machining Center Setup Procedure:
- Machine Home Position
- Setting the Part Origin
- Manual Setting
- Absolute Zero Shift
- Work Coordinates
- Tool Length Offsets
- Edge Finder Setup Method
- Coaxial Indicator Setup Method
- Gage Block Touch-off Setup Method
- Wiggler Setup Method

3. **Describe CNC Lathe Control and Operation.** **25%**

a. CNC Lathe CRT and Keypad Panel Functions:
- CRT and Keypad Descriptions

b. CNC Lathe Operation Panel Functions:
- CNC Lathe Operation Panel
- CNC Lathe Control Buttons
- Mode Selections
- Feed Hold, Dry Run, Single Block, and Optional Block Skip
- Feed Hold Button
- Dry Run
- Single Block
- Optional Block Skip
- Feedrate, Spindle Speed, and Rapid Traverse Overrides
- Manual Pulse Generator Handwheel

c. CNC Lathe Workholding Methods:
- Locating Fundamentals
- Methods of Holding the Part during Machining
- Workholding Devices
- 3-Jaw Chuck Holding Description
- Bump Stop Procedure
- Chuck Types for CNC Lathes
- Chucks
- Self-Centering Chuck
- Collet Chucks
- Independent 4-Jaw Chucks
- Chuck Jaws
- 4-Jaws Chuck Holding Description
- Chuck Jaw Pressures
- Centrifugal Force
- Special Workholding Methods

d. CNC Lathe Setup Procedure:

- Machine Home Position
- Part Origin
- Setup
- Tool Assembly and Mounting Description
- Mounting 3-Jaw Chuck and Jaws
- Hard Jaw and Soft Jaw Operations Description
- Tool Geometry Offsets
- Setting X- and Z-Axes Offsets
- Manual Setting Z-Zero
- Part X-Zero
- CNC Lathe Tool Setter Description
- Setting Z-Zero Description
- Downloading the CNC Program into Memory
- Setup Notes

4. Describe CNC Technical Data. **25%**

a. CNC Machining Calculations:
   - Calculation Example 1
   - Calculation Example 2
   - Calculation Example 3
   - Calculation Example 4
   - Calculation Example 5
   - Calculation Example 6
   - Calculation Example 7

b. CNC Speeds and Feedrates:
   - Tool Speed (SFM and RPM)
   - Tool Feedrate (IPR)

c. Geometric Dimensioning and Tolerancing:
   - Datum Dimensioning
   - Datum Reference

d. Surface Finish

e. Screw Threads:
   - Screw Thread Forms
   - UN Threads (English)
   - UN Threads (Metric)
   - Pipe Threads
   - Thread Features and Identification System
   - UN Thread and NPT Thread Description
   - UN Screw Thread Features

f. CNC Alarm Codes

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Apprenticeship Manitoba

CNC Machinist

Unit: C1 CAD/CAM Processes (Theory)

Level: One

Duration: 20 hours

Theory:	20	hours
Practical:	0	hours

Overview:

This course introduces the student to computer assisted manufacturing. Apprentices will use a CAD system to produce dimensioned engineering drawings, CNC tool paths and programs of various mechanical components. They will also learn to convert drawing geometry from formats accepted by systems to maximize their productivity. They will download the programs to CNC machines or simulators to verify/edit/run.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Identify CAM.	**25%**
a. Identify the need of CNC tool path generation software	
b. Identify the resources needed for the process	
2. Identify general systems terminology.	**25%**
a. Identify files' extensions	
• MC9	
• GE3	
• NCI	
• NC	
• DOC	
b. Create and name a new file	
c. Retrieve an existing file	
d. Plot and print a drawing	
e. Modify properties of a drawing	
f. Identify and activate commands using menu and icon	
3. **Identify drawing.**	**25%**
a. Set level, colour, and line style	
b. Set Z depth	
c. Use point input menu	
d. Create geometry objects	
• Line	
• Circle	
• Arc	
e. View manipulating commands	

f. Import files from other CAD packages

4. Identify editing. 25%

a. Delete objects
b. Move objects
c. Copy objects
d. Modify objects
e. Modify objects' properties
f. Undo and redo operations
g. Post-processor to convert tool paths to CNC program
h. Text Editor to edit CNC program as needed

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Apprenticeship Manitoba

CNC Machinist

Unit: C2 CAD/CAM Processes (Practical)

Level: One

Duration: 20 hours

Theory: 0 hours

Practical: 20 hours

Overview:

