Skilled Trades Ontario | Métiers spécialisés Ontario

# Apprenticeship Curriculum Standard

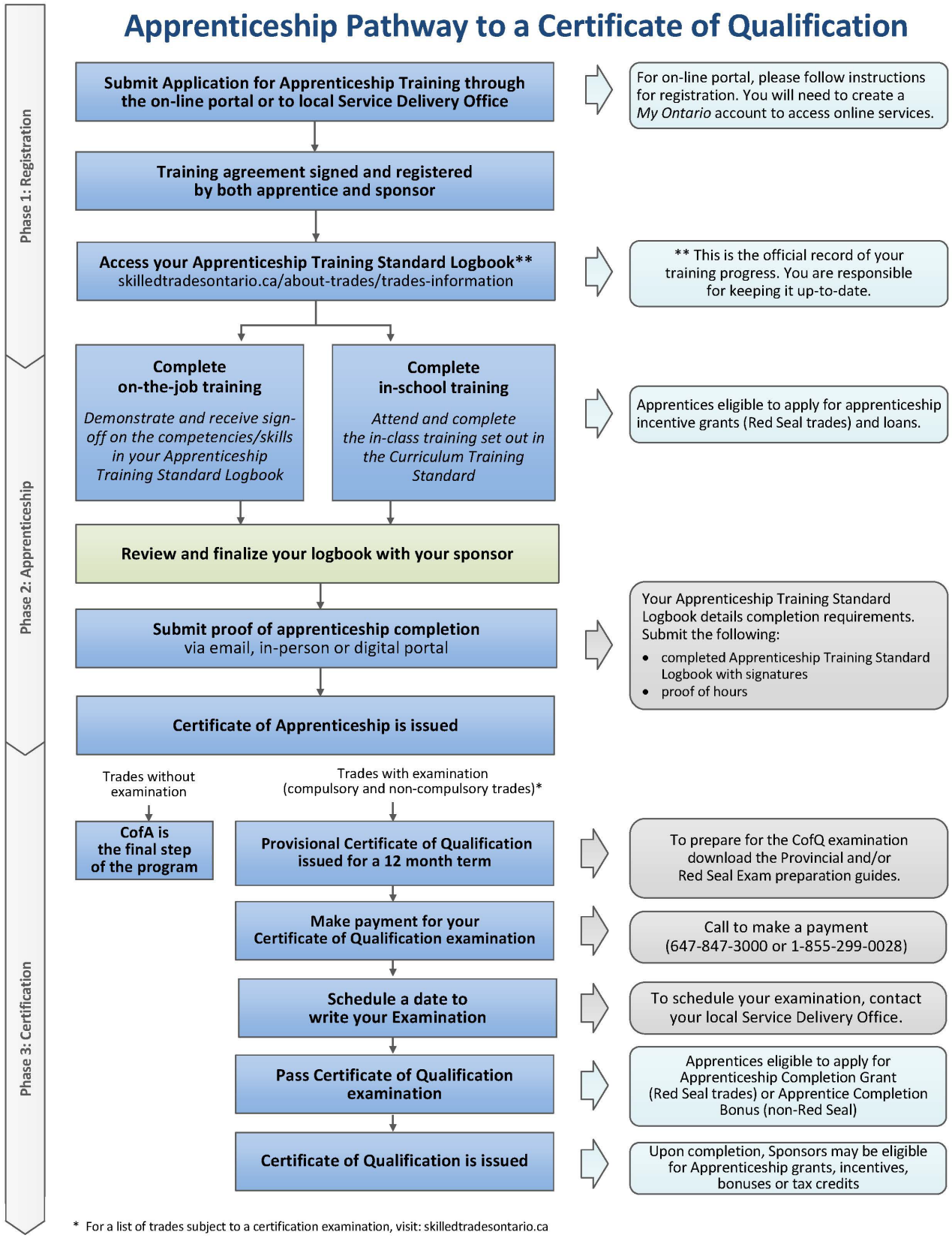
## General Machinist

## Level 2

429A

2008

# Apprenticeship Pathway to a Certificate of Qualification




* For a list of trades subject to a certification examination, visit: skilledtradesontario.ca

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**Please Note:** This Standard has been revised to reflect the visual identity of Skilled Trades Ontario (STO) which replaced the Ontario College of Trades on January 1, 2022. The content of this Standard may refer to the former organization; however, all trade specific information or content remains relevant and accurate based on the original date of publishing.

Please refer to STO's website: **skilledtradesontario.ca** for the most accurate and up to date information. For information about BOSTA and its regulations, please visit ***Building Opportunities in the Skilled Trades Act, 2021* (BOSTA).**

Any updates to this publication are available on-line; to download this document in PDF format, please follow the link: Skilled Trades Ontario.ca.



*Maintained with transfer to Skilled Trades Ontario 2008 (V100)*

## Preface

This curriculum standard for the Level 2 – General Machinist for the Machining and Tooling trades is based upon the on-the-job performance objectives, located in the industry-approved training standard.

The curriculum is organized into 3 levels of training. The Reportable Subjects Summary chart (located on page 2) summarizes the training hours for each reportable subject.

The curriculum identifies the learning that takes place in-school. The in-school program focuses primarily on the theoretical knowledge and the essential skills required to support the performance objectives of the Apprenticeship Training Standards.

Employers/Sponsors are expected to extend the apprentice's knowledge and skills through practical training on a work site. Regular evaluations of the apprentice's knowledge and skills are conducted throughout training to verify that all apprentices have achieved the learning outcomes identified in the curriculum standard.

It is not the intent of the in-school curriculum to perfect on-the-job skills. The practical portion of the in-school program is used to reinforce theoretical knowledge. Skill training is provided on the job.

Please refer to Skilled Trades Ontario website (www.skilledtradesontario.ca) for the most accurate and up-to-date information about Skilled Trades Ontario. For information on *Building Opportunities in the Skilled Trades Act, 2021 (BOSTA)*) and its regulations, please visit Building Opportunities in the Skilled Trades Act, 2021, S.O. 2021, c. 28 - Bill 288 (ontario.ca)

**Pre-requisites**

In order to advance to Level 2 of the apprenticeship program, an individual must have completed all of the units outlined in Level 1. Similarly, in order to advance to Level 3 of the program, an individual must have completed all of the units outlined in Level 1 and 2.

