Skilled Trades Ontario | Métiers spécialisés Ontario

Apprenticeship Curriculum Standard

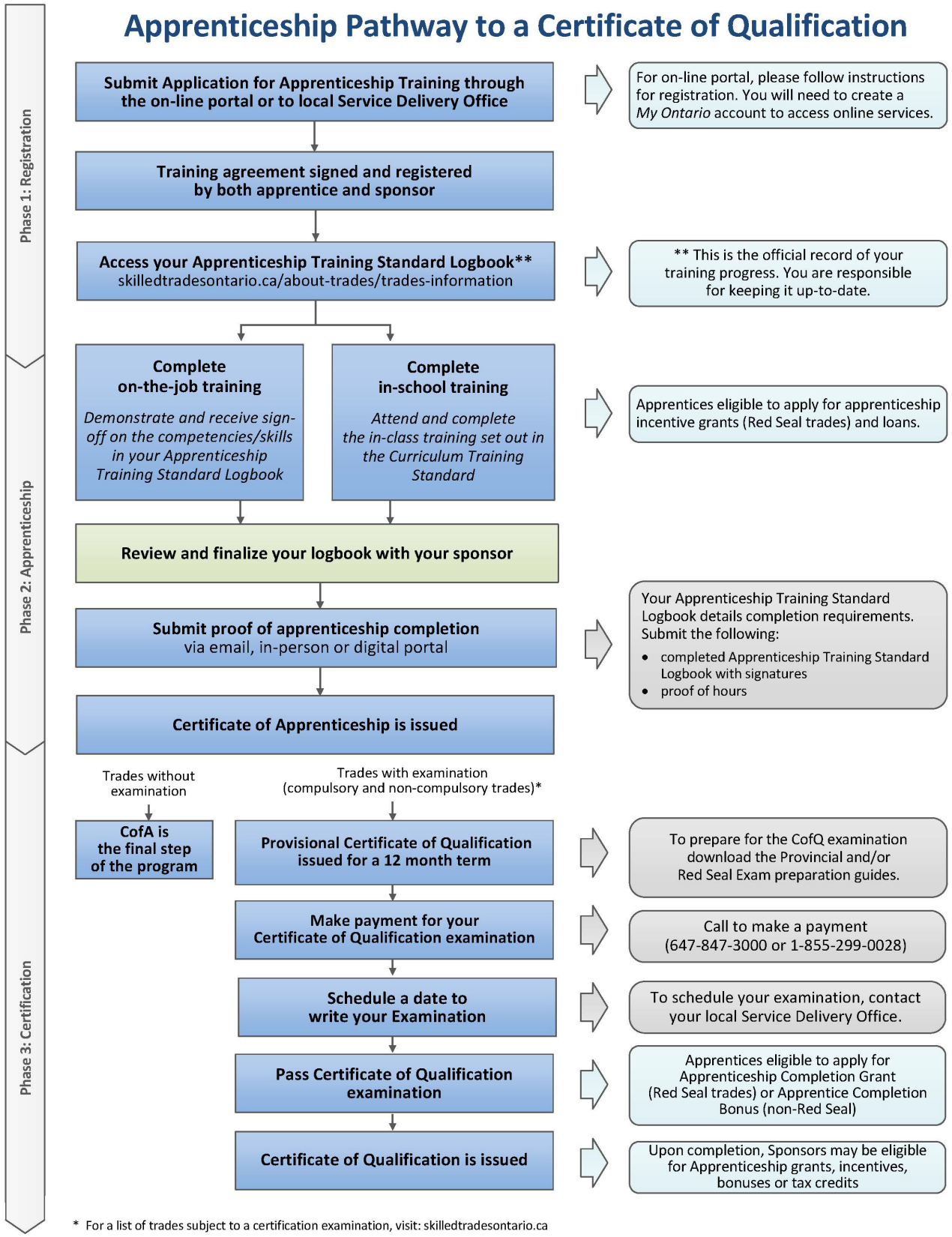
General Machinist

Level 3-Advanced

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 3 – General Machinist for the Machining and Tooling trade program 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 3

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
S0620	Applied Trade Calculations, Charts, Tables	36	36	0
S0621	Complex Engineering Drawings/ CAD Data	42	24	18
S0622	Metallurgy	6	6	0
S0623	Metrology (Measuring and Checking)	6	6	3
S0624	Complex Turning Technology	42	10	32
S0625	Complex Milling Technology	42	10	32
S0626	Complex Grinding Technology	18	6	12
S0627	Machining Centre CNC Technology	48	24	24
	Total	**240**	**129**	**121**

