Received: L&I Tukwila
December 6, 2021

Received: L&I Tukwila
December 14, 2021

Department of Labor & Industries
Apprenticeship Section
PO Box 44530
Olympia WA 98504-4530

REQUEST FOR REVISION OF STANDARDS

L&I apprenticeship coordinator

TO: Washington State Apprenticeship & Training Council

Teri Gardner 12-14-2021

From: **Northwest Machinists Apprenticeship Committee, #95**
(NAME OF PROGRAM STANDARDS)

Teri Gardner 12-6-2021

Please update our Standards of Apprenticeship to reflect the following changes.
Additions shall be underlined.
Deletions shall be ~~struck through~~.
See attached.

Authorized signatures

(chr.)	Approved by: Washington State Apprenticeship & Training Council
(sec.) Tom Hunt	Secretary of WSATC:
date: 12/6/21	date:

attach additional sheets if necessary

Cover Page

Occupational Objective(s):	SOC#	Term [WAC 296-05-015]
MACHINIST	**51-4041.00**	**8000 HOURS**

Sponsor Introductory Statement (Required):

The Northwest Machinists Apprenticeship Committee (NWMAC) is committed to recruiting and developing a diverse and skilled journey level ~~machinists~~ workforce to meet the ~~workforce~~ industry demands in our state. The following standards for the development of apprentices have been prepared in partnership between the NWMAC, Machinists Institute, District 160, District 751, and employers in commitment to registered apprenticeship as a mechanism to support industries that are economic drivers in our state, including Aerospace, Space, Defense, Wood Mills, Advanced Manufacturing, Public Agencies, Heavy Duty Equipment, Automotive, Transportation and Logistics.

I. Geographic Area Covered:

The area to be covered by these standards shall be ~~all of King County (with the exception of employees of the City of Seattle), Island, Pierce, San Juan, Skagit, Snohomish, and Whatcom Counties~~ the state of Washington (with the exception of apprentices registered to the occupation of Heavy Duty Mechanic that are employees of the City of Seattle), Oregon counties of Clatsop, Columbia, Washington, Multnomah, Clackamas and Idaho counties of Bonner, Kootenai, Benewah, Latah and Nez Perce.

Applicants and apprentices note that, while the State of Washington has no responsibility or authority in the States of Oregon and Idaho, the Northwest Machinists Apprenticeship Committee will apply the same standards and guidelines to apprentices registered in the program while working outside the State of Washington.

II. Minimum Qualifications:

Age: **~~Must~~ Applicant shall be ~~a minimum of 17~~ at least 18 years of age.**

Physical: **Must be able to ~~meet the requirements~~ perform the work of the trade, with or without reasonable accommodation.**

III. Conduct of Program Under Washington Equal Employment Opportunity Plan:

A. Selection Procedures:

1. **The Northwest Machinists Apprenticeship Committee is not in any way serving as a referral agency and persons desiring to become an apprentice ~~shall make application to an employer~~ must gain employment with an approved NWMAC Training Agent.~~by the Apprenticeship Committee as a Training Agent. On becoming employed~~ Upon selection as an apprentice by a training agent, if the applicant meets all the minimum qualifications and has completed the application in accordance with the steps outlined**

below, ~~he/she~~ they will be notified to appear in person or virtually before the Apprenticeship Committee for an interview and counseling. At the time of the interview ~~he/she~~ they shall be informed of ~~his/her~~ their obligation to abide by the Standards ~~established for the trade~~ of Apprenticeship. Upon acceptance of the applicant, the Apprenticeship Committee shall make an evaluation as to ~~his/her~~ their ability and, with the ~~employer's~~ approval of the training agent, place ~~him/her~~ them in the program ~~in~~ at the proper ~~work experience and~~ wage progression ~~period~~ step, and register ~~him/her~~ them with the Supervisor of Apprenticeship.

2. **The Apprenticeship Committee shall be responsible for obtaining ~~signed agreement forms~~ a signed Training Agent Agreement and a signed Training Agent Agreement and Understanding of Equal Employment Opportunity Requirements from all individual employers who hire apprentices ~~and that the employer will comply with the State of Washington Affirmative Action Plan~~. ~~Agreement forms are to be furnished by the Washington State Apprenticeship and Training Council, and these~~ These signed agreements ~~are to be~~ will be forwarded to the ~~Washington State Apprenticeship and Training Council~~ Department of Labor & Industries Apprenticeship Section for registration as an approved Training Agent.**

3. **Applicants will be considered qualified and notified to appear for an in person or virtual interview when they complete the following:**

   a. **~~Apprentice applicant to obtain application form at the office of the Secretary of Apprenticeship Committee. Address: District Lodge 160, 9135 15th Place South, Seattle, WA 98108~~ Apprenticeship applications shall be obtained from the Machinists Institute. The completed application and documents verifying Minimum Qualifications stated in Section II of these standards shall be submitted to the Machinists Institute. Requests and submissions will be accepted via e-mail, by US mail, or in person, and be clearly addressed to the attention of the "Apprenticeship and Student Affairs Specialist." Methods to make a request and to submit documents to the Machinists Institute are listed below.**

      - **Electronic requests for an application and for of submittal the completed application with verifying documentation shall be sent to: info@machinistsinstitue.org.**

      - **To request an application or to submit a completed application with verifying documentation by US Mail, use the address below.**

      - **To request an application or to deliver the completed application with verifying documentation in person, please find the address of the Machinists Institute below.**

        Machinists Institute
        9125 15th Place South

b. ~~Application and documentation of Minimum Requirements stated in Section II of these standards shall be returned to District Lodge 160.~~ Applicants will receive official notification to appear for an in-person or virtual interview from the Apprenticeship Committee; the Training Agent (employer) will also be notified of this appointment. Apprenticeship candidates needing assistance or to verify status can make requests to the Machinists Institute at info@machinistsinstitute.org.

B. Equal Employment Opportunity Plan:

3. **Granting credit, advance standing or credit for previously acquired experience, training (such as transcripts showing relevant college classes, certifications or degrees), skills or aptitude without prejudice, to all applicants equally. Determination of the amount of credit granted will be made by the Apprenticeship Committee in coordination with recommendations from the Training Agent and the Machinists Institute.**

4. **Distributing information about the nature of apprenticeship programs, program admission requirements, current apprenticeship opportunities, sources of apprenticeship applications, and the equal opportunity policy of the sponsor.**

IV. Term of Apprenticeship:

The term of apprenticeship shall be as defined below, including the probationary period.

~~**Any extension or reduction of this period of apprenticeship will be granted by the Apprenticeship Committee only upon adequate proof that an apprentice is entitled to such consideration.**~~

Overtime OJT hours will NOT be counted toward the term of apprenticeship. Apprentices are not allowed to report more than 180 regular time OJT hours for any given month.

Automotive Body & Fender	4 years (8000 hours) of employment
Automotive Machinist (Automotive Repair Shops)	4 years (8000 hours) of employment
Heavy Duty Equipment Mechanic	4 years (8000 hours) of employment
Machinist Automotive (Machine Shops)	4 years (8000 hours) of employment
Trailer, Container and Van Repair Mechanic	4 years (8000 hours) of employment
Machinist	4 years (8000 hours) of employment

VI. Ratio of Apprentices to Journey Level Workers:

E.

One apprentice may be employed in any shop where a journey-level worker is steadily employed, and one (1) additional apprentice may be employed for every additional four (4) journey-level workers steadily employed.

1. **Exception: upon ~~JATC~~ approval by the Apprenticeship Committee ~~an employer~~ a training agent may observe the following ~~ration~~ ratio: One (1) apprentice may be employed in any shop where a journey-level worker is steadily employed, and one (1) additional apprentice may be employed for every additional two (2) journey-level workers steadily employed.**

2. **Exception: (The following exception does not apply to Step 1 apprentices within the first 90 days of employment as an apprentice.)**

   All apprentices designated as service technicians in the occupation of Trailer, Container and Van Repair Mechanic performing service work shall be allowed to work alone under the following conditions:

   a. **Apprentices performing service work shall at all times be able to contact a journey-level worker or supervisor for answers and advice.**

   b. **The journey-level worker or supervisor shall ensure that the apprentice is receiving their on-the-job training and shall be responsible for the health and safety of the apprentice.**

VII. Apprentice Wages and Wage Progression:

[Note: I have reverted "C" to read as the boilerplate reads.]

C. Wage Progression Schedules**: All Occupations~~:~~**

Step	Hour Range or competency step	Percentage of journey-level wage rate*
1	**~~0 - 3 months~~ 0 to 500 hours**	**65%**
2	**~~4 - 12 months~~ 501 to 2000 hours**	**73%**
3	**~~13 - 24 months~~ 2001 to 4000 hours**	**77%**
4	**~~25 - 30 months~~ 4001 to 5000 hours**	**80%**
5	**~~31 - 36 months~~ 5001 to 6000 hours**	**85%**
6	**~~37 - 42 months~~ 6001 to 7000 hours**	**90%**

7	~~43 - 48 months~~ 7001 to 8000 hours	95%

The Apprenticeship Committee has the authority to grant credit for previous experience and to award additional credit, and will make a determination after receipt of adequate proof that an apprentice is entitled to such consideration. When apprentice progress is deemed unsatisfactory the Apprenticeship Committee has the authority to withhold wage/step progressions.

VIII. Work Processes:

F. Machinist — Approximate Hours

1. **Introduction to and carrying out duties pertaining to General Shop Safety, Equipment Maintenance, Material Handling, and Shipping/Receiving…...500**

2. **Operate machine shop tools such as deburr tools, rotary tools, sanders, polishers, Assemble and complete bench work……………...…..………. 500**

3. **Read and interpret Work Orders/Job Plans, Engineering Drawings, GD&T, ERP Systems, Shop Math……………………………………..…………300**

4. **Plan work processes, prepare part layout, machine Set-ups, Work Holdings, Tools, manage Toolbox and Tool Room…………………………………..300**

5. **Safely perform manual milling, drilling, facing, boring, reaming, boring tapping, calculate speeds and feeds, control chatter and aggressive climb to expand the scope……….…………………………………………….…1500**

6. **Operate CNC Mill Vertical & Horizontal including start up, shout down, edit programs, maintain feeds and speeds, inspect parts…………………….…1500**

7. **Operate Manual Lathe including drilling, turning, boring, knurling, facing, work support, manage tool interface………………………………………900**

8. **Operate CNC Lathe Single & Multi-Spindle With/Without Live Tooling, Traditional & Bar Feed…………………………………………………..…900**

9. **Operate Additional Machine Types such as precision grinding, drilling, additive, water jet, laser jet…………………………………………………………500**

10. **Perform Inspection and operate inspection equipment including CMM/PCMM, scanners, lasers ……………………………………………………………600**

11. **Miscellaneous……………………………………………………………..…500**

TOTAL HOURS: 8000

IX. Related/Supplemental Instruction:

A. The methods of related/supplemental training must be indicated below (check those that apply):

(X) Other (specify)**: In-House training approved by the Apprenticeship Committee and training provided by the ~~Aerospace~~ Machinists Institute.**

B. ~~144~~ **(See Below)** Minimum RSI hours per year defined per the following [see WAC 296-05-015(6)]: ~~**or 3 quarters of classes at Technical or Community College, (see WAC 296-05-003 Apprenticeable Occupation(d))**~~

1. Automotive Body & Fender, Automotive Machinist (Automotive Repair Shops), Heavy Duty Equipment Mechanic, Machinist Automotive (Machine Shops), and Trailer, Container and Van Repair Mechanic: minimum of 144 hours per year.

2. Machinist: minimum of 180 hours per year.

C. Additional Information:
~~**NONE**~~
Each apprentice will be instructed to attend RSI Classes at or through the Machinists Institute or to attend three (3) quarters of classes per year at a Community or Technical College.

X. Administrative/Disciplinary Procedures:

A. Administrative Procedures:

3. Sponsor Procedures:

a. ~~**Apprentices shall submit completed work progress reports by the 5th of each month to the office of the Secretary of the Apprenticeship Committee (District Lodge 160). Reports must be submitted even if no hours were worked. Hours worked will be verified and reported to the registration agency quarterly. Failure to do so shall be cause for appearance at the next JATC meeting and possible disciplinary action, suspension or cancellation of apprenticeship agreement.**~~ **WorkHands is the official means of reporting apprentice On-The-Job Training (OJT) hours to the Apprenticeship Committee. It is the responsibility of each apprentice to report OJT hours in WorkHands throughout the term of their apprenticeship.**

(1) Apprentices shall not report overtime hours and shall not report more than 180 regular time OJT hours for any given month.

(2) Apprentices shall not report hours such as paid sick leave, paid vacation or other paid personal time off.

(3) Additionally, apprentices are required to report OJT hours when the total hours during a month equals zero. The only exception will be when the apprentice is in suspension for the entire month.

