

Competency-Based Apprenticeship System for the Metalworking Industry



CURRICULUM GUIDE

NIMS Certified Machinist Training and Apprenticeship Program

National Institute for Metalworking Skills, Inc.

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module I: Identify and Demonstrate Usage of Machine Safety and Personal Protective Equipment

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Identify and Demonstrate Usage of Machine Safety and Personal Protective Equipment (PPE)

2. Prerequisites

None

3. Global/Overall Objective(s)

Given written and verbal instructions and checklists based on OSHA requirements and guidelines, apprentice will demonstrate safe workplace practices in material handling, machine operations, handling of tooling, handling and application of cutting fluids and lubricants, and personal precautions.

4. In-Training Assessment

Apprentice will complete a written test developed by supervisor, consisting of multiple choice, true or false and written statements covering all areas of safety training with 100% compliance.

Apprentice will carry out assigned responsibilities while adhering to safe practice in accordance with OSHA requirements and guidelines.

Apprentice will demonstrate accepted safety practices on primary and all supportive equipment required by company job description.

5. NIMS Credentialing

NIMS Level I Machining Skills
Measurement Materials and Safety

Performance Objective #1

I. Performance Objective

Given instruction/demonstration, reading and viewing assignments, apprentice will:

- o Identify areas in plant that require hearing devices and safety glasses.
- o Identify proper clothing required on the job to include shoes, gloves, sleeve and pant length, jewelry items, hair length and personal cleanliness.
- o Apprentice will demonstrate OSHA lifting techniques, proper air gun usage and identification and safe chip handling techniques.
- o Apprentice will identify all pinch points on primary and supportive machine tools and the proper placements of guards.
- o Apprentice will demonstrate both emergency and standard shut down of all required equipment.
- o Apprentice will demonstrate the proper use of hand tools to include hammer, wrenches, screwdrivers, punches and pliers.

2. Training Activities

Theory, Video, Peer Instruction

- o Obtain all company safety manuals and policies
- o View safety videos and films pertaining to job descriptions
- o Locate and understand safety information in company safety manuals and government standards

Demonstration/performance

- o Identify and demonstrate proper use of safety glasses, hearing protective devices and air guns

- Demonstrate proper lifting techniques
- Demonstrate both standard and emergency machine shut down techniques
- Fill out an accident report with all necessary information
- Demonstrate proper use of emergency eye wash station

3. Development Resources

- Safety glasses with side shields
- Safety videos
- Air guns (examples)
- Eye wash station
- Accident reports
- Hearing protection devices (examples)

4. Interim Assessment

Apprentice will be given a written test with 100% compliance required. Given the necessary equipment, apprentice will be observed under both simulated and actual working conditions to verify safe working practices. Safety is an ongoing process that will require continuous reinforcement and observation.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-02-ST-01, MA-I-08-ST-04, MA-I-10-ST-05, MA-I-16-ST-08, MA-I-18-ST-09, MA-I-28-ST-14, MA-I-50-ST-25	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R.	Copyright 2004, Pp. 317-326, 349	The Goodheart-Willcox Co. Inc., Tinley Park, IL		

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Walker				
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 522, 558	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 313-322	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 472, 473	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwillcox.com	
Hand Safety, Eye Safety, Slips and Falls	Publication 203	Precision Machined Products Association	www.pmpa.org	440-526-0300
Safeguarding of Machine Tools	Publication 202	Precision Machined Products Association	www.pmpa.org	440-526-0300
Personal Protective Equipment	OSHA Safety Training Materials	The Safety Doctor	www.thesafetydoctor.com	440-526-0300
Personal Protective Equipment	Safety and Environmental Catalog	Coastal Training Technologies	www.coastal.com	800-725-3418
“Safety and Familiarization on the Radial Arm Drill Press”	MS-50	Videocassette, RMI Media Productions, copyright 1986	www.rmimedia.com	
“Safety and Familiarization on the Vertical Bandsaw”	MS-13	Videocassette, RMI Media Productions, copyright 1986	www.rmimedia.com	

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Safety and Familiarization on the Vertical Bandsaw”	MS- 12	Videocassette, RMI Media Productions, copyright 1986	www.rmimedia.com	
“Safety and Familiarization on the Bridgeport Series I Milling Machine”	MS- 21	Videocassette, RMI Media Productions, copyright 1986	www.rmimedia.com	
“Safety and Familiarization on the Surface Grinder”	MS-80	Videocassette, RMI Media Productions, copyright 1986	www.rmimedia.com	
“Safety and Familiarization on the Clousing Colchester Engine Lathe”	MS-23	Videocassette, RMI Media Productions, copyright 1986	www.rmimedia.com	
“Safety and Familiarization on the South Bend Lathe”	MS-21	Videocassette, RMI Media Productions, copyright 1986	www.rmimedia.com	

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 2: Demonstrate Compliance with Lock-out/Tag-out Procedures and OSHA Requirements and Guidelines

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Demonstrate Compliance with Lock-out/Tag-out Procedures and OSHA Requirements and Guidelines

2. Prerequisites

None

3. Global/Overall Objective(s)

Know, identify and understand energy sources; i.e., electrical, hydraulic, air, thermal, cord and plug, etc. Know and name Lock-out/Tag-out personnel. Know and understand company procedure for restarting equipment. Know the limitations of Lock-out/Tag-out devices.

4. In-Training Assessment

A Written Test With 100% Compliance:

- Identify at least 7 energy sources
- Detail location of company Lock-out/Tag-out plan
- Identify the procedure for locking out and or tagging out equipment in your facility
- Explain two limitations of normal Lock-out/Tag-out procedures
- Name at least one individual in your facility that is authorized to do Lock-out/Tag-out
- Explain the necessary steps involved in a start-up procedure
- Identify and explain two stored energy sources in your facility

5. NIMS Credentialing

None Available

Performance Objective #1

1. Performance Objective

Apprentice will know procedure for shutting down and starting up equipment following OSHA Lock-out/Tag-out requirements as outlined in the company procedures manual.

2. Training Activities

- Obtain company written Lock-out/Tag-out program
- Knowledge of an actual Lock-out/Tag-out procedure on Machine Tool
- Recognize and read standard and company designed tags
- Identify various locking devices used for Lock-out/Tag-out
- Obtain and read a copy of U.S. Department of Labor Minimal Lock-out/Tag-out procedures (1910.147 APP.A)
- Describe and detail operator responsibility after Lock-out/Tag-out procedures
- Deplete a stored energy source in your plant (airline, hydraulic system, etc.)

3. Development Resources

Physical Resources:

- Lock-out/Tag-out energy isolating devices (examples)
- Copy of company Lock-out/Tag-out procedures
- Copy of U.S. Department of Labor Minimal
- Lock-out/Tag-out Procedures 1910.147 APP.A

4. Interim Assessment

Apprentice will be required to identify all locking devices used at the facility and demonstrate the proper operator procedure used when equipment is locked or tagged out.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Personal Protection Lock-out/Tag-out of Energy Sources	ANS/Z244. 1-1982	American National Standards Institute	www.ansi.gov	(212)642-4900
Occupational and Health Standards	No. 1910 Subpart J Standard 1910-147 (The Control of Hazardous Energy)	U. S. Department of Labor – Occupational Safety and Health Administration	www.osha.gov	
Trainers Tool Kit	Item No. LOT003 VTK	Coastal Training Technologies Corp.	www.coastal.com	800-725-3418
Lock-out/Tag-out	Index-Electrical/Lighting/HVAC/Plumbing	Lab Safety Supply	www.lss.com	800-356-0783
Lock-out for Safety	Precision Metalforming Association	Lock-out for Your Safety Video	http://www.pmaef.org/	216-901-8800
Lock-out/Tag-out	Separate videos for supervisors and employees plus workbooks	National Tooling and Machining Assoc. Ft. Washington, MD	www.ntma.org (Bookstore)	800-832-7753

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 3: Hazardous Materials Handling and Storage Including EPA, HAZMAT and OSHA

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Hazardous Materials (HAZMAT) Handling and Storage Including Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA)

2. Prerequisites

None

3. Global/Overall Objective(s)

Performance Standard:

Given written and verbal safety instructions detailing identification, handling, and storage of hazardous materials in compliance with OSHA and EPA requirements and guidelines, apprentice will demonstrate safe workplace practices in the identification, handling and storage of hazardous materials.

4. In-Training Assessment

- Take written test with 100% compliance on Material Safety Data Sheets (MSDS) terminology to include at a minimum MSDS, Threshold Limit Value (TLV) and labeling
- Locate and retrieve an MSDS sheet related to a fluid commonly used at the facility
- Demonstrate the use of commonly used materials for cleaning up spills (Oil Dry, absorbent pads, and rubber dyking and drain blocks)

5. NIMS Credentialing

Measurement, Materials and Safety, Level I

Performance Objective #1

1. Performance Objective

Given written and verbal safety instructions detailing the identification, handling and storage of hazardous materials in compliance with OSHA and EPA requirements and guidelines, apprentice will demonstrate safe workplace practices in the identification, handling and storage of hazardous materials.

2. Training Activities

Theory, Video, Peer Instruction:

- Review MSDS (lubricants) coolants, cutting fluids, solvents and gasses
- Identify chemical labels, tags and anchor signage applicable to that job
- Locate and understand safety information in company safety manuals and government standards

Demonstration/Performance:

- Demonstrate the proper cleaning methods for spills and leaks
- Demonstrate the proper storage, disposal and recycling of hazardous materials and waste products
- Demonstrate proper techniques for mixing and measuring water based cutting fluids

3. Development Resources

- Common water based metalworking fluid measuring instruments
- Company safety, health and environmental policies and procedures
- Company specific checklist, records and documentation
- Material safety data sheets (MSDS)
- OSHA and EPA requirements, records and documents
- Spill containment devices (absorbents), absorbent pads, drain blocks and dykes

4. Interim Assessment

Given a sampling of Material Safety Data Sheets (MSDS) commonly used at the facility, apprentice will identify and explain the color-coding designations, labeling system and “Right to Know” information. Apprentice will identify and explain the following for each MSDS:

- Name of chemical or gas including mixture of ingredients if applicable
- Name of the manufacturer
- Physical and/or chemical characteristics (boiling point, evaporation rate, normal odor, appearance, etc.)
- How to handle emergencies (exposure, spills, fumes release, etc.)
- Possible physical hazards (combustibility, fire, explosion, asphyxiation, reactivity, incompatible materials, radioactivity, etc.)
- Potential health hazards (poisons/toxins, carcinogens, irritations, illness/fever, vomiting, dizziness, etc.)
- Specialized protective clothing, monitoring equipment and required safety devices
- Special handling, using, storing or disposal procedures

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-01-OR-01, MA-I-02-ST-01	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
Plant Safety and Environmental Compliance	Manual No. 189	PMPA	www.pmpa.org	440-526-0300
Employee Hazard Communication Training	Manual No. 31	PMPA	www.pmpa.org	440-526-0300
Hazard Communication Training Program Series	Part I- Managing Chemical Hazards Part II- Don't Be Alarmed Be Aware! Includes Videos, Leader's Guides, Workbooks, Quizzes, and Verification Forms	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org (Bookstore)	800-832-7753

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 4: Part Inspection

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Part Inspection

2. Prerequisites

None

3. Global/Overall Objective(s)

Given the necessary job process sheets for a part and verbal instructions, identify and select the required measuring instruments and conduct the required inspection procedure(s). Complete required written inspection report and make a decision to accept or reject component parts. Provide brief verbal explanation of inspection procedures, results and decisions. Develop a basic, informal inspection plan and inspect simple parts using precision measuring tools and techniques.

4. In-Training Assessment

- Apprentice will develop an inspection plan and inspect simple parts using precision tools and techniques, and prepare reports on the compliance of the parts.
- Apprentice will complete all procedural steps without assistance in a specified period of time to all company set standards.
- Apprentice will achieve 100% compliance to all dimensions and tolerances and other quality control criteria and record keeping practices.

5. NIMS Credentialing

NIMS Level I Machining Skills:

Measurement, Materials, and Safety

Performance Objective #1

1. Performance Objective

Given the necessary job process sheet for a part and verbal instructions, identify and select the required measuring instruments and conduct the required inspection procedures. Complete required written inspection report and make a decision to accept or reject component parts. Provide brief verbal explanation of inspection procedures, results and decisions. Verify calibrations and sizes of all measuring devices. Take measurements to an accuracy of 1/64 for fractions, .002 for decimals and 1/2 degree for angles. Read prints and understand types of lines, title block information, revision levels, abbreviations, symbols and tolerances. Identify surface defects, burrs and any adverse conditions such as flat or torn threads, out-of-round conditions, eccentricity, etc.

2. Training Activities

- Obtain process plan and part print with all necessary information
- Verify that process plan, part and prints all match
- Identify, calibrate and set up necessary handheld measuring tools, plugs and gauges
- Clean part and visually check for defects
- Measure, verify and record all linear measurements
- Measure, verify and record all geometry
- Determine part compliance and complete all documentation forms
- Clean and store all precision measuring instruments and devices

3. Development Resources

- Physical resources
- Process plan and part print
- Surface plate

- A finished part matching the requirements of the part inspection blueprint
- Go/No-Go gauges smooth plug/thread plug
- Assorted precision measuring tools, indicators, micrometers and calipers to match the size and shape of the part to be inspected
- Surface finish comparison chart

4. Interim Assessment

- Given a print, apprentice will identify common lines, title blocks, revision levels and notes scale information and tolerances.
- Given a part with known dimensions, apprentice will use all required precision measuring tools, including both standard outside and depth micrometers to measure and verify designated dimensions.
- Provide apprentice with a part that incorporates both external and internal threads. Apprentice will verify the thread size by the use of thread plug and thread ring gauges.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-31-MT-01, MA-I-35-MT-02, MA-I-39-MT-03, MA-I-43-MT-04, MA-I-67-MT-13, MA-I-17-BW-04, MA-I-21-BW-05, MA-I-25-BW-06, MA-I-29-BW-07, MA-I-03-BP-01, MA-I-05-BW-01, MA-I-07-BP-02, MA-I-11-BP-03, MA-I-15-BP-04, MA-I-19-BP-05, MA-I-23-BP-06, MA-I-27-BP-07, MA-II-01-BP-01, MA-II-03-BP-02, MA-II-05-BP-03, MA-II-07-BP-04, MA-II-09-BP-05, MA-II-13-BP-07, , MA-II-17-BP-09	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 29-80	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 83-194	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 23-36, 47-70	Delmar Publishers	info@delmar.com	1-800-347-7707

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 47-62, 69-96	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
The Micrometer	The Micrometer	PMPA	www.pmpa.org	440-526-0300
Meeting Customer Specifications	The Blueprint and How to Inspect Finished Parts	PMPA	www.pmpa.org	440-526-0300
Quality Control	Manual Volume I-IV	PMPA	www.pmpa.org	440-526-0300
Geometric Dimensioning and Tolerancing	Units 1, 2, 3 & 4	Technicomp	http://www.filmo.com/tecprodu.htm	800-735-4440
Modern Geometric Dimensioning and Tolerancing		The National Tooling and Machining Association	www.ntma.org	
<i>Tools and Rules</i>		Starrett Video Production	www.starrett.co.uk	
<i>The Combination Square Set</i>		Starrett Video Production	www.starrett.co.uk	
<i>The Bevel Protractor</i>		Starrett Video Production	www.starrett.co.uk	
<i>The Vernier Height Gage</i>		Starrett Video Production	www.starrett.co.uk	
<i>The Vernier Caliper</i>		Starrett Video Production	www.starrett.co.uk	
<i>The Outside Micrometer</i>		Starrett Video Production	www.starrett.co.uk	

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Modules 5 & 6: Process Control and Process Adjustment

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for *Machinist*

1. Title of Core Competency or Cluster of Competencies

Process Control and Process Adjustment

2. Prerequisites

None

3. Global/Overall Objective(s)

Performance Standard:

Given the necessary job process sheets for a part, verbal instructions, and the necessary charts and inspection tools, apprentice will inspect parts according to the sampling plan, collecting the data required for the process control chart. Working with the supplied control and warning limits, apprentice will place the data, produce new data as needed, graph the data, and take the Stop or Go actions as indicated by the results of producing the process control chart. Apprentice will provide brief verbal explanation regarding the decision taken.

4. In-Training Assessment

- Following a sampling plan, apprentice will inspect the samples for the required data, enter the data on the appropriate chart, graph the data and respond to the warning conditions indicated by the process chart.
- Apprentice will participate in a capability study, and perform the required statistical calculations to support the capability study. With the assistance of a team leader, apprentice will prepare the necessary reports for the capability study.
- Apprentice must be able to monitor a process using SPC charting techniques by listing the correct information in the correct location, using the appropriate procedures and measuring techniques. Equipment, procedures and techniques must correlate to the control plan or inspection plan. The supervisor will check the control chart for accuracy.
- Apprentice must then determine if the process is in or out of control and verbally inform the supervisor. If the process is out of control, apprentice will verbally describe containment procedures and a possible corrective action.
- Apprentice will take part in a capability study, participating in data acquisition and calculation (except of C_p or C_{pk}), and determine if the capability index is or is not

acceptable for the process. If the process is not capable, apprentice will participate as a team member to improve the capability of the process.

5. NIMS Credentialing

(Process Control and Process Adjustment are components of the following credentials and are not all-inclusive.)

- Machining Skills – Level I: Measurement, Material and Safety (refer to the NIMS Skill Standards for Competencies and KSAO competencies)
- Machining Skills – Level I: Job Planning, Benchwork and Layout (refer to the NIMS Skill Standards for Competency and KSAO competencies)

Performance Objective #1

1. Performance Objective

Given the necessary job process sheets for a part, verbal instructions and the necessary charts and inspection tools, apprentice will inspect the parts according to the sampling plan or inspection plan, collecting the data required for the process adhering to the time parameter. Working with the supplied control and warning limits, apprentice will record the data, produce new data as needed (mean and range), graph the data and take Stop or Go actions as indicated by the results of producing the process control chart. Apprentice will provide a brief verbal explanation supporting the decision taken.