Number:	S0620	
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, L2: S0612; S0613, S0614, S0615, S0616, S0617, S0618, S0619	
Content:	S0620.1	Solve trade-specific problems involving oblique triangles and solve for unknown values. (9 hrs)
	S0620.2	Solve trade-specific problems involving the law of sines and solve for unknown values. (9 hrs)
	S0620.3	Solve trade-specific problems involving the law of cosines and cotangents and solve for unknown values. (9 hrs)
	S0620.4	Solve trade-specific problems involving compound angles. (9 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 Minimum of one mid-term test during the term Final test at end of term Periodic quizzes	

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

Number:	S0620.0		
Title:	**Applied Trade Calculations, Charts, Tables**		
Duration:	Total Hours: 36	Theory: 36	Practical: 0
Cross Reference to Training Standards: GM 5231, U5232, U5233, U5234, U5235, U5236, U5237, U5238, U5239			

General Learning Outcomes

Upon successful completion the apprentice is able to solve problems involving oblique triangle, law of sines, law of cosines/cotangents, and compound angles.

Learning Outcomes and Content

20.1 Solve trade-specific problems involving oblique triangles and solve for unknown values. (9 hrs)

Describe an oblique triangle.

Calculate the values of the unknown sides of oblique triangles.

20.2 Solve trade-specific problems involving the law of sines and solve for unknown values. (9 hrs)

Describe law of sines.

Calculate the values of unknown sides and angles of oblique triangles using the law of sines:
- values of two angles and one side
- values of two sides and one angle

20.3 Solve trade-specific problems involving the law of cosines and cotangents and solve for unknown values. (9 hrs)

Describe the law of cosines and cotangents.

Calculate the values of the unknown sides and angles of oblique triangles using the law of cosines and cotangents:
- values of two sides and the included angle
- values of three sides

20.4 Solve trade-specific problems involving compound angles. (9 hrs)

Describe compound angles.

Calculate the values of compound angles for tilt and rotation.

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

Number:	S0621	
Title:	**Complex Engineering Drawings/CAD DATA**	
Duration:	Total Hours: 42	Theory: 24 Practical: 18
Prerequisites:	L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 L2: S0612; S0613, S0614, S0615, S0616, S0617, S0618, S0619	
Content:	S0621.1	Identify sectional views. (2 hrs)
	S0621.2	Describe the ISO system of limits and fits as applied to features of a workpiece. (8 hrs)
	S0621.3	Describe geometric dimensioning and tolerancing symbols and terminology. (30 hrs)
	S0621.4	Interpret geometric drawing symbols. (2 hrs)
Evaluation & Testing:	Assignments related to theory and application skills Minimum of one mid-term test during the term Final test at end of term	

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

Number:	S0621.0		
Title:	**Complex Engineering Drawings/CAD Data**		
Duration:	Total Hours: 42	Theory: 24	Practical: 18

Cross Reference to Training Standards: GM 5231, U5232, U5233, U5234, U5235, U5236, U5237, U5238, U5239

General Learning Outcomes

Upon successful completion the apprentice is able to read and interpret geometric tolerancing and dimensioning on engineering drawings/CAD data.

Learning Outcomes and Content

21.1 Identify sectional views. (2 hrs)

Identify sectional conventions.

21.2 Describe the ISO system of limits and fits as applied to features of a workpiece. (8 hrs)

Describe ISO, standard limits, and fits:
- designation
- description
- clearance
- interference
- interchangeability
- nominal size
- standards

21.3 Describe geometric dimensioning and tolerancing symbols and terminology. (30 hrs)

Describe geometric dimensional and tolerancing terminology:
- regardless of feature size
- least material condition
- basic dimension
- datums
- feature control frame
- general rules
- virtual condition

- symbols
- individual and related features
- terms
- maximum material condition
- flatness
- straightness
- circularity
- cylindricity
- profile of a line
- profile of a surface
- perpendicularity
- angularity
- parallelism
- circular runout
- position
- concentricity
- coplanarity
- symmetry
- datum targets
- correlative tolerance

Describe geometric form control symbols:
- flatness
- straightness
- circularity
- cylindricity

Describe geometric profile control symbols:
- profile of a line
- profile of a surface

Describe geometric orientation control symbols:
- perpendicularity
- angularity
- parallelism

Describe geometric run-out control symbols:
- circular
- total

Describe geometric location control symbols:
- position
- concentricity
- symmetry

Describe geometric control symbols:
- coplanarity
- correlative tolerance

Describe geometric datum control:
- symbol
- target point
- target area
- line

Describe the feature control frame and the order of elements.

