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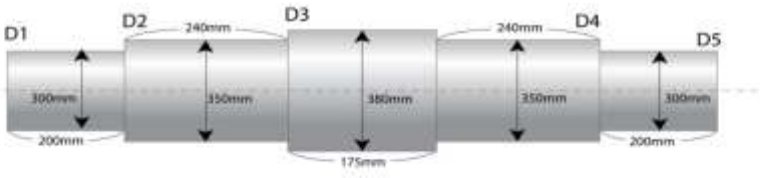

MATPC501

MANUFACTURING TECHNOLOGY

Parts Production On CNC Machine

TRAINER'S MANUAL

October 2024

PARTS PRODUCTION ON CNC MACHINE

KOICA Korea International Cooperation Agency

TQUM TVET Quality Management Project

2024

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TABLE OF CONTENT

ACRONYMS

2D: Two Dimension

3D PDF: 3 Dimension Portable Document Format

3D: Three Dimension

ACIS: Andy, Charles, Ian's System

CAD: Computer-Aided Design

CADD: Computer-Aided Design and Drafting

CAE: Computer-Aided Engineering

CAM: Computer-Aided Manufacturing

CBT/A: Competency-Based Training and Assessment

CD: Compact Disc

CNC: Computer Numerical Control

CPU: Computer Processing Unit

DVD: Digital Video Disc

G-code: Geometric Code

GUI: Graphical User Interface

KOICA: Korea International Cooperation Agency

M-code: Miscellaneous Code

RTB: Rwanda TVET Board

STEP: Standard for the Exchange of Product model data

TQUM Project: TVET Quality Management Project

TVET: Technical and Vocational Education Training

USB: Universal Serial Bus

INTRODUCTION

This trainer's manual includes all the methodologies required to effectively deliver the module titled **"Parts Production on CNC Machine".** Trainees enrolled in this module will engage in practical activities designed to develop and enhance their competencies.

The development of this training manual followed the Competency-Based Training and Assessment (CBT/A) approach, offering ample practical opportunities that mirror real-life situations.

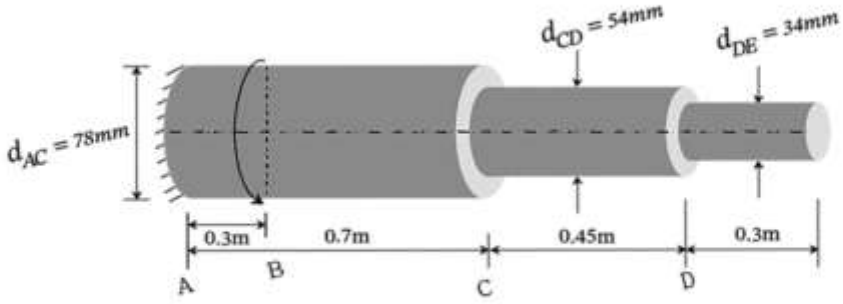
The trainer's manual is organized into Learning Outcomes, which is broken down into indicative content that includes both theoretical and practical activities. It provides detailed information on the key competencies required for each learning outcome, along with the objectives to be achieved.

As a trainer, you will begin by asking questions related to the activities to encourage critical thinking and guide trainees toward real-world applications in the labor market. The manual also outlines essential information such as learning hours, didactic materials, and suggested methodologies.

This manual outlines the procedures and methodologies for guiding trainees through various activities as detailed in their respective trainee manuals. The activities included in this training manual are designed to offer trainees opportunities for both individual and group work. Upon completing all activities, you will assist trainees in conducting a formative assessment known as the end learning outcome assessment. Ensure that trainees review the key reading and the points to remember section.

MODULE CODE AND TITLE: MATPC501 PARTS PRODUCTION ON CNC MACHINE

Learning Outcome 1: Generate NC files
Learning Outcome 2: Set up CNC Machine
Learning Outcome 3: Execute the work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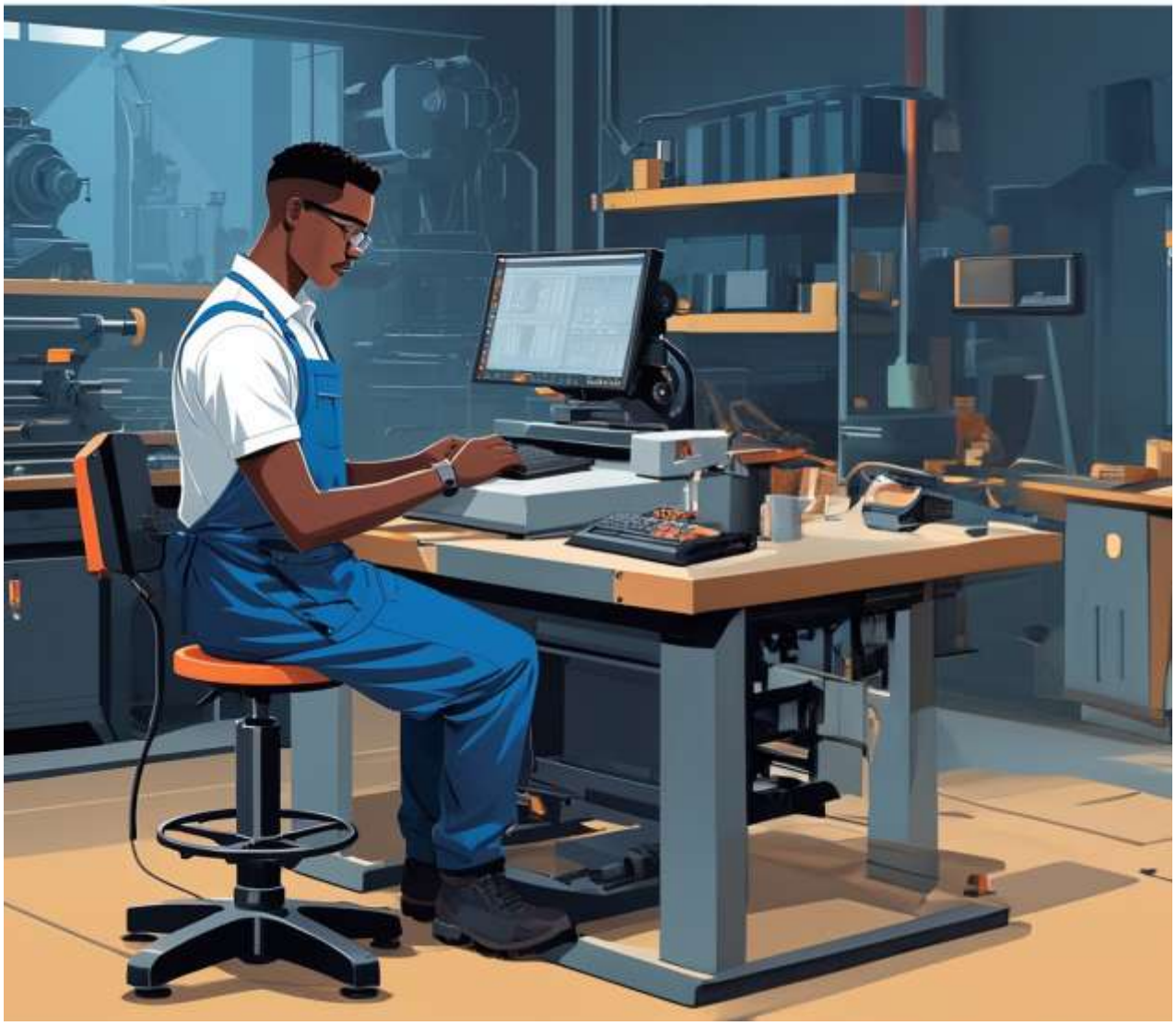