2. Training Activities

- Obtain the job process sheet confirming print, part number, material, inspection plan, gauging (if applicable) and process control documentation
- Use the job process sheet or control plan to gather the necessary measuring instruments to monitor the process and determine what part features need control charts, reviewing the control chart to confirm:
 - Part number
 - Name of the part
 - Feature to be controlled (dimension and tolerance)

- Measuring instrument and time interval
- Identify the mean, upper control limit and lower control limit for the measurement of variation and areas to document the measurement of each sample of the sampling and location for charting the results
- Basic understanding of SPC (Statistical Process Control)
- Identify the area to chart the range (measurement of dispersion) of each sampling and the mean and control limits (if applicable to the type of range chart being applied)
- Record the measurement of the feature for each member of the sampling in the proper areas and graph the results accordingly for both the measurement of variation (mean) and measurement of dispersion (range)
- Name at least four trends that indicate a process is out of control when examining the control chart
- From the data provided by the control chart, determine if the process is in or out of control
- If the process is in control, continue running product
- If the process is out of control, notify the supervisor of the situation, determine containment procedures on suspect product (stop and contain), troubleshoot and determine the root cause of the variation and perform/verify the corrective action to alleviate the variation.
- Give a verbal rationale for the Stop or Go decision, root cause and suggested corrective action to the supervisor. Participate in the implementation and validation of the corrective action.
- Resume the production run and continue to validate the effectiveness of the corrective action through control chart techniques

3. Development Resources

Physical Resources:

- All the physical resources specified in objective #1
- Charts and materials to perform a capability study
- Calculator
- Meeting room, flip charts and overhead

4. Interim Assessment

Given a dimension with a tolerance and set of data to create a control chart, apprentice will find the mean and range of each sampling set. The size of the sampling set will be defined by the control plan or the inspection plan. Graph the mean, range, and determine if the process is in or out of control. If the process is out of control, verbally define the next steps for containment and corrective action.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Online SPC Training	Complete program – online training	Quality America	www.qualityamerica.com/	800-643-9889
Q101	Complete program – online training	American Society for Quality	www.asq.org	800-248-1946
SPC Training Software	CD-ROM, whole program	Quality Coach	www.qualitycoach.net	1- 330-202-9078
SPC Training Software	CD-ROM, whole program	Digital Quality Systems Willcox	www.dqsnet.com	630-510-7529
The Cost of Poor Quality	DVD- whole presentation	Society of Manufacturing Engineers	http://www.sme.org	313-271-1500
“SPC Simplified: Practical Steps to Quality,” by Robert T. Amsden	Textbook	Quality Resources	http://www.amazon.com/	

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Statistical Process Control for Quality Improvement: A Training Guide to Learning SPC, James R. Evans	Textbook	Prentice-Hall Publishers	http://www.amazon.com/	
SPC Methods for Quality Improvement, Charles P. Quesenberry	Textbook	John Wiley & Sons Publishers	http://www.amazon.com/	
Quality Overview 100	Complete module	Tooling U	http://www.toolingu.com/	866-706-8665
Curriculum: Machine Tool Technology II	Process Control Module	Tooling and Manufacturing Association	http://www.tmanet.com/	847-825-1120
Curriculum: Quality Technician Curriculum	Process Control	American Society for Quality	http://www.asq.org	800-248-1946

Performance Objective #2

I. Performance Objective

Given a needed capability study and the data collected to satisfy the needs of the capability study, apprentice will participate as a team member in support of the capability study, through an understanding of capability and determining if a calculated Cpk value is or is not acceptable. With the direction of the team leader, apprentice will provide the machining expertise and

statistical calculation needed to satisfy the requirements of a capability study (Apprentice is not expected to calculate Cpk values through complex formulas.)

2. Training Activities

- Select a part characteristic for the capability study using quality tools, such as Pareto charts, Fishbone chart, inspection sheets and control plans, to separate the trivial many from the crucial few to pinpoint variation and test capability.
- Basic types of quality charting
- Understanding a control plan
- Define the process including material, environment, personnel, methods and system and machinery
- A fishbone chart
- Work within a team environment to define the process and scope of the study
- Within the team, plan, stage and manage the procedure of the capability study defining tasks, roles and responsibilities
- Evaluate the measurement system, evaluate the ability of the measurement system to do the job, and spend the time necessary to get a valid means of measuring the process.
- Prepare a control plan. The purpose of the control plan is twofold: 1) isolate and control as many important variables as possible, and 2) provide a mechanism for tracking variables that cannot be completely controlled. The object of the capability analysis is to determine what the process can do if it is operated the way it is designed to be operated.
- Capability and capability index
- Select a method for the analysis. Variable charts (control charts) will be used for process performance measures. Collect, record and analyze the data.
- Analyze the data. Apprentice, as part of the team, will review the data analysis to catch inadvertent errors in transcribing data or performing the analysis.
- Track down and remove special causes. The effect of the special cause may be good or bad. Removing a special cause that has a bad effect usually involves eliminating the cause itself. A special cause may be operator error caused by poor training. However, the removal of a beneficial special cause may actually involve incorporating the special cause into the normal operating procedure. If it is discovered that materials with a particular chemistry produce a better product, the special cause can be incorporated into the plan. Apprentice must understand the difference between common causes and special causes.
- Knowledge of special causes and common causes trending in charting.
- Process capability cannot be estimated until a state of statistical control has been achieved. After the numerical index of process capability has been determined, it must be compared to management's goals for the process.
- Establish a plan for continuous process improvement. Once a stable process state has been attained, steps should be taken to maintain and improve it. SPC is just one means of doing this. The capability of a process should be one step in an array of steps for continuous improvement.

- If the process is not capable, work within the team environment to manipulate the process, to achieve better capability with awareness for validation of changes.

3. Development Resources

Physical Resources:

- All the physical resources specified in objective #1
- Charts and materials to perform a capability study
- Calculator
- Meeting room, flip charts and overhead

4. Interim Assessment

Apprentice will participate in a team conducting a capability study. This individual will follow the steps listed from the core work activity statements. Apprentice is not expected to calculate C_p or C_{pk} but have the knowledge to determine if a calculated index meets the expectations of the customer or supervisor.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Process Capability and Product Design,”	Process Capability	DRM Associates	www.npd-solutions.com/proccap.html	
“Process Capability Indices in Theory and Practice,” by Samuel Kotz	Textbook	Oxford University Press	www.amazon.com/	
“Machine/Process Capability Study: A Five Stage Methodology for Optimizing Manufacturing Processes,” by Mario Perez-Wilson	Textbook	Advance Systems Consultants	www.amazon.com/	1- 330-202-9078
Process Capability	Seminar format, arrange date and place	American Society for Quality	www.asq.org	800-248-1946
Materials and Processes in Manufacturing, 9 th Ed., E. Paul DeGarmo	Chapter 12 – Process Capability and Quality Control	Wiley Publishers	http://www.wiley.com/	
Process Analysis	Process Capability Indices	Quality Resources	http://www.statsoftinc.com/textbook/stprocan.html	
“SPC for Short Run Manufacturing,” by Leonard A. Doty	Textbook	Hanser Gardner Publications	http://www.amazon.com/	

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Statistical Process Control for Quality Improvement: A Training Guide to Learning SPC, James R. Evans	Textbook	Prentice-Hall Publishers	http://www.amazon.com/	
SPC Methods for Quality Improvement, Charles P. Quesenberry	Textbook	John Wiley & Sons Publishers	http://www.amazon.com/	
Quality Overview 100	Complete module	Tooling U	http://www.toolingu.com/	866-706-8665
Curriculum: Machine Tool Technology II	Process Control Module	Tooling and Manufacturing Association	http://www.tmanet.com/	847-825-1120
Curriculum: Quality Technician Curriculum	Process Control	American Society for Quality	http://www.asq.org	800-248-1946

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 7: Participation in Processes Improvement

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Participation in Processes Improvement

2. Prerequisites

None

3. Global/Overall Objective(s)

As a member of a process team, analyze the performance of a production process. Then, with the team, formulate process adjustments or improvements where appropriate. Where appropriate, notify supervision of the proposed adjustments and/or improvement. Where authorized, carry out the strategies for process adjustment and/or improvement.

4. In-Training Assessment

Given a part with a processing problem, apprentice will identify the problem (variables), gather data (use flow charts, Pareto, inspection sheets, etc.), formulate a solution to the problem, test the solution, revise the solution (if necessary) and implement the solution. Apprentice will document the problem-solving procedure, test results and implementation validation to insure success of the solution.

Apprentice will participate in a continuous improvement team by analyzing a part or process, defining variables, prioritizing variables in the process that need improvement and gathering data. Apprentice will list the process improvement “tool”, such as a Pareto chart, process mapping, capability study, histogram, etc. used to specify the variable needing improvement, explain a procedure to implement the improvement and identify a method to verify the integrity of the change. Apprentice will also provide a method to insure the process improvement has no compromising effect on the quality of the part or process.

5. NIMS Credentialing

(Process Improvement is one component of the following credentials and is not all-inclusive.)

Machining Skills – Level I: Measurement, Material and Safety (refer to the NIMS Skill Standards for Competencies and KSAO competencies)

Machining Skills – Level I: Job Planning, Benchwork and Layout (refer to the NIMS Skill Standards for Competency and KSAO competencies)

Performance Objective #1

I. Performance Objective

Given a process plan, part print, inspection process plan, verbal instructions, the necessary tools and equipment and a part having routine problems being processed, analyze the problem(s), propose a remedy (ies), having been given authorization to implement the process improvement(s) and carry it out. Explain the reasoning used to perform the diagnosis.

Accuracy levels are $\pm 1/64^{\text{th}}$ on all fractions, holes square within .005" per inch and drilled diameters within $+.006/-0.000$ ". Reamed diameters will be held within a tolerance range of $+.001/-0.000$ " and a general tolerance of $\pm .005$ " on all decimals unless otherwise specified by management or the part print.

2. Training Activities

- Obtain the job process sheet confirming print, part number, material, inspection plan, gauging (if applicable) and process control documentation. Continuous improvement initiatives may (use as a reference for improvements):
 - Reduce cycle time,
 - Reduce unscheduled machine downtime and part process flow,
 - Reduce setup time and changeover time,
 - Reduce variation,
 - Reduce the cost of poor quality,
 - Ease assembly and installation of the part (if applicable),
 - Reduce scrap, rework and repair, and/or
 - Reduce waste of materials and labor.

- Use the job process sheet or control plan to assemble the necessary measuring instruments to monitor the process and determine what part features need control charts, reviewing the control chart to confirm:
 - Part number,
 - Name of the part,

- Critical dimensions, variable features and attribute features,
 - Feature to be controlled (dimension and tolerance), and
 - Measuring instrument and time interval.
-
- Use one or a combination of the following for data gathering and problem identification and priority. These are used to set goals:
 - Problem-solving methodology
 - Process mapping
 - Benchmarking
 - Mistake proofing (i.e., Poka-Yoke)
 - Process flowcharting
 - Cause and effect diagram (i.e., fishbone)
 - Pareto analysis
 - Sampling plans
 - Capability studies
 - SPC
 - Inspection sheets (incoming, first piece, in-process and final)
 - Histograms
 - Others
-
- Participate in a continuous improvement model:
 - Participate in the continuous improvement team
 - Define the scope of the initiative (problem, expectations, target date and resources)
 - Set the goals (customer concern, end user (internal or external), benchmarking and metrics)
 - Plan the project
 - Determine the information needed to assess the problem and solution
 - Choose the tools (from step 3) for the initiative
 - Identify the root cause(s)
 - Develop solutions (identify constraints)

- Develop an action plan listing tasks, responsibilities and due dates
- Implement the solution (i.e., Plan, Do, Check, Act Cycle)
- Review the results and verify the improvement
- Implement the improvement, which includes proper documentation procedures
- Identify and define the problem to be addressed by identifying the steps of components of the process. These may involve:
 - Improvement of a process with poor or borderline capability,
 - Improvement of a process where the process average (mean) is not centered on target values,
 - Reducing excessive handling and storage,
 - Improve methods of inspection and verify calibration,
 - Addressing customer dissatisfaction, and/or
 - Group parts of operations to reduce machining time.

- Gather data on the current situation, understand the background, identify and collect information to understand variability within the process.
- Identify improvements or solution to the process addressing the critical dimension or feature in question.
- Implement the improvement and gather data to verify the improvement or corrective action through data acquisition.
- Execute the improvement as part of the process through permanent implementation into the process plan or work instructions.
- Determine if actions have corrected problem.
- Participate in a process improvement event (i.e., Kaizen)
- Identify the problem
- Design the improvement
- Supervisor reviews it and encourages immediate action
- Implement the idea
- Write up the idea
- Post the idea to stimulate other employees and for individual recognition.

- Describe a reduction improvement. (i.e., setup)
- Describe housekeeping procedures (i.e., 5S)

3. Development Resources

Physical Resources:

- Workbench
- Material for the process
- Necessary forms and charts to prioritize
- Machine tool with a setup in use
- Cutting fluids
- Tooling necessary for the set up
- Inspection tools appropriate to the problem presented
- Charts and materials to perform a capability study
- Calculator
- Meeting room, flip charts and overhead

4. Interim Assessment

Given a part, an inspection sheet and other quality related data, identify the problem and create an improvement process plan to improve quality or eliminate the problem. Create the necessary documentation to support the process improvement initiative and validate the effectiveness of the change. The supervisor will be aware of the problem, alternative solutions and will monitor the effectiveness of problem solving, continuous improvement implementation and documentation.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Kaizen and You: Personal Success Through Continuous Improvement, Popovich, Igor	Textbook	Management Books	www.amazon.com	
Process Improvement: Enhancing Your Organization's Effectiveness, Flanigan, Eileen	Textbook	Crisp Productions	www.amazon.com	
Continuous Improvement-Sustaining the Effort	Video	Society of Manufacturing Engineers	www.sme.org	313-271-1500
Mistake-Proof It!	CD-ROM	Society of Manufacturing Engineers	www.sme.org	313-271-1500
Eaton Doubles Productivity for the Long Haul	Case Study	Makino Corporation	www.makino.com	
Curriculum: Machine Tool Technology II	Process Control Module	Tooling and Manufacturing Association	http://www.tmanet.com/	1-800-730-2214
Curriculum: Quality Technician Curriculum	Process Improvement Module	American Society for Quality	www.asq.org	800-248-1946
8-D Problem Solving	CD-Rom	Resource Engineering	www.qualitytrainingportal.com	800-810-8326

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
<i>Using Quality Objectives to Drive Strategic Performance Improvement</i> , Craig Cochran	Website	Quality Digest	http://www.qualitydigest.com/nov00/html/objectives.html	
<i>America's Best Plants</i> , Theodore B. Kinni	Website	Quality Digest	http://www.qualitydigest.com/nov00/html/objectives.html	
Systematic Problem Solving – Solving for Sustained Improvement	Course	American Society for Quality	http://www.asq.org/ed/curriculum/qtech.html	
Quality Overview 100	Complete Course	Tooling U	www.toolingu.com	866-706-8665

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 8: Manual Operations: Layout

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Manual Operations: Layout

2. Prerequisites

NIMS Level I - Job Planning, Materials, Measurement and Safety

3. Global/Overall Objective(s)

Performance Standard:

Given a surface plate, surface gage, layout height gage, combination set, scribe, layout ink, prick punch, ball peen hammer, process plan, and part print, apprentice will layout hole locations, radii, and surfaces matching the specifications.

4. In-Training Assessment

Apprentice will read the part print to consider the job, procedure, layout tools available and required. Apprentice will then develop the sequence of operations for layout of the part. Apprentice will decide the material, tool selection and strategy for layout. A trained and knowledgeable supervisor will evaluate the process apprentice chose, the tools selected, and their usage. Performance assessment of apprentice's mastery of stated objectives will consist of a finished part produced within the specified tolerances on a part print, in the required time (if applicable).

5. NIMS Credentialing

NIMS - Job Planning, Benchwork, and Layout, Level I

Performance Objective #1

1. Performance Objective

Given instruction/demonstration and reading assignments, apprentice will demonstrate knowledge and understanding of blueprint reading, and understand orthographic projections in order to perform all machining tasks.

2. Training Activities

- Theory
- Video
- Peer instruction
- Blueprint reading work sheets
- Sketched orthographic projections

3. Development Resources

- Blueprint reading workbook
- Textbook

4. Interim Assessment

- Written assessment of:
 1. Understanding blueprints and work sheets
 2. Orthographic projections need to be sketched in order to convey machining ideas (developed by supervisor)
- Demonstration of learned materials

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-03-BP-01, MA-I-07-BP-02, MA-I-11-BP-03, MA-I-15-BP-04, MA-I-19-BP-05, MA-I-23-BP-06, MA-I-27-BP-07, MA-II-03-BP-02	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by John R. Walker	Copyright 2004, Pp. 29-41	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002, Pp. 26-35	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 23-37	Delmar Publishing	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 47-63	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Trades Print Reading”	Copyright 1986, Pp. 14-14, 21-23	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Elementary Blueprint Reading for Machinists”, David Taylor	3rd Edition, Copyright 1986, entire workbook	Delmar Publishing		1-800-347-7707

Performance Objective #2

1. Performance Objective

Given a part print, surface plate and all the required layout tools, apprentice will select proper tools, and use correct procedure, to layout a part including the location of hole centers and surfaces within the accuracy of +/- .015.