Describe the supplementary symbols:
- diameter
- radius
- reference
- counterbore/spotface
- square
- dimension origin
- projected tolerance zone
- spherical diameter
- spherical radius
- arc length
- counter sink
- depth
- conical taper

Describe datums:
- primary
- secondary
- tertiary
- axis
- minimum location points
- datum precedence

Describe material condition symbols:
- maximum material condition (MMC)
- regardless of feature size (RFS)
- least material condition (LMC)

Describe maximum material condition, least material condition, and regardless of feature size, with reference to the size of mating parts.

Describe virtual condition and the application to gauge design:
- in relation to MMC
- in relation to LMC
- in relation to RFS
- with respect to holes
- with respect to shafts

Describe positional tolerances to hole locations:
- bonus tolerance
- basic size
- assembly of two plates with floating fasteners
- assembly with a fixed and floating fastener

21.4 Interpret geometric drawing symbols. (2 hrs)

Interpret geometric engineering drawing symbols:
- location
- datum
- target

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
58%	42%	100%

Number:	S0622	
Title:	**Metallurgy**	
Duration:	Total Hours: 6	Theory: 6 Practical: 0
Prerequisites:	L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 L2: S0612; S0613, S0614, S0615, S0616, S0617, S0618, S0619	
Content:	S0622.1	Describe safe working procedures when working with heat-treating equipment.
	S0622.2	Describe ferrous metal heat-treating processes. (4 hrs)
	S0622.3	Describe the properties and characteristics of non-metallic materials. (2 hrs)
Evaluation & Testing:		Assignments related to theory and application skills Minimum of one mid-term test during the term Final test at end of term 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:	S0622.0		
Title:	**Metallurgy**		
Duration:	Total Hours: 6	Theory: 6	Practical: 0
Cross Reference to Training Standards: GM U5230, U5231, U5232, U5233			

General Learning Outcomes

Upon successful completion the apprentice is able to describe ferrous heat-treating processes and the characteristics of non-metallic materials.

Learning Outcomes and Content

22.1 Describe safe working procedures associated with heat-treating furnaces and hand held equipment.

Describe heat-treating safety procedures and equipment including:
- protective clothing
- protective equipment and gear
- good housekeeping
- temperatures
- ventilation
- fire hazards
- storage and handling of equipment

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

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

Describe the process and advantages of nitriding alloy steels:
- heat-treating specifications
- nitriding process
- types of alloy steels
- toughness

- wear resistance
- machinability
- type of furnace
- depth of hardness
- quenching media and procedures

Describe the process and advantages of gas carburizing parts:

- types of gases
- hardness
- toughness
- strength
- type of furnace
- quenching media and procedures
- heat-treating specification
- machinability
- type of metal

Describe the process and advantages of liquid carburizing of steel:

- heat-treating specifications
- quenching media and procedures
- hardness
- toughness
- strength
- materials

Describe the process and advantages of induction hardening:

- heat-treating specifications
- type of metal
- depth of hardness
- frequency levels
- toughness
- strength
- quenching media and procedures

22.3 Describe the properties and characteristics of non-metallic materials. (2 hrs)

Describe the properties and characteristics of non-metallic materials:

- composites
- fiberglass
- carbon fiber
- plastics
- ceramics
- chemical
- physical
- mechanical
- optical
- shapes
- sizes
- tolerances
- surface conditions
- SPE code classifications
- heating response
- machinability
- applications
- surface finish
- fumes