Indicative contents
1.1. Introduction to CNC machine **1.2. Producing NC file** **1.3. Simulating NC files**

Key Competencies for Learning Outcome 1: Generate NC file

Knowledge	Skills	Attitudes
• Explanation of key terms used in CNC machine • Description of types of CNC machine • Description of parts of CNC machine • Description of CNC programming language • Identification of methods of CNC programming • Description of CAM software • Identification of Methods of transferring data	• Applying safety precautions on CNC machine • Interpreting drawing • Interpreting CNC codes • Writing CNC program • Installing CAD and CAM software • Simulating CNC program	• Being careful while applying safety precautions on CNC machine • Being proactive to problem-solving and troubleshooting abilities during installation of CAD and CAM software • Having critical thinking while writing CNC program • Having critical thinking while interpreting drawings and CNC codes. • Having self-confidence in simulating CNC program

Duration: 30 hrs

Learning outcome 1 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Explain correctly key terms used in CNC machine operation.
2. Apply properly safety precautions as used CNC machine operation.
3. Interpret correctly drawing used in CNC machine
4. Describe efficiently types of CNC machine used in the manufacturing industry.
5. Describe clearly CNC programming language used in machining operations
6. Identify properly methods of CNC programming used in machining operations
7. Interpret correctly CNC codes used CNC programming
8. Describe clearly CAM software used in the manufacturing industry.
9. Install correctly CAD and CAM software used in the manufacturing industry.
10. Identify properly methods of transferring data according to the product design
11. Simulate appropriately CNC program according to the product design

Resources

Equipment	Tools	Materials
● CNC lathe machine, ● CNC milling machine ● CNC router machine ● CNC drilling machine ● CNC laser cutter machine ● Computer ● Printers	● CN Rulers ● Squares ● Extension cable ● Flash disk ● ARTCAM ● MARTCAM, ● MASTERCAM ● FUSION 360 ● SINUMERIK	● CAD models of parts or components to be manufactured ● Papers ● Pens ● Rubbers ● Lubricants

	● CNC Simulator Pro	

Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Avail a computer(s) with sufficient capacity for CAD and CAM software
- Avail CNC machines with their accessories
- Avail pictures/videos that show the types of CNC machines as didactic material

Indicative content 1.1: Introduction to CNC Machine

Duration: 7 hrs

Theoretical Activity 1.1.1: Explanation of key terms used in CNC machine

Notes to the trainer:

- While delivering this activity, trainer may use small groups to define key terms used in CNC machine operations.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and request trainees to answer the following questions:

i. What do you understand by the following terms used in CNC machine operations:
   a) CNC Machine
   b) Part program
   c) G-code/ M-code
   d) CAD/CAM
   e) Axis
   f) Cutting Parameters
   g) Fixture
   h) Rapid Traverse
   i) DRO (Digital Readout)

Step 2: Ask trainees to write provided answers on paper or flipchart

Step 3: Ask trainees to present their findings

Step 4: Provide an expert view and clarify concepts using didactic materials, then address any questions or concerns.

Step 5: Ask trainees to read the key reading 1.1.1. In trainee manual.

Points to Remember

- A CNC (Computer Numerical Control) machine automates machining processes through programmed commands, increasing precision and efficiency, they automate repetitive tasks, increasing production speed and reducing manual labor.
- CNC machine requires a high-performance and comes at a significant cost, which can be a barrier for some users
- CNC machines can easily switch between different tasks by changing the programmed instructions, making them versatile for various manufacturing applications

Practical Activity 1.1.2: Applying safety precautions on CNC machine

Notes to the trainer

- Facilitation of this activity trainer may show trainees how to apply safety precautions on CNC machine.
- For delivering this activity effectively trainer may use the tutorials video related to safety precautions on CNC machine. For the effective delivery; it is recommended to:
  - ✓ Avail CNC machine.
  - ✓ Avail signposts.
  - ✓ Avail video tutorials for applying safety precaution to CNC machine as didactic materials.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to go to the manufacturing workshop to implement safety precautions on the CNC machine to prevent accidents and ensure smooth operations while producing mechanical parts.

Step 2: Provide clear work instructions (Task, PPE, Time allocated)

Step 3: Demonstrate how to implement safety precautions on the CNC machine. While demonstrating, explain the procedures for each technique.

Step 4: Ask trainees to implement safety precautions on CNC machine.
Step 5: Verify whether the safety precaution is implemented correctly
Step 6: Ask trainees to read key reading 1.1.2
Step 7: Ask trainees to perform the task provided in the application of learning 1.1

Points to Remember

- Failure to follow safety precautions to CNC machine can lead to accidents, such as cuts, burns, or more severe injuries from moving parts or sharp tools.
- Proper machine shutdown procedures lead to quickly address any malfunctions and maintain a safe working environment.
- Without proper safety practices, accidents and equipment failures can disrupt workflow, leading to downtime and decreased productivity.
- Remember to check the nameplate of the CNC machine before using it.

Theoretical Activity 1.1.3: Description of CNC machines

Notes to the trainer:

- While delivering this activity, the trainer may use small groups to describe the types of CNC machines and their parts.
- For delivering this activity effectively, the trainer may use the pictures to show the types of CNC machine and their parts.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to answer the following questions:
   a. What should be the types of CNC machines?
   b. What do you think are the main parts of a CNC machine?

Step 2: Ask trainees to write provided answers on paper or flipchart
Step 3: Ask trainees to present their findings
Step 4: Provide an expert view and clarify concepts using didactic materials, then address any questions or concerns.
Step 5: Ask trainees to read the key reading 1.1.3 in the trainee manual.

Points to Remember

- CNC Milling Machines are used for cutting and shaping materials with rotating tools, featuring parts like the spindle, table, and axis controls for precise movement in multiple directions.
- CNC Lathes focus on turning operations, where the material rotates against a stationary cutting tool, including key parts like the chuck, tailstock, and tool post.
- CNC Routers are designed for cutting softer materials like wood and plastic, with parts including the router spindle, worktable, and gantry system for large-scale operations.
- CNC Plasma Cutters use a plasma torch to cut metal, incorporating parts like the plasma torch, work surface, and motion control system to handle various thicknesses and shapes.
- CNC Wire EDM Machines employ a thin wire as an electrode to cut through metal with high precision, featuring parts such as the wire spool, worktable, and electrode guide system.

Theoretical Activity 1.1.4: Identification the aspects of CNC machines

Notes to the trainer:

- While delivering this activity, the trainer may use small groups to describe the specifications of CNC machines and their Control features.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to answer the following questions:

i. What should be the axis of CNC Machine?
ii. What are the typical specifications of CNC machines?
iii. What can be the Control features of CNC Machine?
iv. What should be the parameters of CNC machine?

Step 2: Ask trainees to write provided answers on paper or flipchart

Step 3: Ask trainees to present their findings

Step 4: Provide an expert view and clarify concepts using didactic materials, then address any questions or concerns.

Step 5: Ask trainees to read the key reading 1.1.4 in trainee manual.

Points to Remember

- Axes in CNC machines refer to the directions in which the machine's tool or workpiece can move, allowing for precision in machining operations
- The specifications of CNC machines refer to the technical details that describe the machine's capabilities and limitations. These include various parameters that define the machine's performance, accuracy, and operational features
- CNC machine control features refer to the key functionalities and tools that allow the operator to program, manage, and monitor machine operations
- CNC parameters refer to the specific settings and configurations that control the operation of a CNC machine. These parameters govern various aspects of the machining process, influencing how the machine performs tasks such as cutting, drilling, milling, and turning.