2. Training Activities

- Theory
- Video
- Peer instruction
- Practice layout projects

3. Development Resources

- Textbook
- Surface plate, surface gage, layout height gage, combination set, scribe, layout ink, prick punch, ball peen hammer, process plan and part print

4. Interim Assessment

Performance assessment of apprentice's mastery of stated objective will consist of a finished part produced within the accuracy of +/- .015.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-05-BW-01, MA-I-09-BW-02, MA-I-11-BP-03	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 81-91	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 237-268	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 71-82	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 47-63	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Trades Print Reading”	Copyright 2004, Pp. 97-108	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 9: Manual Operations: Benchwork

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Manual Operations: Benchwork

2. Prerequisites

NIMS Level I - Job Planning, Materials, Measurement and Safety

3. Global/Overall Objective(s)

Performance Standard:

Given a process plan, blueprint, access to hand tools, apprentice will produce a part with two holes prepared for hand tapping, a hole prepared (reamed) for the press fit of a bushing, a stud for one of the tapped holes, de-burr the part, hand drill and hand tap the holes, press in the bushing and install the stud.

4. In-Training Assessment

Apprentice will read the part print to consider the job, procedure, and hand tools required. Apprentice will then develop the sequence of benchwork operations for producing the part. Apprentice will decide the material, tool selection and strategy for benchwork operations. A trained and knowledgeable supervisor will evaluate the process apprentice chose, the tools selected and their usage. Performance assessment of apprentice's mastery of stated objectives will consist of a finished part produced within the specified tolerances on a part print, in the required time (if applicable).

5. NIMS Credentialing

NIMS - Job Planning, Benchwork, and Layout, Level I

Performance Objective #1

1. Performance Objective

Given instruction/demonstration and reading assignments, apprentice will demonstrate knowledge and understanding of blueprint reading, and understand orthographic projections in order to perform all machining tasks.

2. Training Activities

- Theory
- Video
- Peer instruction
- Blueprint reading work sheets
- Sketched orthographic projections

3. Development Resources

- Blueprint reading workbook
- Textbook

4. Interim Assessment

- Written assessment of:
 1. Understanding blueprints work sheets
 2. Orthographic projections need to be sketched in order to convey machining ideas (developed by supervisor)
- Demonstration of learned materials

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-03-BP-01, MA-I-07-BP-02, MA-I-11-BP-03, MA-I-15-BP-04, MA-I-19-BP-05, MA-I-23-BP-06, MA-I-27-BP-07, MA-II-03-BP-02	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 29-41	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 47-63	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002, Pp. 26-35	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 23-37	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
<i>Machine Trades Print Reading</i>	Copyright 1986, Pp. 14-14, 21-23	The Goodheart-Willcox Company Inc.	www.goodheartwilcox.com	
<i>Elementary Blueprints</i>	3rd Edition, Copyright 1986, entire workbook	Delmar Publishing Inc.	info@delmar.com	1-800-347-7707

Performance Objective #2

1. Performance Objective

Given a part print, surface plate and all the required layout tools, apprentice will select proper tools, and use correct procedure, to lay out a part including the location of hole centers and surfaces within the accuracy of +/- .015.

2. Training Activities

- Theory
- Video
- Peer instruction
- Practice layout projects

3. Development Resources

- Textbook
- Surface plate, surface gage, layout height gage, combination set, scribe, layout ink, prick punch, ball peen hammer, process plan and part print.

4. Interim Assessment

Performance assessment of apprentice's mastery of stated objective will consist of a finished part produced within the accuracy of +/- .015.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-05-BW-01, MA-I-09-BW-02, MA-I-II-BP-0307, MA-II-03-BP-02	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 29-41	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 97-108	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 237-268	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 71-82	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707

Performance Objective #3

1. Performance Objective

Given instruction/demonstration, reading assignment, information sheets, and reference charts, apprentice will select the correct tap drills to achieve a minimum of 75% thread in the required tapped holes, and the correct pre-drill hole for reaming operations to achieve tolerances specified on the part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Drill selection work sheets

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Calculator
- Part print

4. Interim Assessment

- Written assessment of:
 - I. Drill chart work sheets (developed by supervisor)
- Demonstration of learned materials

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-12-ST-06, MA-I-14-ST-07	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1890-1900, 807-826	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 237-268	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 71-82	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707

Performance Objective #4

1. Performance Objective

Given instruction/demonstration, reading assignment, information sheets and reference charts, apprentice will calculate cutting speeds required to perform benchwork-machining operations.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Calculator
- Part print

4. Interim Assessment

- Written assessment:
 - I. Cutting speed calculations (developed by supervisor)
- Performance of practical applications on learned materials by apprentice:
 - I. Machining operations performed by apprentice using the correct cutting speed.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-14-ST-07	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 167,180	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 363-392	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 279-282	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 189-210	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition, Copyright 1986, Pp. 359, 361-364	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1012-1043	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852

Performance Objective #5

1. Performance Objective

Given instruction/demonstration, reading assignment, information sheets and reference charts, apprentice will calculate dimensions required for a press fit, and use an arbor to perform press fit operations.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Part print
- Press fit reference materials
- Required hand and measuring tools
- Arbor press

4. Interim Assessment

- Written assessment of:
 - I. Understanding press fits work sheet (developed by supervisor)
- Demonstration of learned materials

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 455	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 187. 36-39	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Page 29,30	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition, Copyright 1986, Pp. 167-198	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 627-657	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852

Performance Objective #6

1. Performance Objective

Given instruction/demonstration on the procedure used for hand filing, drilling and reaming, apprentice will perform filing, drilling and reaming operations within the specified tolerances on the part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Part print
- Required layout tools
- Required hand and measuring tools
- Required drill bits and reamers

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure of hand filing operations
 2. Set-up procedure of hand drill for drilling operations
 3. Set-up procedure of hand drill for reaming operations
- Performance of practical applications of learned materials:
 1. Part filed, drilled and reamed within the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-10-ST-05, MA-I-14-ST-07	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 107-126	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 123-150	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 35-78	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 139-162	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
National Tooling and Machining Association		NTMA, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862

Performance Objective #7

1. Performance Objective

Given instruction/demonstration on the proper tap selection and the procedure used for hand tapping, apprentice will perform tapping operations within the specified tolerances on the part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Part print
- Required layout tools
- Required hand and measuring tools
- Required drill bits and taps

4. Interim Assessment

- Demonstration of learned materials:
 - I. Set-up procedure of hand tapping operations
- Performance of practical applications of learned materials:
 - I. Part tapped within the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-10-ST-05, MA-I-14-ST-07	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 107-126	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 123-150	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 35-78	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 139-162	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 10: Sawing

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Sawing

2. Prerequisites

NIMS Level I - Materials, Measurement and Safety

3. Global/Overall Objective(s)

Performance Standard:

Given a part with a finished layout and access to an appropriate band saw and blades, finish saw the part to the layout.

4. In-Training Assessment

Apprentice will perform various sawing operations on a previously laid out part. Operations to be performed should include the selection, mounting and/or welding of band saw blades. A supervisor will evaluate the part and insure that it is dimensionally correct. Apprentice has successfully completed the competency when all operations have been performed and the part has been sawed within all of the tolerances specified on the finished layout and part print.

5. NIMS Credentialing

NIMS – Job Planning, Benchwork, and Layout, Level I

Performance Objective #1

1. Performance Objective

Given instruction/demonstration and reading assignments, apprentice will demonstrate knowledge of band saw safety procedures, and the identification of band saw parts and their function.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Band saw manuals
- Machine diagram
- Textbook

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Band saw safety procedures
 2. Band saw parts identification and function
- Demonstration of learned materials

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-08-ST-04, MA-II-02-ST-01	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 194, 197-200	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 305-348	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 163-178	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 393-402	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Performance Objective #2

1. Performance Objective

Given instruction/demonstration on the proper selection, mounting, set-up and usage procedure for necessary work-holding devices on the band saw, apprentice will select, mount, set up, hold, and align work using work-holding devices on the band saw to perform the required sawing operations.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Band saw
- Required work-holding devices
- Required hand tools
- Process plan and part print

4. Interim Assessment

- Demonstration of learned materials:
 - I. Set-up procedure and usage of work-holding devices
- Performance of practical applications on learned materials by apprentice:
 - I. Part sawed within the tolerances specified on part print

5. Additional Education and Training Resource

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-08-ST-04, MA-II-02-ST-01	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 194, 197-200	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 305-348	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 163-178	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 393-402	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Performance Objective #3

1. Performance Objective

Given instruction/demonstration, reading assignment, information sheets and reference charts, apprentice will choose the correct blade for specific sawing operations, and calculate cutting speeds and apply these calculations while performing required sawing operations on the band saw.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Saw blade manufacturers reference charts
- Calculator
- Speed dial calculator (usually found on saw)
- Process plan and part print

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Blade selection work sheets
 2. Cutting speed calculation work sheet
- Demonstration of learned materials:
 1. Proper band saw blade selected to perform sawing operations
 2. Band saw set to proper cutting speed to perform sawing operations
- Performance of practical applications on learned materials by apprentice:
 1. Part sawed within layout line and the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page References	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-08-ST-04, MA-II-02-ST-01	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 194-197	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 342-348	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 163-178	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 393-402	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Resource Title	Module/Page References	Name of Company/Organization	Internet Address	Phone
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1890-1900, 807-826	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888- 528- 7852
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition, Copyright 1986, Pp. 365	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888- 528- 7852

Performance Objective #4

1. Performance Objective

Given instruction/demonstration, reading assignment and the correct band saw blade material to perform a specific sawing operation, apprentice will properly weld and mount the finished blade on the band saw.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Textbook
- Process plan, and part print
- Machine manual

- Band saw
- Band saw blade material
- Band saw blade welder
- Required hand and measuring tools

4. Interim Assessment

- Demonstration of learned materials:
 1. Band saw blade welded correctly to perform sawing operations
 2. Band saw blade mounted correctly to perform sawing operations
- Performance of practical applications on learned materials by apprentice:
 1. Part sawed within layout line and the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 193-197	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 342-348	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 163-178	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 393-402	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Performance Objective #5

1. Performance Objective

Given a band saw, process plan, part print, part with finished layout, band saw blade, hand tools, band saw accessories, instruction/demonstration on the proper setup and procedures used for sawing, apprentice will perform the sawing operations on the part to the layout specified on the part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Process plan and part print
- Part with proper layout
- Band saw
- Band saw blade
- Band saw accessories
- Required hand and measuring tools

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure of band saw to perform sawing operations
- Performance of practical applications on learned materials:
 2. Part sawed within the layout lines specified on the part print.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 191-200	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 305-348	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 163-178	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 393-402	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module II: Job Process Planning

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Job Process Planning

2. Prerequisites

NIMS Level I - Measurement, Materials and Safety

3. Global/Overall Objective(s)

Performance Standard:

Given a print detailing a part requiring milling, drilling, turning, and grinding, verbal instructions and appropriate references, apprentice will formulate a set of strategies to manufacture the part and fill out an operation sheet reflecting the chosen strategies, including the required speeds and feeds.

Identify all major components and functions of the machine tools, and all major hand tools, measuring tools, tools and fixtures, work materials and provide the rationale for the speeds and feeds selected.

4. In-Training Assessment

Performance assessment of apprentice's mastery of stated objectives will consist of the development of a finished process plan for a part requiring milling, drilling, turning or grinding. Completion of an operation sheet detailing the process plan and required speeds and feeds.

5. NIMS Credentialing

NIMS Level I - Job Planning, Benchwork and Layout

Performance Objective #1

1. Performance Objective

Apprentice will be able to choose the most appropriate location for the origin on the part, and establish a method for defining that location during set up.

2. Training Activities

A project requiring apprentice to study part prints to identify datums and select the most appropriate and practical location for the origin.

3. Development Resources

- Sample part prints
- Calculator

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will be able to identify the critical datums and reference points on a part print with 100% accuracy.
- Apprentice will be able to describe why a particular point should be used as an origin or a reference point on a particular part.
- Apprentice will be able to describe an efficient and accurate method for locating the origin during machine set up of a particular part.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-03-BP-01, MA-I-07-BP-02, MA-I-11-BP-03	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 29-41	The Goodheart-Willcox Co. Inc., Tinley Park, IL		
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 185-194	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 23-36	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 47-62	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwillcox.com	

Performance Objective #2

1. Performance Objective

Apprentice will be able to select appropriate work-holding devices for various work pieces.

2. Training Activities

- A project requiring apprentice to evaluate a blueprint and determine the most appropriate work-holding device for the job
- A project requiring apprentice to gain hands-on experience using various work-holding devices to properly position sample work pieces

3. Development Resources

- Part print
- Various work-holding devices for milling, drilling, grinding and turning.
- Vises, fixtures, hold-down clamps, chucks, magnetic chucks, etc.
- Various differently shaped sample work pieces

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will be able to evaluate a blueprint and job order and determine the most appropriate work-holding device for the job, to industry standard.
- Apprentice will be able to verbally identify different work-holding devices with 100% accuracy when asked.
- Apprentice will be able to choose the appropriate work-holding device for a particular job and provide justification for its use. Selection and justification are appropriately made when acceptable by supervisor's standards.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-10-ST-05, MA-I-20-ST-10, MA-I-34-ST-17, MA-I-52-ST-26	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 164-167, 222-236, 310-316, 356-358	The Goodheart-Willcox Co. Inc., Tinley Park, IL		
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 372-383, 435-473, 526-532, 571-576, 636-639	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	

Performance Objective #3

1. Performance Objective

Apprentice will be able to select appropriate tooling and toolholders for various operations and materials.

2. Training Activities

- A project requiring apprentice to fill in the blanks on a cutting tool and toolholder identification work sheet (developed by supervisor)

- A project requiring apprentice to identify various different tools and state the advantages and disadvantages of each (developed by supervisor)
- A project requiring apprentice to identify carbide inserts in the ISO standardized designation (developed by supervisor)
- A project requiring apprentice to select the appropriate tooling for each operation of a particular job, and provide rationale as to why they selected each tool (developed by supervisor)

3. Development Resources

Sample Tooling for Demonstration:

- End Mills
- Drills
- End mill holders
- Collets
- Reamers
- Boring heads, etc.
- Toolholders and carbide inserts
- Tool bits
- Chucks
- Grinding wheels
- Magnetic chuck
- Angle plate, cube, etc.

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will be able to complete a tooling identification work sheet with 100% accuracy (developed by supervisor).
- Apprentice will be able to complete a tooling use work sheet with 100% accuracy (developed by supervisor).
- When asked, apprentice will be able to name the benefits and drawbacks of various different tooling types, configurations, and materials, with 100% accuracy.
- Apprentice will be able to evaluate a job order, part print, available machinery and equipment; and determine each specific tool that will be used in the machining process. All will be performed to industry standard as determined by supervisor.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-12-ST-06, MA-I-24-ST-12, MA-I-32-ST-16, MA-I-54-ST-27	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 158-164, 211-220, 293-304, 358-367	The Goodheart-Willcox Co. Inc., Tinley Park, IL		
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 358-392, 410-424, 526-532, 566-571, 613-621	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	

Performance Objective #4

1. Performance Objective

Apprentice will be able to calculate speeds and feeds for proper tool life and surface finish.

2. Training Activities

- A project requiring apprentice to fill in the blanks on a partially completed speed and feed work sheet (developed by supervisor)
- A hands-on project requiring apprentice to apply various speeds and feeds on different materials in a manual milling, drilling, grinding and turning machine
- A project requiring apprentice to calculate unknown speeds and feeds on a partially completed process plan

3. Development Resources

- Calculator
- Surface Feet Per Minute chart for each piece of tooling required

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will be able to fill in a speeds and feeds work sheet that is acceptable to the supervisor.
- When asked, apprentice will be able to explain the importance of proper cutting speeds and explain the components of the formula used.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-12-ST-06, MA-I-22-ST-11, MA-I-36-ST-18, MA-I-51-MT-06	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 167-170, 220-222, 308-310, 358-367	The Goodheart-Willcox Co. Inc., Tinley Park, IL		
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 279, 280, 372,373, 449, 540,541,576,577	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 130, 194, 234, 327, 328	Delmar Publishers	info@delmar.com	1-800-347-7707
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1006-1043	Industrial Press	www.industrialpress.com	1-888-528-7852
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition, Copyright 1986, Pp. 336-367	Industrial Press	www.industrialpress.com	1-888-528-7852

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 12: Drilling Operations

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for *Machinist*

1. Title of Core Competency or Cluster of Competencies

Drilling Operations

2. Prerequisites

NIMS Level I - Materials, Measurement and Safety

Or

NIMS Level I – Job Planning, Benchwork and Layout

3. Global/Overall Objective(s)

Performance Standard (Level I):

Given a semi-finished part, process plan, part print, precision hand and cutting tools, and access to a drill press and its accessories, produce a part matching the process plan and the blueprint specifications. The part specified will be in the semi-finished state having been squared-up and the outer surfaces completed with five center-drilled locations. Finishing the part will require the finishing of the five center-drilled locations. Each hole must have at least two secondary operations. The secondary operations will consist of reaming, spot facing, countersinking and counter-boring. At least one hole must be a blind hole and one a through hole. At least one hole may be power tapped.

Performance Standard (Level II) Radial Drill:

Set up, center drill, drill, countersink counter bore, and tap a series of holes to part print specification. Perform other operations as required by the part print.

4. In-Training Assessment

Apprentice will perform various drilling operations on a semi-finished part containing previously center-drilled holes. Operations to be performed should include: drilling, reaming, spot facing, tapping, countersinking and counter-boring. A supervisor will evaluate the part and ensure that it is dimensionally correct. Apprentice has successfully completed the competency when all operations have been performed and the part has been machined within all of the tolerances specified on the part print.