(4) Monthly OJT hour reports are due by the 10th day of the following month (i.e. Sept. OJT report is due Oct. 10th.) OJT hour reports submitted after the 10th of the following month shall be considered late.

b. OJT hour reports submitted to WorkHands by the apprentice must be approved by the foreperson or supervisor who must verify the apprentice OJT hours by the last day of the month the report is due (i.e. Sept. OJT report must be approved or disapproved by Oct. 31st.) Overtime hours, paid leave and regular hours in excess of 180 that the apprentice submits into WorkHands will not be approved by the foreperson or supervisor.

When OJT hour reports for any given month are disapproved by the foreperson or supervisor, the apprentice must correct the report and resubmit to WorkHands within 15 days of notification.

c. Failure of the foreperson or supervisor to approve or disapprove OJT hours shall result in contact by the Machinists Institute to remind, or assist in approving or not approving the OJT hours submitted by the apprentice.

d. The Machinists Institute will provide oversight and reporting of OJT hours to the Apprenticeship Division of Labor and Industries.

~~c~~e. Satisfactory progress must be maintained in all ~~related training~~ Related/Supplemental Instruction (RSI) classes. Apprentices are to maintain a minimum grade point average of ~~"C" grade~~ 75%, or f~~or all technical or community college classes attended and~~ for pass/fail courses, must achieve a passing score, whether the class is taken at or through the Machinists Institute at a Community or Technical College.

~~d~~f. Each apprentice not taking related training classes at or through the Machinists Institute will provide a record of ~~school~~ related training class attendance (in hours), noting which are paid, by the ~~5th~~ 10th day of ~~each~~ the following month, ~~to the office of the Secretary of the Apprenticeship Committee (District Lodge 160~~ submitted electronically to info@MachinistsInstitute.org or via US mail to: Machinists Institute attention Apprenticeship and Student Services Specialist, 9125 15th Place

South, Seattle, WA 98108. This record of related training classes must be provided even if the hours equal zero for any given month. In addition, upon request, apprentices shall submit copies of school transcripts and/or verification of course completion to the ~~Joint~~ Apprenticeship Committee. ~~Failure to submit reports timely may be cause for cancellation of the apprenticeship agreement.~~

The Machinists Institute will track related training class (RSI) enrollment, hours attended, and course completion in WorkHands for each apprentice taking related training classes directly at or through the Machinists Institute.

g. RSI Attendance Policies:

It is the intent of this Apprenticeship Committee to ensure quality training for each apprentice. Full attendance at related training classes is therefore expected. The following provisions address issues consequent to missed classes.

(1) Each apprentice shall attend all RSI classes as scheduled. The apprentice will be sent information concerning the start date and time of each class. Full attendance and punctuality are mandatory.

(2) For any absence from class due to illness or an emergency, the apprentice must notify the Instructor by telephone before the start time of the class stating the reason for the absence, or if unable to call, then to ensure another person makes the call. Written reason for absence along with relevant documentation should be submitted to the Instructor who will see it is forwarded to Apprenticeship Committee for consideration of hardship and to determine whether the absence will be excused. Failure to do so will mean the absence is unexcused.

(3) Sickness will be considered an acceptable excuse when the apprentice misses time from work. Overtime work may be considered as an excuse for absence if the employer contacts the Instructor in advance. An apprentice who has three (3) unexcused absences from class during a quarter will be removed from class. The apprentice will receive a failing grade and be required to repeat and complete the class.

(4) Two instances of leaving class early or being tardy, will be considered as an absence. An apprentice who is late for class, leaves early, or is absent from class will be required to make up the class hours in a manner acceptable to the Instructor.

h. The Apprentice shall be responsible for maintaining current contact

information (mailing address, email address, and cell phone number) with the Apprenticeship office and Machinists Institute. The Apprenticeship office and the Machinists Institute will send a variety of correspondence to the apprentice's mailing address, email address and/or cell phone. Official notices to appear before the Apprenticeship Committee will be sent by US mail.

~~e~~i. Apprentices may request credit for advanced standing (additional credit) during the term of apprenticeship by sending a request addressed to the Apprenticeship Committee. The request must ~~including~~ include an employer evaluation and recommendation, or a letter ~~verifying~~ describing performance and recommending advancement. Requests must be submitted electronically to info@MachinistsInstitute.org or via US mail to: Machinists Institute attention Apprenticeship and Student Services Specialist, 9125 15th Place South, Seattle, WA 98108.

~~f~~j. Employment with an approved Training Agent must be maintained to participate in this registered apprenticeship program. ~~Termination from employment may result in suspension or cancellation of the apprenticeship agreement. The apprentices will be sent notice to appear at the next regularly scheduled Apprenticeship Committee meeting to show-cause why the agreement should not be cancelled.~~

~~g~~k. An employer shall not terminate an apprentice without first contacting the Apprenticeship Committee, as continued employment is required to maintain status as an apprentice.

~~h. Issues for which an apprentice may be notified to appear before the committee include:~~

~~a. Poor attendance or punctuality problems at work or school~~
~~b. Poor work habits~~
~~c. Quitting an employer without cause~~

~~i~~l. Local Apprenticeship Committee Policies:

(1~~.~~) The apprenticeship committee shall meet a minimum of 3 times per year.

(2~~.~~) Special meetings of the ~~apprenticeship committee~~ Apprenticeship Committee may be called by the Chairman or Secretary of the committee. A notice will be sent in advance informing committee members of the date, time, and purpose of such meeting.

(3~~.~~) The committee will approve new ~~register~~ Training Agents ~~to the program including a signed~~ requiring two documents be signed, the Training Agent Agreement and the Training Agent ~~Equal Employment Opportunity form. This form~~ Training Agent Understanding of Equal

Employment Opportunity Requirements, which outlines the employer's responsibility to cooperate in the recruitment of minorities and females, ~~to~~ and for which the Washington State Apprenticeship and Training Council (WSATC) will hold the Apprenticeship Committee accountable.

B. Disciplinary Procedures:

3. Sponsor Disciplinary Procedures:

~~(insert text)~~

a. Failure on the part of the apprentice to submit OJT hours timely into WorkHands twice in any given quarter shall be cause for the apprentice to be notified to appear before the Apprenticeship Committee and have the next wage step progression withheld, or have other disciplinary action the Apprenticeship Committee deems appropriate imposed, up to and including cancellation of the apprenticeship agreement.

b. Failure to submit records of related training classes timely, and failure to submit copies of school transcripts and/or verification of course completion to the Apprenticeship Committee when requested will be sufficient cause for the apprentice to be notified to appear before the Apprenticeship Committee for possible disciplinary action up to and including cancellation of the apprenticeship agreement.

c. It is the intent of this Committee to ensure quality training for each apprentice. Full attendance at related training classes is therefore expected. The following provisions address issues consequent to missed classes.

d. Unexcused absences shall be adequate reason for the apprentice to be notified to appear before the Apprenticeship Committee for disciplinary action. Apprentices who have missed RSI classes, as outlined in these Standards, may not be eligible for a wage step advancement until such time as the classes are made up or the RSI class is repeated.

e. Termination from employment may result in suspension or cancellation of the apprenticeship agreement. The apprentice will be sent notice via US mail to appear at the next regularly scheduled Apprenticeship Committee meeting to show-cause why the apprenticeship agreement should not be suspended or cancelled.

f. Issues for which an apprentice may be notified to appear before the Apprenticeship Committee include:

(1) Poor attendance or punctuality problems at work or school

(2) Poor work habits

(3) Quitting an employer without cause

XI. Sponsor – Responsibilities and Governing Structure:

E. Committee governance (see WAC 296-05-009):

1.

[Please delete and replace the committee in its entirety]

c. The employer representatives shall be:

Joey Arnold, Chair
Stevedoring Service of America
1131 SW Klickitat Way
Seattle, WA 98134

Isaac Wisdom
King Street Center
Fleet Operations
MS: KSC-ES-0822
201 S. Jackson, Ste. 822
Seattle, WA 98104

Ben Lepak
Ball Corporation
1220 Second Avenue North
Kent, WA 98032

Chris Gavigan, Alternate
King Street Center
Fleet Operations
MS: KSC-ES-0822
201 S. Jackson, Ste. 822
Seattle, WA 98104

d. The employee representatives shall be:

Tommy Hunt, Secretary
9135 15th Pl. S., 2nd Floor
Seattle, WA 98108

Joseph Gallegos
Stevedoring Service of America
1131 SW Klickitat Way
Seattle, WA 98134

Chris McElroy
Cadence Aerospace
4101 Industry Drive E.
Tacoma, WA 98424

Ray Castro, Alternate
Stevedoring Service of America
1131 SW Klickitat Way
Seattle, WA 98134

Shana Peschek, Alternate
9135 15th Pl. S., 2nd Floor
Seattle, WA 98108

Teri Gardner 12-6-2021

Received: L&I Tukwila
December 6, 2021

Department of Labor & Industries
Apprenticeship Section
PO Box 44530
Olympia WA 98504-4530

Journey Level Wage Rate

From which apprentices' wages rates are computed

TO: Washington State Apprenticeship & Training Council

From Northwest Machinists Apprenticeship Committee
(NAME OF STANDARDS)

Occupations	County(s)	Journey Level Wage Rate	Effective Date:
Machinist	The state of Washington (with the exception of apprentices registered to the occupation of Heavy Duty Mechanic that are employees of the City of Seattle), Oregon counties of Clatsop, Columbia, Washington, Multnomah, Clackamas and, Idaho counties of Bonner, Kootenai, Benewah, Latah and Nez Perce.	$23.00/hour	1/20/22

Received: L&I Tukwila
December 6, 2021

Apprenticeship Related/Supplemental Instruction (RSI) Plan Review

Program Sponsor Northwest Machinists Apprenticeship Committee	Teri Gardner 12-6-2021
Skilled Occupational Objective Machinist	
Term/OJT Hours 8000	Total RSI Hours 720
Training Provider Machinists Institute	

By the signature placed below, the **program sponsor** agrees to provide the prescribed RSI for each registered apprenticeship and assures that:

1. The RSI content and delivery method is and remains reasonably consistent with the latest occupational practices, improvements, and technical advances.
2. The RSI is coordinated with the on-the-job work experience.
3. The RSI is provided in safe and healthful work practices in compliance with WISHA and applicable federal and state regulations.

Tommy Hunt	Tom Hunt
Printed Name of Program Sponsor	Signature of Program Sponsor

By the signature placed below, the **training provider** assures that:

1. The RSI will be conducted by instructors who meet the qualifications of “competent instructor” as described in WAC 296-05-003.
    - Has demonstrated a satisfactory employment performance in his/her occupation for a minimum of three years beyond the customary learning period for that occupation; and
    - Meets the State Board for Community and Technical Colleges requirements for a professional technical instructor (see WAC 131-16-080 through -094), or be a subject matter expert, which is an individual, such as a journey worker, who is recognized within the industry as having expertise in a specific occupation; and
    - Has training in teaching techniques and adult learning styles, which may occur before or within one year after the apprenticeship instructor has started to provide the related technical instruction.
2. If using alternative forms of instruction, such as correspondence, electronic media, or other self-study, such instruction is clearly defined.

Shana Peschek	Shana Peschek
Print Name Training Provider	Signature of Training Provider
Executive Director	Machinists Institute
Title of Training Provider	Organization of Training Provider

If there are additional training providers, please provide information and signatures on the next page.

Additional Resources: *Apprenticeship Related Supplemental Instruction (RSI) Plan Review Glossary of Term (F100-519-000)* *and* *Apprenticeship Related Supplemental Instruction (RSI) Plan Review Criteria (F100-521-000)*.

SBCTC Program Administrator has reviewed RSI plan and recommendations of the Trade Committee.

Click or tap here to enter text.		
Print Name of SBCTC Program Administrator	Signature of SBCTC Program Administrator	Date

☐ SBCTC recommends approval ☐ SBCTC recommends return to sponsor

Additional Training Providers (if necessary)

Print Name Training Provider

Signature of Training Provider

Title of Training Provider

Organization of Training Provider

Click or tap here to enter text.
Print Name Training Provider

Signature of Training Provider

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Organization of Training Provider

Click or tap here to enter text.
Print Name Training Provider

Signature of Training Provider

Click or tap here to enter text.
Title of Training Provider

Click or tap here to enter text.
Organization of Training Provider

Program Sponsor: Northwest Machinists Apprenticeship Committee	Skilled Occupational Objective: Machinist

Note: The description of each element must be in sufficient detail to provide adequate information for review by the SBCTC and Review Committee. To add more elements, click on the plus sign that appears below the "Description of element/course" field.

Describe minimum hours of study per year in terms of (check one):

☒ 12-month period from date of registration.

☐ Defined 12-month school year.