**Hours Disclaimer** (if applicable)

It is agreed that Training Delivery Agents (TDAs) may need to make slight adjustments (with cause) according to particular apprentice needs and may deviate from the unit sequencing and the prescribed practical and theoretical hours shown within the standard. However, all TDAs will comply with the hours at the reportable subject level.

Personal and Safety Equipment: Personal protective equipment is at the discretion of the TDA who must conform to Ontario Provincial Health and Safety Regulations.

**Reportable Subject Summary-Level 2**

| Number | Reportable Subjects | Hours Total | Hours Theory | Hours Practical |
|---|---|---|---|---|
| S0612 | Applied Trade Calculations, Charts and Tables | 36 | 36 | 0 |
| S0613 | Engineering Drawings, CAD Data, Layout Processes | 36 | 24 | 12 |
| S0614 | Metallurgy | 12 | 12 | 0 |
| S0615 | Metrology (Measuring and Checking) | 12 | 6 | 6 |
| S0616 | Turning Technology | 42 | 10 | 32 |
| S0617 | Milling Technology | 42 | 10 | 32 |
| S0618 | Cylindrical Grinding Technology | 24 | 6 | 18 |
| S0619 | CNC Turning Technology | 36 | 20 | 16 |
| | **Total** | **240** | **124** | **116** |

| | | | |
|---|---|---|---|
| Number: | S0612 | | |
| **Title:** | **Applied Trade Calculations, Charts, Tables** | | |
| Duration: | Total Hours: 36 | Theory: 36 | Practical: 0 |
| Prerequisites: | L1 CC: S0601, S0602, S0603, S0604, S0605, S0606,S0607, S0608, S0609, S0610, S0611 | | |
| Content: | S0612.1 | Solve trade-specific problems involving the Pythagorean Theorem and solve for unknown values. (7 hrs) | |
| | S0612.2 | Solve trade-specific problems involving right angle trigonometry and solve for unknown values. (7 hrs) | |
| | S0612.3 | Calculate the values of angles and sides of right angle triangles. (7 hrs) | |
| | S0612.4 | Solve trade-specific problems involving circles and solve for unknown values. (7 hrs) | |
| | S0612.5 | Perform calculations to produce parts. (8 hrs) | |
| **This module is intended to review appropriate mathematical principles as applied to trade-specific applications.** | | | |
| Evaluation & Testing: | Assignments related to theory and application skills<br>Minimum of one mid-term test during the term<br>Final test at end of term<br>Periodic quizzes | | |

| | |
|---|---|
| Instructional and Delivery Strategies: | Lecture<br>Video<br>Paper based material<br>CBT<br>Internet On-Line |
| Reference Materials: | Technology of Machine Tools<br>Shop Text Books<br>Mathematics for Machine Technology<br>Interpreting Engineering Drawings |

| | | | |
|---|---|---|---|
| Number: | S0612.0 | | |
| **Title:** | **Applied Trade Calculations, Charts, Tables** | | |
| Duration: | Total Hours: 36 | Theory: 36 | Practical: 0 |

Cross Reference to Training Standards: 429A: 5231, 5232, 5233, 5234, 5235, 5236, 5237, 5238, 5239

## General Learning Outcomes

Upon successful completion the apprentice is able to solve problems involving the Pythagorean Theorem; solve problems involving right angle trigonometry; describe the sides of a right angle triangle using trigonometric functions; calculate the values of angles and sides of right angle triangles; solve problems involving circles; and, perform trade-specific calculations.

## Learning Outcomes and Content

12.1 Solve trade-specific problems involving the Pythagorean Theorem and solve for unknown values. (7 hrs)

Describe the application of the Pythagorean Theorem.

Calculate the values of the unknown sides of right angle triangles using the Pythagorean Theorem.

12.2 Solve trade-specific problems involving right angle trigonometry and solve for unknown values. (7 hrs)

Describe definitions and relations of trigonometric functions:
- variations of trigonometric functions from 0° 90°
- fundamental relations between trigonometric functions
- definitions of trigonometric functions

Describe the sides of a right angle triangle using trigonometric functions:
- opposite
- adjacent
- hypotenuse
- sine
- cosine
- tangent
- cotangent
- secant
- cosecant

12.3 Calculate the values of angles and sides of right angle triangles. (7 hrs)

Perform trigonometric calculations of angles and sides of right angle triangles including:

- unknown side
- angle corresponding to a given trigonometric function
- angle when two sides of a right angle triangle are given
- rule for finding the function of an angle
- ratio method

12.4 Solve trade-specific problems involving circles and solve for unknown values. (7 hrs)

Describe a circle and the parts of a circle:

- circumference
- chord
- arc
- central angle
- tangent
- secant
- segment
- inscribed angle
- diameter
- radius

Calculate the values of unknown parts of a circle:

- angles formed inside a circle
- angles formed outside a circle
- internally tangent circles
- externally tangent circles

12.5 Perform calculations to produce parts. (8 hrs)

Perform calculations required to machine parts involving:

- tapers
- bevels
- isosceles triangles
- distance between holes
- distance between v-slots
- Vee-block applications
- dovetails

Select reference materials and tables/charts used to calculate machining parameters by determining:

- applications
- types
- format
- magnitudes and dimensions
- standards
- abbreviation
- terminology
- graduations
- accuracy
- limitations

Perform calculations for machining using reference material and charts/tables:

- taper calculation
- thread data
- thread measurement
- mathematical formulae
- three wire method

| **Evaluation Structure** | | |
|---|---|---|
| Theory Testing | Practical Application Testing | Final Assessment |
| 100% | 0% | 100% |

| | | |
|---|---|---|
| Number: | S0613 | |
| **Title:** | **Engineering Drawings, CAD Data, Layout Processes** | |
| Duration: | Total Hours: 36 | Theory: 24 Practical: 12 |
| Prerequisites: | L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 | |
| Content: | S0613.1 | Describe the graphic language and symbols of engineering drawings. (3 hrs) |
| | S0613.2 | Describe dimensional terminology, symbols, and practices. (5 hrs) |
| | S0613.3 | Describe orthographic projection and auxiliary views. (5 hrs) |
| | S0613.4 | Describe tolerance, allowance, and symbols as applied to the dimensioned features of a workpiece. (5 hrs) |
| | S0613.5 | Demonstrate sketching procedures for revolved, removed, partial, and broken-out sectional views. (8 hrs) |
| | S0613.6 | Describe the features, elements, and types of gears, cams, and bearings. (5 hrs) |
| | S0613.7 | Develop an operational plan for machining parts. (5 hrs) |
| Evaluation & Testing: | Assignments related to theory and application skills<br>Minimum of one mid-term test during the term<br>Final test at end of term<br>Periodic quizzes | |

| | |
|---|---|
| Instructional and Delivery Strategies: | Lecture<br>Video<br>Paper based material<br>CBT<br>Internet On-Line |
| Reference Materials: | Technology of Machine Tools<br>Shop Text Books<br>Mathematics for Machine Technology<br>Interpreting Engineering Drawings |

| | | | |
|---|---|---|---|
| Number: | S0613.0 | | |
| **Title:** | **Engineering Drawings, CAD Data, Layout Processes** | | |
| Duration: | Total Hours: 36 | Theory: 24 | Practical: 12 |

Cross Reference to Training Standards: 429A: 5231, 5232, 5233, 5234, 5235, 5236, 5237, 5238, 5239

## General Learning Outcomes

Upon successful completion the apprentice is able to describe engineering drawings graphic language and symbols, dimensional terminology, symbols, practices, orthographic projections and auxiliary views; describe dimensioned workpiece tolerances, allowances, and symbols; demonstrate sketching procedures for revolved, removed, partial and broken-out sectional views; describe the features, elements and types of gears, cams, and bearings; and develop an operational plan for machining parts.

## Learning Outcomes and Content

13.1 Describe the graphic language and symbols of engineering drawings. (3 hrs)

Describe the types of the graphic language and symbols of engineering drawings:

- detail
- assembly
- sub assembly
- working assemblies
- grade numbers
- location
- tolerancing methods
- features symbols
- surface texture
- not to scale

13.2 Describe dimensional terminology, symbols, and practices. (5 hrs)

Describe dimensional terms:

- break lines
- (PCD) pitch circle diameter
- (BCD) bolt circle diameter
- across flats
- pictorial
- schematic

Describe thread representations and designations:
- thread forms ISO
- acme
- square
- pipe
- whitworth
- metric

**Desc**ribe dimensioning methods:
- point-to-point
- datums
- tabular
- arrowless

Describe screw thread designations for CSA, ANSI, and ISO forms:
- nominal diameter
- outside diameter (O/D)
- turns per inch (TPI)
- pitch and pitch diameter
- class of fit
- external/internal
- left/right
- thread forms

Describe drawing elements related to workpiece processing techniques:
- welding symbols
- draft angles
- fillets and rounds
- un-machined dimensioned features
- nominal dimension
- surface texture
- machined surfaces

13.3 Describe orthographic projections and auxiliary views. (5 hrs)

Identify orthographic projections:
- first and third angle
- ISO orthographic projection symbol

Describe auxiliary views of orthographic projection.

Describe the basic function of an auxiliary view:
- angular position
- inclined surface
- true shape
- profile

Describe the types of auxiliary views:
- primary
- secondary
- sectional

Interpret engineering drawings to identify features of a finished component using first or third angle projection.

13.4 Describe tolerance, allowance, and symbols as applied to the dimensioned features of a workpiece. (5 hrs)

Describe engineering drawing dimensional terms:
- bilateral
- unilateral
- limits
- fits
- allowance
- clearance
- interference
- interchangeability
- nominal size
- basic size (hole/shaft)
- ANSI standards

13.5 Demonstrate sketching procedures for revolved, removed, partial, and broken- out sectional views. (8 hrs)

Sketch to scale sectional views:
- partial
- revolved
- removed
- offset
- aligned
- broken out

Describe sectional conventions:
- spokes
- ribs
- lugs

13.6 Describe features, elements and types of gears, cams, and bearings. (5 hrs)

Describe graphic language for gears, cams, and bearings:
- shape
- terminology
- symbols
- sizes

Interpret documentation to identify gear, cam, and bearing designations:
- addendum
- dedendum
- circular pitch
- diametral pitch
- clearance
- whole depth
- pressure angle
- rise
- follower
- fall
- anti-friction
- taper
- sleeve
- dwell

13.7 Develop an operational plan for machining parts. (5 hrs)

Interpret drawings to develop a plan for machining methods and procedures.

Interpret drawings to develop a plan for operational sequences.

| **Evaluation Structure** | | |
|---|---|---|
| Theory Testing | Practical Application Testing | Final Assessment |
| 67% | 33% | 100% |

| | | | |
|---|---|---|---|
| Number: | S0614 | | |
| **Title:** | **Metallurgy** | | |
| Duration: | Total Hours: 12 | Theory: 12 | Practical: 0 |
| Prerequisites: | L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 | | |
| Content: | S0614.1 | Describe safe working procedures associated with heat-treating furnaces and hand held equipment. (1 hr) | |
| | S0614.2 | Describe ferrous metal heat-treating processes. (4 hrs) | |
| | S0614.3 | Describe hardness testing methods. (3 hrs) | |
| | S0614.4 | Describe elements and machinability non-ferrous metals. (3 hrs) | |
| Evaluation & Testing: | Assignments related to theory and application skills<br>Minimum of one mid-term test during the term<br>Final test at end of term<br>Periodic quizzes | | |

| | |
|---|---|
| Instructional and Delivery Strategies: | Lecture<br>Video<br>Paper based material<br>CBT<br>Internet On-Line |
| Reference Materials: | Technology of Machine Tools<br>Shop Text Books<br>Interpreting Engineering Drawings |

| | | | |
|---|---|---|---|
| Number: | S0614.0 | | |
| **Title:** | **Metallurgy** | | |
| Duration: | Total Hours: 12 | Theory: 12 | Practical: 0 |
| Cross Reference to Training Standards: 429A: 5230, 5231, 5232, 5233 | | | |

**General Learning Outcomes**

Upon successful completion the apprentice is able to describe elements of non- ferrous metals and the heat-treating and testing of ferrous metal.