Theoretical Activity 1.1.5: Description of major components of CNC machines

Notes to the trainer:

- While delivering this content, the trainer may use small groups to describe the major components of CNC machines.
- For delivering this activity effectively, the trainer may use the pictures/photos to show the major components of CNC machine.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to answer the following questions:

i. How can you explain the following major components of CNC machines

a) Machine control unit
b) Control Panel/Interface
c) Machine tool (mechanical part)
d) Program input device
e) Drive system
f) Feedback system

Step 2: Ask trainees to write provided answers on paper or flipchart

Step 3: Ask trainees to present their findings

Step 4: Provide an expert view and clarify concepts using didactic materials, then address any questions or concerns.

Step 5: Ask trainees to read the key reading 1.1.5 in trainee manual.

Points to Remember

- The key components of a CNC machine include the Machine Control Unit (MCU), which acts as the machine's brain by interpreting part programs and controlling all machining operations. The interface enables communication between the machine and the user, while the drive system converts electrical signals into precise mechanical movements of the machine's axes. Finally, the feedback system monitors the machine's performance in real-time, ensuring accuracy by comparing actual conditions to programmed values and making necessary adjustments.
- The main components of a CNC machine includes machine control unit, interface, machine tool, program input, drive system and a feedback system.

Application of learning 1.1.

Ask the trainees to go to the manufacturing workshop where CNC machines are widely used, and perform the following tasks:

1. Wear Personal Protective Equipment (PPE).
2. Interpret the signs and symbols on the CNC machines.
3. Identify the various types of CNC machines present.
4. Interpret the typical specifications of CNC machines

Checklist:

SN	Criteria	Indicators	Yes	No
1	PPEs are correctly worn	1.1 Overall is worn		
		1.2 Safety shoes are worn		
		1.3 Safety glasses are worn		
		1.4 Hand gloves are worn		
2	Signs and symbols are correctly	2.1 Emergency Stop symbol is interpreted		

	interpreted	2.2 Power On/Off symbol is interpreted		
		2.3 Safety Guard Warning symbol is interpreted		
		2.4 Rotating Parts Hazard symbol is interpreted		
		2.5 No Access symbol is interpreted		
3	Types of CNC machines are correctly identified	3.1 Parts of CNC machine is identified		
		3.2 Specifications of CNC machine is identified		
		3.3 The nameplate of CNC machine is interpreted		

Indicative content 1.2: Producing NC File

Duration: 13 hrs

Practical Activity 1.2.1: Interpreting drawing

Notes to the trainer

- Facilitation of this activity trainer may show trainees how to interpret drawings to be used in CNC machine
- For delivering this activity effectively, the trainer may use the drawings of different mechanical parts. For effective delivery, it is recommended to:
  - ✓ Avail of different drawings of mechanical parts.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to go to the manufacturing workshop and interpret the technical drawing of work piece

Step 2: Provide clear work instructions (Task, PPE, Time allocated)

Step 3: Demonstrate how to Interpret the drawing to be used in the CNC machine, while demonstrating, explain the procedures for each technique.

Step 4: Ask trainees to Interpret the drawing of the workpiece to be produced in the CNC machine

Step 5: Verify whether the Interpreting drawing is done correctly

Step 6: Ask trainees to read key reading1.2.1

Step 7: Ask trainees to perform the task provided in the application of learning 1.2

Points to Remember

- Poor interpretation of drawings in CNC machining can lead to various issues, impacting both the quality of the finished product and the efficiency of the machining process**.**
- Understanding symbols and signs on CNC machines is crucial for enhancing safe and efficient machine operation.

Practical Activity 1.2.2: Writing CNC program

Notes to the trainer

- Facilitation of this activity trainer may demonstrate trainees how to write CNC program in CNC machine
- For delivering this activity effectively, it is recommended to:
  - ✓ Avail of different drawings of mechanical parts.
  - ✓ computer
  - ✓ Avail of CNC machine
  - ✓ Check the availability of electricity

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask the trainee to go to the manufacturing workshop, where the task is to write the program in CNC machine to produce the part of the circular shaft accurately and efficiently.

Step 2: Provide clear work instructions (Task, PPE, Time allocated)

Step 3: Demonstrate how to write a CNC program, while demonstrating, explain the procedures for each procedure.

Step 4: Ask trainees to write a CNC program

Step 5: Verify whether the trainee write correctly CNC program

Step 6: Ask trainees to read key reading1.2.2

Step 7: Ask trainees to perform the task provided in the application of learning 1.2

Points to Remember

- Inaccurate programming can cause the tool to cut too much or too little material, wasting raw materials and potentially ruining the parts
- Incorrect G-code commands can result in parts being machined with incorrect dimensions, leading to unusable products.
- When writing a CNC program, ensure you accurately define the sequence of operations and specify precise G-code and M-code commands to control the machine's movements and functions. Always review the program thoroughly for errors and simulate it, if possible, to avoid potential issues during machining

Application of learning 1.2.

Ask your trainee to go to the school manufacturing workshop, where the school has received an order to produce a circular shaft with the following specifications:

- ✓ Material: Mild Steel
- ✓ Diameter: 50 mm
- ✓ Length: 150 mm
- ✓ Tolerances: ±0.05 mm for both diameter and length

The task is to write the CNC program required to produce the shaft using a CNC lathe, by ensuring that the part meets the provided specifications.

Solution: CNC lathe program to machine the shaft according to the given specifications

```
G21 (METRIC UNITS)
G40 (CANCEL TOOL RADIUS COMPENSATION)
G50 S1500 (SET MAXIMUM SPINDLE SPEED)
G96 S200 (CONSTANT SURFACE SPEED)

(TOOL SELECTION)
T0101 (SELECT TOOL 1)
G00 X55 Z2 (MOVE TOOL TO SAFE POSITION ABOVE WORKPIECE)
G01 Z0 F0.2 (MOVE TO FACE THE FRONT OF THE PART)
G01 X0 (FACE THE FRONT OF THE PART)

(TURNING OPERATION TO DIAMETER 50 mm)
G00 X52 Z2 (RETRACT TOOL)
G01 Z0 F0.25 (MOVE TO START TURNING POINT)
G01 X50 (ROUGH TURN DIAMETER TO 50 mm)

(TURNING ALONG THE LENGTH OF THE SHAFT TO 150 mm)
G01 Z-150 F0.25 (TURN LENGTH OF THE PART TO 150 mm)
G01 X52 Z-152 (RETRACT TOOL)
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G21 (METRIC UNITS)
G40 (CANCEL TOOL RADIUS COMPENSATION)
G50 S1500 (SET MAXIMUM SPINDLE SPEED)
G96 S200 (CONSTANT SURFACE SPEED)

(TOOL SELECTION)
T0101 (SELECT TOOL 1)
G00 X55 Z2 (MOVE TOOL TO SAFE POSITION ABOVE WORKPIECE)
G01 Z0 F0.2 (MOVE TO FACE THE FRONT OF THE PART)
G01 X0 (FACE THE FRONT OF THE PART)

(TURNING OPERATION TO DIAMETER 50 mm)
G00 X52 Z2 (RETRACT TOOL)
G01 Z0 F0.25 (MOVE TO START TURNING POINT)
G01 X50 (ROUGH TURN DIAMETER TO 50 mm)

(TURNING ALONG THE LENGTH OF THE SHAFT TO 150 mm)
G01 Z-150 F0.25 (TURN LENGTH OF THE PART TO 150 mm)
G01 X52 Z-152 (RETRACT TOOL)
```

Indicative content 1.3: Simulating NC Files

Duration: 10 hrs

Practical Activity 1.3.1: Simulating CNC program

Notes to the trainer

- Facilitation of this activity trainer may demonstrate to trainees how to simulate CNC program in CNC machine
- For delivering this activity effectively, it is recommended to:
  - ✓ Avail written CNC program
  - ✓ Avail different drawings of mechanical parts.
  - ✓ Avail a computer
  - ✓ Avail CNC machine
  - ✓ Check the availability of electricity

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to go to the manufacturing workshop to simulate CNC program.