☐ 2,000 hours of on-the-job training.

Year 1 (180 hours)

Element/Course:	Year 1 / Quarter 1 Machining Fundamentals	Planned Hours:	60 Total

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of quarter: This is a preparatory quarter for the machining apprenticeship program. Course work includes shop safety; basic math, workplace documentation; and an introduction to machinery as applied to real-world manufacturing. The course explores manual machining training options available in the Aerospace and Advanced Manufacturing sectors. Instruction will include a mix of classroom, virtual and lab.

Courses include:

1. **Safety for Machinists**
2. **Math Fundamentals 1**
3. **Introduction to Manual Machining**
4. **Introduction to Work Documentation**

The above courses are described in detail as follows with the 60 hours of RSI broken down:

Q1/Course 1:	Safety for Machinists	Planned Hours:	20

Mode of Instruction (check all that apply)

☒ Classroom ☐ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: This is a preparatory course for the machining apprenticeship program. Coursework includes shop safety; workplace documentation; and an introduction to machinery as applied to real-world manufacturing. The course explores manual machining training options available in the Puget Sound Aerospace and Advanced Manufacturing sectors.

At the completion of this course, students will be able to define OSHA; distinguish between employees covered by OSHA; describe the various hazards covered by OSHA standards and compliance program; describe the involvement of employees in OSHA onsite inspections; describe employer and employee responsibilities for workplace safety standards; recordkeeping and reporting requirements for employers; and elaborate on the effect that OSHA has on workplace accidents. Students will identify methods of blocking; the basic requirements of an energy control program; OSHA's typical minimal lockout procedure; the steps in the lockout sequence for a typical minimal lockout procedure and the sequence of steps for restoring equipment to service after lockout. Students will describe the ways hazard communication exists and is enforced and identify chemical hazard classifications, types of physical and health hazards with systemic effects. They will describe the labeling requirements necessary for a hazardous communication program. In addition, students will learn the general guidelines for hand and power tool safety and how to identify characteristics of a well-organized work including proper tool maintenance, materials handling, Personal Protective Equipment (PPE), ergonomics, and the safety risks of tasks that require repetition, force, or vibration. Students will describe arc flash and common causes of arc flash; the dangers associated with arc flash; the different pieces of PPE employees most commonly use to protect against arc flash; how to use NFPA 70E tables to select arc flash PPE; different safeguarding devices used to prevent arc flash; the steps for establishing Electrically Safe Work Conditions (ESWC); and the arc flash safety responsibilities of employers and employees.

Students will describe the importance of safety when performing maintenance duties; how lockout/tagout keeps employees safe during maintenance; and how safety blocking prevents movement of machine components. Students will identify common hazards during metal cutting; the importance of personal responsibility when operating machine tools; safe lifting practices; common fire hazards for cutting operations; basic procedures necessary before operating a machine tool safely; common point-of-operation hazards and safety hazards associated with cutting fluids; methods to minimize operator contact with chips; safety hazards on the manual lathe and mill; machine guarding methods for CNC machines and the characteristics of a well-organized worksite. Students will identify machine motion hazards and other hazardous activity; basic safeguarding standards and devices; maintenance safeguarding; and machine safeguard training.

Topics include: Intro to OSHA 101, Lockout/Tagout Procedures 141, SDS/Hazardous Communication 151, Hand and Power Tool Safety 201, Arc Flash Safety 251, Stamping Safety 115, Safety for Mechanical Work 111, Safety for Metal Cutting 101, Press Brake Safety 100, Rigging Inspection and Safety 210, and Machine Guarding 271

Q1/Course 2:	Math Fundamentals 1	Planned Hours:	10

Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute
Description of course: In this course, students develop basic and foundational math skills that are useful for calculations and problem solving within the manufacturing industry. Topics include fractions, decimals, metric conversions, tolerances, and an introduction to basic geometry, angular measure, and dimensional analysis. Mathematics as a form of industry-based communication is emphasized. Students will define geometry, points, lines, and rays; parts of, and different types of angles and angle pairs; finding perpendicularity, parallelism, and planes; variables; how to solve a bolt circle problem with angle relationships and how to solve bolt circle problems using angle relationships. Students will also define interior angles of triangles; properties of lines and adjacent and vertical angles; and the identification of the different types of triangles by their sides and by their angles. Students will be able to solve for the missing measurements in singular or multiple right triangles and describe the basic properties of circles and semicircles including contrasting radiuses and diameters, circumference, area, and the angles of a circle. They will solve for missing angles in a bolt circle problem; tangents; and polygons; emphasize the characteristics of a right triangle using the Pythagorean theorem including relationships between the sides and angles of right triangles; common trigonometric ratios; SOHCAHTOA; solving for missing dimensions using less common trigonometric ratios; common methods for specifying tapers in prints; calculating the taper per foot of conical tapers; and solving for the total included angle of conical tapers. **Topics include:** Math Fundamentals 101, Math: Fractions and Decimals 111, Units of Measurement 112, Algebra Fundamentals 141 Geometry

Q1/Course 3: Introduction to Manual Machining	Planned Hours:	15
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute		
Description of course: This is an introductory machine shop class using conventional lathes and mills in a manufacturing facility. Skills taught and practiced include inside diameter (ID) and outside diameter (OD) turning, knurling, parting off on engine lathes; and drilling, boring; face, end, slot, and contour milling on milling stations. Milling and turning calculations for speeds and feeds are covered. At completion of this course, students will safely setup and operate manual mills and lathes; describe basic functions and operations of manual mills and engine lathes; identify machine components of the vertical column and knee mill, common cutting operations performed on the mill, and various cutting tools and toolholders used on the mill; identify machine components for engine lathes, including cutting tools and toolholders used on the engine lathe. Students will describe workholding devices used on mill and lathes; and how to calculate cutting speeds, feed rates, and depths of cuts. Students will demonstrate and perform milling operations such as drilling, facing, end and contour milling; and turning operations such as boring and parting off operations per drawing and machining industry standards; external and internal turning to specifications per drawings; internal and external threading to specifications per drawings; and knurling to specifications per drawing and machining industry standards. **Topics include:** Manual Mill Basics 201, Engine Lathe Basics 211, Manual Mill Setup 221, Engine Lathe Setup 231, Manual Mill Operation 251, Engine Lathe Operation 261, and Threading on the Engine Lathe 301		

Q1/Course 4: Introduction to Work Documentation	Planned Hours:	15
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute		
Description of course: Introduction to Workplace Documentation emphasizes students' ability to develop effective communication skills for the workplace using technical reports. Students will apply formal and informal documentation practices that include familiarity and proficiency with workorders, travelers, and Enterprise Resource Planning (ERP) / Material Requirement Planning (MRP) systems. An overview of quality auditing, the various types of industry audits, and the elements and applications of each audit; documentation processes for First Articles (FA), inspection, and sampling; business management; ERP/MRP systems; details and applications of different quality systems and standards used in advanced manufacturing industries. **Topics include:** Communication skills, Utilization of Workorders, Job Travelers, ERP Systems, Fundamentals of Print Reading, Mentorship Matters for the Apprentice		

Element/Course: Year 1 / Quarter 2 Intermediate Machining I	Planned Hours:	60
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute		

Description of element/course: This is an intermediate machining quarter focusing on shop math and interpreting engineering drawings. Students are introduced to engineered materials and tooling for machining and applied math, blueprint reading, and knowledge of materials to identify and select the appropriate tooling for various machining processes. Instruction will include a mix of classroom, virtual and lab.

Courses include:

1. **Math Fundamentals 2**
2. **Engineering Drawings / Blueprint Reading 1**
3. **Material Science**
4. **Machine Tooling**

The above courses are described in detail as follows with the 60 hours of RSI broken down:

Q2/Course 1: Math Fundamentals 2	Planned Hours:	20
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute		

Description of course: In this second math course, students will develop intermediate shop math skills that are useful for calculations and solving dimensional problems within the manufacturing industry. Topics include intermediate geometry, fractions and decimals, metric conversions, tolerances, and an introduction to Sine, Cosine, Tangents, and Sine bar applications. Mathematics as a form of communication is emphasized.

At the completion of this course, students will be able to define and describe sine bar characteristics and sine bar applications in inspection and in machining. Students will explain how to set up a sine bar; define sine, cosine, and tangent functions; explain how trigonometry relates to the sine bar; describe how to find the gage block size for a specific sine bar angle; and how to calculate the gage block size for a specific sine bar angle. Students will describe how to find the measurement of the sine bar angle using a gage block height; calculate the measurement of the sine bar angle using a gage block height; and describe how to use gage pins to find missing distances on a part. They will be able to explain how to find missing dimensions with a sine bar and a gage pin; and calculate missing dimensions using a sine bar and gage pin. In this course, students will identify why measurements are important in a manufacturing environment; define tolerance and how tolerance is determined, and its impact on product cost. Students will compare tolerances used in machining operations; identify methods of describing tolerance; list the advantages of different tolerance methods when identifying elements of tolerance for holes and surfaces. Students will identify and apply the relationship between dimensions and tolerance.

Topics include: Geometry: Lines and Angles 151, Geometry: Triangles 161, Geometry: Circles and Polygons 171, Trigonometry: The Pythagorean Theorem 201, Trigonometry: Sine, Cosine, Tangent 211, Trigonometry: Sine Bar Applications 221, and Basics of Tolerance 121

Q2/Course 2: Engineering Drawings / Blueprint Reading 1	Planned Hours:	10
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute		

Description of the course: The first course on the fundamentals of creating and interpreting blueprints and/or engineering drawings focuses on the basic concepts of print reading such as defining line types, applying orthographic projections, identifying dimensions, and applying tolerances described in the print in manufacturing processes.

Students will identify orthographic projections and the alphabet of lines; dimensions and tolerances of specified parts; what blueprints are; differences between auxiliary and section views; types of section views; different lines and their applications such as object and hidden lines; differences in dimensions; what tolerances are and how they are used; title blocks; notes; and special considerations such as inspection tools for round and angled features, threads, and custom surface finish callouts.

Topics include:

Blueprint Reading 131 and Interpreting Prints 231

Q2/Course 3: Material Science	Planned Hours:	20
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute		
Description of course: This is an introductory course in Materials Science and its applications in Advanced Manufacturing. Students will classify materials based on their physical and mechanical properties; identify metals and metal alloys including what metal alloys are comprised of and how they are processed, and the machinability of various engineered materials. Students will list, define, describe, and apply the four types of manufacturing materials based on physical and mechanical properties; how atomic structure of materials affect physical properties related to manufacturing applications; how volumetric, electrical, magnetic, and thermal properties affect materials; what thermal expansion and thermal stresses are; and how corrosion and thermal degradation affect performance. Students will apply principles of stress and strain; elastic and plastic deformation; tensile stress, compressive stress, and shear stress in aspects of stress-strain graphs. Students will describe tensile testing, ductility, toughness, and hardness, including the major types of hardness tests. This course introduces the main types of metal crystal structures and properties found in each type; grain growth; grain structures, and mechanical properties. Students will distinguish between ferrous metals and nonferrous metals; steel and cast iron, exotic metals, and superalloys. They will classify steels and identify heat treatment options for steels such as annealing, normalizing, and tempering. Properties of basic and advanced cutting tool materials such as tool geometry, tool builder manufacturing processes, tool properties, composition, and coatings will be introduced. **Topics include:** Intro to Physical Properties 101, Intro to Mechanical Properties 111, Intro to Metals 121, Intro to Plastics 131, Classification of Steel 201, Essentials of Heat Treatment of Steel 211, Hardness Testing 221, Ferrous Metals 231, Nonferrous Metals 241, Exotic Alloys 301, Cutting Tool Materials 321, and Advanced Tool Materials 345		

Q2/Course 4: Machine Tooling	Planned Hours:	10
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute		
Description of course: Machine Tooling introduces the principles and techniques of tool selection and geometries for engine lathes and mills. Students demonstrate proper tool selection for the set up and operation of vertical and horizontal mills and engine lathes, including identifying common cutters; selecting proper cutters for machining tasks; performing and aligning the workpiece on the table and/or vise; align the tool head and locate the edges of the workpiece relative to the spindle; and calculating speeds and feeds for milling and turning operations based on tooling. Students will apply fundamentals of tool geometry; features of a single-point tool; how workpiece materials affect cutting operations; how various tool materials are used in lathe machining operations; how back and side rake angles work; the effects of positive and negative rake angles; what the end and side relief angles measure in single-point tooling; the effects of adjusting relief angles; what the end and side cutting edge angles measure in single-point tooling; the effects of the cutting-edge angles; the appearance and function of the nose radius; how to read tool signatures and insert numbers; and how different cutting operations require different tool geometries. **Topics include:** Strategies for Setup Reduction 251, Lathe Tool Geometry 351, Optimizing Tool Life and Process 381		

Element/Course: Year 1 / Quarter 3 Intermediate Machining 2	Planned Hours:	60
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute		
Description of quarter: This quarter introduces fundamentals of metrology, hand programming basics, applying proper conventions for interpreting more advanced drawing layouts and machining specifications. Students learn how to manually input data, simulate toolpaths on controllers, and safely setup and operate Haas, FANUC, and Mazak CNC machining equipment. Instruction will include a mix of classroom, virtual and lab. **Courses include:** 1. **Metrology Fundamentals – Tolerance, Measurement, Calibration** 2. **Engineering Drawings – Blueprint Reading 2** 3. **Intro to Hand Programming / G&M Codes** 4. **Intro to CNC Controllers: Haas, FANUC, Mazak**		

5. **Machine Setup & Operation**

The above courses are described in detail as follows with the 60 hours of RSI broken down:

Q3/Course 1:	**Metrology Fundamentals**	**Planned Hours:**	**10**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: The Metrology Fundamentals course introduces students to the importance of metrology in manufacturing. Students will differentiate between accuracy and precision; apply basic geometric tolerance and dimensioning specifications for metrology; describe basic metrology tools used for surface textures, part interiors, contact and non-contact probes for CMMs. Students will evaluate metrology issues for inspection processes such as post-processing inspections and advanced technologies.