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

Number:	S0623	
Title:	**Metrology (Measuring and Checking)**	
Duration:	Total Hours: 6	Theory: 3 Practical: 3
Prerequisites:	L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 L2: S0612; S0613, S0614, S0615, S0616, S0617, S0618, S0619	
Content:	S0623.1	Describe safe working procedures when setting up and operating measuring and checking equipment.
	S0623.2	Describe the fundamentals of measuring, checking, and gauging equipment. (1 hr)
	S0623.3	Describe the components, adjusting mechanisms, and working principles of an optical comparator. (1 hr)
	S0623.4	Set up workholding devices and accessories for an optical comparator. (0.5 hrs)
	S0623.5	Describe terminology and measuring techniques for an optical comparator. (0.5 hrs)
	S0623.6	Demonstrate operational procedures for an optical comparator. (1 hr)
	S0623.7	Demonstrate measuring and checking techniques using an optical comparator. (1 hr)
	S0623.8	Describe the functions and operating principles of Coordinate Measuring Machines (CMM). (1 hr)
Evaluation & Testing:	Assignments related to theory and application skills Minimum of one mid-term test during the term Final test at end of term 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:	S0623.0		
Title:	**Metrology (Measuring and Checking)**		
Duration:	Total Hours: 6	Theory: 3	Practical: 3
Cross Reference to Training Standards: GM U5231, U5232, U5233, U5233.11, U5235.16, U5236.11, U5237.20, U5238.14, U5239.15			

General Learning Outcomes

Upon successful completion the apprentice is able to: demonstrate inspection and checking techniques using measuring and checking equipment; and, describe measuring and checking techniques using Optical Comparators and Coordinate Measuring Machines (CMM).

Learning Outcomes and Content

23.1 Describe safe working procedures when setting up and operating measuring and checking equipment.

Identify potential safety hazards which may occur during the set-up and operating of measuring and checking equipment.

Demonstrate safe work habits including:
- protective clothing
- protective equipment and gear
- good housekeeping
- stabilizing workpieces
- operating procedures
- securing workpieces
- storage and handling of equipment

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

Describe measuring, checking, and gauging equipment:
- sine bar and sine plate
- compound sine plate
- precision cylindrical square
- precision level
- precision rollers
- precision balls
- tooling balls
- thread wires

- precision weight gauge
- plug gauges
- ring gauges
- snap gauges
- surface texture gauge
- square
- dial test gauges
- mechanical comparator
- optical flats
- gauge blocks
- optical comparators
- electrical comparator
- air gauges

23.3 Describe the components, adjusting mechanisms, and working principles of an optical comparator. (1 hr)

Describe parts of an optical comparator:

- illumination mechanism
- surface illumination
- table
- dials
- mylars
- screen
- micrometer dial
- read out
- angular settings/adjustments
- linear settings/adjustments
- locks
- magnification
- on/off

23.4 Set up workholding devices and accessories for an optical comparator. (0.5 hrs)

Identify workholding devices and attachments:

- vise
- Vee-block
- angle plates
- fixtures
- centres

Demonstrate mounting, positioning, aligning, and securing procedures.

23.5 Describe terminology and measuring techniques for an optical comparator. (0.5 hrs)

Describe terms used in optical comparator measurement techniques:
- accuracy
- precision
- tolerances
- reliability
- limits
- fits
- datums
- discrimination

Identify error sources in measurement and machine limitations:
- inherent instrument error
- observational error
- manipulative error
- bias error
- parallel error
- angular error
- profile illumination

23.6 Demonstrate operational procedures for an optical comparator. (1 hr)

Describe cleaning techniques of calibrated test specimen surfaces. Identify features of workpiece to be checked.

Select indicating gauges and comparators by determining:
- type and applications
- component to be checked
- vibration errors
- accessibility to location
- predetermined values
- temperature variations
- graduating values
- checking ranges
- measuring ranges
- surface comparison
- magnification
- illumination of part profile/part surface

23.7 Demonstrate measuring and checking techniques using an optical comparator. (1 hr)

Demonstrate cleaning techniques of workpiece surfaces.

Describe geometric features to be measured and/or checked.

Demonstrate measurement and checking of geometric features.

Demonstrate inspection and recording techniques.

23.8 Describe the functions and operating principles of Coordinate Measuring Machines (CMM). (1 hr)

Describe cleaning techniques of workpiece surfaces.

Describe calibration/orientation techniques.

Identify features to be measured and/or checked.

Describe recording techniques.