This course introduces the student to computer assisted manufacturing. Apprentices will produce dimensioned engineering drawings, CNC tool paths and programs of various mechanical components. They will also learn to convert drawing geometry from CAD/CAM to maximize their productivity. They will download the programs to CNC machines or simulators to verify/edit/run.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Prepare files.	**25%**
a. Create and name a new file b. Retrieve an existing file	
2. Prepare drawings.	**25%**
a. Plot and print a drawing b. Modify properties of a drawing c. Identify and activate commands using menu and icon	
3. Manipulate drawings.	**25%**
a. Set level, colour, and line style b. Set Z depth c. Use point input menu d. Create geometry objects • Line • Circle • Arc e. View manipulating commands f. Import files from other CAD packages	
4. Edit drawings.	**25%**
a. Delete objects b. Move objects c. Copy objects d. Modify objects e. Modify objects' properties f. Undo and redo operations g. Use appropriate post-processor to convert tool paths to CNC program h. Use text editor to edit CNC program as needed	

Apprenticeship Manitoba

CNC Machinist

Unit: C3 Solid Model (Theory)

Level: One

Duration: 20 hours

Theory: 20 hours

Practical: 0 hours

Overview:

This course introduces the apprentice to computer assisted manufacturing. They will produce dimensioned engineering drawings, CNC tool paths and programs of various mechanical components. They will also learn to convert drawing geometry from formats accepted by CAM systems to maximize their productivity. They will download the programs to CNC machines or simulators to verify/edit/run.

Objectives and Content: **Percent of Unit Mark (%)**

1. Identify Solid Edge Modeling. **25%**

a. Feature based modeling
b. CAD/CAM file extensions PAR, DFT, PSM, ASM
c. Producing and storing drawings
d. Software Graphical User Interface and Common Setting

2. Identify Solid Modeling in the Part Environment. **25%**

a. Base feature
b. Sketches/features
c. Profiles
   - Open
   - Closed
   - Multiple
   - Unfinished
d. Construction Elements
   - Lines, arcs, circles
   - Relationship handles, Intellisketch
   - Trim, fillets
   - Offset, move rotate, mirror
   - Smart Dimension, distance between Part Edges
e. Primitive Solids
   - Features
   - Sketches
f. Rounds and fillets
g. Cut-outs
h. Holes
   - Patterns

- Definition tables

3. Identify drawing. **25%**

a. Generating shop drawings
b. Annotating (adding notes and dimensions)

4. **Identify assembly.** **25%**

a. Bill of materials

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Apprenticeship Manitoba

CNC Machinist

Unit: C4 Solid Model (Practical)

Level: One

Duration: 20 hours

Theory: 0 hours

Practical: 20 hours

Overview:

This course introduces the apprentice to computer assisted manufacturing. They will produce dimensioned engineering drawings, CNC tool paths and programs of various mechanical components. They will also learn to convert drawing geometry from formats accepted by CAM systems to maximize their productivity. They will download the programs to CNC machines or simulators to verify/edit/run.

Objectives and Content:	**Percent of Unit Mark (%)**

1. Practice solid modeling. **25%**

a. Feature based modeling
b. CAD/CAM file extensions PAR, DFT, PSM, ASM
c. Producing and storing drawings
d. Software Graphical User Interface and Common Setting

2. Practice solid modeling in the part environment. **25%**

a. Base feature
b. Sketches/features
c. Profiles
   - Open
   - Closed
   - Multiple
   - Unfinished
d. Construction Elements
   - Lines, arcs, circles
   - Relationship handles, Intellisketch
   - Trim, fillets
   - Offset, move rotate, mirror
   - Smart Dimension, distance between Part Edges
e. Primitive Solids
   - Features
   - Sketches
f. Rounds and fillets
g. Cut-outs
h. Holes
   - Patterns

- Definition tables

i. Ribs

3. Practice drawing. **25%**

a. Generating shop drawings
b. Annotating (adding notes and dimensions)

4. **Identify assembly.** **25%**

a. Bill of materials

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Apprenticeship Manitoba

CNC Machinist

Unit: D1 CNC Lathe (Theory)

Level: One

Duration: 15 hours

Theory:	15	hours
Practical:	0	hours

Overview:

This unit of instruction is designed to provide the CNC Machinist apprentice with the knowledge and understanding of CNC Lathe fundamentals. Material covered includes: CNC lathe fundamentals, CNC lathe cutting fundamentals, CNC lathe control and operation and CNC lathe technical data.