**Learning Outcomes and Content**

14.1 Describe safe working procedures associated with heat-treating furnaces and hand held equipment. (1 hr)

Describe furnace heat-treating safety procedures and equipment including:
- protective clothing
- protective equipment
- temperatures
- ventilation
- fire hazards

Describe hand held heat-treating safety procedures including:
- protective clothing
- protective equipment
- temperatures
- ventilation
- storage and handling of equipment
- fire hazards

14.2 Describe ferrous metal heat-treating processes. (4 hrs)

Describe flame hardening and tempering processes:
- tempering colours
- quenching media
- surface preparation
- workpiece holding/positioning

Describe the process for hardening of ferrous metals:

- heat-treating specifications
- metallurgical structural change
- maximum hardness
- strength
- toughness
- wear resistance
- machinability
- distortion
- work preparation procedures
- time-temperature cycle
- depth of hardness
- quenching procedures
- pre-heating
- cooling
- case hardening

Describe the process and advantages for pack carburizing of steel:

- heat-treating specifications
- carbon content
- hardenablity
- strength
- toughness
- wear resistance
- machinability
- type of furnace
- carbonaceous mixtures
- depth of case
- selective areas to be carburized
- time-temperature cycle

Describe the process and advantages for tempering of ferrous metals:

- heat-treating specifications
- metallurgical structural change
- hardness
- strength
- toughness
- wear resistance
- machinability
- type of furnace
- temperature colours
- workpiece application colours

Describe the process and advantages for annealing of ferrous metals:
- heat-treating and cooling procedures
- internal stresses
- machinability
- type of furnace

14.3 Describe hardness testing methods. (3 hrs)

Describe hardness testing methods and procedures.

Describe types and operating principles of hardness testers:
- Rockwell
- Brinell
- Vickers
- Scleroscope
- Scratch

Describe the range and values of hardness tester scales.

Describe equipment for hardness testers:
- penetrators
- anvils
- loads

14.4 Describe elements and machinability of non-ferrous metals. (3 hrs)

Describe non-ferrous metals:
- smelting and shaping process
- shapes
- sizes
- tolerances
- surface conditions
- SAE/ASTM code classifications
- manufacturers= code classifications
- applications
- chemical/physical properties
- alloying elements
- tensile strength
- malleability
- ductility
- machinability
- castability
- weight comparison

- hardness
- corrosion resistance
- wear resistance
- colour
- melting point

| Evaluation Structure | | |
|---|---|---|
| Theory Testing | Practical Application Testing | Final Assessment |
| 100% | 0% | 100% |

| | | |
|---|---|---|
| Number: | S0615 | |
| **Title:** | **Metrology (Measuring and Checking)** | |
| Duration: | Total Hours: 12 | Theory: 6 Practical: 6 |
| Prerequisites: | L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 | |
| Content: | S0615.1 | Identify the fundamentals of dimensional metrology. (1 hr) |
| | S0615.2 | Describe the fundamentals of measuring, checking, and gauging equipment. (1 hr) |
| | S0615.3 | Demonstrate measuring techniques using direct/indirect reading linear measuring equipment. (1 hr) |
| | S0615.4 | Describe measuring and checking procedures using inspection and checking gauges. (4 hrs) |
| | S0615.5 | Describe measuring and checking procedures using indicating gauges and comparators. (3 hrs) |
| | S0615.6 | Describe surface roughness measurement procedures. (2 hrs) |
| Evaluation & Testing: | Assignments related to theory and application skills<br>Minimum of one mid-term test during the term<br>Final test at end of term<br>Periodic quizzes | |

| | |
|---|---|
| Instructional and Delivery Strategies: | Lecture<br>Video<br>Paper based material<br>CBT<br>Internet On-Line |
| Reference Materials: | Technology of Machine Tools<br>Shop Text Books |

| | | | |
|---|---|---|---|
| Number: | S0615.0 | | |
| **Title:** | **Metrology (Measuring and Checking)** | | |
| Duration: | Total Hours: 12 | Theory: 6 | Practical: 6 |

Cross Reference to Training Standards: 429A: 5231, 5232, 5233, 5233.11, 5235.16, 5236.11, 5237.20, 5238.14, 5239.15

## General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate measuring techniques using inspection and checking gauges, direct/indirect reading linear and measuring equipment, and check surface roughness.

## Learning Outcomes and Content

15.1 Identify the fundamentals of dimensional metrology. (1 hr)

**Describe t**he fundamentals of dimensional metrology:

- accuracy
- precision
- tolerances
- reliability
- limits
- fits
- datums
- discrimination
- lengths/widths
- angular
- straight
- flat
- square
- round
- surface texture
- perpendicularity
- parallel

15.2 Describe fundamentals of measuring, checking, and gauging equipment. (1 hr)

Describe direct reading linear measuring equipment:
- depth micrometer
- interchangeable anvil micrometer
- bench micrometer
- thread micrometer
- indicating micrometer
- deep throat micrometer
- V-anvil micrometer
- disc micrometer
- blade micrometer
- tube micrometer
- wire micrometer
- gear tooth vernier caliper

Describe indirect reading angular equipment:
- sine plate
- toolmakers square
- precision level

Describe inspection and checking gauges:
- plug gauges
- ring gauges
- snap gauges
- profilometer
- precision rollers
- precision balls
- thread wires
- gear tooth rollers
- angular gauge blocks

15.3 Demonstrate measuring techniques using direct/indirect reading linear measuring equipment. (1 hr)

Demonstrate measuring techniques using direct reading linear measuring equipment.

Demonstrate measuring techniques using indirect reading angular equipment.

Demonstrate measuring techniques using inspection and checking gauges.