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

Number:	S0624	
Title:	**Complex Turning Technology**	
Duration:	Total Hours: 42	Theory: 10 Practical: 32
Prerequisites:	L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 L2: S0612; S0613, S0614, S0615, S0616, S0617, S0618, S0619	
Content:	S0624.1	Describe safe working procedures when setting up and operating a lathe.
	S0624.2	Describe lathe workholding devices, attachments, and accessories. (5.5 hrs)
	S0624.3	Describe lathe cutting, trepanning, and forming tools, and tool holders. (6.5 hrs)
	S0624.4	Develop a plan for lathe machining. (14 hrs)
	S0624.5	Perform turning. (15 hrs)
	S0624.6	Perform routine maintenance. (1 hr)
Evaluation & Testing:	Assignments related to theory and application skills Minimum of one mid-term test during the term Final test at end of term 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:	S0624.0		
Title:	**Complex Turning Technology**		
Duration:	Total Hours: 42	Theory: 10	Practical: 32
Cross Reference to Training Standards: GM U5230, U5231, U5232, U5237			

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate: turning of internal or external tapers and angles using a taper turning attaching; turning of internal or external tapers and angles using a compound rest; turning of profiles; cutting ACME threads and multiple start threads; and describe sharpening of cutting tools.

Learning Outcomes and Content

24.1 Describe safe working procedures when setting up and operating a lathe.

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

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

24.2 Describe lathe workholding devices, attachments, and accessories. (5.5 hrs)

Describe lathe workholding devices, attachments, and accessories:
- face plates
- mandrel and split
- steady rest
- follower rest
- fixture
- soft jaw chucks
- radius attachment
- bungs and spigots
- tool post grinder
- tracing attachment

24.3 Describe lathe cutting, trepanning, and forming tools, and tool holders. (6.5 hrs)

Identify tool geometry for lathe cutting tools. Describe lathe-cutting tools:
- form threading tool
- trepanning tools
- forming tools

Identify lathe cutting, trepanning, and forming tools and tool holders by determining:
- type
- shape
- size
- angle
- cutting tool geometry
- cutting capacity
- function
- holding characteristics
- mounting characteristics
- cutting characteristics
- shaping characteristics
- alignment
- tolerances
- surface finish
- chip development and flow
- workpiece characteristics

Describe mounting, positioning, alignment, and securing procedures.

Describe tool post grinding.

24.4 Develop a plan for lathe machining. (14 hrs)

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

Select lathe machining procedures:
- profile turning
- tool post grinding
- ACME thread cutting

Identify machining operations and procedures for profile turning or tool post grinding:
- operating principles
- rough cutting
- finish cutting
- surface finish
- tolerances
- speeds
- feeds
- coolant requirements
- mounting of tool
- positioning of tool
- securing of tool
- cutting capacity of lathe

Identify measuring and checking procedures.

24.5 Perform turning. (15 hrs)

Demonstrate turning of internal and external tapers or angles using a taper turning attachment.

Demonstrate turning of external and internal tapers or angles using a compound rest.

Demonstrate the cutting of ACME threads.

Demonstrate turning of profiles.

Demonstrate sharpening of cutting tools.

Demonstrate cutting of multiple start threads.

24.6 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 instruments.

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

Number:	S0625	
Title:	**Complex Milling Technology**	
Duration:	Total Hours: 42	Theory: 10 Practical: 32
Prerequisites:	L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 L2: S0612; S0613, S0614, S0615, S0616, S0617, S0618, S0619	
Content:	S0625.1	Describe safe working procedures when setting up and operating milling machines.
	S0625.2	Identify milling attachments used for complex milling operations. (3 hrs)
	S0625.3	Develop a plan for complex milling operations. (2 hrs)
	S0625.4	Describe procedures for using mill workholding devices and accessories. (3 hrs)
	S0625.5	Describe the assembly of cutting tools and tool holders for complex milling operations. (2 hrs)
	S0625.6	Demonstrate complex milling operations. (31 hrs)
	S0625.7	Perform routine maintenance. (1 hr)
Evaluation & Testing:	Assignments related to theory and application skills Minimum of one mid-term test during the term Final test at end of term 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:	S0625.0		
Title:	**Complex Milling Technology**		
Duration:	Total Hours: 42	Theory: 10	Practical: 32
Cross Reference to Training Standards: GM U5230, U5231, U5232, U5238			

General Learning Outcomes

Upon successful completion the apprentice is able to demonstrate milling of complex geometric shapes.