5. NIMS Credentialing

Performance Objective #1

1. Performance Objective

Given instruction/demonstration and reading assignments, demonstrate knowledge of drill press safety procedures and the identification of drill press, and radial drill press parts and their function.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Drill press manual
- Machine diagram
- Textbook

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 3. Drill press safety procedures
 4. Drill press parts identification and function
- Demonstration of learned materials

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-10-ST-05	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 153-158	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 349-358	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 179-189	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 363-392	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Performance Objective #2

1. Performance Objective

Given instruction/demonstration on the proper selection, mounting, set up and usage procedure for necessary work-holding devices on the drill press, apprentice will select, mount, set-up, hold and align work using work-holding devices on the drill press to perform the required drill press operations.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Drill press
- Required work-holding devices
- Required hand tools
- Process plan and part print

4. Interim Assessment

- Demonstration of learned materials:
 - I. Set-up procedure and usage of work-holding devices
- Performance of practical applications on learned materials by apprentice:
 - I. Part machined within the tolerances specified on part print (NIMS Level II Drill Press Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-10-ST-05	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 164-167	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 358-368	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 181-199	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 363-392	The Goodheart-Willcox Co.	www.goodheartwilcox.com	

Performance Objective #3

1. Performance Objective

Given instruction/demonstration on the proper selection, mounting, set up and usage procedure for necessary tool-holding devices on the drill press, apprentice will select, mount, set-up and align tool-holding devices on the drill press to perform the required drill press operations.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Drill press
- Required tool-holding devices
- Required hand tools
- Process plan and part print

4. Interim Assessment

- Demonstration of learned materials:
 - I. Set-up procedure and usage of tool- holding devices
- Performance of practical applications on learned materials by apprentice:
 - I. Part machined within the tolerances specified on part print (NIMS Level II Drill Press Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-10-ST-05	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, P. 163	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 358-368	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 179-199	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 363-392	The Goodheart-Willcox Co.	www.goodheartwilcox.com	

Performance Objective #4

1. Performance Objective

Given instruction/demonstration, reading assignment, information sheets and reference charts, apprentice will calculate cutting speeds and feeds and apply these calculations while performing required machining operations on the drill press.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Tooling manufacturers reference charts
- Calculator
- Process plan and part print

4. Interim Assessment

- Written assessment (developed by supervisor):
 1. Cutting speed calculations
 2. Feed rate calculations
- Demonstration of learned materials:
 1. Drill press set to proper cutting speed to perform machining operations
 2. Drill press set to proper feed rate to perform machining operations
- Performance of practical applications on learned materials by apprentice.
 1. Part machined within the tolerances specified on part print (NIMS Level II Drill Press Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-10-ST-05, MA-I-12-ST-06	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, P.167	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 358-392	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 179-199	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 363-392	The Goodheart-Willcox Co.	www.goodheartwilcox.com	

Performance Objective #5

1. Performance Objective

Given a drill press, process plan, part print, semi-finished part, cutting tools, hand tools, drill press accessories, instruction/demonstration on the proper set up and procedures used for drilling, tapping, reaming, spot facing, countersinking and counter-boring, apprentice will perform these secondary operations on the semi-finished part to the tolerances specified on the part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Process plan and part print
- Drill press and radial arm drill press
- Work holding devises
- Tool holding devises
- Drill bits, taps, reamers, spot facing tool, countersink and counter bore
- Required hand and measuring tools

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure of drill press to perform drilling operations
 2. Set-up procedure of drill press to perform tapping operations
 3. Set-up procedure of drill press to perform reaming operations
 4. Set-up procedure of drill press to perform spot facing operations
 5. Set-up procedure of drill press to perform countersinking operations
 6. Set-up procedure of drill press to perform counter-boring operations
- Performance of practical applications on learned materials :
 1. Part machined within the tolerances specified on part print (NIMS Level II Drill Press Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-10-ST-05, MA-I-12-ST-06, MA-I-14-ST-07	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 173-182	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 358-392	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 179-210	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 363-392	The Goodheart-Willcox Co.	www.goodheartwilcox.com	

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Modules 13 & 14: Turning Operations: Turning between Centers

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Turning Operations: Turning between Centers

2. Prerequisites

NIMS Level I - Job Panning, Materials, Measurement and Safety

3. Global/Overall Objective(s)

Performance Standard (Level I):

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate turning machine and its accessories, produce a part matching the process plan and the part print specifications using appropriate trade techniques and speeds and feeds. The part specified should have at least three diameters within ± 0.002 , one UNC external thread, one UNF external thread, and require an end-for-end swap.

Performance Standard (Level II):

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate turning machine and its accessories, produce a part matching the process plan and the part print specifications using appropriate trade techniques and speeds and feeds. The part specified should have at least two straight diameters within ± 0.001 , an appropriate taper at each end of the part, and requires a reversal of the part end for end.

4. In-Training Assessment

Performance assessment of apprentice's mastery of stated objectives will consist of a finished part produced within the specified tolerances on a part print, in the required time (if applicable).

5. NIMS Credentialing

NIMS - Turning between Centers, Levels I & II

Performance Objective #1

1. Performance Objective

Given instruction/demonstration and reading assignments, apprentice will demonstrate knowledge of engine lathe safety procedures, and the identification of engine lathe components/controls and their function.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Engine lathe manual
- Machine diagram
- Textbook

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Engine lathe safety procedures
 2. Engine lathe components/controls identification and function

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-26-ST-13, MA-I-28-ST-14, MA-II-10-ST-05	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 23-75, 201-211	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Pp. 1-26, 393-410	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 37-39, 213-223	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp. 63-69, 403-435	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Performance Objective #2

1. Performance Objective

Given instruction/demonstration on cutting tool geometry and inserted tooling, apprentice will demonstrate the proper insert and toolholder selection, necessary to perform all required turning operations within the specified tolerances on a blueprint.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Tooling manufacturers reference charts
- Inserts or tool bit blanks
- Toolholders
- Part print

4. Interim Assessment

- Performance of practical applications of learned materials by apprentice:
 1. Required tool bits ground with correct tool geometry
 2. Selection and understanding of inserted tooling
 3. Selection of required toolholding devices
- Demonstration of learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Turning between Centers Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-30-ST-15, MA-I-32-ST-16, MA-I-76-ST-38, MA-I-77-ST-39	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	26th-Edition Copyright 2000 Pp. 723-770	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp.416-430	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 223-233	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp. 403-435	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 3

1. Performance Objective

Given instruction/demonstration, reading assignment, information sheets, and reference charts, apprentice will calculate cutting speeds and feeds and apply these calculations while performing required various turning operations on the engine lathe.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Tooling manufacturers reference charts
- Calculator
- Part print

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Cutting speed calculations
 2. Feed rate calculations
- Demonstration of learned materials:
 1. Engine lathe set to proper cutting speed to perform machining operations
 2. Engine lathe set to proper feed rate to perform machining operations
 3. Part machined within the tolerances specified on part print (NIMS Level II Turning between Centers Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-36-ST-18, MA-II-14-ST-07	National Tooling and Machining Association, Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 220-222	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 279-280	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 233-239	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp. 415-420	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition Copyright 2000 Pp. 1712-1754	Industrial Press, New York, NY	www.industrialpress.com	888-528-7852

Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	I st Edition Copyright 1986 Pp. 250-277	Industrial Press, New York, NY		
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall,		

Performance Objective # 4

1. Performance Objective

Given instruction/demonstration on the proper selection, mounting, set up and usage procedure for turning (face plate and dog, and draw-in collet chuck), apprentice will select, mount, set up, hold and align work using work-holding devices on the engine lathe to perform the required turning operations.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Textbook
- Engine lathe
- Engine lathe work-holding devises
- Required tools
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure and usage of face plate and dog
 2. Set-up procedure for turning between centers

- Performance of practical applications on learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Turning between Centers Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-34-ST-17, MA-II-12-ST-06	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 222-231	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 424-459	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp.223-267	Delmar Publishers	info@delmar.com	1-800-347-7707

Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
"Modern Metalworking" by: John R. Walker	Copyright 2004 Pp. 403-435	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
"Basic Machine Tool Operations" by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 5

1. Performance Objective

Given instruction/demonstration on the proper set up and procedures used for drilling and center drilling on the engine lathe, apprentice will perform drilling and center drilling operations within the tolerances specified on a part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Textbook
- Engine lathe
- Drills and center drills
- Required hand and measuring tools
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure of engine lathe for center drilling operations
 2. Set-up procedure of engine lathe for drilling operations

- Performance of practical applications on learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Turning between Centers Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-40-ST-17	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 222-236	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 435-444	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp.239-259	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R.	Copyright 2004 Pp. 403-435	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
Walker				
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 6

1. Performance Objective

Given instruction/demonstration on the proper procedure used for turning, facing, necking and grooving operations on the engine lathe, apprentice will perform turning, facing, necking and grooving operations within the specified tolerances on the part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Engine lathe
- Turning, facing, necking and grooving tools
- Required hand and measuring tools
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure of engine lathe to perform turning operations
 2. Set-up procedure of engine lathe to perform facing operations
 3. Set-up procedure of engine lathe to perform necking operations
 4. Set-up procedure of engine lathe to perform grooving operations

- Performance of practical applications on learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Turning between Centers Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-38-ST-19, MA-II-20-ST-10, MA-II-36-ST-18	National Tooling and Machining Association Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 223-237	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 435-444	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp.239-259	Delmar Publishers	info@delmar.com	1-800-347-7707

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp. 403-435	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 7

1. Performance Objective

Given instruction/demonstration on the proper procedure used for performing shouldering operations on the engine lathe, apprentice will perform square, angular and filleted shouldering operations within the tolerances specified on a part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Textbook
- Engine lathe
- Shouldering tools
- Required hand and measuring tools
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure of engine lathe to perform square shouldering operations
 2. Set-up procedure of engine lathe to perform angular shouldering operations
 3. Set-up procedure of engine lathe to perform filleted shouldering operations

- Performance of practical applications on learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Turning between Centers Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-38-ST-19, MA-II-20-ST-10	National Tooling and Machining Association, Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 237-241	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 459-474	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 267-275	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R.	Copyright 2004 Pp. 403-435	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
Walker				
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall, Upper Saddle River, NJ		

Performance Objective # 8

1. Performance Objective

Given instruction and demonstration on the proper set-up procedure used for knurling on the engine lathe, apprentice will set up the machine and perform knurling operations within the tolerances specified on the part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Textbook
- Engine lathe
- Knurling tool
- Required hand and measuring tools
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 - I. Set-up procedure of engine lathe to perform knurling operations

- Performance of practical applications on learned materials by apprentice:
- I. Part machined within the tolerances specified on part print (NIMS Level II Turning between Centers Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-II-22-ST-11	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 265-267	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White		Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check		Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker		The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Machine Tool Operations” by: John E. Neely		Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	

Performance Objective # 9

1. Performance Objective

Given instruction/demonstration on Unified National Thread nomenclature, formulas and the proper set-up procedure used for cutting threads on the engine lathe, apprentice will cut an external U.N. thread within the tolerances specified on the part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Unified National Thread reference charts
- Calculator
- Engine lathe
- Required hand and measuring tools (i.e., center gage, thread wires, thread micrometer, thread ring gage, etc.)
- Threading tools
- Part print

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Thread nomenclature identification
 2. Thread formula calculations
- Demonstration of learned materials:
 1. Set-up procedure of engine lathe to perform threading operations
 2. Procedure used to perform threading operations

- Performance of practical applications on learned materials:
 - I. Part machined within the tolerances specified on part print (NIMS Level II Turning between Centers Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-42-ST-21, MA-II-24-ST-12, MA-II-26-ST-13, MA-II-28-ST-14	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 250-261	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 479-494	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 299-311	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp.435-449	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 247-271	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 10

1. Performance Objective

Given a blueprint, and instruction/demonstration on taper calculations, and the proper set-up procedure used for cutting internal and external tapers on the engine lathe, apprentice will cut a taper on the engine lathe using the tailstock set-over method, or compound rest, or a taper attachment to within the tolerances specified on a part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Standard taper reference charts
- Trigonometry tables reference book/charts
- Calculator
- Required hand and measuring tools
- Turning tools
- Part print

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Taper calculations containing taper per inch, taper per foot and angular measurement
- Demonstration of learned materials:
 1. Set-up procedure of engine lathe to perform taper turning operations using the tailstock set-over method
 2. Set-up procedure of engine lathe to perform taper turning operations using the compound rest
 3. Set-up procedure of engine lathe to perform taper turning operations using the taper attachment
- Performance of practical applications on learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Turning between Centers Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-42-ST-21, MA-II-24-ST-12, MA-II-26-ST-13, MA-II-28-ST-14	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 250-261	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 479-494	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 299-311	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp.435-449	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition Copyright 2000 Pp. 906-918	Industrial Press INC., 200 Madison Ave, New York, NY		

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
<p>“Student’s Shop Reference Handbook” by: Edward G. Hoffman</p>	<p>1st Edition Copyright 1986 Pp. 199-214; Pp. 250-277</p>	<p>Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078</p>		
<p>“Basic Machine Tool Operations” by: John E. Neely</p>	<p>Copyright 2000 Pp. 247-271</p>	<p>Prentice Hall, Upper Saddle River, NJ. Columbus, OH</p>		

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Modules 15 & 16: Turning Operations: Chucking

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for *Machinist*

1. Title of Core Competency or Cluster of Competencies

Turning Operations: Chucking

2. Prerequisites

NIMS Level I - Job Planning, Materials, Measurement and Safety

3. Global/Overall Objective(s)

Performance Standard (Level I):

Given raw material, process plan, part print, hand, precision, and cutting tools, as well as access to an appropriate turning machine and its accessories, produce a part matching the process plan and the part print specifications using appropriate trade techniques and speeds and feeds. The part specified should have at least three diameters within $\pm .002$, one UNC external thread, one UNF internal thread, and requires an end-for-end swap.

Performance Standard (Level II):

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate turning machine with a taper attachment and its accessories, produce a part matching the process plan and the part print specifications using appropriate trade techniques and speeds and feeds. The part specified should have at least two diameters within $\pm .002$ ", one bore within $\pm .002$ ", one external and one internal taper, and requires at least two chucking or other work-holding setups.

4. In-Training Assessment

Performance assessment of apprentice's mastery of stated objectives will consist of a finished part produced within the specified tolerances on a part print, in the required time (if applicable).

5. NIMS Credentialing

NIMS – Turning Chucking, Levels I & II

Performance Objective #1

1. Performance Objective

Given instruction/demonstration and reading assignments, apprentice will demonstrate knowledge of engine lathe safety procedures, and the identification of engine lathe parts and their function.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Engine lathe manual
- Machine diagram
- Textbook

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 - Engine lathe safety procedures
 - Engine lathe parts identification and function
- Demonstration of learned materials

5. Available Education and Training Resources

Resource Title	Specific Reference to Items/Pages/ Modules	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-26-ST-13, MA-I-28-ST-14, MA-II-10-ST-05	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 23-75, 201-211	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Pp. 1-26, 393-410	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 37-39, 213-223	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp. 63-69, 403-435	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Performance Objective #2

1. Performance Objective

Given instruction/demonstration on cutting tool geometry and inserted tooling, apprentice will demonstrate the proper insert and toolholder selection, necessary to perform all required turning, and boring operations within the specified tolerances on a part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Tooling manufacturers reference charts
- Inserts or tool bit blanks
- Toolholders
- Part print

4. Interim Assessment

- Performance of practical applications of learned materials:
 1. Required tool bits ground with correct tool geometry
 2. Selection and understanding of inserted tooling
 3. Selection of required tool-holding devices
- Demonstration of learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Chucking Project must be completed within the required time.)

5. Available Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-30-ST-15, MA-I-32-ST-16, MA-I-76-ST-38, MA-I-77-ST-39	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 211-220	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 416-430	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 223-233	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp. 403-435	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition Copyright 2000 Pp. 723-770	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078		

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition Copyright 1986 Pp. 366-373	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078		
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 3

1. Performance Objective

Given instruction/demonstration, reading assignment, information sheets and reference charts, apprentice will calculate cutting speeds and feeds and apply these calculations while performing required various turning operations on the engine lathe.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Machinery’s Handbook
- Student’s Shop Reference Handbook
- Textbook
- Tooling manufacturers reference charts
- Calculator
- Part print

4. Interim Assessment

- Written assessment (developed by instructor) of:
 1. Cutting speed calculations
 2. Feed rate calculations
- Demonstration of learned materials:
 4. Engine lathe set to proper cutting speed to perform machining operations
 5. Engine lathe set to proper feed rate to perform machining operations
- Performance of practical applications on learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Chucking Project must be completed within the required time.)

5. Available Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-36-ST-18, MA-II-14-ST-07	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 220-222	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 233-239	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R.	Copyright 2004 Pp. 415-420	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Walker				
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition Copyright 2000 Pp.991-1008	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078		
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition Copyright 1986 Pp. 325-366	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078		
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 4

I. Performance Objective

Given instruction/demonstration on the proper selection, mounting, set up, and usage procedure for the four specified work-holding devices (3-jaw chuck, 4-jaw chuck, face plate and dog and draw-in collet chuck), apprentice will select, mount, set up, hold, and align work using work-holding devices on the engine lathe to perform the required turning operations.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Textbook
- Engine lathe
- Engine lathe work-holding devises (3-jaw chuck, 4-jaw chuck and draw-in collet chuck)
- Required tools
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure and usage of 3-jaw chuck
 2. Set-up procedure and usage of 4-jaw chuck
 3. Set-up procedure and usage of draw-in collet chuck

- Performance of practical applications on learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Chucking Project must be completed within the required time.)