Students will define how measuring system analysis work; compare Statistical Process Control (SPC) with Measurement System Analysis (MSA); identify common factors that impact measuring systems; apply the four variables that combine to yield a measurement value; how measurement uncertainty affects tolerance limits; common practices that are included in measurement assurance operations; sources of gage, random variation, and system variation. Students will identify the commonality between gage linearity and gage stability; how to conduct an ideal gage capability study; gage repeatability, and reproducibility experiments. The course will introduce common approaches for choosing optimum test variables and list the steps of effective measurement study preparation using a typical range of acceptable criteria used in manufacturing.

Topics include: Intro to Laser Trackers 365, NIMS Core Measurement and Material Skill 211, Measurement System Analysis 300, and Metrology for Additive Manufacturing 202

Q3/Course 2:	**Engineering Drawings – Blueprint Reading 2**	**Planned Hours:**	**15**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: The second course in blueprint reading emphasizes orthographic views; distinguishing between auxiliary and section views; between object, hidden, center, dimension, and extension lines; Applying phantom, leader, and break lines; and describing what cutting plane and section lines do to orthographic views. Students will evaluate blueprint dimensions and differentiate common types of dimensions and tolerances. They will read and interpret title and change blocks; scale, and tolerance information contained in the notes section.

Students will evaluate angled features in prints; inspection tools for angled features; and identify rounded features in prints. They will use inspection tools for rounded features to describe holes and hole features in prints; use inspection tools for holes and hole features; describe threaded features in prints; use inspection tools for threaded features; and describe surface finish in prints using inspection tools for surface finish such as profilometers.

Topics include: Types of Prints & Engr Drawings 132, Interpreting Prints 231, and Prints for Metal Cutting Ops 241

Q3/Course 3:	**Introduction to Hand Programming / G&M Codes**	**Planned Hours:**	**10**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of the course: This is an introduction to hand programming using G, M and T codes. Students will build a foundation on how to create, define, and operationalize the role of part programs. They will identify and apply the major steps required for the creation of a part program. Students will demonstrate how standardization impacts CNC programs; how Computer-Aided Manufacturing (CAM) improves hand programming by minimizing human errors; and how to assemble the components of a good program.

Students will identify and apply N, M, and G codes, including the function of coordinate systems within written codes. They will describe and define the functions of F and S codes, including T and H codes, and standard calculations for feeds and speeds when creating a single or multiple operation toolpath.

Instructor-led projects are designed to extend knowledge, skills, and abilities in manual and/or CNC machines, G code programming, CAD/CAM simulation, verification and optimization processes. The focus of these assignments is on how each student learns to model and machine simple or complex free form surfaces, and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include: Instructor-determined Assignments/Projects, Basics of G Code Programming 231

Q3/Course 4:	**Introduction to CNC Controllers: Haas, FANUC, Mazak**	**Planned Hours:**	**15**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: Introduction to (Computer Numerically Control) CNC controllers prepare students for the safe operation of CNC machines by familiarizing them with the three main types of controllers commonly found in manufacturing. Students will demonstrate the recommended responsibilities of a CNC operator by distinguishing between machine operations and CNC control panel functions on a CNC lathe; describe CNC lathe control displays and the functions of basic CNC controls. Students will identify operational modes on a CNC lathe including manual control modes such as pulse handle and jog modes on a CNC lathe; functions of Manual Data Input (MDI) mode; single block mode; types and uses of overrides. They will describe manual operations for coolant; the role of the CNC operator in optional stop and block delete. They will demonstrate manual turret indexing; manual operations for the chip conveyor; and proving out a program on a CNC controller.

Students will describe the responsibilities of the CNC mill operator, between machine operations and control panel functions on a CNC mill. They will familiarize themselves with the functions of a CNC mill control display and distinguish between machine operations and CNC control panel functions on a CNC mill. Describe the function of the basic CNC mill controls. Identify the operational modes on a CNC mill. Describe the manual control modes on a CNC mill. Distinguish between pulse handle and jog modes on a CNC mill. Describe the function of MDI mode on a CNC mill. Describe the function of single block mode on a CNC mill. Identify the types of overrides on a CNC mill. Describe the use of overrides on a CNC mill. Describe manual operations for coolant on a CNC mill. Describe the role of the CNC mill operator in optional stop and block delete. Describe manual operations for loading tools on an ATC. Describe manual operations for the chip conveyor on a CNC mill. Describe proving out on a CNC mill.

Students will distinguish between EDIT, MEMORY, HANDLE JOG, ZERO RETURN, and LIST PROGRAM mode keys. Distinguish between mode keys; between the orientations and movements of various lathe and milling tools, between types of offsets, how to access the tool and work offset menus on the Haas Next Generation Controller (NGC); how to navigate the tool and work offset menus on the Haas NGC; how to clear offsets on the Haas NGC; and how to determine tool length offsets. Students will calculate tool length offsets on the Haas NGC; prepare a part face surface to touch off tools in the Z axis; enter Z axis tool length offsets by touching off a tool; prepare an OD surface to touch off tools in the X axis; enter an X axis tool length offset by touching off a tool; and they will record tool length offsets using the Haas NGC's automatic tool pre-setter. Students will describe tool nose radius and tool tip position offsets and evaluate how to enter radius and tip offsets on Haas NGC; tool wear and work offsets, including how to enter them on the Haas NGC.

Topics include: Control Panel Functions of the CNC Lathe 251, Control Panel Functions of the CNC Mill 252, Haas NG and Classic Controls 111, Haas NGC: Entering Lathe Offsets 202, Haas NGC: Program Execution 221, Haas NGC: First Part Runs 317, and Mazak Lathe: Control Panel Overview 287

Q3/Course 5:	**Machine Set-up and Operation**	**Planned Hours:**	**10**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of the course: This is an introductory course in the set-up and operation of CNC machines. Students will apply basic knowledge of machine setup operations using tools such as spring and electronic edge finders; dial and coaxial indicators, tool setters, and 1-2-3 blocks. Creation and/or use of custom fixtures is strongly emphasized.

Students will demonstrate hands-on skills in the safe operation of CNC equipment to set up for high volume production or custom job shop parts, using blueprints and/or instructor determined operations, per industry standards.

Instructor-led projects are designed to extend knowledge, skills, and abilities in manual and/or CNC machine set up and orientation. The focus of these assignments is on how each student learns to model and machine simple or complex free-form surfaces; and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include:
Instructor-determined Assignments/Projects

Year 2 (180 hours)

Element/Course: Year 2 / Quarter 1 Machine Operations 1 Milling	Planned Hours: 60

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of quarter: This quarter introduces setup and operation of manual and CNC mills including the basics of feeds and speeds, tool selection, metrology, and part dimensioning. Students will apply knowledge, skills, and abilities to successfully mill a part per blueprint and/or instructor specifications. Instruction will include a mix of classroom, virtual and lab.

Courses include:

1. **Manual Milling Operations – Setup, Operation, Work Holding, Fixturing**
2. **CNC Milling Operations – Setup, Operation, Haas**
3. **Mill Tooling Selection & Utilization – Feeds & Speeds, Chip loads, Tool & Materials selection**
4. **Quality Assurance 1 – First Article Inspection, Documentation**
5. **Metrology 1 – GD&T 1, Symbols, Nomenclature**
6. **Manual and CNC Mill Project 1**

The above courses are described in detail as follows with the 60 hours of RSI broken down:

Q1/Course 1: Manual Milling Operations	Planned Hours: 10

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: In this course, students will hone their skills in manual machining using knee mills. Students will evaluate and apply prints in metal cutting operations for application on manual machines. They will: describe basic metal cutting print components; distinguish between different lines used on metal cutting prints, between the different types of print views; and between the different tolerances represented on prints. They will evaluate how contours are represented on prints. They will evaluate and interpret how pockets and slots are represented on a print; how tapers are represented; how chamfers, fillets, and different types of holes appear on prints; how threads and different thread specifications and systems are used; and how counterbores, spot faces, and countersinks are shown. Students identify and apply the appropriate surface finish per print, and surface finish callout specifications for custom features.

They will Identify machine components of the vertical column and knee mill and evaluate common toolholders used on the mill. Students will prepare standard bar stock for machining operations and workholding devices used on the mill. Students will apply cartesian coordinates to orient the three axes related to manual mills. They will check mill head alignment using a dial indicator and they will tram a manual mill vice. Students will demonstrate the function of gibs and gib adjustments, vise, and workpiece alignment. They will apply a Work Coordinate System (WCS) to set part zero; demonstrate how to locate part zero with an edge finder; and scribe how machinists use technical data references from sources such as the Machinists Handbook. Students will determine the order of operations for milling a part, list and present proper principles of face, end, plunge, and slot milling. They will demonstrate basic principles of drilling and drilling operations and reaming by hand using different types of hand reamers.

Instructor-led projects are designed to extend knowledge, skills, and abilities in manual machines, understanding and applying prints, and WCS.. The focus of these assignments is on how each student learns to model and machine simple or complex free-form surfaces; and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include: Instructor-determined Assignments/Projects, NIMS Core Manual Milling Skills 261

Q1/Course 2: CNC Milling Operations	Planned Hours: 10

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of the course: CNC Milling operations introduces students to machining using CNC milling equipment. Students apply the Cartesian coordinate system to identify the axes and Work Coordinate System (WCS) of the part origin. They determine the relationship between blueprints and Cartesian coordinates including polar and spherical coordinates, to evaluate general guidelines for the locations of axes on CNC machines using 3-axes on a vertical CNC mill and their rotational axes. Students assess and determine cutting tool positions and movements associated with axes on machining centers needed for contouring. They will demonstrate safe and proper setting of machine and program zero; compare incremental and absolute coordinates; and define the role of a part program. They will list the major steps necessary before the creation of a part program; create toolpaths including codes used to determine the mode of tool movements.

Students will describe how program codes translate into tool movement; identify common codes located at the beginning of toolpaths; the codes that perform tool changes; cutting variable measurements used in speed and feed codes; and the role of templates in program creation. Students will demonstrate how to program facing and pocket milling operations using G code programming; differentiate between arc center and radius methods for programming circular interpolation. Students will demonstrate the setup and execution of a subprogram. They will program a canned cycle to demonstrate how the drilling and milling of holes is programmed, including explaining how parameters are necessary when programming tapped holes. Students will apply trigonometry in twist drilling operations to calculate total drill depth coordinate locations necessary to drill a bolt-hole pattern. They will identify components of canned cycles used for hole such as spot, tapping, drilling cycles with dwell, spot, peck, and continuous drilling. Students will interpolate circularly, bore and ream using canned cycles; identify and troubleshoot common canned cycle errors. They will program rectangular and circular pocket milling canned cycles. Students will apply offsets to locate machine zero and program zero; perform homing procedures on a CNC mill; and demonstrate the three different types of CNC milling offsets: Work coordinate system (WCS), Tool length offsets (TLO), and Cutter Compensation for cutter radius compensation adjustments for different cutter sizes.