Step 2: Provide clear work instructions (Task, PPE, Time allocated)

Step 3: Demonstrate how to simulate the CNC program, while demonstrating, explain the procedures for each

Step 4: Ask the trainee to simulate the CNC program.

Step 5: Verifying whether the trainee simulated CNC program is correctly done.

Step 6: Ask trainees to read key reading1.3.1

Step 7: Ask trainees to perform the task provided in the application of learning 1.3

Points to Remember

- To convert a CAD file to a CNC program, the design must first be exported in a format compatible with CAM software (such as DXF or IGES), where toolpaths and machining parameters are defined. Once the toolpaths are set, the CAM software generates the G-code/M-code needed for the CNC machine to execute the design.
- When simulating NC files in a CNC program, ensure that the toolpath is accurately visualized to identify potential errors before actual machining. Verify cutting parameters and machine movements to prevent collisions and optimize efficiency during the machining process.

Application of learning 1.3.

The school plans to produce a circular shaft with dimensions of 150 mm in length and 50 mm in diameter, requiring high precision to meet product specifications. Ask trainee to go to the manufacturing workshop where the CNC lathe is located, and perform the following tasks:

1. Create a CAD design of the circular shaft.
2. Export the CAD file to CAM software in STEP format.
3. Set up the toolpaths for machining.
4. Generate the NC file in G-code format.
5. Simulate the NC file using the CAM software's simulation feature

Checklist

SN	Criteria	indicators	Yes	No
1	Circular shaft is correctly designed	1.1 Circular shaft is designed by using CAD		
		1.2 Tool paths are set		
		1.3 Dimensions of circular shaft are respected		

2	NC File is correctly Simulated for accuracy	2.1. Simulation shows correct tool movement without collisions		
		2.2. Simulation confirms that final dimensions of the shaft match design space		
		2.3. Simulation runs without any software errors or warnings		

Learning outcome 1 end assessment

Theoretical assessment

1. Read carefully the statement below and answer by **TRUE** if the statement is correct or **FALSE** the statement is wrong**:**

i. A CNC machine automates the operation of machinery to shape materials like metal, plastic, or wood with high precision.

Answer: TRUE

ii. Part programs do not define toolpaths or select tools in CNC machines.

Answer: FALSE

iii. G-code controls non-geometrical functions such as turning the spindle on or off.

Answer: FALSE

iv. CAD software is used to design parts, while CAM software converts these designs into machine instructions.

Answer: TRUE

v. The number of axes in a CNC machine determines the complexity of its movements and machining operations.

Answer: TRUE

vi. Cutting parameters like spindle speed and feed rate do not affect the precision of the CNC machining process.

Answer: FALSE

vii. A fixture is used to hold a workpiece securely in place during CNC machining.

Answer: TRUE

2. Match the items in **Column B,** which describe Personal protective equipment (PPE), with their corresponding list of type of PPE in **Column C** and provide answers in **Column A**

Column A: Answer	**Column B: Description**	**Column C: Types of PPE**
1…B……	1.Protects the hands from cuts, burns, and chemicals	A. safety glasses
2…D….	2. Protects the feet from heavy objects and sharp materials	B. Safety gloves
3…A……	3.Shields eyes from debris, dust, and chemical	C. Hard Hat

	splashes.	
4…C……	4.Protects the head from falling objects and impacts.	D. Safety Shoes
5…….G	5.Protect the mouth from dust	E. Earplugs
6…..E……	6.Reduces exposure to loud noises in the work environment	F. Emergency Stop
		G. Air Mask

3. Fill the gap of the following statement by using the correct types of CNC machine among the list provided (**CNC waterjet machine**, **CNC lathe, CNC EDM (Electrical Discharge Machine), CNC milling machine**, CNC **laser cutter**, **CNC plasma, CNC drilling)**

a) The CNC machine used primarily for cutting and shaping materials into cylindrical shapes is called a …**CNC lathe**……
b) A ……**CNC milling machine** ……is commonly used for cutting materials with a rotating tool that moves along multiple axes.
c) The **…CNC EDM (Electrical Discharge Machine) ……**uses electrical discharges to shape hard materials, usually for die-making.
d) The ……**CNC waterjet machine** ……uses a high-pressure stream of water mixed with abrasive particles to cut through materials.
e) A …**CNC laser cutter.** …is specialized for cutting materials in flat sheets using a laser beam.

4. Read the below statement and choose the right answer by encircling the corresponding to the correct answer

i. What is the purpose of sectional views in CNC drawings?

A) To show the color of the material

B) To provide a view of internal features

C) To indicate tolerances

D) To display dimensions only

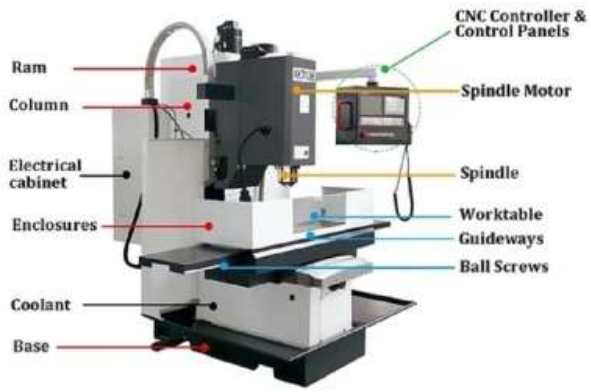
Answer: B) To provide a view of internal features

ii. What is the primary purpose of a CNC drawing?
a) To provide aesthetic appeal to the final product.
b) To communicate the exact dimensions and specifications for machining.
c) To serve as a blueprint for the machinist's artistic interpretation.
d) To document the history of the part's design and production

Answer: b)To communicate the exact dimensions and specifications for machining.

5. Observe the following CNC milling machine figure and name the marked parts by using the following words in bracket (**ram, column, electrical cabinet, enclosures, coolant, base, splinder motor, ball screw)**

Answers:



Practical assessment

The school is facing an issue with outdated circular shafts in their milling machine. They plan to announce a tender for the production of a new circular shaft with dimensions of 150 mm in length and 50 mm in diameter, to be manufactured using a CNC machine. Ask your trainees to perform the following task:

1. Create a CAD design of the circular shaft.
2. Export the CAD file to CAM software in STEP format.
3. Set up the toolpaths for machining.
4. Generate the NC file in G-code format.
5. Simulate the NC file using the CAM software's simulation feature

Checklist

SN	Criteria	indicators	Yes	No
1	Circular Shaft is correctly designed in CAD Software	1.1. CAD model is generated		
		1.2. Design is constrained and error-free		
2	CAD File is correctly export to CAM Software (STEP Format	2.1. CAD file is exported to CAM software in STEP format		
		2.2. No file compatibility issues during import in CAM software		
3	Toolpaths is appropriately Configurated	3.1. Tools are selected		
		3.2. Feed rate, spindle speed, and depth of cut are specified		
		3.3 Toolpaths avoid collisions and maintain precision for required dimensions		
4	NC File are correctly generated in G-code Format	4.1. NC file is generated		
		4.2. G-code format is generated		
		4.3. All machining steps are represented in the NC file		
5	NC File is correctly Simulated	5.1. Simulation shows tool movement without collisions		
		5.2. Simulation confirms that final dimensions of the shaft match design space		
		5.3. Simulation runs without any software errors or warnings		

Further information to the trainer

Madison, J. (1996). CNC machining handbook: basic theory, production data, and machining

Negi, P., Ram, M., & Yadav, O. P. (2022). Basics of CNC Programming. CRC Press.