5. Available Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-34-ST-17, MA-II-12-ST-06	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 222-231	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 424-459	Prentice Hall	www.prenhall.com	

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp.223-267	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp. 403-435	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 5

1. Performance Objective

Given instruction/demonstration on the proper set up and procedures used for drilling and center drilling on the engine lathe, apprentice will perform drilling and center drilling operations within the tolerances specified on a part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Textbook
- Engine lathe
- Drills and center drills
- Required hand and measuring tools
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure of engine lathe for center drilling operations
 2. Set-up procedure of engine lathe for drilling operations
 3. Performance of practical applications on learned materials
- Part machined within the tolerances specified on part print (NIMS Level II Chucking Project must be completed within the required time.)

5. Available Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-40-ST-17	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 222-236	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 435-444	Prentice Hall	www.prenhall.com	

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 239-259	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp. 403-435	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 6

1. Performance Objective

Given instruction/demonstration on the proper procedure used for turning, facing, necking and grooving operations on the engine lathe, apprentice will perform turning, facing, necking, boring and grooving operations within the specified tolerances on the part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Textbook
- Engine lathe
- Turning, facing, necking and grooving tools
- Required hand and measuring tools
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure of engine lathe to perform turning operations
 2. Set-up procedure of engine lathe to perform facing operations
 3. Set-up procedure of engine lathe to perform necking operations
 4. Set-up procedure of engine lathe to perform boring operations
 5. Set-up procedure of engine lathe to perform grooving operations

- Performance of practical applications on learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Chucking Project must be completed within the required time.)

5. Available Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-38-ST-19, MA-II-20-ST-10, MA-II-36-ST-18	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 223-237	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and	7 th Edition Copyright 2002 Pp. 444-474	Prentice Hall	www.prenhall.com	

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
White				
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 251-275	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp. 435-449	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 7

I. Performance Objective

Given instruction/demonstration on the proper procedure used for performing shouldering operations on the engine lathe, apprentice will perform square, angular and filleted shouldering operations within the tolerances specified on a part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Textbook
- Engine lathe
- Shouldering tools
- Required hand and measuring tools
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 4. Set-up procedure of engine lathe to perform square shouldering operations
 5. Set-up procedure of engine lathe to perform angular shouldering operations
 6. Set-up procedure of engine lathe to perform filleted shouldering operations
- Performance of practical applications on learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Chucking Project must be completed within the required time.)

5. Available Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-38-ST-19, MA-II-20-ST-10	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 237-241	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 459-474	Prentice Hall	www.prenhall.com	

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 267-275	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp. 403-435	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 227-247	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 8

1. Performance Objective

Given instruction/demonstration on Unified National Thread nomenclature, formulas and the proper set-up procedure used for cutting threads on the engine lathe, apprentice will cut an external and internal U.N. thread within the tolerances specified on the part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Machinery’s Handbook
- Student’s Shop Reference Handbook

- Textbook
 - Unified National Thread reference charts
 - Calculator
 - Engine lathe
- Required hand and measuring tools (i.e., center gage, thread wires, thread micrometer, thread ring gage, etc.)
 - Threading tools
 - Part print

4. Interim Assessment

- Written assessment (developed by instructor) of:
 1. Thread nomenclature identification
 2. Thread formula calculations
- Demonstration of learned materials:
 3. Set-up procedure of engine lathe to perform threading operations
 4. Procedure used to perform threading operations
- Performance of practical applications on learned materials:
 1. Part machined within the tolerances specified on part print (NIMS Level II Chucking Project must be completed within the required time.)

5. Available Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-42-ST-21, MA-II-24-ST-12, MA-II-26-ST-13, MA-II-28-ST-14	National Tooling and Machining Association 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004 Pp. 250-261	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 479-494	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 299-311	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp.435-449	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition Copyright 2000 Pp. 1712-1754	Industrial Press INC., 200 Madison Ave, New York, NY		
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition Copyright 1986 Pp. 250-277	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078		
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 247-271	Prentice Hall, Upper Saddle River, NJ. Columbus, OH		

Performance Objective # 9

1. Performance Objective

Given a blueprint, and instruction/demonstration on taper calculations, and the proper set-up procedure used for cutting tapers on the engine lathe, apprentice will cut an external and internal and taper on the engine lathe using the tailstock set-over method, compound rest and a taper attachment to within the tolerances specified on a part print.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Standard taper reference charts
- Trigonometry tables reference book/charts
- Calculator
- Engine lathe with taper attachment
- Required hand and measuring tools (indicator)
- Turning tools
- Part print

4. Interim Assessment

- Written assessment (developed by instructor) of:
 1. Taper calculations containing taper per inch, taper per foot and angular measurement
- Demonstration of learned materials:
 1. Set-up procedure of engine lathe to perform taper turning operations using the tailstock set-over method
 2. Set-up procedure of engine lathe to perform taper turning operations using the compound rest
 3. Set-up procedure of engine lathe to perform taper turning operations using the taper attachment

- Performance of practical applications on learned materials:
- I. Part machined within the tolerances specified on part print (NIMS Level II Chucking Project must be completed within the required time.)

5. Available Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-II-30-ST-15	National Tooling and Machining Association	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	7 th Edition Copyright 2002 Pp. 494-506	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition Copyright 2002 Pp. 494-506	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998 Pp. 275-287	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004 Pp. 435-440	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition Copyright 2000 Pp. 906-918	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078		

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition Copyright 1986 Pp. 199-214	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078		
“Basic Machine Tool Operations” by: John E. Neely	Copyright 2000 Pp. 271-282	Prentice Hall, Upper Saddle River, NJ		

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 17: Milling: Square Up A Block

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for *Machinist*

1. Title of Core Competency or Cluster of Competencies

Milling: Square up a Block

2. Prerequisites

NIMS Level I- Job Planning, Benchwork and Layout

AND

NIMS Level I- Measurement, Materials and Safety

3. Global/Overall Objective(s)

Performance Standard:

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate milling machine and its accessories, apprentice will produce a part matching the process plan and the part print specifications. The part will require squaring up from its raw state.

4. In-Training Assessment

Performance assessment of apprentice's mastery of stated objectives will consist of set-up procedures and to perform squaring up operations of six surfaces on a raw cut block, to within $\pm .002$ and $.002$ over 4.5" square shape, in the required time (if applicable).

5. NIMS Credentialing

NIMS - Manual Milling Skills, Level I

Performance Objective #1

1. Performance Objective

Given instruction/demonstration and reading assignments, apprentice will demonstrate knowledge of milling machine safety procedures, and the identification of milling machine parts and their function.

2. Training Activities

- Theory relevant to machine safety and operation
- Video relevant to machine safety and operation
- Supervisor and/or peer instruction
- Demonstration/performance

3. Development Resources

- Milling machine manual
- Machine diagram
- Textbook

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Milling machine safety procedures
 2. Milling machine parts identification and function
- Demonstration of learned materials

5. Additional Education and Training Resources

Resource Title	Specific Reference to Items/Pages/ Modules	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-16-ST-08, MA-I-18-ST-09	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 317-326, 349	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 472, 473	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 522, 558	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 313-322	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Safety and Familiarization on the Bridgeport Series I Milling Machine”	Videocassette, MS-21	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Performance Objective #2

1. Performance Objective

Given instruction/demonstration on cutting tool geometry for High Speed Steel milling cutters, apprentice will perform proper cutting tool selection necessary to perform all required milling operations within the specified tolerances on a part print.

Or:

Given instruction/demonstration on cutting tool geometry and inserted tooling, apprentice will demonstrate the proper insert and toolholder selection necessary to perform all required milling operations within the specified tolerances on a blueprint.

2. Training Activities

- Theory on cutting tool geometry, inserted tooling, cutting tool selection
- Video on cutting tool geometry, inserted tooling, cutting tool selection
- Supervisor and/or peer instruction
- Demonstration/performance

3. Development Resources

- Textbook
- Tooling manufacturers reference charts
- Inserts or H.S.S. milling cutters
- Toolholders
- Process plan
- Part print

4. Interim Assessment

- Performance of practical applications of learned materials:
 1. Selection and understanding of H.S.S. milling cutters and tool geometry
 2. Selection of required H.S.S. tool-holding devices
- Or:
 1. Selection and understanding of inserted tooling
 2. Selection of required tool-holding devices
- Demonstration of learned materials:
 1. Milling machine, and milling cutter set-up procedures in preparation to machine part to within the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-24-ST-12, MA-III-08-ST-02, MA-III-30-ST-09, MA-III-34-ST-11, MA-LLL-38-ST-13, MA-III-56-ST-28	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 317-339	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 479-481	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 526-531, 576-596	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 331-360	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Basic Milling Procedures”	Videocassette, MS-66	RMI Media Productions, copyright 1985	www.rmimedia.com	

Performance Objective # 3

1. Performance Objective

Given instruction/demonstration, reading assignment, information sheets, and reference charts, apprentice will calculate cutting speeds and feeds and apply these calculations while performing required milling operations on the milling machine.

2. Training Activities

- Theory relevant to cutting speeds and feeds calculations
- Video relevant to cutting speeds and feeds calculations
- Demonstration/performance

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Tooling manufacturers reference charts
- Calculator
- Process Plan
- Part print

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Cutting speed calculations
 2. Feed rate calculations
- Demonstration of learned materials:
 1. Milling machine set to proper cutting speed to perform machining operations
 2. Milling machine set to proper feed rate to perform machining operations

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-22-ST-11	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 317-350	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 483-486	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 526-530, 566-570	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 311-360	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1009-1023	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition, Copyright 1986, Pp. 330-358	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852
“Safety and Familiarization on the Bridgeport Series I Milling Machine”	Videocassette, MS-21	RMI Media Productions, copyright date unknown	www.rmimedia.com	
“Basic Milling Procedures”	Videocassette, MS-66	RMI Media Productions, copyright 1985	www.rmimedia.com	

Performance Objective # 4

1. Performance Objective

Given instruction/demonstration on the proper selection, mounting, set up, usage procedure for work-holding devices, and an understanding of climb and conventional milling, apprentice will select, mount, set up, hold, and align work using work-holding devices on the milling machine to perform the required milling and squaring operations.

2. Training Activities

- Theory relevant to selection, mounting, set up, usage procedure for work-holding devices, and an understanding of climb and conventional milling on the milling machine
- Video relevant to selection, mounting, set up, usage procedure for work-holding devices, and an understanding of climb and conventional milling on the milling machine
- Supervisor or peer instruction
- Practice performance application
- Independent demonstration of performance application

3. Development Resources

- Textbook
- Milling machine and accessories
- Milling machine work-holding devices (milling machine vise)
- Required layout and hand tools
- Required measuring tools
- Process plan
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure and usage of milling machine work-holding devices (milling machine vise).
- Performance of practical applications on learned materials:
 1. Part machined using proper conventional milling procedures
 2. Part machined within the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-20-ST-10, MA-III-08-ST-02, MA-III-26-ST-07	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 317-336	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 473-487	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 526-540, 571-596	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 311-359	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Basic Milling Procedures”	Videocassette, MS-66	RMI Media Productions, copyright 1985	www.rmimedia.com	
“Squaring a Block on the Milling Machine”	Videocassette, MS-67	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Performance Objective # 5

1. Performance Objective

Given instruction/demonstration on the proper set up and procedures used to perform the squaring up operation, apprentice will square up six primary surfaces of a raw cut block within the tolerance of $\pm .002$ " maintaining parallelism and perpendicularity measurement with a TIR of .002" at least 4.5".

2. Training Activities

- Theory on the proper set up and procedures used to perform the squaring up operation
- Video on the proper set up and procedures used to perform the squaring up operation
- Supervisor or peer instruction
- Practice performance application
- Independent demonstration performance

3. Development Resources

- Textbook
- Milling machine and accessories
- Required cutting tools
- Required hand and layout
- Required measuring tools
- Process plan
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 - I. Set-up procedure of milling machine to perform the squaring up operations
- Performance of practical applications of learned materials:
 - I. Part machined within the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Specific Reference to Items/Pages/ Modules	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-III-12-ST-03, MA-III-30-ST-09	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 320, 321	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 491-494	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 582-586	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Squaring a Block on the Milling Machine”	Videocassette, MS-67	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Modules 18 & 19: Manual Milling: Vertical and Horizontal

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Manual Milling: Vertical and Horizontal

2. Prerequisites

NIMS Level I- Job Planning, Benchwork and Layout

NIMS Level I- Measurement, Materials and Safety

3. Global/Overall Objective(s)

Performance Standard:

Given raw material, process plan, print, hand, precision, and cutting tools, as well as access to an appropriate vertical milling machine and its accessories, apprentice will produce a part matching the process plan and the blueprint specifications using appropriate trade techniques and speeds and feeds. The part specified should require squaring up from the raw state, have at least one milled slot, require the location of at least two drilled and reamed holes within +/- .005" and have three steps controlled by tolerances of +/- .005".

Performance Standard:

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate milling machine and its accessories, produce three bores to specification. The holes will be between $\frac{3}{4}$ " and $1\frac{1}{2}$ " and their locations are to be held within +/- .001 and hold diameters within +/- .0005. One hole is to be counter bored to a decimal depth holding +/- .002" and counter bore diameter within +/- .005".

Performance Standard:

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate milling machine and its accessories, apprentice will produce a part matching the process plan and the part print specifications using appropriate trade techniques and speeds and feeds. The part specified would require milling two key seats whose characteristics match the ANSI B17.1 keys and key seat standards.

Performance Standard:

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate milling machine and its accessories, apprentice will produce a part matching the process plan and the part print specifications. The part specified will require the milling of three deep slots two parallel to one another, the third at right angles to the first two.

Performance Standard:

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate milling machine, an appropriately sized rotary table, and their accessories, apprentice will produce a part matching the process plan and the part print specifications. The part specified will require two groups of holes arrayed on bolt circles, as well as several surfaces at various angles to one another.

Performance Standard:

Given raw material, process plan, part print, hand, precision, and cutting tools, as well as access to an appropriate milling machine, an appropriately sized dividing head, and their accessories, apprentice will produce a part matching the process plan and the part print specifications. The part specified will require two groups of holes arrayed on an outer diameter, as well as several surfaces at various angles to one another.

4. In-Training Assessment

- Demonstrate knowledge of milling machine safety procedures, and the identification of milling machine parts and their function
- Perform tramming of vertical milling machine head to achieve setting the head perpendicular to the table within +/- .001
- Indicate of vise of the vertical or horizontal milling machine
- Setup and operate vertical milling machines. Perform routine milling, and location of hole centers within +/- .005"
- Set up and perform boring for location, size, and finish
- Set up and perform milling key seats on a shaft
- Set up and perform the cutting of a deep slot.

- Set up and perform the development of surfaces at a specified non-right angle using a rotary table. Set up and establish hole locations in various relationships to one another using a rotary table. The holes are in the same plane. Establish the profile of a radius with respect to two surfaces and the connecting points of tangency.
- Set up and perform operations requiring a dividing head. Set up and establish hole locations in various relationships to one another using a dividing head. Establish the profile of a radius with respect to two surfaces and the connecting points of tangency.

5. NIMS Credentialing

NIMS Milling Skills – Levels I & II

<h3>Performance Objective #1</h3>

1. Performance Objective

Given instruction/demonstration and reading assignments, apprentice will demonstrate knowledge of milling machine safety procedures, and the identification of milling machine parts and their function.

2. Training Activities

- Theory relevant to machine safety and operation
- Video relevant to machine safety and operation
- Supervisor and/or peer instruction
- Demonstration/performance

3. Development Resources

- Milling machine manual
- Machine diagram
- Textbook

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Milling machine safety procedures
 2. Milling machine parts identification and function
- Demonstration of learned materials

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-16-ST-08, MA-I-18-ST-09	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 29-41	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 522, 558	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 313-322	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 472, 473	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Safety and Familiarization on the Bridgeport Series I Milling Machine”	Videocassette, MS-21	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Performance Objective #2

1. Performance Objective

Given instruction/demonstration on cutting tool geometry for High Speed Steel milling cutters, apprentice will perform proper cutting tool selection necessary to perform all required milling operations within the specified tolerances on a part print.

Or:

Given instruction/demonstration on cutting tool geometry and inserted tooling, apprentice will demonstrate the proper insert and toolholder selection, necessary to perform all required milling operations within the specified tolerances on a blueprint.

2. Training Activities

- Theory on cutting tool geometry, inserted tooling, cutting tool selection
- Video on cutting tool geometry, inserted tooling, cutting tool selection
- Supervisor and/or peer instruction
- Demonstration/performance

3. Development Resources

- Textbook
- Tooling manufacturers reference charts
- Inserts or H.S.S. milling cutters
- Toolholders
- Process plan
- Part print

4. Interim Assessment

- Performance of practical applications of learned materials:
 1. Selection and understanding of H.S.S. milling cutters and tool geometry
 2. Selection of required H.S.S. tool-holding devices
- Or:
 1. Selection and understanding of inserted tooling
 2. Selection of required tool-holding devices
- Demonstration of learned materials
 1. Milling machine, and milling cutter set-up procedures in preparation to machine part to within the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-24-ST-12, MA-III-08-ST-02, MA-III-30-ST-09, MA-III-34-ST-11, MA-LLL-38-ST-13, MA-III-56-ST-28	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 317-339	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	Copyright 1998, Pp. 331-360	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 331-360	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 479-481	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Milling Procedures”	Videocassette, MS-66	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Performance Objective # 3

1. Performance Objective

Given instruction/demonstration, reading assignment, information sheets and reference charts, apprentice will calculate cutting speeds and feeds and apply these calculations while performing required milling, drilling and boring operations on the milling machine.