Objectives and Content: **Percent of Unit Mark (%)**

1. **Describe CNC lathe fundamentals.** **20%**
   a. CNC Lathe
   b. CNC Lathe Components
      - CNC Lathe Control
      - CRT Display
      - Bed
      - Headstock
      - Chuck and Jaws
      - Tool Turret
      - CNC Lathe 3-Jaw Chuck Features and Descriptions
      - CNC Lathe Turret Features and Descriptions
      - Tool Indexing
      - Tailstock
      - Ways and Way Covers
      - Way Lube Systems
      - Electrical Control Panel
      - Ball Screw
      - CNC Lathe Tailstock Features and Descriptions
      - CNC Lathe Tailstock Setup Descriptions
      - Servo Drive Motors
      - Auto Bar Feeder
      - Parts Catcher
      - Secondary Turret
      - Subturret
      - Tool Setter
      - Dual Spindle/Chuck
      - Live Tooling
      - Chip Conveyor

- Open-Loop Systems
- Closed-Loop Systems
- Point-to-Point and Continuous Path
- Input Media

c. CNC Lathe Cartesian Coordinate System
- Absolute and Incremental Programs
- CNC Lathe Cartesian Quadrants
- Rotary Cartesian Coordinate System for CNC Lathe Movement

d. CNC Lathe Program Format
- CNC Lathe Program Example

e. CNC Lathe Command Codes
- Letter Address Commands
- M Code Commands
- G Code Commands

2. Describe CNC lathe cutting fundamentals. 20%

a. CNC Lathe Cutting Terms and Features
- RPM
- Feedrate
- Depth of Cut
- Chuck
- Jaws
- Lathe Cutting Terms and Features
- Turret
- Turn Tool
- Insert
- Metal Chip
- Chipbreaker
- Workpiece

b. CNC Turning Operations
- Facing
- Turning
- Taper Turning
- Chamfer
- Boring
- Taper Boring
- Counterboring
- Grooving
- OD Threading
- ID Threading
- Drilling
- Drilling with Carbide Indexable Insert Drills
- Spade Drilling
- Reaming
- Tapping
- Parting

c. CNC Lathe Cutting Tools
- OD Cutting Tools
- OD Toolholder Insert Geometry Shapes and Features
- Insert Toolholder Rake Angle Descriptions
- ID Cutting Tools
- Twist Drills

- Center Drills
- Carbide Indexable Insert Drills
- Carbide-Tipped Coolant-Fed Drills
- Spade Drills
- Boring Bars
- Reamers
- Taps

d. Carbide Insert Technology
- Insert Identification and Grades
- Insert Nose Radius Selection
- Insert Geometry Selection
- Other Insert Cutting Materials
- Cutting Tool Pressure
- Cutting Fluids (Coolant)

e. CNC Lathe Applications

3. Describe CNC lathe control and operation. 20%

a. CNC Lathe CRT and Keypad Panel Functions
- CRT and Keypad Descriptions

b. CNC Lathe Operation Panel Functions
- CNC Lathe Operation Panel
- CNC Lathe Control Buttons
- Mode Selections
- Feed Hold, Dry Run, Single Block, and Optional Block Skip
- Feed Hold Button
- Dry Run
- Single Block
- Optional Block Skip
- Feedrate, Spindle Speed, and Rapid Traverse Overrides
- Manual Pulse Generator Handwheel

c. CNC Lathe Workholding Methods
- Locating Fundamentals
- Methods of Holding the Part during Machining
- Workholding Devices
- 3-Jaw Chuck Holding Description
- Bump Stop Procedure
- Chuck Types for CNC Lathes
- Chucks
- Self-Centering Chuck
- Collet Chucks
- Independent 4-Jaw Chucks
- Chuck Jaws
- 4-Jaws Chuck Holding Description
- Chuck Jaw Pressures
- Centrifugal Force
- Special Workholding Methods

d. CNC Lathe Setup Procedure
- Machine Home Position
- Part Origin
- Setup
- Tool Assembly and Mounting Description
- Mounting 3-Jaw Chuck and Jaws

- Hard Jaw and Soft Jaw Operations Description
- Tool Geometry Offsets
- Setting X- and Z-Axes Offsets
- Manual Setting Z-Zero
- Part X-Zero
- CNC Lathe Tool Setter Description
- Setting Z-Zero Description
- Downloading the CNC Program into Memory
- Setup Notes

4. **Describe CNC Lathe Technical Data.** **20%**
   a. CNC Lathe Machining Calculations
      - Calculation Example 1
      - Calculation Example 2
      - Calculation Example 3
      - Calculation Example 4
      - Calculation Example 5
      - Calculation Example 6
      - Calculation Example 7
   b. CNC Turning Speeds and Feedrates
      - Tool Speed (SFM and RPM)
      - Tool Feedrate (IPR)
   c. Lathe Geometric Dimensioning and Tolerancing
      - Datum Dimensioning
      - Datum Reference
   d. Surface Finish
   e. Screw Threads
      - Screw Thread Forms
      - UN Threads (English)
      - UN Threads (Metric)
      - Pipe Threads
      - Thread Features and Identification System
      - UN Thread and NPT Thread Description
      - UN Screw Thread Features
   f. CNC Lathe Alarm Codes

5. Describe CNC lathe fixed cycles. **20%**
   a. CNC Lathe Fixed Cycles
   b. CNC Fixed Cycles G70-G74
      - G70 Finishing Cycle
      - G71 Rough Turn/Bore Cycle
      - G72 Rough Face Cycle
      - G73 Pattern Repeat Cycle
      - G74 Multiple-Face Grooving Cycle
      - G74 Peck Drilling Cycle
   c. Instructions for CNC Program Example 9000
   d. Coordinate Worksheet 9000
   e. CNC Program Example 9000