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Indicative contents
2.1 Applying Techniques of Setting tools in CNC machine
2.2 Transferring data to CNC machine
2.3 Setting CNC machine parameters

Key Competencies for Learning Outcome 2: Set up CNC Machine

Knowledge	Skills	Attitudes
● Identification of techniques of setting tools in CNC machine. ● Identification of methods of transferring data to CNC machine	● Applying techniques of setting tools in CNC machines ● Transferring the data to a CNC machine ● Setting CNC machine parameters according to the work to be done	● Paying attention while setting tools in CNC machine. ● Being careful while transferring data to CNC machine ● Being accurate when setting parameters in CNC machine

Duration: 30hrs

Learning outcome 2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify properly techniques of setting tools in CNC machine
2. Identify properly the methods of transferring data to CNC machine as used in manufacturing industry.
3. Apply correctly techniques of setting tools in CNC machine as used in manufacturing industry.
4. Transfer properly the data to CNC machine as used in manufacturing industry.
5. Set properly CNC machine parameters according to the work to be done

Resources

Equipment	Tools	Materials
● CNC Machine ● CNC Milling ● CNC Turning ● CNC Grinding ● CNC Drilling ● CNC router ● CNC laser cutter	● Hammer ● Collets ● Wrenches ● Allen keys ● Torque wrenches ● Tool setter ● Dial Test Indicators ● Tool Balancer ● Torque Wrenches ● Cutting tool set ● SINUMERIK Software	● N/A

	• CNC Simulator Pro • Autodesk fusion 360 • USB Drive • Memory Card • Flash disc • ARTCAM, • MARTCAM, • MASTERCAM	

Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Avail a computer(s) with sufficient capacity for CAD and CAM software
- Avail tools used to transfer data to CNC machine
- Avail CNC machines with their accessories
- Avail pictures/video that shows how to Set parameters CNC machine as didactic material

Indicative content 2.1: Applying Techniques of Setting tools in CNC Machine

Duration: 10 hrs

Practical Activity 2.1.1: Applying techniques of setting tools in CNC

Notes to the trainer

- The trainer can demonstrate to the trainee how to apply techniques of setting tools in CNC machine. For effective delivery; it is recommended to:
  - ✓ Avail a CNC machine
  - ✓ Avail all tools required in setting tools in CNC machine
  - ✓ Avail tutorials showing techniques of setting tools in CNC machine.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to go to the manufacturing workshop and apply techniques of setting tools in CNC machine.
Step 2: Provide clear work instructions (Task, PPE, Time allocated)
Step 3: Demonstrate how to set tools in CNC machine. While demonstrating, explain the procedures for each technique.
Step 4: Ask trainees to set tools in CNC machine
Step 5: Ask trainees to read key reading 2.1.1
Step 6: Ask trainees to perform the task provided in the application of learning 2.1

Points to Remember

- Manual Tool Setup is straightforward but depends heavily on the operator's skill, making it prone to errors and time-consuming.
- Tool Setters automate tool length and diameter measurement, improving speed and accuracy in production environments.
- Probe Systems provide highly precise measurements for both tools and workpieces, ideal for high-precision machining.
- Edge Finders are manually operated, offering moderate accuracy for locating workpiece edges in simpler tasks.
- Optical Tool Measurement Systems use lasers and cameras to deliver extremely accurate, non-contact tool measurements, perfect for delicate or complex tools

Application of learning 2.1

The school requires a car circular shaft with a length of 150 mm and a diameter of 50 mm. Ask trainees to set CNC machine by using the proper tool-setting techniques.

1. Position the tool
2. Install the tool setter at a fixed position
3. Locate the edge of the workpiece by using the edge finders
4. Use optical measurement system

Checklist

SN	Criteria	Indicator	Yes	No
1.	Manual tool setup is correctly done	1.1. The tool is Inserted into the tool holder.		
		1.2. The tool is positioned closer to the part using hand wheels		
		1.3. The tool is manually to touch the surface of the workpiece		
		1.4. The tool offset is recorded manually into the CNC control panel		
2.	Tool setter is appropriately done	2.1. The tool is loaded into the machine spindle		
		2.2. The tool is brought to the tool setter		

		(a stationary device in the machine)		

Indicative content 2.2: Transferring Data to CNC Machine

Duration: 10 hrs

Theoretical Activity 2.2.1: Identification of methods of transferring data to CNC machine

Notes to the trainer:

- While delivering this activity, the trainer may use small groups to identify different methods of transferring data to CNC machine.
- For delivering this activity effectively, the trainer may use the pictures/photos to show different tools used for transferring data to CNC machine.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to answer the following question:

a) What do you understand about the methods of transferring data to CNC machine?

Step 2: Ask trainees to write provided answers on paper or flipchart

Step 3: Ask trainees to present their findings

Step 4: Provide an expert view and clarify concepts using didactic materials

Step 5: Ask trainees to read the key reading 2.2.1. In trainee manual.

Points to Remember

- Perform a dry run (without cutting material) to ensure the program behaves as expected
- Multiple methods exist to transfer data to a CNC machine, including Manual Data Input (MDI), USB drives, and wireless file transfer.
- Manually review the G-code for errors such as incorrect coordinates, speeds, or tool selections.
- Network transfer allows direct communication between the computer and the CNC machine for seamless data transfer.

- Data transfer cables are suited for older machines but less efficient than modern alternatives.
- Use MDI for quick manual inputs but avoid for complex jobs.
- Always double-check your program for errors before running it to prevent costly mistakes.
- Check for any G-code errors, validate tool and work offsets, and confirm cutting parameters to ensure the program is error-free.

Practical Activity 2.2.2: Transferring data to CNC machine

Notes to the trainer

- Trainer avails all tools which may be required in transferring data to CNC machine
- The trainer can demonstrate to the trainee on how to transfer data to CNC machine. For effective delivery, it is recommended to:
  - ✓ Avail a CNC machine
  - ✓ Avail tools used to transfer CNC machine (USB, Flash disc)
  - ✓ Avail tutorials showing transfer of data to CNC machine.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to go to a manufacturing workshop and apply methods of transferring data to CNC machine.
Step 2: Provide clear work instructions (Task, PPE, Time allocated).
Step 3: Demonstrate methods of transferring data to CNC machine, while demonstrating, explain the procedures.
Step 4: Ask trainee to transfer data to CNC machine.
Step 5: Verify whether the data is transferred correctly.
Step 6: Ask trainees to read key reading 2.2.1
Step 7: Ask trainees to perform the task provided in the application of learning 2.2.

Points to Remember

- Manually review the G-code for errors such as incorrect coordinates, speeds, or tool selections.
- Perform a dry run (without cutting material) to ensure the program behaves as expected.
- MDI is useful for quick manual input but not practical for long programs.
- USB cables and external storage devices are widely used and convenient for data transfer.
- Wireless and network transfer methods provide seamless and efficient file transfer in large production environments.
- USB and External Storage are simple and effective for most jobs.
- Wireless and Network Transfer are efficient for large operations with multiple CNC machines.
- Always double-check your program for errors before running it to prevent costly mistakes.

Application of learning 2.2.