Demonstrate measuring techniques using indicating gauges.

15.4 Describe measuring and checking procedures using inspection and checking gauges. (4 hrs)

Describe cleaning techniques of calibrated test specimen surfaces.

Select inspection and checking gauges:
- gear forms (profiles)
- pitch diameters
- gear parts
- gear teeth

Demonstrate inspection and recording techniques.

Identify error sources in measurement techniques:
- inherent instrument error
- observational error
- manipulative error
- bias error
- parallelism error

15.5 Describe measuring and checking procedures using indicating gauges and comparators. (3 hrs)

Describe cleaning techniques of calibrated test specimen surfaces.

Describe features of a workpiece to be checked.

Describe indicating gauges and comparators:
- optical comparators
- mechanical comparator
- air gauges
- optical flats

Describe procedures for inspection and recording techniques.

15.6 Describe surface roughness measurement. (2 hrs)

Describe cleaning techniques of calibrated test specimen surface.

Describe surface roughness range.

Describe surface roughness measurement equipment:
- profilometer
- surface texture gauge

| Evaluation Structure | | |
|---|---|---|
| Theory Testing | Practical Application Testing | Final Assessment |
| 50% | 50% | 100% |

| | | | |
|---|---|---|---|
| Number: | S0616 | | |
| **Title:** | **Turning Technology** | | |
| Duration: | Total Hours: 42 | Theory: 10 | Practical: 32 |
| Prerequisites: | L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 | | |
| Content: | S0616.1 | Describe safe working procedures when setting up and operating a lathe. (0.5 hrs) | |
| | S0616.2 | Set up lathe workholding devices, attachments, and accessories. (8 hrs) | |
| | S0616.3 | Set up lathe threading and/or form cutting tools. (11 hrs) | |
| | S0616.4 | Develop a plan for producing threads, eccentrics, and grooves. (8 hrs) | |
| | S0616.5 | Perform turning. (14 hrs) | |
| | S0616.6 | Perform routine maintenance. (0.5 hrs) | |
| Evaluation & Testing: | Assignments related to theory and application skills<br>Minimum of one mid-term test during the term<br>Final test at end of term<br>Periodic quizzes | | |

| | |
|---|---|
| Instructional and Delivery Strategies: | Lecture<br>Video<br>Paper based material<br>CBT<br>Internet On-Line |
| Reference Materials: | Technology of Machine Tools<br>Shop Text Books |

| | | | |
|---|---|---|---|
| Number: | S0616.0 | | |
| **Title:** | **Turning Technology** | | |
| Duration: | Total Hours: 42 | Theory: 10 | Practical: 32 |
| Cross Reference to Training Standards: 429A: 5230, 5231, 5232, 5237 | | | |

**General Learning Outcomes**

Upon successful completion the apprentice is able to use a lathe to: drill and bore holes; turn internal and external recesses and grooves; part-off workpieces; turn internal tapers/angles; cut external and internal screw threads; and turn eccentrics.

**Learning Outcomes and Content**

16.1 Describe safe working procedures when setting up and operating a lathe. (0.5 hrs)

Identify potential hazards which may occur during a lathe set-up and operating procedures.

Demonstrate safe working habits including:
- protective clothing
- protective equipment and gear
- good housekeeping
- start up procedures
- shut off procedures
- securing workpiece
- stabilizing workpiece
- lock out procedures
- tagging procedures

16.2 Set up lathe workholding devices, attachments, and accessories. (8 hrs)

Identify lathe workholding devices, attachments, and accessories:
- face plates
- mandrels
- steady rests
- follower rests
- fixtures
- chucks

- radius attachment
- bungs and spigots
- tool post grinder
- tracing attachment

Demonstrate mounting, positioning, alignment, and securing procedures.

Demonstrate contact surface cleaning procedures.

16.3 Set up lathe threading and/or form cutting tools and tool holders. (11 hrs)

Describe cutting tool geometry (nomenclature).

Identify threading and/or cutting tools:
- right hand
- left hand
- form
- internal
- external

Demonstrate mounting, positioning, alignment, and securing procedures.

16.4 Develop a plan for producing threads, eccentrics, and grooves. (8 hrs)

Interpret drawings and/or process sheets to determine:
- workpiece material
- number of workpieces
- form and shape of workpiece
- machining operations
- tolerances
- surface finish
- machining sequence

Select lathe machining procedures:
- internal/external threading
- turning eccentrics
- forming

Identify lathe tools, workholding and tool holding devices, and accessories by determining:

- angular values for compound setting
- linear values on tailstock spindle
- steady rest clearance
- tool holding and support requirements
- boring bar characteristics
- workpiece characteristics
- four-jaw chucks
- face plate
- steady/follower rest
- bungs/spigots
- chip development and flow
- cutting edges and angles
- taper turning attachment

Select turning sequences by determining:

- workpiece material
- speeds and feeds
- lubricant
- tool characteristics
- rigidity of the tool and workpiece
- machine tool capacity

16.5 Perform turning. (14 hrs)

Demonstrate drilling and boring of holes.

Demonstrate turning of internal and external recesses, grooves, and the parting-off of workpieces.

Demonstrate turning of internal tapers/angles.

Demonstrate cutting external and internal screw threads.

Demonstrate turning of eccentrics.

16.6 Perform routine maintenance. (0.5 hrs)

Demonstrate maintenance and cleaning procedures.

Demonstrate lubrication procedures.