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Apprenticeship Manitoba

CNC Machinist

Unit: D2 CNC Lathe (Practical)

Level: One

Duration: 45 hours

Theory: 0 hours

Practical: 45 hours

Overview:

This unit of instruction is designed to provide the CNC Machinist apprentice with the knowledge and understanding of CNC Lathe fundamentals. Material covered includes: CNC lathe fundamentals, CNC lathe cutting fundamentals, CNC lathe control and operation and CNC lathe technical data.

Objectives and Content: **Percent of Unit Mark (%)**

1. **Practice using the CNC lathe.** **20%**
   a. CNC Lathe
   b. CNC Lathe Components
      - CNC Lathe Control
      - CRT Display
      - Bed
      - Headstock
      - Chuck and Jaws
      - Tool Turret
      - CNC Lathe 3-Jaw Chuck Features and Descriptions
      - CNC Lathe Turret Features and Descriptions
      - Tool Indexing
      - Tailstock
      - Ways and Way Covers
      - Way Lube Systems
      - Electrical Control Panel
      - Ball Screw
      - CNC Lathe Tailstock Features and Descriptions
      - CNC Lathe Tailstock Setup Descriptions
      - Servo Drive Motors
      - Auto Bar Feeder
      - Parts Catcher
      - Secondary Turret
      - Subturret
      - Tool Setter
      - Dual Spindle/Chuck
      - Live Tooling
      - Chip Conveyor

- Open-Loop Systems
- Closed-Loop Systems
- Point-to-Point and Continuous Path
- Input Media

c. CNC Lathe Cartesian Coordinate System
- Absolute and Incremental Programs
- CNC Lathe Cartesian Quadrants
- Rotary Cartesian Coordinate System for CNC Lathe Movement

d. CNC Lathe Program Format
- CNC Lathe Program Example

e. CNC Lathe Command Codes
- Letter Address Commands
- M Code Commands
- G Code Commands

2. Practice cutting with the CNC lathe. 20%

a. CNC Lathe Cutting Terms and Features
- RPM
- Feedrate
- Depth of Cut
- Chuck
- Jaws
- Lathe Cutting Terms and Features
- Turret
- Turn Tool
- Insert
- Metal Chip
- Chipbreaker
- Workpiece

b. CNC Turning Operations
- Facing
- Turning
- Taper Turning
- Chamfer
- Boring
- Taper Boring
- Counterboring
- Grooving
- OD Threading
- ID Threading
- Drilling
- Drilling with Carbide Indexable Insert Drills
- Spade Drilling
- Reaming
- Tapping
- Parting

c. CNC Lathe Cutting Tools
- OD Cutting Tools
- OD Toolholder Insert Geometry Shapes and Features
- Insert Toolholder Rake Angle Descriptions
- ID Cutting Tools
- Twist Drills

- Center Drills
- Carbide Indexable Insert Drills
- Carbide-Tipped Coolant-Fed Drills
- Spade Drills
- Boring Bars
- Reamers
- Taps

d. Carbide Insert Technology
- Insert Identification and Grades
- Insert Nose Radius Selection
- Insert Geometry Selection
- Other Insert Cutting Materials
- Cutting Tool Pressure
- Cutting Fluids (Coolant)

e. CNC Lathe Applications

3. **Practice CNC lathe control and operation.** **20%**

a. CNC Lathe CRT and Keypad Panel Functions
- CRT and Keypad Descriptions

b. CNC Lathe Operation Panel Functions
- CNC Lathe Operation Panel
- CNC Lathe Control Buttons
- Mode Selections
- Feed Hold, Dry Run, Single Block, and Optional Block Skip
- Feed Hold Button
- Dry Run
- Single Block
- Optional Block Skip
- Feedrate, Spindle Speed, and Rapid Traverse Overrides
- Manual Pulse Generator Handwheel

c. CNC Lathe Workholding Methods
- Locating Fundamentals
- Methods of Holding the Part during Machining
- Workholding Devices
- 3-Jaw Chuck Holding Description
- Bump Stop Procedure
- Chuck Types for CNC Lathes
- Chucks
- Self-Centering Chuck
- Collet Chucks
- Independent 4-Jaw Chucks
- Chuck Jaws
- 4-Jaws Chuck Holding Description
- Chuck Jaw Pressures
- Centrifugal Force
- Special Workholding Methods

d. CNC Lathe Setup Procedure
- Machine Home Position
- Part Origin
- Setup
- Tool Assembly and Mounting Description
- Mounting 3-Jaw Chuck and Jaws