2. Training Activities

- Theory relevant to cutting speeds and feeds calculations
- Video relevant to cutting speeds and feeds calculations
- Supervisor or peer instruction/demonstration

3. Development Resources

- Machinery's Handbook
- Student's Shop Reference Handbook
- Textbook
- Tooling manufacturers reference charts
- Calculator
- Process plan
- Part print

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Cutting speed calculations
 2. Feed rate calculations
- Demonstration of learned materials:
 1. Milling machine set to proper cutting speed to perform machining operations
 2. Milling machine set to proper feed rate to perform machining operations

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-22-ST-11	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 317-339	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	Copyright 1998, Pp. 331-360	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 311-360	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 483-486	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Milling Procedures”	Videocassette, MS-66	RMI Media Productions, copyright date unknown	www.rmimedia.com	
“Safety and Familiarization on the Bridgeport Series I Milling Machine”	Videocassette, MS-21	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Performance Objective # 4

I. Performance Objective

Given instruction/demonstration on the proper selection, mounting, set up, usage procedure for work-holding devices, and an understanding of climb and conventional milling, apprentice will select, mount, set-up, hold and align work using work-holding devices on the milling machine to perform the required milling and squaring operations.

2. Training Activities

- Theory relevant to selection, mounting, set up, usage procedure for work-holding devices, and an understanding of climb and conventional milling on the milling machine
- Video relevant to selection, mounting, set up, usage procedure for work-holding devices, and an understanding of climb and conventional milling on the milling machine
- Supervisor or peer instruction
- Practice performance application
- Independent demonstration of performance application

3. Development Resources

- Textbook
- Milling machine and accessories
- Milling machine work-holding devices (milling machine vise)
- Required layout and hand tools
- Required measuring tools
- Process plan
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure and usage of milling machine work-holding devices (milling machine vise).
- Performance of practical applications on learned materials:
 1. Part machined using proper conventional milling procedures
 2. Part machined within the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-20-ST-10, MA-III-08-ST-02, MA-III-26-ST-07	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 317-336	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 526-540, 571-596	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 311-359	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 473-487	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Milling Procedures”	Videocassette, MS-66	RMI Media Productions	www.rmimedia.com	
“Squaring a Block on the Milling Machine”	Videocassette, MS-67	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Performance Objective #5

I. Performance Objective

Given required hand and precision tools, instruction/demonstration on the proper set-up and procedures used to perform tramming operations on the vertical milling machine, and the process used to indicate a vise, apprentice will adjust the milling machine head perpendicular to the table within $\pm .001$, and indicate a vise maintaining parallelism and perpendicularity measurement of $.002''$ over $4.5''$.

2. Training Activities

- Theory on the proper set-up and procedures used to perform the tramming operations of a milling machine head, and indicating a vise on the milling machine
- Video on the proper set-up and procedures used to perform the tramming operations of a milling machine head, and indicating a vise on the milling machine
- Supervisor or peer instruction
- Practice performance application
- Independent demonstration of performance application

3. Development Resources

- Textbook
- Milling machine and accessories (vise)
- Required indicators and accessories
- Required hand tools
- Required measuring tools

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure of tramming the head on a vertical milling machine
 2. Set-up procedure for indicating a vise on the table of a milling machine
- Performance of practical applications on learned materials:
 1. Vertical milling machine head adjusted perpendicular to the table within $\pm .001$.
 2. Milling machine vise indicated maintaining parallelism and perpendicularity measurement of $.002''$ over $4.5''$.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-20-ST-10, MA-III-08-ST-02, MA-III-26-ST-07	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 317-336	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 526-540, 571-596	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 311-359	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 473-487	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Basic Milling Procedures”	Videocassette, MS-66	RMI Media Productions, copyright date unknown	www.rmimedia.com	
“Squaring a Block on the Milling Machine”	Videocassette, MS-67	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Performance Objective #6

1. Performance Objective

Given instruction/demonstration on the proper set-up and procedures used to perform the squaring up operation, apprentice will square up six primary surfaces of a raw cut block within the tolerance of $\pm .002$ " maintaining parallelism and perpendicularity measurement with a TIR of .002" over 4.5".

2. Training Activities

- Theory on the proper set up and procedures used to perform the squaring up operation
- Video on the proper set up and procedures used to perform the squaring up operation
- Supervisor or peer instruction
- Practice performance application
- Independent demonstration of performance application

3. Development Resources

- Textbook
- Milling machine and accessories
- Required cutting tools
- Required hand and layout
- Required measuring tools
- Process plan
- Part print

4. Interim Assessment

- Demonstration of learned materials:
 - I. Set-up procedure of milling machine to perform the squaring operations
- Performance of practical applications on learned materials:
 - I. Part machined within the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-III-12-ST-03, MA-III-30-ST-09	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 320, 321	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 582-586	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 311-359	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 491-494	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Squaring a Block on the Milling Machine”	Videocassette, MS-67	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Performance Objective #7

1. Performance Objective

Given raw material, process plan, print, hand, precision, and cutting tools, as well as access to an appropriate vertical milling machine and its accessories, apprentice will produce a part matching the process plan and the blueprint specifications using appropriate trade techniques and speeds and feeds. The part specified should require squaring up from the raw state, have at least one milled slot, require the location of at least two drilled and reamed holes within +/- .005" and have three steps controlled by tolerances of +/- .005".

2. Training Activities

- Theory on the proper set-up and procedures used to perform squaring, slotting, drilling and reaming operations
- Video on the proper set-up and procedures used to perform squaring, slotting, drilling and reaming operations
- Theory on the proper set-up and procedures used to perform accurate hole-to-hole locations with the use of an edge finder
- Supervisor or peer instruction
- Practice performance application
- Independent demonstration of performance application

3. Development Resources

- Textbook
- Machinery's Handbook (cutting speed reference charts)
- Student's Shop Reference Handbook
- Process plan
- Part print
- Raw material
- Edge finder
- Milling machine and accessories
- Required drills and milling cutters
- Required hand tools
- Required layout tools
- Required measuring tools

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure of milling machine to perform the squaring operations
 2. Set-up procedure of milling machine and edge finder to perform slotting operations
 3. Set-up procedure of milling machine and edge finder to perform drilling and reaming operations
- Performance of practical applications on learned materials:
 1. Part machined to within the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-10-ST-05, MA-I-12-ST-06, MA-I-22-ST-II, MA-III-08-ST-02, MA-III-12-ST-03, MA-III-30-ST-09, MA-III-38-ST-13, MA-III-70-ST-42	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 325-340	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 534-539	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 343-359	Delmar Publishers	info@delmar.com	1-800-347-7707

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 473-503	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Drilling on the Bridgeport Milling Machine”	Videocassette, MS-74	RMI Media Productions, copyright date unknown	www.rmimedia.com	
“Machinery’s Handbook” by: Jones, Horton, and Ryffel	26th-Edition, Copyright 2000, Pp. 1009-1023	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition, Copyright 1986, Pp. 330-358	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852

Performance Objective #8

I. Performance Objective

Given raw material, process plan, part print, hand, precision, and cutting tools, as well as access to an appropriate milling machine and its accessories, apprentice will produce three bores to specification. The holes will be between $\frac{3}{4}$ " and $1\frac{1}{2}$ " and their locations are to be held within $\pm .001$ and hold diameters within $\pm .0005$. One hole is to be counter bored to a decimal depth holding $\pm .002$ " and counter bore diameter within $\pm .005$ ".

2. Training Activities

- Theory on the proper set up and procedures used to perform boring and counter boring operations

- Video on the proper set up and procedures used to perform boring and counter-boring operations
- Theory on the proper set up and procedures used to perform accurate hole-to-hole locations with the use of an edge finder
- Theory on the proper set up and procedures used to perform boring operations using a boring head
- Supervisor or peer instruction
- Practice performance application
- Independent demonstration of performance application

3. Development Resources

- Textbook
- Machinery's Handbook (cutting speed reference charts)
- Student's Shop Reference Handbook
- Process plan
- Part print
- Squared material
- Edge finder
- Boring head
- Milling machine and accessories
- Required drills, boring bars and cutters
- Required hand tools
- Required layout tools
- Required measuring tools

4. Interim Assessment

- Demonstration of learned materials:
 1. Set-up procedure of milling machine and edge finder to perform hole location operations
 2. Set-up procedure of milling machine to perform drilling operations
 3. Set-up procedure of milling machine to perform counter-boring operations
 4. Set-up procedure of milling machine to perform boring operations
- Performance of practical applications on learned materials:
 1. Part machined to within the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-20-ST-10, MA-III-58-ST-30, MA-III-62-ST-34, MA-III-70-ST-42	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 317-328	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 534-539	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 343-359	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 473-503	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machinery’s Handbook” by: Jones, Horton, and Ryffel	26th-Edition, Copyright 2000, Pp. 1009-1023	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition, Copyright 1986, Pp. 343-350, 351-364	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
"Using the Boring Head"	Videocassette, MS-71	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Performance Objective #9

1. Performance Objective

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate milling machine and its accessories, apprentice will produce a part matching the process plan and the part print specifications using appropriate trade techniques and speeds and feeds. The part specified would require milling two key seats whose characteristics match the ANSI B17.1 keys and key seat standards.

2. Training Activities

- Theory on the proper set up and procedures used to perform key seat cutting operations
- Video on the proper set up and procedures used to perform key seat cutting operations
- Theory on the proper set up and procedures used to perform accurate center of round shaft locations with the use of an edge finder
- Supervisor or peer instruction
- Practice performance application
- Independent demonstration of performance application

3. Development Resources

- Textbook
- Machinery's Handbook (ANSI B17.1 keys and key seat standards reference charts)
- Student's Shop Reference Handbook
- Process plan

- Part print
- Raw material (round)
- Edge finder
- Milling machine and accessories
- Required milling cutters
- Required hand tools
- Required layout tools
- Required measuring tools

4. Interim Assessment

- Demonstration of learned materials:
 1. Proper selection of milling cutters and key seat calculations
 2. Set-up procedure of milling machine and edge finder, to locate center of shaft to perform key seat cutting operations
- Performance of practical applications on learned materials:
 1. Two key seats machined to within the tolerances specified on part print and in accordance to ANSI B17.1 key and key seat standards

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-24-ST-12, MA-III-16-ST-04, MA-III-30-ST-09, MA-III-66-ST-38, MA-III-70-ST-42	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 323-328, 336-339	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwillcox.com	

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 535-539, 545-547	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 357, 358	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 494-502	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Cutting a Keyway”	Videocassette, MS-71	RMI Media Productions, copyright date unknown	www.rmimedia.com	
“Cutting a Woodruff Key Seat”	Videocassette, MS-70	RMI Media Productions, copyright date unknown	www.rmimedia.com	
“Finding the Center of a Shaft on the Vertical Milling Machine”	Videocassette, MS-75	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Performance Objective #10

1. Performance Objective

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate milling machine and its accessories, apprentice will produce a part matching the process plan and the part print specifications. The part specified will require the milling of three deep slots, two parallel to one another, the third at right angles to the first two.

2. Training Activities

- Theory on the proper set up and procedures used to perform deep slot milling operations
- Video on the proper set up and procedures used to perform deep slot milling operations
- Theory on the proper set up and procedures used to perform accurate center of slot locations with the use of an edge finder
- Supervisor or peer instruction
- Practice performance application
- Independent demonstration of performance application

3. Development Resources

- Textbook
- Process plan
- Part print
- Raw material
- Edge finder
- Milling machine and accessories
- Required milling cutters
- Required hand tools
- Required layout tools
- Required measuring tools

4. Interim Assessment

- Demonstration of learned materials:
 - I. Proper selection of milling cutters to perform deep slot milling operations

2. Set-up procedure of milling machine and edge finder to locate center of slots to perform deep slot milling operations
 - Performance of practical applications on learned materials:
 1. Two deep slot machined parallel to one another within the tolerances specified on part print
 2. One deep slot machined at right angles to the first two within the tolerances specified on part print.

5. Additional Education and Resource Training

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-22-ST-11, MA-I-24-ST-12, MA-III-16-ST-04, MA-III-34-ST-11, MA-III-38-ST-13	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 323-328, 336-339	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	Copyright 1998, Pp. 317-320, 352-358	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 317-320, 352-358	Delmar Publishers	info@delmar.com	1-800-347-7707
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 494-496, 500-502	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Performance Objective #11

1. Performance Objective

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate milling machine, an appropriately sized rotary table, and their accessories, apprentice will produce a part matching the process plan and the part print specifications. The part specified will require two groups of holes arrayed on bolt circles, as well as several surfaces at various angles to one another.

2. Training Activities

- Theory on the proper set up and procedures used to perform rotary table machining operations
- Video on the proper set up and procedures used to perform rotary table machining operations
- Theory on the proper set up and procedures used to perform accurate center of hole locations with the use of an indicator
- Supervisor or peer instruction
- Practice performance application
- Independent demonstration of performance application

3. Development Resources

- Textbook
- Process plan
- Part print
- Raw material
- Indicator with attachments
- Rotary table
- Milling machine and accessories
- Required milling cutters
- Required hand tools
- Required layout tools
- Required measuring tools

4. Interim Assessment

- Demonstration of learned materials:
 1. Proper set-up procedure of rotary table on milling machine
 2. Correctly used formulas to calculate and/or ability to access reference tables to produce the required bolt circles
 3. Proper set-up procedure of milling machine and indicator to locate center of part to machine bolt circles
 4. Proper set-up procedure of milling machine and rotary table to machine several surfaces at various angles to one another
- Performance of practical applications on learned materials:
 1. Two groups of holes arrayed on bolt circles within the tolerances specified on part print
 2. Several surfaces at various angles to one another machined to within the tolerances specified on part print

5. Additional Education and Training Resources

Name of Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-III-04-ST-01, MA-III-26-ST-07, MA-III-50-ST-22	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 547-549, 573-358	Prentice Hall	www.prenhall.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 487	The Goodheart-Willcox Co., Tinley Park, IL	www.goodheartwilcox.com	

Name of Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1009-1023	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition, Copyright 1986, Pp. 330-358	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852

Performance Objective #12

I. Performance Objective

Given raw material, process plan, part print, hand, precision and cutting tools, as well as access to an appropriate milling machine, an appropriately sized dividing head, and their accessories, apprentice will produce a part matching the process plan and the part print specifications. The part specified will require two groups of holes arrayed on an outer diameter, as well as several surfaces at various angles to one another.

2. Training Activities

- Theory on the proper set up and procedures used to perform dividing head machining operations
- Video on the proper set up and procedures used to perform dividing head machining operations
- Theory on the formulas used to calculate and/or where to access reference tables to determine the correct index plate, hole circle, turns and holes needed to achieve proper indexing
- Supervisor or peer instruction
- Practice performance application
- Independent demonstration of performance application

3. Development Resources

- Textbook
- Machinery's Handbook
- Students Shop Reference Handbook
- Process plan
- Part print
- Raw material
- Indicator with attachments
- Indexing head and accessories
- Milling machine and accessories
- Required drill bits and milling cutters
- Required hand tools
- Required layout tools
- Required measuring tools

4. Interim Assessment

- Demonstration of learned materials:
 1. Proper set-up procedure of indexing head on milling machine
 2. Correctly used formulas to calculate and/or ability to access reference tables to determine the correct index plate, hole circle, turns and holes needed to achieve proper indexing
 3. Proper set-up procedure of indexing head on milling machine to produce two groups of holes arrayed on an outer diameter
 4. Proper set-up procedure of indexing head on milling machine to produce several surfaces at various angles to one another
- Performance of practical applications on learned materials:
 1. Two groups of holes arrayed on an outside diameter within the tolerances specified on part print
 2. Several surfaces at various angles to one another machined to within the tolerances specified on part print

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-III-04-ST-01, MA-III-26-ST-07, MA-III-50-ST-22	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	N/A
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 573-575	Prentice Hall	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 311-360	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 340-349	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwillcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 472, 473	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwillcox.com	
“Machinery’s Handbook” by: Jones, Horton, and Ryffel	26th-Edition, Copyright 2000, Pp. 1947,1948, 1979-1985	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition, Copyright 1986, Pp. 320-323	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852
“Using the Index Head”	Videocassette, MS-73	RMI Media Productions, copyright date unknown	www.rmimedia.com	

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 20: Surface Grinding: Grinding Wheel Safety

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for *Machinist*

1. Title of Core Competency or Cluster of Competencies

Surface Grinding: Grinding Wheel Safety

2. Prerequisites

None

3. Global/Overall Objective(s)

Performance Standard:

Given a selection of wheels in various conditions, determine which are suitable for use, mount one on the spindle and dress it in preparations for surface grinding. Include the understanding of the grinding wheel code.

4. In-Training Assessment

Apprentice will read the part print to consider grinding wheel selection; perform ring test, visual safety inspection, balancing (where applicable) mounting, and wheel dressing procedure activities with 100% compliance. Carry out all procedural steps to company standards without assistance and within company-specific time limits. Follow all safety, environmental, record keeping and plant/shop procedures.