Demonstrate dismantling, handling and storage of tools, tooling, workholding devices, and measuring instruments.

| **Evaluation Structure** | | |
|---|---|---|
| Theory Testing | Practical Application Testing | Final Assessment |
| 25% | 75% | 100% |

| | | |
|---|---|---|
| Number: | S0617 | |
| **Title:** | **Milling Technology** | |
| Duration: | Total Hours: 42 | Theory: 10 Practical: 32 |
| Prerequisites: | L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 | |
| Content: | S0617.1 | Describe safe working procedures when setting up and operating milling machines. |
| | S0617.2 | Identify vertical milling machine controls and attachments. (3 hrs) |
| | S0617.3 | Describe components of a horizontal milling machine. (2 hrs) |
| | S0617.4 | Demonstrate the setting up of horizontal milling workholding devices and accessories. (9 hrs) |
| | S0617.5 | Assemble cutting tools and tool holders for horizontal milling. (8 hrs) |
| | S0617.6 | Develop a plan for horizontal milling. (5 hrs) |
| | S0617.7 | Perform milling. (14 hrs) |
| | S0617.8 | Perform routine maintenance. (1 hr) |
| Evaluation & Testing: | Assignments related to theory and application skills<br>Minimum of one mid-term test during the term<br>Final test at end of term<br>Periodic quizzes | |

| | |
|---|---|
| Instructional and Delivery Strategies: | Lecture<br>Video<br>Paper based material<br>CBT<br>Internet On-Line |
| Reference Materials: | Technology of Machine Tools<br>Shop Text Books |

| | | | |
|---|---|---|---|
| Number: | S0617.0 | | |
| **Title:** | **Milling Technology** | | |
| Duration: | Total Hours: 42 | Theory: 10 | Practical: 32 |
| Cross Reference to Training Standards: 429A: 5230, 5231, 5232, 5238 | | | |

**General Learning Outcomes**

Upon successful completion the apprentice is able to mill horizontal, vertical, and angular flat surfaces; mill forms using form cutters; bore holes; drill and ream holes, and, mill geometric shapes using a rotary table on a dividing head.

**Learning Outcomes and Content**

17.1 Describe safe working procedures when setting up and operating milling machines.

Identify potential safety hazards which may occur during milling set-up and operating procedures.

Demonstrate safe working habits including:
- protective clothing
- protective equipment and gear
- good housekeeping
- start up procedures
- shut off procedures
- securing workpiece/cutting tool
- stabilizing of workpiece/cutting tool
- lock out procedures
- tagging procedures

17.2 Identify vertical milling machine controls and attachments. (3 hrs)

Identify parts of vertical milling machines:
- base
- column
- knee
- saddle
- table
- ram and turret
- spindle feed

- table feed
- vertical feed
- tool head feed
- slide locks

17.3 Describe components of a horizontal milling machine. (2 hrs)

Describe horizontal milling components:
- over arm
- arbor support
- slotting attachment
- stub boring bar

Identify horizontal milling machine switches, selectors, and controls:
- on and off switch
- start and stop switch
- spindle speed selector
- table feed
- cross slide feed
- rapid traverse motion
- back lash eliminator
- feed selector
- coolant switch
- reverse switch

Determine and select cutting fluids.

Describe horizontal milling machine attachments:
- vertical attachment
- digital read-outs
- slotting head
- universal boring head

17.4 Demonstrate the setting up of horizontal milling workholding devices and accessories. (9 hrs)

Identify horizontal milling workholding devices:
- plain vise
- swivel base vise
- universal vise
- vise accessories
- angle plates

- Vee-blocks
- adjustable stops
- screw jacks
- parallels
- fixtures
- clamping accessories

Identify set-up procedures for workholding devices.

Describe horizontal milling workholding devices:
- dividing head
- rotary table

Demonstrate contact surface cleaning procedures.

Demonstrate setting up of workholding devices:
- mounting
- positioning
- aligning
- securing

17.5 Assemble cutting tools and tool holders for horizontal milling. (8 hrs)

Describe milling cutting tool geometry (nomenclature).

Identify horizontal milling cutting tools and tool holders:
- plain cutter
- side cutter
- angular cutter
- slitting saws
- indexable inserts
- key seat cutter
- dovetail cutter
- arbors
- form cutter

Select cutting tools and tool holders for horizontal milling by determining:
- type
- size
- cutting tool material
- shape
- application

- operating principles
- holding/mounting characteristics
- cutting and shaping characteristics
- tolerances
- surface finish required
- workpiece material

17.6 Develop a plan for horizontal milling. (5 hrs)

Interpret drawings and/or process sheets to determine:
- workpiece material
- number of workpieces
- form and shape of workpiece
- machining operations
- tolerances
- surface finish
- machining sequences

Select milling procedures:
- horizontal, vertical, and angular flat surfaces
- forms
- straddle milling
- gang milling
- bore holes
- slotting

Select horizontal milling machine by determining:
- size and cutting capacity
- cutting parameters
- operating principles
- speed and feed
- micrometer collar graduations
- vertical attachments
- cutting fluid requirements
- table and saddle locking devices
- workpiece characteristics
- workholding requirements
- set-up rigidity
- tool rotation direction

- type and depth of cut
- operational clearances

Select horizontal mill workholding device.

Select horizontal milling cutting tools and tool holding devices.

Identify measuring and checking procedures.

17.7 Perform milling. (14 hrs)

Demonstrate milling of vertical or angular flat surfaces.

Demonstrate milling of forms using form cutters.

Demonstrate boring holes.

Demonstrate drilling and reaming holes.

Demonstrate milling of geometric shapes using direct, simple, and/or angular indexing with a rotary table with a vertical or horizontal mill.

Demonstrate milling of geometric shapes using direct, simple, and/or angular indexing on a dividing head on vertical or horizontal mill.

17.8 Perform routine maintenance. (1 hr)

Demonstrate routine maintenance and cleaning procedures.

Demonstrate lubrication procedures.