Learning Outcomes and Content

25.1 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 and shut off procedures
- securing and stabilizing of workpiece
- lock out procedures
- use of lifting devices

25.2 Identify milling attachments used for complex milling operations. (3 hrs)

Identify attachments used for complex milling operations:
- slotting head
- right angle attachment
- vertical/horizontal attachment
- high speed attachment
- boring/facing heads
- swivel attachments
- dividing heads

25.3 Develop a plan for complex milling operations. (2 hrs)

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

Identify complex milling techniques:
- gear cutting
- helical milling
- line boring
- back boring
- cam milling (CNC application)

Identify workholding devices by determining:
- application
- operating principles
- graduation values
- angular and rotation settings
- workpiece characteristics
- positioning, mounting and securing procedures
- discrimination

Identify required cutting tools, tool holding devices, and accessories by determining:
- type and application
- clearances
- tolerances
- surface finish
- machining operations and sequences
- cutting fluid requirements
- operating principles
- toolholding and support requirements
- speed and feed values
- workpiece characteristics
- handling, storing, and maintenance procedures

Describe measuring and checking procedures.

25.4 Describe procedures for using mill workholding devices and accessories. (3 hrs)

Identify mill workholding devices:
- dividing head
- mandrels
- rotary table

Describe workholding device set-up procedures by determining:
- application
- operating principles
- type
- size
- function
- tool selection
- type of tool
- workpiece features
- holding characteristics
- mounting characteristics
- location accessibility
- workpiece characteristics
- handling procedures
- storing procedures
- maintenance procedures

Describe contact surface cleaning procedures.

Demonstrate mounting, positioning, aligning, and securing procedures.

25.5 Describe the assembly of cutting tools and holders for complex milling operations. (2 hrs)

Identify cutting tool geometry (nomenclature). Describe milling cutting tools and tool holders:
- gear cutters
- solid carbide
- boring tools
- boring and facing heads

Describe required cutting tools and tool holders by determining:
- type and size
- cutting tool material
- shape
- application
- holding/mounting characteristics
- cutting and shaping characteristics
- tolerances
- surface finish

Demonstrate the assembly of cutting tools and holders.

25.6 Demonstrate complex milling operations. (31 hrs)

Describe helical milling techniques.

Describe cam milling techniques.

Demonstrate the milling of complex geometric shapes.

25.7 Perform routine maintenance. (1 hr)

Describe routine maintenance and cleaning procedures.

Describe lubrication procedures.

Describe 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:	S0626	
Title:	**Complex Grinding Technology**	
Duration:	Total Hours: 18	Theory: 6 Practical: 12
Prerequisites:	L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 L2: S0612; S0613, S0614, S0615, S0616, S0617, S0618, S0619	
Content:	S0626.1	Describe safe working procedures when setting up and operating grinders.
	S0626.2	Describe internal grinding techniques and processes. (1.5 hrs)
	S0626.3	Identify workholding devices or attachments used for internal grinding. (1.5 hrs)
	S0626.4	Describe grinding wheels used for internal grinding and sharpening of end mills. (2 hrs)
	S0626.5	Develop a plan for internal grinding and sharpening of end mills. (2 hrs)
	S0626.6	Demonstrate internal grinding and end mill sharpening. (10 hrs)
	S0626.7	Perform routine maintenance. (1 hr)
Evaluation & Testing:	Assignments related to theory and application skills Minimum of one mid-term test during the term Final test at end of term 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:	S0626.0		
Title:	**Complex Grinding Technology**		
Duration:	Total Hours: 18	Theory: 6	Practical: 12
Cross Reference to Training Standards: GM U5230, U5231, U5232, U5236			

General Learning Outcomes

Upon successful completion the apprentice is able to perform end mill sharpening and internal grinding.

Learning Outcomes and Content

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

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

Demonstrate safe working habits including:
- protective clothing and equipment
- good housekeeping
- start up and shut off procedures
- securing and stabilizing of workpiece
- guards and dust extraction system
- dressing and inspection of grinding wheel
- lock out procedure
- maximum wheel RPM
- ring test of wheel

26.2 Describe internal grinding techniques and processes. (1.5 hrs)

Identify machining processes and components of plain or universal cylindrical grinders:
- universal cylindrical grinding
- tool post grinding
- tool and cutter grinder
- I/D grinder
- jig grinder

Describe cutting fluid applications.