- Hard Jaw and Soft Jaw Operations Description
- Tool Geometry Offsets
- Setting X- and Z-Axes Offsets
- Manual Setting Z-Zero
- Part X-Zero
- CNC Lathe Tool Setter Description
- Setting Z-Zero Description
- Downloading the CNC Program into Memory
- Setup Notes

4. **Practice using the CNC lathe technical data.** **20%**
   a. CNC Lathe Machining Calculations
      - Calculation Example 1
      - Calculation Example 2
      - Calculation Example 3
      - Calculation Example 4
      - Calculation Example 5
      - Calculation Example 6
      - Calculation Example 7
   b. CNC Turning Speeds and Feedrates
      - Tool Speed (SFM and RPM)
      - Tool Feedrate (IPR)
   c. Lathe Geometric Dimensioning and Tolerancing
      - Datum Dimensioning
      - Datum Reference
   d. Surface Finish
   e. Screw Threads
      - Screw Thread Forms
      - UN Threads (English)
      - UN Threads (Metric)
      - Pipe Threads
      - Thread Features and Identification System
      - UN Thread and NPT Thread Description
      - UN Screw Thread Features
   f. CNC Lathe Alarm Codes

5. Practice CNC lathe fixed cycles. **20%**
   a. CNC Lathe Fixed Cycles
   b. CNC Fixed Cycles G70-G74
      - G70 Finishing Cycle
      - G71 Rough Turn/Bore Cycle
      - G72 Rough Face Cycle
      - G73 Pattern Repeat Cycle
      - G74 Multiple-Face Grooving Cycle
      - G74 Peck Drilling Cycle
   c. Instructions for CNC Program Example 9000
   d. Coordinate Worksheet 9000
   e. CNC Program Example 9000

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Apprenticeship Manitoba

CNC Machinist

Unit: D3 CNC Mill (Theory)

Level: One

Duration: 7 hours

Theory: 7 hours

Practical: 0 hours

Overview:

This unit of instruction is designed to provide the CNC Machinist apprentice with the knowledge and understanding CNC Mill fundamentals. Material covered includes: CNC machining centers, CNC machining center cutting fundamentals, CNC machining center control and operation, CNC machining center technical data, CNC machining center rapid and feed moves, CNC machining center circular interpolation, CNC diameter compensation, CNC drilling canned cycles, CNC canned cycles G84, G86 and G76.

Objectives and Content: **Percent of Unit Mark (%)**

1. Describe introduction to CNC machining centers. **10%**

a. Introduction to CNC
   - NC technology
   - Advantages of CNC
   - CNC technology
   - CNC machining centers

b. CNC Lathe Cartesian Coordinate System

c. CNC machining center safety rules

d. CNC machining center processing

2. Describe CNC machining center cutting fundamentals. **20%**

a. CNC machining center operation types
   - Drilling operations
   - Chamfer
   - Countersink
   - Spotface
   - Counterbore
   - Spot drilling
   - Spade drilling
   - Boring
   - Reaming
   - Tapping
   - Face milling
   - End milling
   - Slot milling

b. CNC machining center hole descriptions

c. CNC machining center cutting tools
   - CNC toolholders
   - Clamping the tools into the machine spindle
   - Collet holders
   - CNC V-Flange holder description
   - Drilling tools
   - Twist drills
   - Spot drills and center drills
   - Coolant-Fed drills
   - Spade drills
   - Carbide-Indexable insert drills
   - Boring bars
   - Floating reamer holder
   - Reamer
   - Tap holders
   - Taps
   - Shell mill holders
   - Face mills
   - End mill holders
   - End mills
   - Slot mill holders
   - Slot mills
   - Milling operation description
   - Climb milling
   - Conventional milling

d. Carbide insert data
   - Cutting fluids (coolant)
   - Carbide insert features and identification number system
   - Insert identification and grades
   - Other insert cutting materials
   - Insert nose radius selection
   - Insert geometry selection

e. CNC machining center application
   - OD Cutting Tools

3. **Describe CNC machining center control and operation.** **10%**

a. CNC machining center CRT and keypad panel functions
   - CRT and keypad descriptions

b. CNC machining center operation panel functions
   - Mode selections
   - Feed hold, dry run, single block, and optional block skip
   - Feed hold button
   - Dry run
   - Single block
   - Optional block skip
   - Feedrate, spindle speed, and rapid traverse overrides

c. CNC machining center workholding
   - Locating fundamentals
   - CNC fixture
   - Methods of holding the part during machining
   - Workholding devices
   - Fixtures

- Modular fixtures
- Tombstone fixtures
- Clamping hints
- Pin locators and bushings
- Workholding methods

d. CNC machining center setup procedure
- Machine home position
- Setting the part origin
- Manual setting
- Absolute zero shift
- Work coordinates
- Tool length offsets
- Edge finder setup method
- Coaxial Indicator setup method
- Gage block touch-off setup method
- Wiggler setup method