Instructor-led projects are designed to extend knowledge, skills, and abilities in manual and/or CNC machines, G & M code programming, CAD/CAM simulation, verification and optimization processes. The focus of these assignments is on how each student learns to model and machine simple or complex free-form surfaces; and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include: Instructor-determined Assignments/Projects, Coordinates of the CNC Mill 222, Creating a Milling Program 302, Calculations for Programming the Mill 312, Canned Cycles for the Mill 322, NIMS Core CNC Milling Skills 141

Q1/Course 3: Mill Tooling Selection and Utilization	**Planned Hours: 10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	

Description of course: Mill tooling selection and utilization focuses on proper tool selection to complement the machining operation required to make parts. Students will discuss, list, and evaluate metal cutting tools for milling and the basic components of a lathe tool post. They will identify how a lathe's carriage and compound rest operate, and the different cutting tools required. They will identify various types of milling machines; the tooling for vertical and horizontal milling machines; the adjustable parts of the milling machine; and the different types of milling cutting tools. Students will differentiate between single-point and multi-point cutting tools; chip load; and chip formation. They will evaluate how tool angles affect cutting processes; distinguish between continuous and discontinuous chips; and demonstrate the functions and methods of chip control. Students will investigate the occurrence and causes of built-up edges; why cutting variables matter and their significance in tooling. They will calculate speed, feed, and depth of cut in turning, milling, and drilling operations and their influences on machinability. Students will interact with the variables associated with machinability and their relationship with cutting tool properties. They will evaluate how to balance, or trade-off properties involved in selecting tool materials, between early cutting tool qualities and modern cutting tool qualities. Students will analyze and evaluate high-speed steel (HSS) tools and the heat treatment processes used to improve HSS properties; the advantages provided by HSS tools, and carbide cutting tool composition. They will discuss the advantages and disadvantages of carbide tool use and distinguish between chemical vapor deposition (CVD) and physical vapor deposition (PVD) process and between indexable inserts and solid tools.

Students will describe cermet cutting tool properties and their uses; ceramic cutting tool properties and their uses; cubic boron nitride tool properties and uses; and diamond cutting tool properties and uses. They will define properties of carbide cutting tools; the material components of carbide cutting tools; and how carbide cutting tools are manufactured. The various types and properties of the carbides used in cutting tools; common carbide tool coatings and their properties; and the processes used to coat carbide tools, will be discussed. Students will identify the factors involved in selecting the best carbide tools for an operation; the carbide grade; and the systems used to classify it. The ANSI C-system carbide grade classification and the different American National Standards Institute (ANSI) C-system carbide grades; the International Organization of Standardization (ISO) system of classifying carbide grades; the different ISO carbide grades; and the similarities and differences between the ANSI and ISO systems will be discussed. The measurements of the nose radius, facet angle, and facet clearance, as they relate to the ANSI insert numbers; the various types of cutting edges designated by the eighth character in an ANSI insert numbers; the 9th, 10th, and any subsequent characters represented in the ANSI insert numbers, will be discussed. Students will identify how ISO insert identification numbers differ from ANSI insert identification numbers. They will demonstrate proficiency with tool geometries; the features of a single-point tool; and the basic considerations of lathe operations. This includes how workpiece material affects a cutting operation; the various tool materials used in lathe machining operations; and back and side rake angles.

Students will explain the effects of positive and negative rake angles; what the end and side relief angles measure in single-point tooling are for; the effects of adjusting relief angles; what the end and side cutting edge angles measure in single-point tooling; and the effects of the cutting-edge angle. They will describe the appearance and function of the nose radius; tool signatures and insert numbers; and how different cutting operations require different tool geometries.

Topics include:
Overview of Machine Tools 121, Basic Cutting Theory 201, Cutting Tool Materials 321, Carbide Grade Selection 331, ANSI Insert Selection 341, and Mill Tool Geometry 352

Q1/Course 4: Quality Assurance 1	**Planned Hours: 10**

Mode of Instruction (check all that apply)
☒ Classroom ☒ Lab ☒ Online ☐ Self-Study
Provided by: Machinists Institute

Description of course: This is an introductory course in the study of the ISO 9000 series of quality system standards with emphasis on manufacturing industry applications. The course addresses standards interpretation, documentation, and implementation including preparation for, and creation of internal and external audits. Students will apply the fundamental quality requirements to successfully procure and allocate resources and to effectively deliver end products or manufacturing operations. Topics include basic supplier issues of specifications, process inspection, tool selection, rating, certification, and related quality audits.

Students will learn how to complete first article inspection documents necessary for process verification and validity, including how to apply geometric dimension and tolerance (GD&T) to read blueprints and notes for the setup and inspection of first article parts.

Instructor-led projects are designed to extend knowledge, skills, and abilities in ISO 9000 standards and inspection processes. The focus of these assignments is on how each student learns and applies skills related to quality assurance in the manufacturing process and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include: Instructor-determined Assignments/Projects, First Article Inspection and Documentation

Q1/Course 5: Metrology 1	**Planned Hours: 10**

Mode of Instruction (check all that apply)
☒ Classroom ☒ Lab ☒ Online ☐ Self-Study
Provided by: Machinists Institute

Description of course: Metrology 1 is an in-depth introduction to geometric dimension and tolerance (GD&T), advanced hole inspection techniques, coordinate measuring machines (CMM) arms, and CMM inspection equipment. Students will identify and associate GD&T symbols with their definitions; the scope of GD&T standards; differences between a datum and a feature; and traditional tolerancing and GD&T. Students will define GD&T and differentiate between traditional tolerancing and GD&T and between datums and features. Students will list the advantages of applying GD&T; the major categories of geometric tolerances; GD&T modifiers not dealing with material conditions; material condition modifiers; contents of the feature control frame; basic dimensions and their purpose; straightness, flatness, circularity, cylindricity, line, and surface tolerances. They will define angularity, perpendicularity, and parallelism; position, circular and total runout tolerances will be discussed. They will demonstrate inspection of the circular runout and total runout tolerance.

Topics on concentricity, symmetry, circular, and total runout tolerances; material condition modifiers, and how bonus tolerance are applied to a hole; contents of feature control frames, and advantages of GD&T will be covered. Students will evaluate the purpose of advanced hole inspection and identify common methods of describing tolerance. Students will evaluate allowances for clearance, inference, and allowance for a transition fit; describe characteristics of non-contact instruments used to inspect holes such as borescopes. They will demonstrate how to inspect holes using air gages; how to inspect holes using a laser system; and how to inspect holes using an optical comparator. Students will demonstrate how to inspect holes using a measuring microscope and describe how CMMs are used, including main components.

Students will distinguish between measured and constructed features; datums; and the machine coordinate system and the part coordinate system. They will describe the purpose of alignment and identify types of software used on CMMs and describe their purpose. Students will demonstrate different methods for programming a coordinate measuring machine and how CMMs prevent or compensate for environmental influences. Students will compare the characteristics of air bearings, magnetic bearings, and mechanical bearings using CMMs. They will discuss how contact and noncontact probes inspect parts. Students will describe the methods and benefits of incorporating CMMs into production processes and identify types of portable CMMs including the components, coordinate systems, alignment, part workholding, and arm operation. Students will demonstrate comprehension of what to do with collected CMM arm data.

Topics include: Intro to GD&T 200; Intro to GD&T 301, Advanced Hole Inspection 341, Inspecting with CMMs 361, and Intro to CMM Arms 362

Q1/Course 6: Manual Mill Project 1	**Planned Hours: 10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	

Description of course: This is an advanced machine shop class utilizing conventional mills in a manufacturing facility. Students will apply knowledge, skills, and abilities taught and assembled from previous quarters related to manual milling to complete an instructor-determined project.

Students will apply print reading to select the tooling and machining operations required to successfully complete milling the part, per specifications stipulated by the instructor and accepted as industry norms including performing operations to square the stock material; face, contour, edge, and/or slot mill.

Instructor-led projects are designed to extend knowledge, skills, and abilities in manual mill, inspection, and optimization processes. The focus of these assignments is on how each student learns to model and machine simple or complex free-form surfaces; and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include: Instructor-determined Assignments/Projects

Element/Course: Year 2 / Quarter 2 Machine Operation 2 Turning	**Planned Hours: 60**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	

Description of quarter: This quarter introduces setup and operation of manual and CNC lathes and turning centers including the basics of feeds and speeds, tool selection, metrology, and part dimensioning. Students will apply knowledge, skills, and abilities to successfully machine a part per blueprint and/or instructor specifications. Instruction will include a mix of classroom, virtual and lab.

Courses include:

1. **Manual Lathe Operations – Setup, Operation, Work Holding, Fixturing**
2. **CNC Turning Operations – Setup, Operation, Haas**
3. **Lathe Tooling Selection and Utilization – Feeds & Speeds, Chip loads, Tool & Materials selection**
4. **Quality Assurance 2 – First Article Inspection, Documentation**
5. **Metrology 2 – GD&T 2**
6. **Manual Lathe and CNC Turning Project 1**

The above courses are described in detail as follows:

Q2/Course 1: Manual Lathe Operations	**Planned Hours: 10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	

Description of course: In this course, students will hone their skills in manual turning using engine lathes. Students will evaluate and apply prints in metal cutting operations for application on manual machines. They will contrast different types of manual lathes and identify the components of the manual lathe. Students will demonstrate how manual lathe components move during cutting operations; describe common outer diameter (OD) operations; toolholders used on the manual lathe, and the functions of the engine lathe tool post.

Students will demonstrate workholding tools used on the manual lathe and the Cartesian coordinate system used to make parts. They will demonstrate how to perform set zeros on a part, and how to dial in 3-jaw chucks in a lathe; how to convert between rev/min (rpm) and surface feed/min (sfm) or rpm and m/min; and explain what constant surface speeds are; lathe feed measurements, lathe cutting tool, and holder inspection. They will demonstrate how to inspect a cylindrical feature for circularity and cylindricity; how to inspect a cylindrical feature for concentricity; how to inspect a cylindrical feature for total runout; how to inspect a cylindrical feature for position; and how to inspect cylindrical features for circular runout.

Instructor-led projects are designed to extend knowledge, skills, and abilities in manual lathe, cutting and OD operations. The focus of these assignments is on how each student learns to model and machine simple or complex free-form surfaces; and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include: Instructor-determined Assignments/Projects, NIMS Core Manual Turning Skills 132 & 262

Q2/Course 2:	**CNC Turning Operations**	**Planned Hours: 10**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: CNC Turning Operations introduces students to machining using CNC lathe equipment. Students apply the Cartesian coordinate system to identify the two main axes and work coordinate system (WCS) positioning for the part origin. Students will interpret blueprints; evaluate computer-aided design (CAD) models; and the general guidelines for locating axes on CNC lathe centers. Students will manually position axes of CNC lathes using CNC controllers; read and interpret blueprints; make edits to canned cycles; demonstrate how incremental and absolute coordinates are applied to lathe operations; the role of a part program; and the major steps necessary before the creation of a part program.

Students will describe simple turning toolpaths; the codes used to determine the mode of tool movement; how program codes translate into tool movements; and common codes located at the beginning of a toolpath. Students will distinguish between the two feed modes and two speed modes; the role of the repeating codes throughout a program; and how to program facing and rough turning operations using G code programming. They will demonstrate the operation of canned cycles; the parameters of a boring operation; and the operation of the finish turn canned cycles. Students will identify and apply tool nose radius (TNR) to compensations by calculating offsets for chamfers, partial or full arcs. They will apply G & M codes to program full and partial arcs using canned cycles for boring, drilling, and performing multiple repetitive contour turning and facing canned cycles. They will describe multiple operations for profile turning, finishing, and threading.

At the completion of the course, students will differentiate between types of CNC lathes, including components of the CNC lathe; how CNC lathe components move during cutting operations; and common outer diameter (OD) operations. They will identify toolholders used on the CNC lathe; the functions of a CNC lathe turret; and workholding tools used on the CNC lathe and will demonstrate how to perform a homing procedure on a CNC lathe. Students will describe the three different types of CNC lathe offsets including work, tool, and geometry offsets, and will apply tool, work, and geometry offset in a turning operation.