Demonstrate dismantling, handling, and storage of tools, tooling, workholding devices, and measuring equipment.

| **Evaluation Structure** | | |
|---|---|---|
| Theory Testing | Practical Application Testing | Final Assessment |
| 25% | 75% | 100% |

| | | |
|---|---|---|
| Number: | S0618 | |
| **Title:** | **Cylindrical Grinding Technology** | |
| Duration: | Total Hours: 24 | Theory: 6 Practical: 18 |
| Prerequisites: | L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 | |
| Content: | S0618.1 | Describe safe working procedures when setting up and operating grinders. |
| | S0618.2 | Set up cylindrical grinder machine controls and coolant. (3 hrs) |
| | S0618.3 | Set up cylindrical grinder workholding devices, accessories, and attachments. (3 hrs) |
| | S0618.4 | Describe mounting and truing and dressing of grinding wheels. (3 hrs) |
| | S0618.5 | Develop a plan for cylindrical grinding. (3 hrs) |
| | S0618.6 | Perform cylindrical grinding. (11 hrs) |
| | S0618.7 | Perform routine maintenance. (1 hr) |
| Evaluation & Testing: | Assignments related to theory and application skills<br>Minimum of one mid-term test during the term<br>Final test at end of term<br>Periodic quizzes | |

| | |
|---|---|
| Instructional and Delivery Strategies: | Lecture<br>Video<br>Paper based material<br>CBT<br>Internet On-Line |
| Reference Materials: | Technology of Machine Tools<br>Shop Text Books |

| | | | |
|---|---|---|---|
| Number: | S0618.0 | | |
| **Title:** | **Cylindrical Grinding Technology** | | |
| Duration: | Total Hours: 24 | Theory: 6 | Practical: 18 |
| Cross Reference to Training Standards: 429A: 5230, 5231, 5232, 5236 | | | |

**General Learning Outcomes**

Upon successful completion the apprentice is able to cylindrical grind: external parallels; external tapers; profiles; and plunge grinding.

**Learning Outcomes and Content**

18.1 Describe safe working procedures when setting up and operating grinders.

Identify potential safety hazards which may occur during a grinder set-up and operating procedures.

Describe safe working habits including:

- protective clothing
- protective equipment and gear
- good housekeeping
- start up procedures
- shut off procedures
- securing workpiece
- stabilizing of workpiece
- guards and dust extraction system
- dressing grinding wheel
- inspection of grinding wheel
- lock out procedures
- maximum wheel rpm
- ring test of wheel
- lock-out procedures
- tagging procedures

18.2 Set up cylindrical grinder machine controls and coolants. (3 hrs)

Describe parts of cylindrical grinder:
- in-feed control
- table
- bedways
- base
- wheelhead
- table traverse mechanism
- trip dogs
- saddle
- footstock
- swivel table adjustment
- workhead

Set up cylindrical grinder controls:
- main switch
- stop-start switch
- table traverse
- in-feed selection
- cross-feed
- wheel feed
- cutting fluid
- table dwell
- workhead speed

Set up external grinder controls by determining:
- workhead speeds
- feeds
- grinder controls/switches
- table travel motions

Describe cutting fluids including:
- soluble oils
- synthetics
- semi-synthetics

18.3 Set up cylindrical grinder workholding devices, accessories, and attachments. (3 hrs)

Identify cylindrical grinder workholding devices, accessories, and attachments:

- centres
- steady rest
- centre rest
- back rest
- footstock
- magnetic chuck
- mandrels
- arbors
- radius wheel dresser
- tangent wheel dresser
- wheel dressing attachment
- crush roll forming attachment

Set up cylindrical grinder workholding devices, accessories, and attachments by determining:

- type
- size
- function
- workpiece characteristics
- holding characteristics
- mounting characteristics
- type of wheel
- handling
- storing
- maintenance

Demonstrate contact surface cleaning procedures.

Describe magnetizing procedures for permanent and/or electro magnetic chucks.

Describe procedures for demagnetizing the workpiece.

Demonstrate mounting, positioning, aligning, and securing procedures.

18.4 Describe mounting, truing, and dressing of grinding wheels. (3 hrs)

Demonstrate dressing of grinding wheel.

Describe mounting, truing, and balancing of wheel.

Describe dressing for side grinder/form grinding.

Describe radius tangent wheel dresser.

18.5 Develop a plan for cylindrical grinding. (3 hrs)

Select cylindrical grinding procedures:
- plunge
- crush roll forming
- profile
- parallel/traverse
- external taper

Select grinder workholding devices and accessories.

Select cylindrical grinder.

Describe measuring and checking techniques.

18.6 Perform cylindrical grinding. (11 hrs)

Demonstrate external parallel grinding.

Demonstrate external taper grinding.

Demonstrate cylindrical grinding of profiles.

Demonstrate plunge grinding.

18.7 Describe routine maintenance. (1 hr)

Describe routine maintenance and cleaning procedures.

Describe lubrication procedures.

Describe dismantling, handling, and storage of tools, tooling, and measuring equipment.

| **Evaluation Structure** | | |
|---|---|---|
| Theory Testing | Practical Application Testing | Final Assessment |
| 25% | 75% | 100% |

| | | | |
|---|---|---|---|
| Number: | S0619 | | |
| **Title:** | **CNC Turning Technology** | | |
| Duration: | Total Hours: 36 | Theory: 20 | Practical: 16 |
| Prerequisites: | L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 | | |
| Content: | S0619.1 | Describe safe working procedures when setting up and operating CNC turning centres. | |
| | S0619.2 | Describe operating principles and applications of CNC turning centres. (1 hr) | |
| | S0619.3 | Describe the basics of CNC dimensioning. (1.5 hrs) | |
| | S0619.4 | Describe part programming methods, set-up sheets, tooling lists, part program manuscripts, and input media. (4.5 hrs) | |
| | S0619.5 | Describe manual operation systems for CNC turning centres. (5 hrs) | |
| | S0619.6 | Develop a plan for CNC programming a turning centre. (5 hrs) | |
| | S0619.7 | Demonstrate procedures for entering and verifying programs for CNC turning centres to perform linear and circular machining. (19 hrs) | |
| Evaluation & Testing: | Assignments related to theory and application skills<br>Minimum of one mid-term test during the term<br>Final test at end of term<br>Periodic quizzes | | |

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
CBT
Internet On-Line

Reference Materials:
Technology of Machine Tools
Shop Text Books

| | | | |
|---|---|---|---|
| Number: | S0619.0 | | |
| **Title:** | **CNC Turning Technology** | | |
| Duration: | Total Hours: 36 | Theory: 20 | Practical: 16 |
| Cross Reference to Training Standards: 429A: 5230, 5231, 5232, 5239 | | | |

**General Learning Outcomes**

Upon successful completion the apprentice is able to describe numerically controlled turning centre procedures and demonstrate procedures for entering and verifying CNC programs.