4. Describe CNC machining center technical data. 10%

a. CNC machining center calculations
- Calculation example 1
- Calculation example 2
- Calculation example 3
- Calculation example 4
- Calculation example 5
- Calculation example 6

b. CNC cutting speeds and feedrates
- Cutting speed (SFM) and spindle speed (RPM) for hole operations
- Tool feedrate (IPR and IPM) for hole operations
- Tool speed and feedrates for milling operations
- Tool speed (RPM) for milling operations
- Tool speed (IPM) for milling operations

c. Geometric Dimensioning and Tolerancing
- GDandT
- Datum dimensioning
- Datum reference
- GDandT symbols and descriptions
- GDandT datum system fixturing
- Feature control frame
- Maximum material condition
- Least material condition
- Projected tolerance zone

d. Surface finish
- Surface finish characteristics and finish notes
- Surface finish produced by process type

e. Material types and hardness rating
- Types of steel
- Tool steels
- Hardness rating methods
- Brinell hardness number (BHN)
- Rockwell hardness test (Rc or Rb)
- Scleroscope hardness test
- Vickers Diamond Pyramid Number (DPN)

f. CNC Machine alarm codes

5. Describe CNC machining center rapid and feed moves. 10%

a. Rapid traverse and feed moves
b. G00 rapid movement
   G00 X-axis rapid traverse description for VMC
   G00 Y-axis rapid traverse description for VMC
   - G00 Z-axis rapid traverse description for VMC
   - G00 X-axis rapid traverse description for HMC
   - G00 Y-axis rapid traverse description for HMC
   - G00 Z-axis rapid traverse description for HMC
c. G01 feed movement
   - G01 X-axis feed move description for VMC
   - G01 Y-axis feed move description for VMC
   - G01 Z-axis feed move description for VMC
d. HMC five-axis machining
e. Instructions for CNC Program Example 1000
   - Coordinate worksheet
   - Engineering drawing
   - CNC machine setup plan
   - CNC tool list
   - Instructions for CNC Program Example 1000
f. Coordinate worksheet 1000
g. CNC program example 1000

6. Describe CNC machining center circular interpolation. 10%

a. Circular Interpolation
b. G02 Circular Interpolation CW
   - G02 Circular Interpolation VMC Description
c. G03 Circular Interpolation CCW
   - G03 Circular Interpolation VMC Description
d. Spindle function codes
   - M03, M04, and “S” Spindle function codes
   - M05 spindle stop code
   - Contour milling description for VMC
   - 360° contour milling description for VMC
   - G02 code description
   - G03 code description
e. Instructions for CNC program example 2000
   - Instructions for CNC program 2000
f. Coordinate worksheet 2000
g. CNC program example 2000

7. Describe CNC diameter compensation. 10%

a. Cutter Diameter Compensation
   - Cutter Diameter Compensation Codes
   - G41 Cutter Diameter Compensation Left
   - G42 Cutter Diameter Compensation Right
   - G40 Cutter Diameter Compensation Cancel
   - G43 Tool Length Compensation
   - G49 Tool Length Compensation Cancel
   - G28 Machine Home Return

- G41 and G42 Code Description: External Cutting
- G41 and G42 Code Description: Pocket Cutting

b. G41 Cutter Diameter Compensation VMC Description
c. G42 Cutter Diameter Compensation VMC Description
d. Instructions for CNC Program Example 3000
   - Instructions for CNC Program Example 3000

e. Coordinate Worksheet 3000
f. CNC Program Example 3000

8. Describe CNC drilling canned cycles. 10%

a. Canned Cycles Codes
b. CNC Drilling Canned Cycles
   - G81 Drilling Canned Cycle
   - G82 Counterboring Canned Cycle
   - G83 Peck Drilling Canned Cycle
   - G80 Canned Cycle Cancel
   - Z-Return Codes
   - G99 Return to Reference (R) Level Code
   - G98 Return to Initial Level Code

c. Instructions for CNC Program Example 4000
   - Instructions for CNC Program Example 4000

d. Coordinate Worksheet 4000
e. CNC Program Example 4000

9. Describe CNC canned cycles G84, G86, and G76. 10%

a. G84 Tapping Canned Cycle
   - G86 Boring Canned Cycle
   - G76 Fine Boring Canned Cycle
   - G98 and G99 Return Codes
   - G80 Canned Cycle Cancel
   - G20 Inch and G21 Metric Format Codes
   - G54-G59 Work Coordinate System Codes
   - HMC B-Axis

b. Instructions for CNC Program Example 5000
   - Instructions for CNC Program Example 5000

c. Coordinate Worksheet 5000
d. CNC Program Example 5000

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Apprenticeship Manitoba

CNC Machinist

Unit: D4 CNC Mill (Practical)

Level: One

Duration: 40 hours

Theory: 0 hours

Practical: 40 hours

Overview:

This unit of instruction is designed to provide the CNC Machinist apprentice with the knowledge and understanding CNC Mill fundamentals. Material covered includes: CNC machining centers, CNC machining center technical data, CNC machining center rapid and feed moves, CNC machining center circular interpolation, CNC diameter compensation, CNC drilling canned cycles, CNC canned cycles G84, G86 and G76.