Instructor-led projects are designed to extend knowledge, skills, and abilities in manual and/or CNC machines, G & M code programming, CAD/CAM simulation, verification and optimization processes. The focus of these assignments is on how each student learns to model and machine simple or complex free-form surfaces; and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include:
Instructor-determined Assignments/Projects, Coordinates of the CNC Lathe 221, Creating a Turning Program 301, Calculations for Programming the Lathe 311, Canned Cycles for the Lathe 321, NIMS Core CNC Milling Skills 142

Q2/Course 3:	**Lathe Tooling Selection and Utilization**	**Planned Hours:**	**10**

Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute
Description of course: The Lathe Tooling Selection and Utilization course emphasizes the principles and techniques of turning operations; tool measurement and optimization; cutting theory for lathe tooling and equipment; and turning operations. Students identify, evaluate, and apply proper tool theory for metal cutting tools used to saw stock material for lathes; the basic components of lathe tooling; and the different cutting tools for turning. By identifying various metal cutting techniques, students distinguish between single-point and multi-point cutting tools; chip load and formation; how tool angles affect cutting processes; and between continuous and discontinuous chips. They will describe the functions and methods of chip control; the occurrence of built-up edges; cutting variables; and their significance. Students will apply proper speed, feed, and depth of cut in turning and define stock machinability, including variables associated with machinability. They will describe cutting tool properties; the balance or trade-off of properties involved in selecting tool materials; and between early cutting tool qualities and modern cutting tool qualities. Students will use high-speed steel (HSS) tools; and explore the treatment processes used to improve HSS properties and the advantages provided by HSS tools. They will elaborate on carbide cutting tool compositions; the advantages and disadvantages associated with carbide tool use; between chemical vapor deposition (CVD) and physical vapor deposition (PVD) processes; and between indexable inserts and solid tools. Students will use properties of carbide cutting tools to describe the material components of a carbide tools as they relate to manufacturing; types and properties of carbides; common carbide tool coatings and their properties; the processes used to coat carbide tools; and the factors involved in selecting the best carbide tool for an operation. Students will classify carbide grades and the systems; ANSI C-system carbide grade classifications and C-system carbide grades; ISO system of classifying carbide grades and the similarities and differences between the ANSI and ISO systems. At the end of the course, students will apply tool geometry to describe the features of a single-point tool and the basic considerations of a lathe operation; how workpiece material affects cutting operations; tool materials used in lathe machining operations. Students will describe how back, and side rake angles work and the effects of adjusting relief angles. Students will evaluate the end and side cutting edge angles when measuring single-point tooling, including how different cutting operations require different tool geometries. **Topics include:** Overview of Machine Tools 121, Basic Cutting Theory 201, Cutting Tool Materials 321, Advanced Tool Materials 345, Carbide Grade Selection 331, ANSI Insert Selection 341, Lathe Tool Geometry 351

Q2/Course 4: **Quality Assurance 2**	**Planned Hours:** **10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	
Description of course: Quality Assurance 2 expands on quality system standards with emphasis on manufacturing industry applications. Students will evaluate quality standards; apply production, defect, variation documentation; detail implementation of corrective actions including responses to internal and external audits. Students apply fundamentals of quality assurance to maintain, control, and alter quality in product or manufacturing operations. Advanced supplier issues of specifications, process inspection, tool selection, rating, certification, and related quality audits will be explored. Students will apply follow-up techniques to corrective actions for first articles, process verifications and validity, including how to make notes on blueprints and engineering drawings using geometric dimension and tolerance (GD&T) for machining processes and inspection of first article parts. Instructor-led projects are designed to extend knowledge, skills, and abilities in quality assurance, verification and optimization processes. The focus of these assignments is on how each student learns inspection and correction process associated with machining and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams. **Topics include:** Instructor-determined Assignments/Projects, Quality Assurance and Documentation	

Q2/Course 5: **Metrology 2**	**Planned Hours: 10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	

Description of course: Metrology 2 is an intermediate course in geometric dimension and tolerance (GD&T), advanced inspection techniques using 3D scanners, ISO 9000 inspection standards, and calibration equipment. Students will be able to apply inspection methods used in manufacturing to distinguish between laser and structured light scanning; laser line scanners; 3D laser line scanner applications; and what laser light colors mean. They will distinguish between single-line and multiple-line scanners and between flying dot principle and solid beam principles. Students will describe how lasers function and the data collection and analysis methods. They will identify how laser line scanners are integrated with other components and why 3D scanning is used in smart manufacturing. In this course, students will define the main purpose of calibration and how tolerances and variations impact the necessity of calibration.

Students will elaborate on why calibration requires measurement standards; the hierarchy of measurement standards; International Organization of Standards (ISO 9000) calibration requirements; what traceability is; and the role of working standards. They will define measurement uncertainty and distinguish between uncertainty and error; random and systematic errors; and apply gage blocks in calibration. Students will learn why regular calibration is important and identify the key factors that affect calibration. They will distinguish between static and dynamic surfaces, and evaluate how machining processes cause surface finish and texture variations. Distinguish between the actual surface and its specifications, and how surface finish variations affect cost. They will list factors that affect optical system quality; common methods for improving part illumination; the properties of the viewing screen; and describe their purpose. Students will apply edge detection on optical comparators and describe methods of measurement by comparison. They will demonstrate how to measure "what is not there" and ways to reduce variation when measuring with optical comparators. Students will list steps to properly maintain optical comparators; the advantages and disadvantages of an optical comparator; and the characteristics of manually operated, digitally operated, and software-driven optical comparators.

Students will apply geometric dimension and tolerance (GD&T) to define virtual and resultant conditions; projected tolerance zones; the 3-2-1 rule and how it restricts the six degrees of freedom; datum feature simulators; and how the feature control frame locates a part. They will apply and elaborate the roles of datum targets on gaging; composite, single-segment, and statistical tolerancing. Students will apply dimensioning rules for conical and flat tapers; threads; and gears.

Topics include: Major Rules of GD&T 311, GD&T Applications 312, Structured Light 3D Scanners 375, 3D Laser Scanners 376, Calibration Fundamentals 111, Surface Texture and Inspection 201, Inspecting with Optical Comparators 351

Q2/Course 6: Manual Lathe and CNC Turning Project 1	**Planned Hours: 10**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: Manual Lathe and Computer Numerically Controlled (CNC) Turning Project 1 is a hands-on course that emphasizes the synthesis and application of manual engine lathe and CNC turning to complete a part. This is an advanced machine shop class utilizing conventional and CNC lathes in a manufacturing facility. Students will apply the knowledge, skills and abilities taught and assembled from previous courses to complete a project defined by the instructor.

Students will apply their print reading skills to select the tooling, manual, and CNC machining operations required to successfully complete machining a part to the specifications stipulated by the instructor and as accepted by industry standards.

Instructor-led projects are designed to extend knowledge, skills, and abilities in manual and/or CNC machines, G & M code programming, CAD/CAM simulation, verification and optimization processes. The focus of these assignments is on how each student learns to model and machine simple or complex free-form surfaces; and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include: Instructor-determined Assignments/Projects

Element/Course: Year 2 / Quarter 3 Machine Operation 3	**Planned Hours: 60**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of quarter: This quarter introduces more advanced machining techniques including the use of live tooling (also known as driven tooling), Swiss-type lathes, and multi-axis machining. Also covered are more advanced metrology concepts including geometric dimension and tolerance (GD&T), advanced inspection techniques, ISO 9000 inspection standards, and documentation. Instruction will include a mix of classroom, virtual and lab.

Courses include:

1. **Understanding Machines with Live Tooling**
2. **Swiss Lathes**
3. **Multi-Axis Milling**
4. **Metrology 3**

The above courses are described in detail as follows with the 60 hours of RSI broken down:

Q3/Course 1: Understanding Machines with Live Tooling	**Planned Hours: 20**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	
Description of course: Understanding Machines with Live Tooling introduces students to setting up and operating lathes and turning centers with live tooling (also known as driven tooling). In standard lathes/turning centers, the workpiece is turned against a static cutting tool. The addition of live tooling to a lathe/turning center allows the machine to perform operations such as radial drilling and milling on a stationary workpiece. Since these operations would otherwise have required setup on another machine, this saves time and prevents errors. This course examines the various forms that live tooling can take, its advantages and limitations, and how it can be set up to perform a variety of axial and radial milling, boring, drilling and tapping operations. **Topics include:** Working with Sub-spindles; Cross Axis drilling; Cross Axis tapping; Using live tooling to mill on the Y and Z Axis; Using driven tooling to drill and tap on the Y and Z Axis	

Q3/Course 2: Swiss Lathes	**Planned Hours: 20**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	
Description of course: A Swiss lathe has a moving headstock which allows the part to move along the z-axis while the cutting tools are stationary. The bar stock is held by a collet which is recessed behind the guide bushing and is not directly be exposed to the lathe bed and the tooling, so the material can be turned within the machine rapidly and tightly thus eliminating deflection and increasing the accuracy. Students will describe how manual and CNC Swiss lathes work, and the differences between conventional and Swiss lathes. They will identify the characteristics and benefits of guide bushings; additional components on Swiss lathes; the use of live tooling; possible axes; cutting variables; and common cutting operations performed on Swiss lathes. They will distinguish between different operational factors and the potential future use of Swiss lathes in modern manufacturing. Instructor-led projects are designed to extend knowledge, skills, and abilities in manual and/or CNC machines, G & M code programming, CAD/CAM simulation, verification and optimization processes. The focus of these assignments is on how each student learns to model and machine simple or complex free form surfaces, and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams. **Topics include:** Conventional Lathe vs. Swiss-Type Lathe; Importance of the Guide Bushing; Additional Machine & Tooling Components; Live Tooling	

Q3/Course 3: Multi-Axis Milling	**Planned Hours: 10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study	

Provided by: Machinists Institute
Description of course: The Multi-Axis Milling course is an advanced study of multi-axis milling beyond traditional 3-axis milling. Students will be introduced to fundamentals of programming, setting up, and operating 4th and 5th axis milling centers. They will identify and select workholding for multi-axis CNC machines. Students will describe and apply benefits of multi-axis workholding and list how workholding devices affect machine programming. Students will design and use multi-axis dovetail fixtures; multi-axis hard jaws; and/or multi-axis pallets. Common adapters for workholding devices and multi-part setups will be discussed including alternative workholding devices. Students will evaluate multi-axis CNC machine operations; CAD and CAM for multi-axis machines; program and part zero; two common multi-axis workholding devices; and operating characteristics of multi-axis machines. They will list common part features and their impact design for multi-axis machining; what tool interference is, and ways to prevent it. Students will discuss common misalignments for multi-axis machines. Instructor-led projects are designed to extend knowledge, skills, and abilities in manual and/or CNC machines, G & M code programming, CAD/CAM simulation, verification and optimization processes. The focus of these assignments is on how each student learns to model and machine simple or complex free-form surfaces; and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams. **Topics include:** Instructor-determined Assignments/Projects, Workholding for Multi-Axis CNC Machines 219, and Multi-Axis CNC Operations 218

Q3/Course 4: Metrology 3	**Planned Hours: 10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	
Description of course: Metrology 3 is an advanced course in geometric dimension and tolerance (GD&T), advanced inspection techniques, ISO 9000 inspection standards, and documentation. This instructor led class will build on theory and topics covered in Metrology Fundamentals, Metrology 1 and Metrology 2 allowing students to demonstrate skills and knowledge in projects. Activities may include a reverse-engineering project that incorporates documentation, process planning, measure-manufacture-measure iterative cycles, and variation control to determine the effectiveness of the selected manufacturing operation. This work will discuss in detail those experiments utilized in class. Students will work on projects and activities over the course of the class to illustrate competency and skill mastery. Instructor-led projects are designed to extend knowledge, skills, and abilities in manual and/or CNC machines, G & M code programming, CAD/CAM simulation, verification and optimization processes. The focus of these assignments is on how each student learns to model and machine simple or complex free form surfaces, and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams. **Topics include:** Instructor-determined Assignments/Projects	

Year 3 (180 hours)

Element/Course: Year 3 / Quarter 1 Machining Optimization 1	**Planned Hours: 60**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	
Description of element/course: Machining Optimization 1 will cover advanced machining that emphasizes the systematic approaches to product and process design focusing on developing high quality products for the lowest costs and the shortest cycle times. Students will apply DFM to develop products and processes that optimize efficiency and reduce revisions and redesigns. Instruction will include a mix of classroom, virtual and lab. **Courses include:** **1. Design for Manufacturing** **2. Programming for Toolpath Optimization** **3. Work Holding & Fixturing** **4. Lean Manufacturing** **The above courses are described in detail as follows with the 60 hours of RSI broken down:**	

Q1/Course 1: Design for Manufacturing (DFM)	**Planned Hours: 10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	
Description of course: Design for Manufacturing (DFM) is an advanced course that introduces students to Design for Xcellence (DFX) - a methodology that requires all decisions related to products, processes, costs, and constraints be made early in the development process. Design for X encompasses many areas and processes of design, including Design for Manufacturing. Students will describe and explain the applications, benefits, and implementation of DFX as they relate to Design for Manufacturing (DFM). Students will evaluate the fundamental guidelines; the process flow; and appropriate tolerancing for DFM. Other design considerations such as Design for Assembly (DFA) and Design for Quality Control (DFQC) will be discussed. Students will evaluate Design for Cost (DFC) and its relationship to DFX; and ways that traditional cost-cutting can harm a design, product, and the company. They will differentiate between direct costs and indirect costs; total cost and tools for tracking total cost; and the concept of DFC. They will describe the implementation of DFC processes and the role of lean manufacturing. Students will apply part standardization and rationalization for DFC; cost reduction for supply chain costs; methods for quality cost reduction; and various analysis tools. Students will describe and evaluate Design for Serviceability (DFS) including the benefits, processes, and guidelines of DFS. They will list preventative maintenance methods; standardization; and Design for Assembly (DFA). They will assess location considerations for DFS; tools and processes for diagnosing product failure; and safety and reliability in DFS. **Topics include:** Design for Manufacturing 201, Design for Cost 210, Design for Serviceability 220, Design for Additive Manufacturing 201	

Q1/Course 2: Programming for Toolpath Optimization	**Planned Hours: 15**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	
Description of course: Programming for Toolpath Optimization focuses on the optimization of toolpaths created by hand programming or Computer Aided Manufacturing (CAM) software such as Mastercam, Solidworks, Espree, GibbsCam, and CATIA. Students will define CAD/CAM for machining including basic CAD/CAM processes; data storage; and how CAD part designs are input or created. Students will differentiate between 2D/3D CAD models; toolpath simulation; testing and analysis. Students will identify the elements and functions of CAD documentation and describe how CAM converts part geometry into toolpaths. Students will demonstrate how post-processing works including standards for CAD/CAM data. They will describe the purpose of international standards for CAD/CAM data. Describe process planning. Identify how CAD/CAM has improved manufacturing. They will list the order of operations normally performed when machining a part including finishing processes, the setup sheet, and how machinists use technical data references. Students will	

identify the role of a part program; the components; and function of N, G, M, and T codes; including how they interact with tooling selected for the programmed toolpaths.