**Learning Outcomes and Content**

19.1 Describe safe working procedures when setting up and operating CNC turning centres.

Identify potential safety hazards which may occur during CNC turning centre machine set-up and operating procedures.

Demonstrate safe working habits including:
- protective clothing
- protective equipment and gear
- good housekeeping
- start-up procedures
- shut-off procedures
- securing tooling
- securing accessories
- stabilizing workpiece
- securing workpiece
- lock-out procedures

19.2 Describe operating principles and applications of CNC turning centres. (1 hr)

Identify the capabilities of CNC turning centres:
- types of equipment
- editing capability
- program path ability
- processing power

Describe CNC turning centre controls:
- CNC controls
- tapeless control
- PC/DNC systems

Describe features and functions of turning centres:
- CPU
- input devices
- turret
- work envelope
- holding devices
- alarms
- safety interlock

Describe the major features of a CNC manufacturing process:
- engineering drawing
- CNC part program
- input media
- CNC machine tool
- finished part
- repeatability

19.3 Describe the basics of CNC dimensioning. (1.5 hrs)

Describe the Cartesian Coordinate System:
- quadrant notation
- point location in XZ plane

Describe machine tool axis designations:
- primary linear axis
- secondary linear axis
- axis orientation

Identify types of machine zero point locations:
- fixed zero points
- full zero shift
- floating zero

Determine set-up point locations by determining:
- machine home position
- absolute zero position
- Z axis touch-off points

Describe the capabilities of positioning and contouring using CNC lathes:
- linear interpolation
- circular interpolation

Describe use of dimensioning practices:
- baseline (datum) dimensioning
- relative (chain) dimensioning

Describe the set-up and programming practices (fixed cycles) of single point threading:
- part programming using G76 threading cycle
- part programming using G32 threading cycle
- cutting multiple lead threads
- taper threads

19.4 Describe part programming methods, set-up sheets, tooling lists, part program manuscripts, and input media. (4.5 hrs)

Identify documentation for CNC machining processes:
- set-up sheet
- tooling list
- part program manuscript
- input media

Describe the individual components of a part program manuscript:
- sequence numbers
- preparatory functions
- axis motions
- feed rates
- spindle speeds
- tool numbers
- miscellaneous functions

Describe additional word and block structures that exist within the part program code:
- leading zero suppression
- trailing zero suppression
- decimal point programming
- block delete
- comments

Describe the individual components of a set-up sheet:
- part zero position
- part location

Describe the individual components of a tooling list:
- tool type
- tool number
- tool offset X & Z

Describe the common means of producing part program files:
- manual programming
- CAM systems
- conversational programming

19.5 Describe manual operation systems for CNC turning centres. (5 hrs)

Describe manual interruption:
- single block operation
- feedhold
- emergency stop

Describe manual data input (MDI):
- line command execution
- set-up applications

Describe practical applications of the program data override:
- rapid motion override
- spindle speed override
- feedrate override
- dry run operation
- manual absolute setting

Describe interfacing to peripherals:
- RS-232C Interface
- PC/DNC

19.6 Develop a plan for CNC programming of a turning centre. (5 hrs)

Identify CNC machine to produce job:
- machine tool type
- CNC system

Interpret CNC documentation and data to determine:
- workpiece material specifications
- methods or routing instructions

Plan sequence of machining by identifying:
- order of operations
- tooling requirements
- workpiece set-up

19.7 Demonstrate procedures for entering and verifying programs for CNC turning centres to perform linear and circular machining. (19 hrs)

Demonstrate use of preparatory commands:
- modality of G-Codes
- conflicting commands
- order in a block

Demonstrate use of M-codes:
- typical M-codes
- M-codes in a block

Demonstrate use of codes to specify dimensions:
- metric/inch selection
- absolute data input
- incremental data input
- combination in the same program
- diameter programming
- leading and trailing zeros input

Demonstrate use of codes to specify word and block structures:
- program identification
- O-block ISO and EIA identification
- block number
- N-word
- starting number
- increments
- end of block
- carriage return
- semi-colon
- block description
- status block (safe block)

- message block (program comments)
- conflicting words
- modal programming values
- execution priority

Demonstrate use of codes to specify tool function:

- tool offset registration
- lathe application
- tool number
- offset number

Demonstrate use of codes to specify speeds and feeds:

- S-code
- spindle rotation direction
- spindle stop
- spindle speed (rpm)
- feedrate control
- feedrate function
- feedrate per minute
- feedrate per revolution
- feedrate override and feedhold
- feedrate override and functions
- maximum feedrate per revolution

Demonstrate use of codes to specify reference points:

- machine reference point
- manufacturers' setting
- workpiece reference point
- program zero application
- tool reference point
- at the tip
- position register command
- G54 command

Demonstrate use of codes to establish tool compensation:

- general concepts
- difference in tool length
- length from tool tip
- present tool length

Demonstrate use of codes to invoke zero return commands:
- return to machine zero

Demonstrate use of codes for rapid positioning:
- rapid traverse motion
- positioning mode
- G00 command
- tool path
- workpiece approach
- single axis motion
- multi-axis motion
- straight angular motion
- type of motion
- rapid motion formulas
- axis motion completion
- reduction of rapid motion rate

Demonstrate use of codes to create contouring programs:
- linear interpolation
- G01 command
- single axis motion
- interpolation in two axes
- circulation interpolation
- programming format
- direction of motion (G02 and G03)
- start and end point of an arc
- blend radius
- feedrate for circular motion
- rough and finished shape
- methods of calculations
- work sketch and calculations
- sheet of coordinates

Demonstrate entering and verifying programs:
- rough turn
- finish turn
- groove
- thread

Demonstrate downloading of programs:
- feeds
- speeds
- overrides
- axis selection
- mode selection

Demonstrate manual program execution:
- manual data input
- handle controls
- emergency stop buttons
- cancel switches
- cycle start
- feedhold
- single block

| **Evaluation Structure** | | |
|---|---|---|
| Theory Testing | Practical Application Testing | Final Assessment |
| 55% | 45% | 100% |

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