26.3 Identify workholding devices and/or attachments used for internal grinding. (1.5 hrs)

Describe workholding devices, accessories, and attachments used in internal grinding techniques:

- wheel dressing attachment
- radius and tangent wheel dresser
- angular wheel dresser
- radius dresser
- three-jaw chuck
- four-jaw chuck
- magnetic chuck
- collets chuck
- crush roll forming
- steady rest
- arbors
- universal work-head
- internal grinding attachment

26.4 Describe grinding wheels used for internal grinding and sharpening of end mills. (2 hrs)

Identify grinding wheels:

- straight
- recessed
- cup
- dished
- flared
- cut-off
- mounted

Describe mounting, truing, and dressing of grinding wheels. Identify cutting tool geometry on an end mill by determining:

- land
- heel
- flutes
- helix angle
- rake angle
- tooth face
- peripheral cutting edge
- relief angles (clearance)
- peripheral and end face clearance angles

26.5 Develop a plan for internal grinding and sharpening of end mills. (2 hrs)

Interpret drawings, CAD data or process sheets to determine:
- workpiece material characteristics
- form and shape of workpiece
- surface finish
- tolerance
- machining operations and sequences

Identify grinding techniques:
- plunge grinding
- I/D grinding
- profile grinding
- parallel grinding
- internal taper grinding
- centre gashing
- form grinding
- cut off grinding
- grinding primary and secondary angles

Identify workholding devices and/or attachments:
- tooth rest and support
- centre height gauge
- wheel dressing attachment
- collets chuck

26.6 Demonstrate internal grinding and end mill sharpening. (10 hrs)

Demonstrate end mill sharpening.

Demonstrate internal grinding.

26.7 Perform routine maintenance. (1 hr)

Demonstrate routine maintenance and cleaning procedures.

Demonstrate lubrication procedures.

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

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
30%	70%	100%

Number:	S0627	
Title:	**Machining Centre CNC Technology**	
Duration:	Total Hours: 48	Theory: 24 Practical: 24
Prerequisites:	L1 CC: S0601, S0602, S0603, S0604, S0605, S0606, S0607, S0608, S0609, S0610, S0611 L2: S0612; S0613, S0614, S0615, S0616, S0617, S0618, S0619	
Content:	S0627.1	Describe safe working procedures when setting up and operating CNC machining centres.
	S0627.2	Describe operating principles of CNC machining centres. (2 hrs)
	S0627.3	Describe use of job documentation to determine job requirements. (2 hrs)
	S0627.4	Describe the application of machining centres. (2 hrs)
	S0627.5	Describe machining centre operations. (2 hrs)
	S0627.6	Describe manual operating systems for CNC machining centres. (3 hrs)
	S0627.7	Describe circular interpolation on a machining centre. (2 hrs)
	S0627.8	Develop a plan for CNC machining centres. (10 hrs)
	S0627.9	Describe the setting up and application of workholding devices for CNC machining centre operations. (10 hrs)
	S0627.10	Demonstrate procedures for entering and verifying programs for a CNC machining centre to perform linear and circular machining operations. (15 hrs)
Evaluation & Testing:	Assignments related to theory and application skills Minimum of one mid-term test during the term Final test at end of term Periodic quizzes	

Instructional and Delivery Strategies:	Lecture Video Paper based material CBT
Reference Materials:	Technology of Machine Tools Shop Text Books

Number:	S0627.0		
Title:	**Machining Centre CNC Technology**		
Duration:	Total Hours: 48	Theory: 24	Practical: 24
Cross Reference to Training Standards: GM U5230, U5231, U5232, U5239			

General Learning Outcomes

Upon successful completion the apprentice is able to describe numerically controlled machining centres techniques and demonstrate procedures for entering and verifying a program to perform linear and circular machining operations.

Learning Outcomes and Content

27.1 Describe safe working procedures when setting up and operating CNC machining centres.

Identify potential safety hazards which may occur during CNC 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 workplace/cutting tools
- stabilizing workplace/cutting tools
- lubricants
- fire protection

27.2 Describe operating principles of CNC machining centres. (2 hrs)

Identify the capabilities, operating principles, and controls of CNC machining centres:
- types of equipment
- editing capability
- program path ability
- processing power
- high speed machining
- CNC controls
- tapeless controls
- PC/DNC systems

Describe the major features and functions of CNC machining centres and the manufacturing process:

- CPU
- input devices
- work envelope
- tool changer
- holding devices
- safety interlock
- engineering drawing
- CNC part program
- input media
- CNC machine tool
- finished part
- repeatability

Describe the common means of producing part program files:

- manual programming
- CAM systems
- conversational programming

27.3 Describe use of job documentation to determine job requirements. (2 hrs)

Identify job documentation required to complete the job.