Topics include: Intro to CAD/CAM for Machining 241, NIMS Core Advanced Machining Skills 151

Q1/Course 3: Workholding & Fixturing	**Planned Hours: 20**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: Workholding and Fixturing focuses on the design and manufacture of workholding and custom fixturing.

Students will define workholding and applications for workholding devices. They will explain what is repeatability and how it relates to workholding. Students will identify chucks and collets; vises; and custom workholding devices such as jigs and fixtures. They will identify fixture bodies; basic categories and types of locators; fixture supports; basic, and power clamps; and indexable workholding devices.

Students will identify the 12 degrees of freedom; workpiece location, support, and clamping. They will list the general considerations for selecting a locator, locator placement, and locator tolerance. Students will describe general locating principles; location strategies; general locator categories; adjustment mechanisms; synthesize the purpose of clamps for workholding; clamping and cutting forces; clamping principles and general clamping guidelines including different ways to safely protect the workpiece when clamping to describe the purpose of workholding. Students will differentiate between external and internal locating; common locating approaches; and issues that can arise when locating a workpiece. Students will list general considerations for selecting a support and support placement considerations. They will identify workholding devices for lathes; chucks; and collets.

Students will identify types and basic setups for workholding devices for the mill and the lathe including fixture design considerations; how to evaluate the workpiece when creating fixtures; types of fixture bodies; considerations for fixture body selection; and the principles of supporting a workpiece. They will identify common support components; principles of locating; locating components; external and internal locating. Students will distinguish between different types of clamps and how fixture design can impact nonproductive time. They will demonstrate how to use computer-aided design (CAD) in fixture design.

By the end of this course, students will identify and describe the role of a fixture body; the importance of fixture body strength and body weight; ways to reduce costs of workholding devices; cast fixture bodies; welded fixture bodies; and built-up fixture bodies. Students will identify precision ground materials; cast brackets; and structural sections of a workholding. They will differentiate between characteristics of different fixture body materials.

Topics include: Intro to Workholding 101, Workholding for Multi-Axis CNC Machines 219, Supporting and Locating Principles 111, Locating Devices 121, Clamping Basics 131, Chucks, Collets, and Vices 141, Fixture Design Basics 201, and Fixture Body Construction 200

Q1/Course 4: Lean Manufacturing	**Planned Hours: 15**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: Lean Manufacturing is an introductory course in Lean. Students will define lean manufacturing; waste in terms of lean manufacturing; identify common types of waste; goals for high-volume and multiple batch lean companies; and sources of process variation. The importance of reducing product changeover times and the importance of reducing inventory will be discussed. Students will assess how lean companies achieve continuous product flow; pull systems; and the use of cells. They will distinguish between inspection and error detection and describe the necessity of employee involvement.

Students will list the activities of the 5S approach and the importance of continuous improvement. This includes identifying the steps involved in 5S and the advantages to implementing a 5S program. Students will list the main goals of lean manufacturing; disadvantages of push systems; and the three main types of manufacturing shop designs. They will list the basic characteristics of a cell; factors that determine cell design; and cell planning process. Students will apply Kanban to define takt and cycle time by reducing setup time. They will evaluate the purpose of error detection and error prevention; and describe the purpose of total productive maintenance. Students will evaluate Kaizen and

Kaizen events; common reasons for holding Kaizen events; benefits; and possible obstacles. They will determine Kaizen team members; methods of encouraging employee support; and methods used to choose the target project. They will learn how Kaizen event goals are set; typical preparations; and training for a Kaizen event. Students will evaluate the purpose of assessment and planning tools in Kaizen events and effective methods of carrying out implementation and follow-up plans. Students will learn about value stream mapping (VSM); current and future state value stream maps; the main categories of value stream mapping; and the purpose of a current state map.

Students will list the pros and cons of developing a lean culture; cultural enablers of leadership and communication; cultural enablers of human development, teamwork, and empowerment. They will describe the concept of standardization; how to implement Kaizen with Plan-Do-Check-Act (PDCA); idea systems; and Hoshin. Students will describe the required training for transitioning to lean including on-the-job (OJT) training and how to reinforce lean practices. They will identify value flow in a lean system; the philosophy behind cost reduction in a lean system; the role of scientific thinking in a lean system; the role of metrics in lean; and total productive maintenance (TPM). Students will demonstrate how to do a Gemba walk; measuring external and internal quality; and the components used in a Just-In-Time (JIT) system.

By the end of this course, students will define the role of metrics in lean; tools for measuring waste; takt and cycle time; and overall equipment effectiveness. They will define lead time and inventory turns. They will apply lean tools for reducing changeover time and for setting quality standards. Students will describe first pass yield and what rework looks like; cash flow; the customer, and financial sections of the balanced scorecard.

Topics include: Lean Manufacturing Overview 101, 5S Overview 151, Cell Design and Pull Systems 161, Conducting Kaizen Events 191, Metrics for Lean 231, Value Stream Mapping 301, Developing a Lean Culture 135, Transforming Lean into Business Results 340, and Measuring Lean Systems 350

Element/Course: Year 3 / Quarter 2 Machining Optimization 2	**Planned Hours: 60**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of element/course: The second sequence in machining optimization focuses on surface modifications for finishing and coatings, and additive manufacturing applications in subtractive manufacturing. Students will also learn leadership principles useful in manufacturing environments and how hydraulic and pneumatic systems influence machining processes. Instruction will include a mix of classroom, virtual and lab.

Courses include:

1. **Material Coatings – Finishing, Surface Modifications**
2. **Additive Manufacturing**
3. **Work Holding Pneumatics & Hydraulics**
4. **Machine Shop Leadership 1**

The above courses are described in detail as follows with the 60 hours of RSI broken down:

Q2/Course 1: Material Coatings	**Planned Hours: 15**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of elements/course: Material Coatings introduces students to surface modification processes, and factors that affect surface adhesion; the nature of the different types of surfaces used in adhesive bonding; and the methods of selecting and preparing a surface for adhesive bonding.

Students will learn various options for preparing surfaces, the nature of common surfaces, how to finish the surface of composite parts and how to inspect surface finish and methods involved for its inspection. They will gain understanding of boundary layers, factors that prevent adhesive bonding, types of surfaces including metal and plastic the benefits of preparing surfaces and what questions to ask in order to select the appropriate surface.

Students will learn how to distinguish between active and passive surface treatments, understand common methods of surface abrasion, chemical and physical treatment processes and how to store a prepared surface. At the completion of this course, students will adhere to surface texture and finish callouts, and be able to perform surface inspection of plastic, metal, and composite parts; describe manual and bulk material removal processes; and be able to discuss polishing, sanding, priming, painting, and plating as part of surface preparation. The Inspection methods of each process are covered for a complete understanding of why material coatings are used in manufacturing, and why surface processes are important.

Topics include: Surface Preparation 210, Surface Preparation for Coatings 120, Surface Finishing Composites 190, Surface Texture, and Inspection 201

Q2/Course 2: **Additive Manufacturing 1**	**Planned Hours:** **15**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: This introductory course in Additive Manufacturing (AM) exposes students to the history, advantages, disadvantages, steps, methods, and differences between traditional manufacturing and additive manufacturing (AM). Students will be able to describe AM processes, methods and metrology for the different uses of AM, and the potential for future AM industry growth and impact on improved production and products. Students will also learn about different AM processes that are constantly evolving including material extrusion, directed energy deposition (DED), material jetting, binding jetting, powder bed fusion (PBF), vat photopolymerization, and sheet lamination.

Students will distinguish between thermoplastic and thermoset polymers, ferrous metals and nonferrous alloys, and ceramic and composite materials, and more. Students learn skills in metrology, material science components, basics of hybrid additive manufacturing applications to determine which material type is most appropriate for use with a specific AM process and how to integrate AM with traditional manufacturing processes.

Students will demonstrate proficiency with different processes around end-use manufacturing, functional complexity, integration, mass customization, and build parameters that influence an AM operation. They will use computer-aided drafting (CAD) modeling and other design tools and practice how to use reverse engineering in AM processes and be able to discuss the importance of metrology in AM and complete basic geometric tolerance and dimensioning specifications for metrology that show a complete understanding of post-processing inspection and metrology considerations.

Topics include: Intro to Additive Manufacturing 111, Additive Manufacturing Safety 121, The Basic Additive Manufacturing Process 131, Additive Manufacturing Methods and Materials 141, Intro to Hybrid Manufacturing 151, Rapid Prototyping 161, AM: Prototype for Production 162, Design for AM 201, Metrology for AM 202, AM Material Science 211, Integrating AM with Traditional Manufacturing 221, and AM as a Secondary Process 231

Q2/Course 3: **Work Holding Pneumatics & Hydraulics**	**Planned Hours:** **15**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: Workholding Pneumatics and Hydraulics deepens students' understanding of pneumatics and hydraulic systems used in manufacturing processes. Students will be familiarized to fluid systems, safety for hydraulics and pneumatics, hydraulic fluid selection and contamination and filter selection. They will be able to describe the use and components of fluid power systems; Pascal’s Law; and how it is applied to fluid systems. Students will demonstrate experience with fluid conductors, control components, actuators, hydraulic fluids, hydraulic systems, hydraulic pumps, pneumatic fluids, and air compressors.

This course also covers safety for hydraulics and pneumatics and students will be able to demonstrate safe working skills using personal protective equipment (PPE) outlined by occupation safety and hazards administration (OSHA) and understanding working with pressurized fluids. Students will also be able to explain hazards in fluid systems, and how to safely handle and prevent accidents and equipment issues.

Students will demonstrate how to determine, select and use different hydraulic fluids using descriptions of fluids, absolute, kinematic, and ISA viscosity and grade; and the use different types of lubrications. Students will explain what oxidation, rust, and corrosion do to equipment; and foam resistance. They will describe fluid system failures associated with contamination and the role of fluid in a fluid power system. Students will identify filter locations in a hydraulic system; how an International Organization of Standardization (ISO 4406:1999) rating indicates a fluid's cleanliness; what target cleanliness is; and hydraulic filter ratings. They will demonstrate how filter conditions indicators monitor filter performance and provide a list of preventive maintenance processes for fluids, filters, and system flushing.