5. NIMS Credentialing

Surface Grinding Skills

Performance Objective #1

1. Performance Objective

Given instruction/demonstration and reading assignments on grinding wheel selection and the standard wheel marking system, apprentice will determine the proper wheel selection to perform all grinding tasks from information obtained from the part print and process plan.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Machinery's Handbook
- Student's Shop Reference Handbook
- Grinding wheel manufacturers reference guide
- Process plan and part print

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Grinding wheel selection from part print and process plan
 2. Understanding Standard Wheel Marking System:
 - Type of abrasive
 - Grit size
 - Grade or hardness
 - Structure
 - Bond
- Demonstration of learned materials

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-54-ST-27, MA-IV-17-ST-17, MA-IV-19-ST-19	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 358-366	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 354-357	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	Copyright 1998, Pp. 373-382	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1193-1170	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852
“Student’s Shop Reference Handbook” by: Edward G. Hoffman	1 st Edition, Copyright 1986, Pp. 385-388	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852

Performance Objective #2

1. Performance Objective

Given instruction/demonstration and reading assignments apprentice will demonstrate the proper procedure used for visual safety inspection of the grinding wheel, and perform a ring testing, to determine the wheels soundness prior to mounting.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Machinery's Handbook
- Required tools needed to perform ring test

4. Interim Assessment

- Demonstration of learned materials:
(to determine the wheels soundness prior to mounting)
 1. Demonstrate visual safety inspection of the grinding wheel
 2. Demonstrate the proper procedure used to perform ring testing

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-50-ST-5, MA-I-54-ST-27, MA-IV-17-ST-17, MA-IV-18-ST-18	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 362-364	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 354-357	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 613-627	Prentice Hall, Upper Saddle River, NJ	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 376-379	Delmar Publishers, Albany, NY	info@delmar.com	1-800-347-7707
“Machinery’s Handbook” by: Jones, Horton, and Ryffel	26th-Edition, Copyright 2000, Pp. 1170-1174	Industrial Press INC., New York, NY	www.industrialpress.com	1-888-528-7852

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
"Student's Shop Reference Handbook" by: Edward G. Hoffman	1 st Edition, Copyright 1986, Pp. 385-388	Industrial Press INC., New York, NY	www.industrialpress.com	1-888-528-7852

Performance Objective #3

1. Performance Objective

Given instruction/demonstration and reading assignments, apprentice will demonstrate the proper procedure used for balancing (where applicable), mounting, and dressing the grinding wheel on the surface grinder to perform required grinding operations.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Machinery's Handbook
- Grinding wheel
- Grinding wheel balancer
- Surface grinder
- Required tools and materials needed to mount grinding wheels
- Required wheel dressers (diamond, radius, and form)

4. Interim Assessment

- Demonstration of learned materials:
(to prepare the grinding wheels for grinding operations)
 1. Demonstrate the proper procedure used to balance grinding wheels (where applicable)
 2. Demonstrate the proper procedure used to mount grinding wheels on the surface grinder
 3. Demonstrate the proper procedure used to dress the grinding wheel to perform required grinding operations:
 - Diamond wheel dresser
 - Radius wheel dresser
 - Form wheel dresser

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-52-ST-26, MA-I-54-ST-27, MA-I-56-ST-28, MA-IV-15-ST-15, MA-IV-19-ST-19	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 358-367	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 356-360	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	77 th Edition, Copyright 2002, Pp. 621-627	Prentice Hall, Upper Saddle River, NJ Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 377-382	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1170-1174, 1158-1162, 1158-1162	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Modules 21 & 22: Surface Grinding, Horizontal Spindle, Reciprocating Table

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Surface Grinding, Horizontal Spindle, Reciprocating Table

2. Prerequisites

None

3. Global/Overall Objective(s)

Performance Standard (Level I):

Given a block squared up on a mill, a process plan, part print, hand and precision tools, and choice of a grinding wheels, as well as access to a surface grinder and its accessories, dress the wheel, produce a part matching the process plan and the print specifications using appropriate trade techniques. The part specified would be in the semi-finished state having been squared up. Finishing the part will require the precision finishing of the six faces of the block to tolerances common to precision grinding for square shape, size and surface finish characteristics.

Performance Standard (Level II) Finish Flats to +/- .0005:

Given a block squared up on a mill, a process plan, part print, hand and precision tools, and choice of a grinding wheels, as well as access to a surface grinder and its accessories, dress the wheel, produce a part matching the process plan and the part print specifications using appropriate trade techniques. The part specified would be in the semi-finished state having been squared up. Finishing the part will require the precision finishing of the six faces of the block to tolerances common to precision grinding for square shape, size and surface finish characteristics.

Performance Standard (Level II) Finish Flats at Simple Angles and Grind Contour Radii:

Given a block roughed out on a mill, a process plan, part print, hand and precision tools, and choice of a grinding wheels, as well as access to a surface grinder and its accessories, dress the wheel, grind the specified radii and angled surfaces to a finish matching the process plan and the part print specifications using appropriate trade techniques. The part specified would be in the semi-finished state having been roughed out. Finishing the part will require the precision finishing of the specified surfaces of the block to tolerances common to precision grinding for square shape, size and surface finish characteristics.

Performance Standard (Level II) Grinding Wheel Preparation and Balancing:

Given a wheel and appropriate equipment, prepare the wheel to go into service. Mount the wheel. Produce a surface finish of 32 micro inches or better on a cylinder or flat surface of work piece.

4. In-Training Assessment

Apprentice will read the part print to consider grinding wheel selection; perform ring test, visual safety inspection, balancing (where applicable) mounting, and wheel dressing procedure activities with 100% compliance. Carry out all procedural steps to company standards without assistance and within company-specific time limits. Follow all safety, environmental, record keeping and plant/shop procedures. Produce the following parts, and procedures that will require the precision finishing to the tolerances common to precision grinding for square shape, parallelism, size and surface finish characteristics.

- Grind a block's six faces to finished dimensions having tolerances of $\pm .0005$ and square shape of $.0005$ over 4", and 32 micro inch surface finish. Dress the wheel as necessary.
- Set up and perform the finish surface grinding of flat surfaces at simple angles with respect to one another. Dress the wheel as necessary.
- Set up and perform the preparation and balancing of a grinding wheel 14" diameter or greater. Place the wheel into service.

5. NIMS Credentialing

NIMS – Surface Grinding Skills, Level I & II

Performance Objective #1

1. Performance Objective

Given instruction/demonstration and reading assignments on grinding wheel selection and the standard wheel marking system, apprentice will determine the proper wheel selection to perform all grinding tasks from information obtained from the part print, and process plan.

2. Training Activities

- Theory

- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Machinery's Handbook
- Student's Shop Reference Handbook
- Grinding wheel manufacturers reference guide
- Process plan and part print

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Grinding wheel selection from part print and process plan
 2. Understanding Standard Wheel Marking System:
 - Type of abrasive
 - Grit size
 - Grade or hardness
 - Structure
 - Bond
- Demonstration of learned materials

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA MA-I-54-ST-27, MA-IV-17-ST-17, MA-IV-19-ST-19	National Tooling and Machining Association, 9300 Livingston Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 358-366	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 354-357	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 613-620	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 373-382	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1139-1170	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852
“Student’s	1 st Edition, Copyright	Industrial Press INC.,	www.industrialpress.com	1-888-528-

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Shop Reference Handbook” by: Edward G. Hoffman	1986, Pp. 385-388	200 Madison Ave, New York, NY 10016-4078		7852

Performance Objective #2

1. Performance Objective

Given instruction/demonstration and reading assignments apprentice will demonstrate the proper procedure used for visual safety inspection of the grinding wheel, and perform a ring testing, to determine the wheels soundness prior to mounting.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Machinery’s Handbook
- Required tools needed to perform ring test

4. Interim Assessment

- Demonstration of learned materials:
(to determine the wheels soundness prior to mounting)
 1. Demonstrate visual safety inspection of the grinding wheel
 2. Demonstrate the proper procedure used to perform ring testing

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-50-ST-5, MA-I-54-ST-27, MA-IV-17-ST-17, MA-IV-18-ST-18	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 362-364	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 357-360	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 613-627	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 376-379	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707

Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1170-1174	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888- 528- 7852

Performance Objective #3

1. Performance Objective

Given instruction/demonstration and reading assignments, apprentice will demonstrate the proper procedure used for balancing a wheel (14” or greater), mounting and dressing the grinding wheel on the surface grinder to perform required grinding operations.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Machinery’s Handbook
- Grinding wheel
- Grinding wheel balancer
- Surface grinder
- Required tools and materials needed to mount grinding wheels
- Required wheel dressers (diamond, radius and form)

4. Interim Assessment

- Demonstration of learned materials: to prepare the grinding wheels for grinding operations.
 1. Demonstrate the proper procedure used to balance a grinding wheel (14” or greater)
 2. Demonstrate the proper procedure used to mount grinding wheels on the surface grinder
 3. Demonstrate the proper procedure used to dress the grinding wheel to perform required grinding operations

5. Additional Education and Training Resources

Resource Title	Specific Reference to Items/Pages/ Modules	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-52-ST-26, MA-I-54-ST-27, MA-I-56-ST-28, MA-IV-15-ST-15, MA-IV-19-ST-19, MA-IV-21-ST-21	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 358-367	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 356-360	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 621-627	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 377-382	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1170-1174, 1158-1162, 1158-1162	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852

Performance Objective #4

1. Performance Objective

Given instruction/demonstration and reading assignments, apprentice will demonstrate knowledge of surface grinder safety procedures, and the identification of surface grinder controls/components, and their function.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration/performance

3. Development Resources

- Surface grinder manual
- Machine diagram
- Textbook

4. Interim Assessment

- Written assessment (developed by supervisor) of:
 1. Surface grinder safety procedures
 2. Surface grinder controls/components identification and function
- Demonstration of learned materials:

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-50-ST-25, MA-IV-15-ST-15	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 367	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 357, 358	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	Copyright 1998, Pp. 373-382	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 373-382	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 1170	Industrial Press INC., 200 Madison Ave, New York, NY 10016-4078	www.industrialpress.com	1-888-528-7852

Performance Objective #5

1. Performance Objective

Given instruction/demonstration on the proper selection, mounting, set-up, and usage procedure for necessary work-holding devices on the surface grinder, apprentice will select, mount, set-up, hold, and align work using work-holding devices on the surface grinder to perform the required grinding operations.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration
- Practice performance application

3. Development Resources

- Textbook
- Precision layout table
- Indicator, surface gage
- Surface grinder
- Required work-holding devices
- Required hand tools
- Process plan and Part print

4. Interim Assessment

- Demonstration of learned materials:
 - I. Set-up procedure and usage of work-holding devices
- Performance of practical applications on learned materials by apprentice:
 - I. Part machined within the tolerances specified on part print (NIMS Level II Surface Grinding Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Specific Reference to Items/Pages/ Modules	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-52-ST-26, MA-IV-25-ST-25	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	Copyright 1998, Pp. 373-382	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707

Performance Objective #6

1. Performance Objective

Given instruction/demonstration a block squared up on a mill, a process plan, part print, precision tools, choice of grinding wheels and access to a surface grinder and its accessories, choose the appropriate wheel, dress a wheel, produce a part matching the process plan and the part print specifications using the appropriate techniques. Grind a block's six faces to finished dimensions having a tolerance of $\pm .0005$ " and perpendicularity TIR of .0005 " over 4" holding a surface finish of 32 micro inches or better.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration

3. Development Resources

- Machinery's Handbook
- Textbook
- Part print & Process plan
- Block squared up on a mill
- Surface grinder and it's accessories
- Appropriate grinding wheel
- Wheel dresser
- Required hand and measuring tools
- Appropriate work-holding devises & instruments required for set-up
- Surface finish comparator chart

4. Interim Assessment

- Demonstration of learned materials:
 1. Ability of apprentice to read part print and follow process plan
 2. Set-up procedure of appropriate work-holding devises and use of instruments required for set-up
 3. Set-up procedure of surface grinder to perform grinding operations (wheel selection and mounting)
 4. Procedure used to perform wheel dressing operations

- Performance of practical applications on learned materials :
- I. Part ground and squared with the required surface finish, within the tolerances specified on part print (NIMS Level II Surface Grinding Skills Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-54-ST-27, MA-IV-17-ST-17, MA-IV-19-ST-19, , MA-IV-25-ST-25	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 353-382	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 329, 343-362	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 96-97, 597-647	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 30, 361-382	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Machinery’s	Copyright 2004, Pp.	Industrial Press INC.,	www.industrialpress.com	1-888-

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Handbook” by: Jones, Horton, and Ryffell	329, 343-362	200 Madison Ave, New York, NY		528- 7852

Performance Objective #7

1. Performance Objective

Given instruction/demonstration a block squared up on a surface grinder, a process plan, part print, precision measuring tools, a choice of grinding wheels and access to a surface grinder and its accessories, set a radius dresser, dress the wheel, grind the specified radii, angled surfaces and slot to a finish matching the process plan and print specifications using appropriate grinding techniques. Use the appropriate work-holding devices to grind all surfaces, angles and contours.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration

3. Development Resources

- Machinery’s Handbook
- Textbook
- Calculator (trigonometry functions)
- Part print and process plan
- Block squared up on surface grinder
- Surface grinder and it’s accessories
- Appropriate grinding wheel
- Radius wheel dresser
- Required hand and measuring tools
- Appropriate work-holding devises & instruments required for set-up
- Sine vise or sine bar with angle plate
- Gage blocks

4. Interim Assessment

- Demonstration of learned materials:
 1. Ability of apprentice to read part print and follow process plan
 2. Set-up procedure of appropriate work-holding devices and use of instruments required for set-up
 3. Set-up procedure of surface grinder to perform grinding operations (wheel selection and mounting)
 4. Procedure used to perform wheel dressing operations
- Performance of practical applications on learned materials:
 1. Part ground with the specified radii, angled surfaces and slot to a finish matching the process plan and print specifications using appropriate grinding techniques. (NIMS Level II Surface Grinding Skills Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Specific Reference to Items/Pages/ Modules	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-54-ST-27, MA-IV-17-ST-17, MA-IV-19-ST-19, MA-IV-21-ST-21, MA-VI-23-ST-23, MA-IV-25-ST-25	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 353-382	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 329, 343-362	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 96, 97, 597-647	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 30, 361-382	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 84-103, 1124, 1142-1162	Industrial Press INC., 200 Madison Ave, New York, NY	www.industrialpress.com	1-888-528-7852

Performance Objective #8

1. Performance Objective

Given instruction/demonstration, apprentice will dress and grind an internal or external radius tangent to an angle other than 90° or 0° holding tolerances correlated to the NIMS credentialing print for Machining – Level II Surface Grinding.

2. Training Activities

- Theory
- Video
- Peer instruction
- Demonstration

3. Development Resources

- Machinery's Handbook
- Textbook
- Calculator (trigonometry functions)
- Part print and process plan (NIMS credentialing print for Machining – Level II Surface Grinding)
- Block squared up on surface grinder
- Surface grinder and it's accessories
- Appropriate grinding wheel
- Appropriate wheel dresser
- Required hand and measuring tools
- Appropriate work-holding devises & instruments required for set-up
- Sine vise or sine bar with angle plate
- Gage blocks

4. Interim Assessment

- Demonstration of learned materials:
 1. Ability of apprentice to read part print and follow process plan
 2. Set-up procedure of appropriate work-holding devises and use of instruments required for set-up
 3. Set-up procedure of surface grinder to perform grinding operations (wheel selection and mounting)
 4. Procedure used to perform wheel dressing operations

- Performance of practical applications on learned materials :
 - I. Part ground with an internal or external radius tangent to an angle other than 90° or 0° holding tolerances correlated to the NIMS credentialing print for Machining – Level II Surface Grinding. (NIMS Level II Surface Grinding Skills Project must be completed within the required time.)

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-54-ST-27, MA-IV-17-ST-17, MA-IV-19-ST-19, MA-IV-21-ST-21, MA-VI-23-ST-23, MA-IV-25-ST-25	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
ToolingU (Online Learning)	N/A	ToolingU	www.toolingu.com	
“Machining Fundamentals” by: John R. Walker	Copyright 2004, Pp. 353-382	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Modern Metalworking” by: John R. Walker	Copyright 2004, Pp. 329, 343-362	The Goodheart-Willcox Co. Inc., Tinley Park, IL	www.goodheartwilcox.com	
“Machine Tool Practices” by: Kibbe, Neely, Meyer, and White	7 th Edition, Copyright 2002, Pp. 96, 97, 597-647	Prentice Hall, Upper Saddle River, NJ. Columbus, OH	www.prenhall.com	
“Machine Tool and Manufacturing Technology” by: Krar, Rapisarda, and Check	Copyright 1998, Pp. 30, 361-382	Delmar Publishers, 3 Columbia Circle, Box 15015, Albany, NY 12212-5015	info@delmar.com	1-800-347-7707

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
"Machinery's Handbook" by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 84-103, 1124, 1142-1162	Industrial Press INC., 200 Madison Ave, New York, NY	www.industrialpress.com	1-888-528-7852

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 23: General Housekeeping and Maintenance

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for *Machinist*

1. Title of Core Competency or Cluster of Competencies

General Housekeeping and Maintenance

2. Prerequisites

None

3. Global/Overall Objective(s)

Given maintenance, cleaning, housekeeping checklists, and verbal instructions, clean, maintain and respond appropriately to safety hazards on all benchwork tools, conventional and CNC machine tools. Maintain the cleanliness of the general work area.

4. In-Training Assessment

- Perform all housekeeping and maintenance activities with 100% compliance
- Carry out all procedural steps to company standards without assistance and within company-specific time limits
- Follow all safety, environmental, record keeping and plant/shop procedures

5. NIMS Credentialing

Included in all NIMS Machining credentials

Performance Objective #1

I. Performance Objective

Given maintenance, cleaning and housekeeping checklist as well as verbal instructions, apprentice will clean, maintain and respond appropriately to safety hazards on all benchwork tools and conventional and CNC machine tools. Maintain the cleanliness of the general work area.

2. Training Activities

Demonstration/performance:

- Clean primary equipment and floor area before, after, or in between a shift or changeover
- Clean support equipment as specified by company policies
- Identify company policies for cleaning oily floors
- Identify proper containers to store oily rags
- Identify the chip containers for the various metals being machined and the proper procedure for transporting chips
- Identify “Right to Know” information pertaining to hazardous materials being used

3. Development Resources

- Company safety policies and procedures
- Company specific checklist, records and documentation
- Housekeeping and cleaning supplies
- Applicable MSDS

4. Interim Assessment

Observed by supervisor or an experienced and authorized employee, apprentice will clean and maintain assigned equipment and workstation area as per company policies.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-01-OR-01, MA-I-02-ST-01	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
Employee Hazard Communication Training	Manual No. 31	PMPA	www.pmpa.org	440-526-0300

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 24: Preventative Maintenance - Machine Tools

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for Machinist

1. Title of Core Competency or Cluster of Competencies

Preventative Maintenance - Machine Tools

2. Prerequisites

None

3. Global/Overall Objective(s)

Given the preventative maintenance procedures and schedules for a given machine tool, apprentice will inspect and assess the general condition of the equipment. Apprentice will carry out daily, weekly and/or monthly maintenance chores as specified by the machine tool manufacturer or company. Apprentice will report problems that are beyond the scope of authority.