Ask the trainee to go to the manufacturing workshop where a car circular shaft having 150 mm in length and 50 mm in diameter has been designed using CAD software, and perform the following tasks:

1. Transfer the design data to the CNC lathe machine to begin the machining process.
2. Verify the program to ensure it is free of errors before starting production

Checklist:

SN	Criteria	Indicator	Yes	No
1.	NC files are properly transferred to the CNC machine	1.1 File format is respected		
		1.2. USB port is identified		
		1.3. Data transfer cables are identified		
		1.4NC file is transferred		
		1.5. Program error is checked		

Indicative content 2.3: Setting CNC Machine Parameters

Duration: 10 hrs

Practical Activity 2.3.1: Setting CNC machine parameters

Notes to the trainer

- The trainer can demonstrate to the trainee how to set parameters for the CNC machine. For effective delivery, it is recommended to:
  - ✓ Avail a CNC machine (any type)
  - ✓ Avail electricity required to switch on CNC machine

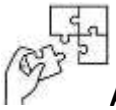
Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to go to the manufacturing workshop and set the parameters of the CNC machine
Step 2: Provide clear work instructions (Task, PPE, Time allocated)
Step 3: Demonstrate the parameters setting of the CNC machine, while demonstrating and explain the procedures.
Step 4: Ask trainees to set CNC parameters.
Step 5: Verify whether the CNC machine is correctly set
Step 6: Ask trainees to read key reading 2.3.1
Step 7: Ask trainees to perform the task provided in the application of learning 2.3

Points to Remember

- Always run a short, non-cutting test program to verify that conversions were applied correctly before proceeding with live machining.
- Regularly maintain the machine to keep sensors, encoders, and other critical components in working order, as these impact parameter accuracy.
- Regularly review and test custom G-codes to ensure they remain functional after machine software updates or changes.



Application of learning 2.3

Trainees may go to the manufacturing workshop where car circular shaft having the following dimensions: 150 mm in length and 50 mm in diameter has been designed using CAD software and transferred in CNC lathe machine, And ask them to perform the following tasks:

1. Set up cutting parameter of CNC machine
2. Set up tool offset
3. Set up coolant and lubrication

Checklist

Criteria	Indicator	Yes	No
CNC machine parameters are appropriately set	1.1 Cutting parameter are set		
	1.2 Lubrication is set		
	1.3 Coolant is set		
	1.4 Tool offset are set		

Learning outcome 2 end assessment

Theoretical assessment

1. Read carefully the following statements and answer by **TRUE** if the statement is **correct or FALSE** if the statement is **wrong**

a) Manual Tool Setup is an automated process that eliminates human error.

Ans. False

b) A tool setter automatically measures tool length and sometimes diameter, sending data to the CNC controller.

Ans. False

c) In manual tool setup, the operator uses feeler gauges or paper to set the tool offset.

Ans. False

d) Probe systems are only used to locate workpiece surfaces and cannot measure tool length or diameter.

Ans. False

e) Edge finders are used to automatically locate the edges of the workpiece without any manual input.

Ans. False

f) Optical Tool Measurement Systems use cameras and lasers to measure tool geometry with high accuracy.

Ans. True

g) Tool setters are highly accurate and often used in high-precision production environments.

Ans. True

h) Manual Tool Setup is typically faster and more accurate than tool setters or probe systems.

Ans. False

i) Edge finders rely on the operator to detect the point when the tool touches the workpiece.

Ans. False

2. Read and match the techniques of setting tools in CNC machine, in column B, with their explanation in column C, and provide answer in Column A

Column A: Answer	**Column B: Technique of Setting Tool in CNC Machine**	**Column C: Explanation of Techniques of Setting Tool in CNC Machine**
I…..5	I. Manual Tool Setup	1. Automatic measurement of workpiece surfaces, edges, and tool offsets; highly accurate.
II…..2	ii. Tool Setter	2. Automates tool length and diameter measurement inside the CNC machine for quick setup.
iii……1	iii. Probe Systems	3. Non-contact, high-precision tool measurement using cameras or lasers outside the machine
iv……4	iv. Edge Finders	4. Manual tool for finding workpiece edges; cost-effective but less accurate.
v…….3	v. optical Tool Measurement Systems	5. Operator manually adjusts tool offsets; simple but time-consuming, prone to human error.
		6. A tool setter automatically measures tool length and sometimes diameter, sending data to the CNC controller.

3. Read the following statements and choose the correct answer by encircling the correct option:

I. Which method of transferring data to a CNC machine involves entering G-codes and M-codes manually?

a) USB Cable
b) Manual Data Input (MDI)
c) Network Transfer
d) External Storage Devices

Answer: b) Manual Data Input (MDI)

II. Which of the following is a widely available and portable method for transferring files to a CNC machine?

a) Wireless File Transfer
b) Data Transfer Cables
c) USB Cable
d) Network Transfer

Answer: c) USB Cable

III. Which method of file transfer does not require a physical connection and is ideal for large workshops?

a) USB Cable
b) Wireless File Transfer
c) Manual Data Input (MDI)
d) External Storage Devices

Answer: b) Wireless File Transfer

IV. In large production environments, which method allows CNC machines to be connected to a central server for program management?

a) Network Transfer
b) External Storage Devices
c) Data Transfer Cables
d) USB Cable

Answer: a) Network Transfer

V. Which method involves using devices like SD cards or external hard drives for file transfer?

a) Network Transfer
b) USB Cable
c) External Storage Devices
d) Data Transfer Cables

Answer: c) External Storage Devices

VI. What is an older but reliable method of file transfer used with machines that do not support USB or wireless capabilities?

a) Wireless File Transfer
b) Data Transfer Cables
c) Manual Data Input (MDI)
d) External Storage Devices

Answer: b) Data Transfer Cables

Practical assessment

The school is facing the issue of a broken lather circular shaft having the following dimensions of 150 mm in length and 50 mm in diameter. The workshop assistant decides to produce a new one on a CNC machine. Ask trainees to perform the following tasks:

1. Set tools in CNC machine.
2. Transfer the design data to the CNC machine to initiate the machining process.
3. Set the CNC machine parameters accordingly.
4. Verify the program to ensure it is error-free before beginning production.

Checklist:

SN	Criteria	Indicator	Yes	No
1	Tools are properly set in CNC machine	1.1 Tools are selected		
		1.2 Tool are fixed		
		1.3. Tools are aligned		
2	Data are correctly Transferred	2.1. File format is respected		
		2.2. USB port is identified		
		2.3. Data transfer cables are identified		
		2.4. NC file is transferred		
		2.5. Program error is checked		
		2.6. Program loaded into the CNC machine's control system is executed		
		2.7 Program simulation run to verify tool paths, tool changes, and machining order		
3	Parameters are correctly set	3.1. Feed rates are set		
		3.2. Depth of cut are set		
		3.3. Spindle speed is set		

Further information to the trainer

Fanuc CNC Custom Macros, Practical Resources for Fanuc Custom Macro B Users ISBN

Kumar, H., Abbas, M., Mohammad, A., & Jafri, H. Z. (2013). Optimization of cutting parameters in CNC Turning. Optimization, 3(3), 331-334.

Madison, J. (1996). CNC machining handbook: basic theory, production data, and machining procedures. Industrial Press Inc.