Develop job set-up sheets by identifying:

- axis alignment
- locating points
- workholding methods
- program zero

Develop tooling list by identifying:

- tools
- tool holders
- type of tool material
- set-up dimensions
- tool numbers
- tool offsets
- cutter radius compensation register
- workpiece materials

27.4 Describe the application of machining centres. (2 hrs)

Describe the methodology of programming parts as opposed to conventional machining:
- differential
- cam
- helical
- thread

27.5 Describe machining centre operations. (2 hrs)

Describe fixed cycles:
- centre drilling
- drilling
- counterboring
- reaming
- tapping

Describe fixed cycle terms and sequences:
- initial level
- R point level
- Z level
- machining increment
- rapid approach
- rapid retract
- dwell time
- feed rate directions

Describe the advanced additional specialized CNC techniques:
- HSM
- thread milling
- live tooling
- 4th and 5th axis

27.6 Describe manual operating systems for CNC machining centres. (3 hrs)

Describe manual interruption on a machining centre:
- single block operation
- feedhold
- emergency stop

Describe manual data input (MDI) on a machining centre:
- line command execution
- set-up applications

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

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

27.7 Describe circular interpolation on a machining centre. (2 hrs)

Describe circular interpolation planes:
- X - Y plane
- Z - X plane
- Y - Z plane
- arc centre modifiers

Describe circular interpolation commands:
- arc modifiers
- radius
- quadrants
- circles
- cutter radius compensation

27.8 Develop a plan for CNC machining centres. (10 hrs)

Interpret documentation to determine:
- workpiece material specifications
- method of routing instructions
- special fixturing requirements

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

27.9 Describe the setting up and application of workholding devices for CNC machining centre operations. (10 hrs)

Describe the setting up of a vise or fixture on a machining centre:
- alignment to axis
- locators for multiple parts
- clamping pressures
- establish program zero
- part geometry considerations

Describe the use of dimensioning practices:
- raw stock pre-machining
- pre-machining
- castings
- locating points
- clamping areas
- multiple parts
- fixture offsets
- quantity of parts

27.10 Demonstrate procedures for entering and verifying programs for a CNC machining centre to perform linear and circular machining operations. (15 hrs)

Demonstrate the use of preparatory commands (G-codes):
- modality of G-codes
- recognize conflicting commands
- order in a block

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

Demonstrate the use of codes to specify word and block structures:
- program identification
- block number
- N-word
- starting number
- increments
- end of block
- block description
- status block (safe block)
- message block (program comments)
- conflicting words
- modal programming values
- execution priority

Demonstrate the use of codes to specify dimensions:
- metric/inch selection
- absolute/incremental selection
- absolute data input
- incremental data input
- syntax
- zero suppression and decimal point
- leading and trailing zeros input

Demonstrate the use of codes to specify:
- tool number
- tool length offset
- tool radius offset

Demonstrate the use of codes to invoke speeds and feeds:
- spindle function
- S-code
- spindle rotation direction
- spindle stop
- spindle orientation
- spindle speed (RPM)
- feedrate control
- feedrate function
- feedrate per minute
- feedrate override and feedhold
- feedrate override and functions

Demonstrate the use of codes to establish reference points:
- machine reference point
- manufacturers' setting
- workpiece reference point
- program zero application
- position register command
- fixture offsets

Demonstrate the use of codes to execute rapid positioning:
- rapid traverse motion
- positioning mode
- tool path
- workpiece approach
- single axis motion
- multi-axis motion
- straight angular motion
- type of motion and time comparison
- rapid motion path
- axis motion completion

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

Demonstrate the use of codes to create contouring programs:
- cutter path determination
- linear interpolation
- circular interpolation
- rough and finished shape
- helical circular interpolation

Describe cutter radius compensation:
- compensation right
- compensation left
- radius offset table
- radius wear offset
- radius setting

Demonstrate procedures to enter and verify a program to mill a workpiece that includes drilling and profiling.

Demonstrate downloading of a program that includes:

- feeds
- speeds
- overrides
- axis selection
- mode selection

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

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Machinist