4. In-Training Assessment

Under the guidance of a trained and experienced employee or trainer, apprentice will perform all basic maintenance duties on a specific machine tool and/or tooling, and fill out all history forms used for tracking maintenance.

5. NIMS Credentialing

NIMS Level I Machining Skills
Measurement, Materials and Safety

Performance Objective #1

1. Performance Objective

Given a specific machine tool, apprentice will locate, check and fill all applicable lubrication reservoirs, check for proper oil pressure, temperature, and check that all lubrication points are functioning properly. Check the general condition of the equipment and make routine adjustments as stated in the maintenance schedule.

2. Training Activities

- Obtain a maintenance schedule
- Determine Lockout/Tag-out procedures
- Locate proper lubricants
- Locate and fill oil reservoirs
- Locate and pack grease fittings
- Locate and observe sight and pressure gauges
- Locate and check all visible lubrication points
- Check for proper placement of all gauges and shields
- Check for proper adjustments of collets and/or chucks
- Check for excessive play in slides and spindles
- Check for proper operating temperature
- Review company PM policy

3. Development Resources

- Machine tool/tooling
- Company maintenance schedule
- Lockout/Tag-out procedures
- Common hand tools
- Trouble light or flashlight
- Equipment manuals
- Dial indicators
- Lubricants
- Shop towels
- Grease guns
- Oil handling containers

4. Interim Assessment

- Demonstrate the proper procedure for shutting down and securing machine tool/tooling
- Identify lubricants used and pull MSDS sheets for reference

- Identify all sight and pressure gauges.
- Fill out a maintenance history report.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Preventive Maintenance	Publication No. 189	Precision Machined Products Association	www.pmpa.org	440-526-0300
Skillstart-Basic Maintenance		Precision Metalworking Association Educational Foundation	www.pmaef.org	
Maintenance Planning Scheduling and Coordination		Travers Tool Co.	www.travers.com	

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 25: Tooling Maintenance

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program for *Machinist*

1. Title of Core Competency or Cluster of Competencies

Tooling Maintenance

2. Prerequisites

None

3. Global/Overall Objective(s)

Inspect and assess the condition of tooling. Refurbish tooling where appropriate and refer tooling for repair or regrind where appropriate.

4. In-Training Assessment

Apprentice will assess samples of tooling in various conditions, diagnose the tooling and take the correct steps to put the tooling back in service. The sample tooling should include turning, milling and drilling tools. These tools should be both insert tooling as well as non-insert tooling. Apprentice must demonstrate the offhand grinding of a drill between the diameter of .125" and 1.000". The offhand regrinding of a turning tool and the correct rotation and replacement of inserts in various types of insert tooling must be demonstrated.

5. NIMS Credentialing

Included in all Level I Machining Credentials

Performance Objective #1

1. Performance Objective

Diagnose tooling in various conditions and take the correct steps to put the tooling back in service.

2. Training Activities

- Study the nomenclature of a high quality, properly sharpened tool and it's geometry.
- Given samples of tooling in various conditions, inspect and diagnose the tooling condition based on chips, craters, thermal cracking, general dullness and wear.

3. Development Resources

- Magnifying inspection equipment (i.e., optical comparator, eye loupe, magnifying glass, microscope, etc.)
- General precision measuring tools
- Sample inserted and non-inserted tooling of various conditions

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will be able to identify most major tool wear
- Apprentice will be able to justify whether a tool should be replaced, re-sharpened or continued for use

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Tool Geometry	Class No. 240	Tooling University	www.toolingu.com	1-800-730-2214
Computer Numerical Control Simplified	Section 8, Unit I 6	Industrial Press	http://www.industrialpress.com	1-888-528-7852
CNC Programming: Principle and Applications	Pp. 48-67	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control Concepts & Programming 4 th Edition	P. 43-66	Goodheart-Willcox	http://www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control Operation and Programming	Pp. 71-91	Prentice Hall	http://www.prenhall.com	
Fundamentals of Computer Numerical Control	P. 240-273	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
“Machinery’s Handbook” by: Jones, Horton, and Ryffell	26th-Edition, Copyright 2000, Pp. 933-940	Industrial Press	www.industrialpress.com	1-888-528-7852

Performance Objective #2

1. Performance Objective

Perform cutter and drill sharpening operations.

2. Training Activities

- Become familiar with the controls, features, operation and safety of various grinders
- View an instructional video on tool and cutter grinding
- View an instructional video on off-hand drill grinding
- Practice grinding twist drills of various diameters between .125 and 1”

3. Development Resources

- Various common precision tools and grinders

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will be able to grind various cutters
- Apprentice will be able to grind a HSS drill tip with 100% accuracy
- Apprentice will be able to identify the various controls and features of various grinders

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Tool Geometry	Class No. 240	Tooling University	www.toolingu.com	1-800-725-3418
Basic Machine Technology Series	Video and Workbooks: A. Sharpening Drill Bits By Hand B. The Pedestal Grinder	Coastal Training Technologies Corp.	www.coastal.com	1-888-528-7852
Precision Grinding	Part 12	National Tooling and Machining Association	www.ntma.org	1-800-832-7753

Performance Objective #3

1. Performance Objective

Apprentice will be able to understand insert identification nomenclature and index or change inserts.

2. Training Activities

- Study and develop a working knowledge of the ISO insert identification system

- Study the various different insert hold-down systems and the proper insert removal and replacement techniques
- Apply the appropriate anti-seize compound to the hold-down threads

3. Development Resources

- Tooling manuals for proprietary specific toolholders and inserts
- Sample toolholders and inserts
- Tooling hold-down tools and wrenches (i.e., Allen® or Torx®)
- Anti-seize compound

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will be able to demonstrate insert removal and replacement techniques
- Apprentice will be able to identify inserts with the proper ISO designation

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Anti-Insert Selection	Class No. 250	Tooling University	www.toolingu.com	1-800-730-2214
Computer Numerical Control Simplified	Section 8, Unit 16	Industrial Press	http://www.industrialpress.com	1-888-528-7852
CNC Programming: Principle and Applications	Pp. 48-67	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control Concepts & Programming 4 th Edition	Pp. 43-66	Goodheart-Willcox	http://www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control Operation and Programming	Pp. 71-91	Prentice Hall	http://www.prenhall.com	
Fundamentals of Computer Numerical Control	Pp. 240-273	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214

Competency-Based Apprenticeship System for the Metalworking Industry



Curriculum Guide

Training and Apprenticeship Program for Machinist

Module 26: CNC Basic Programming

National Institute for Metalworking Skills, Inc.

Training and Apprenticeship Program For Machinist

1. Title of Core Competency or Cluster of Competencies

CNC Basic Programming

2. Prerequisites

None

3. Global/Overall Objective(s)

Given a computer, basic CNC software program and a blueprint for part comparison, apply the principles of three-dimensional coordinate planes in the development of a simple program for the production of the part on a CNC milling machine.

4. In-Training Assessment

Using the principles of Cartesian coordinates, develop a program for the manufacture of a simple part. Apprentice will develop a part program, enter it into an editor/simulation package and verify the program. A supervisor will evaluate the simulation and programmed coordinates in the program and assure that they are dimensionally correct. Apprentice has successfully completed the competency when the program runs smoothly with no collisions and coordinates are 100% correctly identified on the simulation software.

5. NIMS Credentialing

NIMS CNC Milling, Level I

Performance Objective #1

1. Performance Objective

Apprentice will be able to describe the functions and use of basic G and M codes.

2. Training Activities

- A project consisting of matching or fill-in-the blank questions about various G and M codes used in milling

3. Development Resources

- CNC milling program editor/simulator

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will be able to identify major G and M codes on a work sheet with 100% accuracy
- Apprentice will be able to recite major G and M codes verbally with 100% accuracy when asked what code applies to a particular function
- Apprentice will be able to identify major G and M codes and apply them appropriately into a program. Codes are correctly identified when program runs smoothly and functions appropriately according to the process plan.

6. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-16-ST-08, MA-I-18-ST-09	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
Introduction to Computer Numerical Control	Pp. 178-80, p.182	Prentice Hall	www.prenhall.com	
Computer Numerical Control Simplified	Section 4, Unit 6-6 to Unit 6-7; section 4 Unit 6-10	Industrial Press	www.industrialpress.com	1-888-528-7852
CNC Programming: Principles and Applications	Pp. 327-329	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control From Programming to Networking	Pp. 105-109	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control Concepts & Programming 4 th Edition	P. 115, Pp. 363-369	Goodheart-Willcox	http://www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control From Programming to Networking	Pp. 80-93	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Fundamentals of Computer Numerical Control	P. 63; Pp 294-296	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
CNC: A First Look Primer	P. 156 Pp. 181-182 Pp. 377-379	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
CIM Technology	P. 211	Goodheart-Wilcox	http://www.goodheartwilcox.com	

Performance Objective #2

1. Performance Objective

Apprentice will be able to identify coordinates on a blueprint with respect to a part origin.

2. Training Activities

- A project requiring apprentice to plot various coordinate points on a coordinate system grid
- A project requiring apprentice to identify coordinates of several specific points on a sample blueprint

3. Development Resources

- CNC milling program editor/simulator

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will be able to identify all required coordinates on a work sheet with 100% accuracy.
- When asked, apprentice will be able to verbally identify a coordinate pair with 100% accuracy.
- Apprentice will be able to identify coordinates and apply them appropriately to a program. Coordinates are correctly identified when program runs smoothly and functions appropriately according to the process plan.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-III-22-BP-05, MA-III-23-BP-06	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
Introduction to Computer Numerical Control	Section I, Unit 1-3 to Unit 1-5; Section 7, Unit 12-5 to Unit 12-7	Prentice Hall	www.prenhall.com	
Computer Numerical Control Simplified	Section 4, Unit 6-6 to Unit 6-7; section 4 Unit 6-10	Industrial Press	www.industrialpress.com	1-888-528-7852
CNC Programming: Principles and Applications	Pp. 77-84	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control From Programming to Networking	Pp. 80-93	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control Concepts & Programming 4 th Edition	Pp. 26-40; Pp.101-112	Goodheart-Willcox	http://www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control From Programming to Networking	Pp. 80-93	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Fundamentals of Computer Numerical Control	Pp. 35-43	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
CNC: A First Look Primer	Pp. 109-129	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
CIM Technology	Pp. 207,208	Goodheart-Wilcox	http://www.goodheartwilcox.com	

Performance Objective #3

1. Performance Objective

Apprentice will be able to implement linear interpolation into a program to cut straight lines between two points.

2. Training Activities

- View a linear interpolation video
- Complete a project requiring apprentice to evaluate a blueprint containing linear cutting moves, and develop necessary lines of code to execute those cuts
- Complete a project requiring apprentice fill in blanks on a partially completed work sheet containing various different linear-cutting scenarios
- Complete a project requiring apprentice to fill in the blanks on a partially completed program work sheet (manuscript) containing missing linear cutting data
- Complete a project requiring apprentice to debug an existing part program containing linear cutting moves that contains flaws and alarms

3. Development Resources

- Machine or simulator equipped with a flawed program containing circular interpolation
- Various blueprints and work sheets

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will evaluate a blueprint containing linear cutting moves, and develop necessary lines of code to execute those cuts with 100% accuracy.
- Apprentice will fill in blanks on a partially completed work sheet containing various different linear cutting scenarios with 100% accuracy.
- Apprentice will fill in the blanks on a partially completed program work sheet (manuscript) containing missing linear cutting data with 100% accuracy.
- Apprentice will debug an existing part program containing linear cutting moves that contains flaws and alarms.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-I-60-ST-30, MA-I-62-ST-31	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
<i>Introduction to Computer Numerical Control</i>	Pp. 205-210	Prentice Hall	www.prenhall.com	
<i>Computer Numerical Control Simplified</i>	Section 5 Unit 7-6 to 7-7 & Section 5 Unit 7-11 to 7-13	Industrial Press	www.industrialpress.com	1-888-528-7852
<i>CNC Programming: Principles and Applications</i>	Pp. 132-134	Delmar Publishers	www.delmar.com/delmar.html	1-800-730-2214
<i>Computer Numerical Control From Programming to Networking</i>	226	Delmar Publishers	www.delmar.com/delmar.html	1-800-730-2214
<i>Computer Numerical Control Concepts & Programming 4th Edition</i>	Pp. 191-196	Goodheart-Willcox	www.delmar.com/delmar.html	1-800-730-2214

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
<i>Computer Numerical Control From Programming to Networking</i>	Pp. 80-93	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
<i>Fundamentals of Computer Numerical Control</i>	Pp. 63,64	Delmar Publishers	www.delmar.com/delmar.html	1-800-730-2214
<i>CNC: A First Look Primer</i>	Pp. 181,182	Delmar Publishers	www.delmar.com/delmar.html	1-800-730-2214

Performance Objective #4

I. Performance Objective

Apprentice will be able to implement circular interpolation into a program to cut true arcs and circles, using I & J (arc vector) and R (radius value) methods.

2. Training Activities

- View a circular interpolation video
- Complete a project requiring apprentice to evaluate a blueprint containing circular cutting moves, and develop necessary lines of code to execute those cuts
- Complete a project requiring apprentice fill in blanks (i.e., start point, end point, arc center, radius, etc.) on a partially completed work sheet containing various different arc-cutting scenarios
- Complete a project requiring apprentice to fill in the blanks on a partially completed contouring program work sheet (manuscript) containing missing arc-cutting data
- Complete a project requiring apprentice to debug an existing part program containing arc-cutting moves that contain flaws and alarms

3. Development Resources

- Machine or simulator equipped with a flawed program containing circular interpolation

- Various blueprints

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will evaluate a blueprint containing circular cutting moves, and develop necessary lines of code to execute those cuts with 100% accuracy.
- Apprentice will fill in blanks (i.e., start point, end point, arc center, radius, etc.) on a partially completed work sheet containing various different arc-cutting scenarios with 100% accuracy.
- Apprentice will fill in the blanks on a partially completed contouring program work sheet (manuscript) containing missing arc cutting data with 100% accuracy.
- Apprentice will debug an existing part program containing arc-cutting moves that contain flaws and alarms

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-III-28-ST-08, MA-III-30-ST-09, MA-III-32-ST-10, MA-III-38-ST-13	National Tooling and Machining Association (NTMA), Ft. Washington, MD	www.ntma.org	1-800-248-6862
Introduction to Computer Numerical Control	Pp. 205-210	Prentice Hall	www.prenhall.com	
Computer Numerical Control Simplified	Section 5 Unit 8	Industrial Press	www.industrialpress.com	1-888-528-7852

Resource Title	Module/Page Reference	Name of Company/Organization	Internet Address	Phone
CNC Programming: Principles and Applications	Pp. 134-144	Delmar Publishers	www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control From Programming to Networking	10-33	Delmar Publishers	www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control Concepts & Programming 4 th Edition	Pp. 196-212	Goodheart-Willcox	www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control From Programming to Networking	Pp. 80-93	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
Fundamentals of Computer Numerical Control	Pp. 88-91	Delmar Publishers	www.delmar.com/delmar.html	1-800-730-2214
CNC: A First Look Primer	Pp. 233-238	Delmar Publishers	www.delmar.com/delmar.html	1-800-730-2214

Performance Objective #5

1. Performance Objective

Apprentice will be able to write a program using the appropriate format for a particular machine control, and work from a process plan to get guidance for sequences, steps, procedures, machining parameters, etc. that will be used.

2. Training Activities

- A project requiring apprentice to fill in the blanks on a partially completed program work sheet
- A project requiring apprentice to apply codes and coordinates to the appropriate format structure from “scratch”
- A project requiring apprentice to work from a process plan to get guidance for sequences, steps, procedures, machining parameters, etc. that will be used in a program

3. Development Resources

- CNC milling program editor/simulator

4. Interim Assessment

Apprentice assessment will involve at least one of the following activities:

- Apprentice will be able to fill in a program work sheet with 100% accuracy.
- Apprentice will be able to write codes and coordinates into a program for the manufacture of a part using the proper format with 100% accuracy.
- When asked, apprentice will be able to identify, with 90% accuracy, what a given portion of a program is necessary for, so it will function properly.

5. Additional Education and Training Resources

Resource Title	Module/Page Reference	Name of Company/ Organization	Internet Address	Phone
Metalworking Training Curriculum System Machinist Program	MA-III-28-ST-08, MA-III-30-ST-09, MA-III-32-ST-10, MA-III-38-ST-13	NTMA - National Tooling and Machining Association, 9300 Livingston Rd., Ft. Washington, MD 20744	www.ntma.org	1-800-248-6862
Introduction to Computer Numerical Control	Pp. 174-185	Prentice Hall	www.prenhall.com	
Computer Numerical Control Simplified	Section 5, Unit 7-7 to Unit 7-7	Industrial Press	www.industrialpress.com	1-888-528-7852
CNC Programming: Principles and Applications	Pp. 98-110	Delmar Publishers	www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control Concepts & Programming 4 th Edition	Pp. 163-167; 208-210	Goodheart-Willcox	www.delmar.com/delmar.html	1-800-730-2214
Computer Numerical Control From Programming to Networking	Pp. 80-93	Delmar Publishers	http://www.delmar.com/delmar.html	1-800-730-2214
Fundamentals of Computer Numerical Control	Pp. 83-85	Delmar Publishers	www.delmar.com/delmar.html	1-800-730-2214
CNC: A First Look Primer	Pp. 227-229	Delmar Publishers	www.delmar.com/delmar.html	1-800-730-2214