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Indicative contents
3.1 Mounting the work piece in CNC machine
3.2 Producing pieces on CNC machine
3.3 Performing post production activities

Key Competencies for Learning Outcome 3: Execute the work

Knowledge	Skills	Attitudes
• Explanation of clamping methods of work-piece in CNC machine • Identification of Surface finishing techniques • Identification of cleaning methods • Identification of Protective techniques	• Mounting the workpiece in CNC machine • Producing pieces on CNC machine • Applying Surface finishing techniques for workpiece • Applying cleaning methods • Applying protective techniques on workpiece produced by CNC machine • Storing the product	• Being careful while mounting work piece in CNC machine • Having Hygiene Awareness in manufacturing workshop cleaning. • Safety Consciousness while applying protective and surface finish techniques on a produced workpiece

Duration: 30hrs

Learning outcome 3 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Explain properly the methods of clamping the work-piece used in CNC machine during workpiece production
2. Mount properly the workpiece to be produced in CNC machine
3. Produce correctly the pieces by using CNC machine.
4. Identify properly the techniques for finishing the Surface of the workpiece produced by the CNC machine.
5. Apply correctly the techniques for finishing the Surface for the workpiece produced by the CNC machine
6. Apply effectively the cleaning methods required for CNC machine work
7. Apply correctly protective techniques on the workpiece produced by CNC machine
8. Store properly the product produced on CNC machine

Resources

Equipment	Tools	Materials
● CNC Milling ● CNC Turning ● CNC Grinding ● CNC Drilling ● CNC router ● CNC laser cutter ● air compressor	● Milling vices ● Hydraulic vices ● Quick-change vices ● Clamps studs ● Step blocks ● Masking tape ● Wire brushes	● Aluminium materials ● Titanium materials ● Ceramics materials ● Coolant or Lubricant ● Paints ● Varnishes ● Bolts and nuts

• Spray guns • PPEs	• Hummers • Wrenches • Cutting tool set • Wrenches • Cutting tool set • Calipers • Micrometres	• Sand paper • Abrasive wheels • wax • Epoxy • Silicone • Steels materials • Carbide

Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Avail a manufacturing workshop equipped with CNC machines
- Avail a Clamping work piece
- Avail drawings of designed mechanical parts
- Avail images/videos that shows how to produce pieces by using CNC machine as didactic material

Indicative content 3.1: Mounting the Work Piece in CNC Machine

Duration: 10hrs

Theoretical Activity 3.1.1: Explanation of clamping methods of workpiece in CNC machine

Notes to the trainer:

- While delivering this activity, the trainer may use small groups to explain the methods of clamping workpiece in CNC machine
- For delivering this activity effectively, trainer may use the tutorials video related for positioning the work piece in CNC machine.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to answer the following questions:

i. What do you understand by the following:
   a) Positioning accuracy
   b) Positioning mark
ii. What methods should be used to clamp the workpiece in a CNC machine during production?

Step 2: Ask trainees to write provided answers on paper or flipchart.

Step 3: Ask trainees to present their findings.

Step 4: Provide expert view and clarify concepts and answer questions if any.

Step 5: Ask trainees to read the key reading 3.1.1.in trainee manual.

Points to Remember

- Always use the CNC machine's coordinate system and alignment tools such as dial indicators or probing systems to accurately position the workpiece. This ensures precise alignment with the programmed toolpaths, preventing dimensional errors in the finished part.
- Apply visual or physical positioning marks during setup, especially for repeat jobs. This reduces setup time and ensures repeatability, particularly when you have multiple identical parts to the machine.
- For smaller or uniformly shaped parts, use vice clamping. It's a reliable, quick, and cost-effective method for holding parts securely during machining. However, ensure that the jaws of the vice are aligned with the machine's coordinate system.
- If you're working on irregularly shaped workpieces or need to machine multiple parts at once, use fixture plates. They provide flexibility and can secure parts with bolts, allowing for customization to different workpiece geometries.

Practical Activity 3.1.2: Mounting the work piece in CNC machine

Notes to the trainer

- The trainer demonstrates to the trainee how to mount the workpiece in CNC machine. For effective delivery, it is recommended to:
  - ✓ Avail a CNC machine (any type)
  - ✓ Avail drawing of mechanical parts
  - ✓ Avail all clamping tools used in the CNC machine

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to go to the manufacturing workshop and mount a workpiece in CNC machine

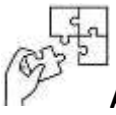
Step 2: Provide clear work instructions (Task, PPE, Time allocated)

Step 3: Demonstrate how the workpiece is mounted in CNC machine, while demonstrating, explain the procedures for each technique.

Step 4: Ask trainees to mount the workpiece in CNC Machine.
Step 5: Verify whether the workpiece is mounted correctly in CNC machine
Step 6: Ask trainees to read the key reading 3.1.2
Step 7: Ask trainees to perform the task provided in the application of learning 3.1

Points to Remember

- The best clamping method depends on the geometry of the workpiece, material type, and the specific machining operation. For high accuracy, always combine precise positioning with appropriate clamping to ensure stability and reduce setup time.
- Verify that there is adequate clearance between the cutting tool and the workpiece. This prevents any accidental contact that could cause tool breakage or damage to the workpiece.
- Confirm that the workpiece is stable and does not vibrate or shift when pressure is applied. Any instability can affect machining precision and surface finish.
- Use clamping kits when flexibility and adjustable forces are required. These kits allow for easy setup changes and are ideal when you need to reposition the workpiece during machining.
- Ensure that all safety measures are in place, including proper guarding around moving parts and ensuring that operators are at a safe distance from the machine during operation.
- Always refer to any setup sheets or documentation specific to the job being performed for additional details on mounting requirements or special considerations.



Application of learning 3.1

Ask the trainees to go to the manufacturing workshop where a car circular shaft with dimensions of 150 mm in length and 50 mm in diameter has been designed, and perform the following task:

- ✓ Mount the workpiece in the CNC machine for machining operation

Checklist

Criteria	Indicators	Yes	No
The circular shaft is properly mounted according to the type of CNC machine.	1.1. Shaft is aligned according to the machine's reference axes and positioned at the correct location		
	1.2. Positioning is double-checked, and any necessary adjustments are made to ensure accuracy		
	1.3. The shaft is held into the machine		
	1.4. Shaft is firmly held in place without movement during operations		

Indicative content 3.2: Producing Pieces on CNC Machine

Duration: 12 hrs

Practical Activity 3.2.1: Producing pieces on CNC machine

Notes to the trainer

- Trainer demonstrates to the trainee how to produce pieces using CNC machine.
- For effective delivery; it is recommended to:
  - ✓ Avail a CNC machine (any type)
  - ✓ Avail drawing of mechanical parts
  - ✓ Avail power source to operate CNC machine

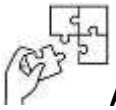
Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to go to the manufacturing workshop and produce a piece on CNC machine.
Step 2: Provide clear work instructions (Task, PPE, Time allocated)
Step 3: Demonstrate how the piece is produced on CNC machine, while demonstrating, explain the procedures.
Step 4: Ask trainees to produce piece by using CNC machine
Step 5: Verify whether the piece is produced correctly using CNC machine
Step 6: Ask trainees to read the key reading 3.2.1
Step 7: Ask trainees to perform the task provided in the application of learning 3.2

Points to Remember

- Perform Double-check the design dimensions, tolerances, and material specifications before starting the machining process.
- Ensure the proper cutting tools are selected for the material and type of operation (e.g., drilling, milling, turning)
- Confirm the CNC machine is calibrated correctly, with accurate zero points and offsets set for the workpiece and tools.
- Apply Proper position and secure the workpiece (e.g., shaft, block) in the chuck or vice to prevent movement during machining
- Keep an eye on tool performance, cutting accuracy, and the machine's behavior to spot any issues (e.g., tool wear, vibration)
- Regularly measure the part during machining to detect any deviations from the expected dimensions early and make corrections.
- Always wear proper personal protective equipment (PPE), such as safety glasses and gloves, and follow all safety protocols around the CNC machine.