Objectives and Content: **Percent of Unit Mark (%)**

1. **Practice CNC machining centers.** **10%**
   a. Introduction to CNC
      - NC technology
      - Advantages of CNC
      - CNC technology
      - CNC turning centers
      - CNC machining centers
   b. CNC machining center safety rules
   c. CNC machining center processing
   d. CNC machining center documentation

2. **Practice CNC machining center cutting fundamentals.** **20%**
   a. CNC machining center operation types
      - Drilling operations
      - Chamfer
      - Countersink
      - Spotface
      - Counterbore
      - Spot drilling
      - Spade drilling
      - Boring
      - Reaming
      - Tapping
      - Face milling
      - End milling
      - Slot milling
   b. CNC machining center hole descriptions

c. CNC machining center cutting tools
   - CNC toolholders
   - Clamping the tools into the machine spindle
   - Collet holders
   - CNC V-Flange holder description
   - Drilling tools
   - Twist drills
   - Spot drills and center drills
   - Coolant-Fed drills
   - Spade drills
   - Carbide-Indexable insert drills
   - Boring bars
   - Floating reamer holder
   - Reamer
   - Tap holders
   - Taps
   - Shell mill holders
   - Face mills
   - End mill holders
   - End mills
   - Slot mill holders
   - Slot mills
   - Milling operation description
   - Climb milling
   - Conventional milling

d. Carbide insert data
   - Cutting fluids (coolant)
   - Carbide insert features and identification number system
   - Insert identification and grades
   - Other insert cutting materials
   - Insert nose radius selection
   - Insert geometry selection

e. CNC machining center application

3. Practice CNC Machining center control and operation. 10%

a. CNC machining center CRT and keypad panel functions
   - CRT and keypad descriptions

b. CNC machining center operation panel functions
   - Mode selections
   - Feed hold, dry run, single block, and optional block skip
   - Feed hold button
   - Dry run
   - Single block
   - Optional block skip
   - Feedrate, spindle speed, and rapid traverse overrides

c. CNC machining center workholding
   - Locating fundamentals
   - CNC fixture
   - Methods of holding the part during machining
   - Workholding devices
   - Fixtures
   - Modular fixtures

- Tombstone fixtures
- Clamping hints
- Pin locators and bushings
- Workholding methods

d. CNC machining center setup procedure
   - Machine home position
   - Setting the part origin
   - Manual setting
   - Absolute zero shift
   - Work coordinates
   - Tool length offsets
   - Edge finder setup method
   - Coaxial Indicator setup method
   - Gage block touch-off setup method
   - Wiggler setup method

4. Practice CNC machining center technical data. 10%

a. CNC machining center calculations
   - Calculation example 1
   - Calculation example 2
   - Calculation example 3
   - Calculation example 4
   - Calculation example 5
   - Calculation example 6

b. CNC cutting speeds and feedrates
   - Cutting speed (SFM) and spindle speed (RPM) for hole operations
   - Tool feedrate (IPR and IPM) for hole operations
   - Tool speed and feedrates for milling operations
   - Tool speed (RPM) for milling operations
   - Tool speed (IPM) for milling operations

c. Geometric Dimensioning and Tolerancing
   - GDandT
   - Datum dimensioning
   - Datum reference
   - GDandT symbols and descriptions
   - GDandT datum system fixturing
   - Feature control frame
   - Maximum material condition
   - Least material condition
   - Projected tolerance zone

d. Surface finish
   - Surface finish characteristics and finish notes
   - Surface finish produced by process type

e. Material types and hardness rating
   - Types of steel
   - Tool steels
   - Hardness rating methods
   - Brinell hardness number (BHN)
   - Rockwell hardness test (Rc or Rb)
   - Scleroscope hardness test
   - Vickers Diamond Pyramid Number (DPN)

f. CNC Machine alarm codes

5. Practice CNC machining center rapid and feed moves. 10%

a. Rapid traverse and feed moves
b. G00 rapid movement
   - G00 X-axis rapid traverse description for VMC
   - G00 Y-axis rapid traverse description for VMC
   - G00 Z-axis rapid traverse description for VMC
   - G00 X-axis rapid traverse description for HMC
   - G00 Y-axis rapid traverse description for HMC
   - G00 Z-axis rapid traverse description for HMC
c. G01 feed movement
   - G01 X-axis feed move description for VMC
   - G01 Y-axis feed move description for VMC
   - G01 Z-axis feed move description for VMC
d. HMC five-axis machining
e. Instructions for CNC Program Example 1000
   - Coordinate worksheet
   - Engineering drawing
   - CNC machine setup plan
   - CNC tool list
   - Instructions for CNC Program Example 1000
f. Coordinate worksheet 1000
g. CNC program example 1000