Application of learning 3.2.

Ask trainee to go to a manufacturing workshop where a car circular shaft with dimensions of 150 mm in length and 50 mm in diameter has been designed, and produce the circular shaft piece by using CNC machine.

Checklist

SN	Criteria	Indicators	Yes	No
1	Shaft is accurately produced according to the design.	1.1. PPEs are worn		
		1.2. The starting process is followed		
		1.3. The shaft design matches the required dimensions (150 mm length, 50 mm diameter)		
		1.4. Shaft tolerance is respected		

Indicative content 3.3: Performing Post Production Activities

Duration: 8 hrs

Practical Activity 3.3.1: Applying Surface finishing techniques for workpiece

Notes to the trainer

- The trainer can demonstrate to the trainee how to apply surface finishing techniques for the workpiece.
- For effective delivery, it is recommended to:
  - ✓ Avail produced mechanical parts
  - ✓ Avail all tools used for finishing the designed mechanical parts
  - ✓ Avail tutorials showing techniques of applying finishing techniques to the parts

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to go to the manufacturing workshop and apply Surface finishing techniques to the workpiece produced.
Step 2: Provide clear work instructions (Task, PPE, Time allocated)
Step 3: Demonstrate how the finishes materials are applied to the produced piece, while demonstrating, explain the procedures for each technique.
Step 4: Ask trainees to apply surface finishing techniques to the workpiece
Step 5: Verify whether the finishing materials are applied correctly to the produced pieces
Step 6: Ask trainees to read the key reading 3.3.1
Step 7: Ask trainees to perform the task provided in the application of learning 3.3.

Points to Remember

- Apply surface finishing techniques such as sanding, polishing, or grinding to achieve the desired texture or appearance
- Choose abrasives and compounds that are suitable for the material being finished, as certain abrasives work better on specific metals or plastics.
- Remove machining residues such as coolant, lubricants, and metal chips
- Monitor the surface roughness and dimensional accuracy throughout the finishing process to ensure that tight tolerances are maintained.

Application of learning 3.3.

Ask trainee to go to a manufacturing workshop where a milling machine circular shaft with dimensions of 150 mm in length and 50 mm in diameter has been produced using CNC machine. Ask trainees to perform the following tasks:

1. Apply finishing techniques to the produced circular shaft
2. Store the produced parts
3. Clean the workshop by using air compressor

Checklist:

SN	Criteria	Indicators	Yes	No
1	Piece/shaft is properly finished	1.1. Smooth surface is produced		
		1.2. Piece/shaft is cleaned		
		1.3. Piece/shaft is protected		

Learning outcome 3 end assessment

Theoretical assessment

1. Read carefully the following statement and answer by **TRUE** if the statement is **correct or FALSE** if the statement is **wrong.**

a) Proper mounting of a work-piece is critical for achieving precision, consistency, and safety in CNC machining.
Answer: TRUE

b) In the mounting process, positioning accuracy refers to how well the work-piece is aligned with the CNC machine's coordinate system.
Answer: TRUE

c) A vice clamping method involves using a suction system to hold the work-piece in place.
Answer: TRUE

d) Fixture plates are equipped with T-slots or mounting holes to attach various fixtures and clamping devices, providing a versatile mounting surface.
Answer: TRUE

e) Magnetic chucks are suitable for holding non-ferrous work-pieces due to their magnetic force**.**
Answer: FALSE

f) Tool breakage can be caused by excessive cutting forces or speeds that exceed the tool's designed capacity.
Answer: TRUE

g) Dimensional deviations in a machined part are only caused by errors in the CNC program.
Answer: FALSE

h) Regular monitoring and tracking of tool wear can help prevent unexpected tool failures.
Answer: TRUE

i) Polishing is generally used to remove scratches and blemishes while enhancing the surface shine.
Answer: **FALSE**

j) Honing is primarily used to improve the surface finish of external and internal cylindrical surfaces.
Answer: TRUE

k) Using cloth rags is suitable for removing large particles and debris from the surface of a part.
Answer: FALSE

l) Proper storage conditions include protecting the product from extreme temperatures, humidity, and corrosive elements.

Answer: **TRUE**

2. Read and match the techniques of apply Surface finishing in **column C**, with their description in **column B**, and provide answer in **Column A**

Column A: Answer	**Column B:** Description	**Column C:** techniques of apply Surface finishing
i….5…	1. Further refining and shining the surface using a soft wheel	I. Grinding
ii….3….	2. Precisely removing material to improve surface accuracy	ii. Polishing
iii……1….	3. Using a fine abrasive to produce a shiny surface	iii. Buffing
iv……2	4. Manual tool for finding workpiece edges; cost-effective but less accurate.	iv. Honing
	5. Smoothing the surface using an abrasive wheel	

3. Read the following statements and choose the letter corresponding to the right answer by encircling:

i. Which of the following is NOT a step in the preparation phase for producing a piece on a CNC machine?

a) Installing the appropriate cutting tools
b) Verifying the G-code program
c) Securing the work-piece onto the machine
d) Performing a safety check

Answer: B) Verifying the G-code program

ii. What is the purpose of setting the machine's coordinate system to zero during the setup phase?

a) To ensure that the machine knows where to start machining relative to the work-piece
b) To install the cutting tools correctly
c) To check the alignment of the machine
d) To load the G-code program into the machine's controller

Answer: A) To ensure that the machine knows where to start machining relative to the workpiece

iii. Which type of wear is caused by the friction between the cutting tool and the work-piece material?

a) Adhesive Wear
b) Chemical Wear
c) Abrasion Wear
d) Thermal Wear

Answer: C) Abrasion Wear

iv. Which of the following is the primary purpose of grinding in surface finishing?

a) To achieve a high-gloss finish on metals
b) To remove scratches and blemishes
c) To remove material and create a smooth surface with precise dimensions
d) To create a reflective surface using fine abrasives

Answer: C) To remove material and create a smooth surface with precise dimensions

v. Which cleaning method is most appropriate for removing large particles and debris from a part's surface?

a) Cleaning with cloth rags
b) Cleaning with a compressor
c) Polishing
d) Buffing

Answer: B) Cleaning with a compressor

vi. What is the primary function of rust prevention techniques?

a) To improve the surface texture and finish
b) To remove contaminants from the surface
c) To prevent the formation of rust or corrosion on metal parts
d) To enhance the appearance and remove blemishes

Answer C) To prevent the formation of rust or corrosion on metal parts

vii. Which method is used to make parts resistant to water damage?

a) Passivation
b) Using a polishing wheel
c) Applying waterproof sealants
d) Surface grinding

Answer: C) Applying waterproof sealants

Practical assessment

Your school is facing the issue of a car circular shaft with dimensions of 150 mm in length and 50 mm in diameter. The workshop assistant has decided to design a replacement shaft. Ask trainees to:

1. Mount the work piece in the CNC machine
2. Produce circular shaft/piece
3. Perform the finishing work

Checklist:

SN	Criteria	Indicators	Yes	No
1	Work piece is properly mounted	1.1. Work piece is positioned in CNC		
		1.2. Work piece is aligned		
		1.3. work piece is clamped		
2	Shaft/piece is correctly produced	2.1 Starting process is followed		
		2.2 CNC machine is monitored		
		2.3. Quality of shaft/piece is checked		
3	Piece/shaft is properly finished	3.1. Smooth surface is produced		
		3.2. Piece/shaft is cleaned		
		3.3. Piece/shaft is protected		

Further information to the trainer

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