6. Practice CNC machining center circular interpolation. 10%

a. Circular Interpolation
b. G02 Circular Interpolation CW
   - G02 Circular Interpolation VMC Description
c. G03 Circular Interpolation CCW
   - G03 Circular Interpolation VMC Description
d. Spindle function codes
   - M03, M04, and “S” Spindle function codes
   - M05 spindle stop code
   - Contour milling description for VMC
   - 360° contour milling description for VMC
   - G02 code description
   - G03 code description
e. Instructions for CNC program example 2000
   - Instructions for CNC program 2000
f. Coordinate worksheet 2000
g. CNC program example 2000

7. Practice CNC diameter compensation. 10%

a. Cutter Diameter Compensation
   - Cutter Diameter Compensation Codes
   - G41 Cutter Diameter Compensation Left
   - G42 Cutter Diameter Compensation Right
   - G40 Cutter Diameter Compensation Cancel
   - G43 Tool Length Compensation
   - G49 Tool Length Compensation Cancel
   - G28 Machine Home Return
   - G41 and G42 Code Description: External Cutting

- G41 and G42 Code Description: Pocket Cutting

b. G41 Cutter Diameter Compensation VMC Description
c. G42 Cutter Diameter Compensation VMC Description
d. Instructions for CNC Program Example 3000
   - Instructions for CNC Program Example 3000
e. Coordinate Worksheet 3000
f. CNC Program Example 3000

8. Practice CNC drilling canned cycles. 10%

a. Canned Cycles Codes
b. CNC Drilling Canned Cycles
   - G81 Drilling Canned Cycle
   - G82 Counterboring Canned Cycle
   - G83 Peck Drilling Canned Cycle
   - G80 Canned Cycle Cancel
   - Z-Return Codes
   - G99 Return to Reference (R) Level Code
   - G98 Return to Initial Level Code
c. Instructions for CNC Program Example 4000
   - Instructions for CNC Program Example 4000
d. Coordinate Worksheet 4000
e. CNC Program Example 4000

9. Describe CNC canned cycles G84, G86, and G76. 10%

a. G84 Tapping Canned Cycle
   - G86 Boring Canned Cycle
   - G76 Fine Boring Canned Cycle
   - G98 and G99 Return Codes
   - G80 Canned Cycle Cancel
   - G20 Inch and G21 Metric Format Codes
   - G54-G59 Work Coordinate System Codes
   - HMC B-Axis
b. Instructions for CNC Program Example 5000
   - Instructions for CNC Program Example 5000
c. Coordinate Worksheet 5000
d. CNC Program Example 5000

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Apprenticeship Manitoba

CNC Machinist

Unit: D5 CNC Electrical Discharge Machining (EDM)

Level: One

Duration: 8 hours

Theory: 0 hours

Practical: 8 hours

Overview:

This unit of instruction is designed to provide the CNC Machinist apprentice with the knowledge and understanding of CNC Electrical Discharge Machining (EDM). Material covered includes: wire-feed EDM process, three benefits of the wire-feed EDM process and basic components of a wore-feed EDM.

Objectives and Content: **Percent of Unit Mark (%)**

1. Practice using EDM fundamentals. **100%**

a. Cutting with EDM
b. Types of wire EDM machines:
   - Simple two
   - Simultaneous four
   - Independent four
   - UV axis
   - XY axis
c. Parts of the wire-feed EDM:
   - Bed
   - Saddle
   - Column
   - UV axis
   - XY axis
   - Wire-feed axis
   - Wire-feed system
   - Dielectric fluid system
   - Machine control
d. Fuzzy logic control
e. Important machining considerations
f. Machine setup
g. Edge detection
h. Hole location detection
i. Slot location detection
j. Test square
k. Skim cuts
l. Programming
m. Four-axis program example

Apprenticeship Manitoba

CNC Machinist

Unit: D6 CNC Grinder

Level: One

Duration: 8 hours

Theory: 0 hours

Practical: 8 hours

Overview:

This unit of instruction is designed to provide the CNC Machinist apprentice with the knowledge and understanding precision grinding operations and machines. Material covered includes: grinding operations that removes metal.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe the CNC grinder characteristics:	**100%**

a. Adding CNC control to grinding wheel selection
- Faster cycle times
  - A CNC grinder dresses its own wheel faster and more accurately
- No longer a need to dress the wheel into the exact shape
  - A CNC grinder dresses its own wheel faster and more accurately
- 3-D Compensation for wheel shape
- Extreme safety planning

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