Topics include: Intro to Fluid Systems 101, Safety for Hydraulics and Pneumatics 211, Hydraulic Fluid Selection 371, Contamination and Filter Selection 381

Q2/Course 4: **Machine Shop Leadership 1**	**Planned Hours: 15**

Mode of Instruction (check all that apply) ☐ Classroom ☒ Lab ☐ Online ☐ Self-Study Provided by: Machinists Institute
Description of course: Machine Shop Leadership 1 is an introductory course covering fundamental theories of leadership; various roles of a manager; leadership ethics; methods of motivation; and empowerment and dimensions of transformational leadership. Students present and demonstrate how to solve conflict, create team-based decision making, and the roles of team leader versus team members. Instructor led activities will involve working in team scenarios, public speaking and demonstration of communication skills. Students will apply strategic planning, organizational design, and project management techniques; and demonstrate uses of Work Breakdown Structures (WBS), Gantt Charts, Critical Path Method, Program Evaluation, and Review techniques. They will explain collective bargaining, due process, aspects of situational leadership, and code of ethics. **Topics include:** Essentials of Leadership 110, Team Leadership 160, and Manufacturing Management 180

Element/Course: Year 3 / Quarter 3 Machining Optimization 3	**Planned Hours: 60**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	
Description of element/course: The final sequence of machining optimization introduces students to CNC programming, smart manufacturing, and shop economics such as estimating and procurement. Students also learn how to apply statistical process control using statistics to improve product quality and reduce defects. Instruction will include a mix of classroom, virtual and lab. **Courses include:** **1. CNC Programming** **2. Smart Manufacturing 1** **3. Machining Economics – Estimating, Pricing, Quoting, Procurements** **4. Statistics and SPC** **The above courses are described in detail as follows with the 60 hours of RSI broken down:**	

Q3/Course 1: CNC Programming	**Planned Hours: 30**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	
Description of course: CNC Programming is an introductory course in hand programming using G & M codes for CNC equipment that use Haas, FANUC, and Mazak controllers. Students will learn how to program simple and complex toolpaths using hand and computer-aided-manufacturing (CAM) programming for operations such as drilling; face milling; end milling; slot milling; pocket milling; boring; tapping and using canned cycles. For Haas and FANUC controllers, students will demonstrate application of work coordinate system (WCS) positioning for machine and part zero; tool and cutter compensation offsets; and collision avoidance for workholding and fixturing. Students will use Cartesian coordinate systems to describe program zero. Students will ensure vise alignment prior to simulate and test out toolpaths programmed for face milling; drilling bolt-hole patterns; pocket milling; milling canned cycles; lathe toolpaths and coordinates; basic turning and facing canned cycles; and finishing canned cycles for multiple repetitive cycles. For Mazak controllers, students will demonstrate proficiency in setting up and operating using conversational programming found in Matrix controls. This includes how programs can be entered into the Matrix; keys on the Matrix display section; how to navigate display menus; keys on the Matrix alpha-numeric keypad; the Matrix control navigation section; how to power the machine on and off; clearing alarms; and homing the machine. Students will demonstrate MAZATROL conversational programming and the basic components of a MAZATROL program. They will identify the major shapes that make up a part and explain how to access the program display and name a program. Students will determine the data fields for a common unit from a sample drawing. For all types of controllers, students will demonstrate the general process necessary to prepare for writing a part program; how part programs are organized; how program codes cause tool movement; reading program blocks to predict linear tool movements; program blocks to determine the starting and ending points of a canned cycles;	

subprograms; program blocks to determine the execution of a subprogram; the advantages of including repetitive startup codes; and the purpose of proving out a part program prior to making the actual part.

Topics include: NIMS Core Mill Programming and Setup Skills 231, NIMS Core Lathe Programming and Setup Skills 232, Creating a CNC Turning Program 301, Creating a CNC Milling Program 302, Creating a Milling Program 290, Creating an EIA/ISO Program for the Mazak Mill 286, Canned Cycles 310, Creating a Mazatrol Program for the Lathe 289, Creating a Mazatrol Program for the Mill 250

Q3/Course 2: Additive Manufacturing 2	**Planned Hours: 10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	

Description of course: Additive Manufacturing 2 is an intermediate course where students extend knowledge into a broader category of manufacturing that employs computer-integrated manufacturing, high levels of adaptability and rapid design changes, digital information technology, and more flexible technical workforce training. Students will learn about hybrid manufacturing and reverse engineering and will demonstrate their understanding of the different tools and processes used in hybrid manufacturing and common applications for reverse engineering (RE).

Students will identify and evaluate common hybrid additive manufacturing (AM) production workflows; advantages of hybrid additive tools; all-in-one hybrid machine used for unique product design; basic additive and subtractive manufacturing processes; methods for optical scanning; and how RE is used to inspect AM parts. They will identify common additive processes used in hybrid manufacturing; hybrid AM production workflows; advantages and disadvantages of hybrid additive manufacturing tools; how all-in-one hybrid machines facilitate unique product design; and the benefits of hybrid AM for various industries. At the completion of this course, students will apply fundamentals of RE; describe how RE is used in AM; the basic AM process; common applications for RE with AM; common methods for optical scanning in RE; point clouds and meshes used in RE with AM; and how RE can be used to inspect AM parts.

Topics include: Intro to Hybrid Manufacturing 151 and Reverse Engineering for Additive Manufacturing 242

Q3/Course 3: Machining Economics	**Planned Hours: 10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	

Description of course: Machining Economics is an introductory course in job planning, benchwork, and layout competencies required for resource and materials management in manufacturing facilities. Students will gain skills and an in-depth understanding of setup reduction using common strategies for decreasing setup times such as the single minute exchange of dies (SMED) method which strives to reduce setups by focusing on transitioning internal steps to external steps, which can be performed while machines are running.

Students will apply standardization, workholding, and fixturing to reduce setup times. Students will map out and plan the order of operations for machining parts in job shop, low or high-volume production and/or assembly lines and evaluate setup reduction using geometric dimension & tolerance (GD&T) callouts. They distinguish between traditional and lean manufacturing procedures; and describe the purpose and benefits of planning for, and scheduling changeovers to reduce setup time.

Topics include: NIMS Core Job Planning Skills 221 and Strategies for Setup Reduction 251

Q3/Course 4: Statistics & Statistical Process Control	**Planned Hours: 10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	

Description of course: The Statistics and Statistical Process Control (SPC) course introduces students to statistics; variations; probability; sampling; and graphical representations using histograms and bell-shaped curves. Students will calculate standard deviations; define the relationship between standard deviation and bell-shaped curves; and the relationships between standard deviation and probability.

Students will correlate customer demands with product specifications; apply statistical process control to common and special cause manufacturing variations; and define how processes are determined to be in control in SPC. They will identify effects of variation on sample averages; the purpose of a control chart; and SPC control limits. They will differentiate between control charts used for continuous data and control charts used for discrete data; between process capability and process control; and signs that a process is in or out of control. They will also learn how SPC leads to process improvements. **Topics include:** Statistics 231, SPC Overview 211

Year 4 (180 hours)

Element/Course:	**Year 4 / Quarter 1 Process Improvement & Quality Assurance**	**Planned Hours: 60**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute		
Description of element/course: This course emphasizes Six Sigma principles, data collection to improve quality assurance, and cybersecurity for manufacturing environments such as malware, wireless networks, and digital enterprises. Students learn continuous improvement using advanced metrology such as scanners, lasers, and Coordinate Measuring Machines (CMMs). Instruction will include a mix of classroom, virtual and lab. **Topics include:** **1. Six Sigma – Process Improvement, Implementation, Continuous Improvement** **2. Cybersecurity in Manufacturing** **3. Quality Assurance – Advanced Inspection Equipment i.e., CMM, Scanners, Lasers** **The above courses are described in detail as follows with the 60 hours of RSI broken down:**		

Q1/Course 1:	**Six Sigma**	**Planned Hours:**	**20**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute			
Description of course: This course introduces students to Six Sigma – a process improvement methodology often used in conjunction with Lean. Students will define Six Sigma and how Six Sigma practitioners choose a target problem; the roles and responsibilities of Six Sigma team members; steps in define, measure, analyze, improve, and control (DMAIC); the main factors that lead to process problems; and root cause analysis. Students will identify and address common cause variation and special cause variations; collect and evaluate data for Six Sigma projects; and differentiate between discrete data and continuous data. They will list common data gathering methods; use pie charts and Pareto charts to display data; and describe how frequency distribution and run charts are used. Students will differentiate between Six Sigma and lean initiatives; the relationship between Six Sigma goals and the DMAIC process; and demonstrate how the DMAIC steps are completed. At the completion of this course, students will identify the importance of quality in products and processes; internal and external customers; traits of an organization committed to quality; the roles of engineering, purchasing, production, and sales in quality. They will be introduced to quality management systems and standards; Lean Six Sigma; and Total Quality Management (TQM). Students will evaluate the importance of data to a digital enterprise; the importance of data collection and maintenance; how continuous optimization is driven by data; predictive analytics; and major applications of continuous optimization and predictive analytics. They will identify product data management and product lifecycle management software; the importance of data updates and cybersecurity; data collection methods; data inventory and maintenance. Students will understand the importance of data inventory and maintenance; steps involved in data creation; basic considerations for data maintenance; data mapping and data management; data inventory; and maintenance applications for automation and automated processes. **Topics include:** Intro to Six Sigma 171, Six Sigma Goals and Tools 310, Quality Overview 111, Data Collection: Inventory and Maintenance 231			

Q1/Course 2:	**Cybersecurity in Manufacturing**	**Planned Hours:**	**20**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study			

Provided by: Machinists Institute

Description of course: Cybersecurity is important to nearly every business but especially so to manufacturing where the use of information technology – both in business administration and on the shopfloor – is increasing dramatically. It is particularly critical as manufacturers adopt Industrial Internet of Things (IIoT) technology, install advanced robotics and automation systems, and use data analytics for optimization and control of manufacturing systems. The Cybersecurity in Manufacturing course is designed to introduce students to this rapidly evolving field and help them understand how to develop and implement strategies for maintaining the confidentiality, integrity and availability of business information.

Students will be introduced to the history of hacking, different types of hackers and the attack strategies that hackers use such as clickjacking and cookie theft, viruses, digital worms, spyware and ransomware, Trojan Horses, DDoS attacks, and evil twin attacks. The specific risks that IIoT systems and wireless networks pose will be examined along with strategies that can be used to protect against compromise, detect and respond to attacks, and recover from attacks as quickly as possible.

At the completion of this course, students will be able to describe hacking and the risk it poses to smart manufacturing; describe the history of criminal hacking; distinguish between different types of hackers; describe various active attack strategies used by criminal hackers; describe eavesdropping tactics used by criminal hackers to passively monitor digital systems; describe how criminal hackers use malware to illegally access systems; distinguish between clickjacking and cookie theft; and describe strategies for protecting against criminal hacking. Students will describe the importance of cybersecurity in manufacturing; describe Industry 4.0 and the Industrial Internet of Things; identify basic capabilities and risks of IIoT devices; distinguish between criminal hacking and ethical hacking; distinguish between basic types of malware; describe how a virus functions; distinguish between different types of common viruses; describe how a digital worm functions; describe basic steps for protecting against cyber-attacks; and identify cybersecurity resources available through the U.S. government. They will describe the risk of malware associated with IIoT technology; describe social engineering and phishing tactics; identify ways to recognize phishing attacks; describe how Trojan horse attacks function; describe how spyware attacks function; describe how ransomware attacks function; describe how DDoS attacks function; identify methods for protecting against malware; describe considerations for promoting user responsibility and awareness for cybersecurity; identify common strategies for responding to malware threats; explain the purpose of mirror servers and server clusters. Student will be able to
describe wireless networks; describe wireless local area networks; distinguish between common wireless personal area networks used in smart manufacturing; distinguish between wardriving and piggybacking; identify common causes of wireless service interruptions; describe evil twin attacks; describe common security protocols used by WiFi networks; describe various ways manufacturers can protect wireless networks. Students will also be able to describe the importance of data to a digital enterprise; describe the importance of data collection and maintenance; explain how continuous optimization is driven by data; define predictive analytics; identify major applications of continuous optimization and predictive analytics; describe product data management software and its benefits; describe product lifecycle management software and its benefits; and describe the importance of data updates and cybersecurity.

Topics include: Cybersecurity for Manufacturing: Hacking Overview 201, Cybersecurity for Manufacturing Basics 101, Cybersecurity for Manufacturing: Malware Overview 102, Cybersecurity for Manufacturing: Wireless Networks 202, Data and Design Management for Digital Enterprise 311

Q1/Course 3: Quality Assurance	**Planned Hours: 20**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: Quality assurance provides students an overview of the functions and mechanics of the coordinate measuring machine (CMM), how, and why they are used for advanced inspection. Students will be able to describe how contact and noncontact probes work in a CMM; the difference between measured and constructed features; the machine coordinate system and the part coordinate system; the purpose of alignment; types of software used on CMMs; methods for programming; and how CMMs prevent or compensate for environmental influences. Students will describe and demonstrate the methods and benefits of incorporating CMMs into production processes. This includes special projects and/or assignments from the instructor that utilize quality assurance principles and equipment such as CMMs.

Instructor-led projects are designed to extend knowledge, skills, and abilities in manual and/or CNC machines, G & M code programming, CAD/CAM simulation, verification and optimization processes. The focus of these assignments is on how each student learns to model and machine simple or complex free form surfaces; and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include: Instructor-determined Assignments/Projects, Inspecting with CMMs 361

Element/Course:	**Year 4 / Quarter 2 Machining 4.0 Robotics/Automation**	**Planned Hours:**	**60**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of element/course: This course focuses on the introduction of robotics and automation to machinists. Students learn how to program robots and automate processes using automation, machine maintenance, and PLCs. An instructor-determined project involving knowledge, skills, and abilities related to robotics, automation, and machine maintenance is required for successful completion of this course. Instruction will include a mix of classroom, virtual and lab.

Courses include:

1. **Introduction to Robotics & Automation**
2. **Machine Maintenance**
3. **PLCs**
4. **Robotics/Automation in Machining Project**

The above courses are described in detail as follows with the 60 hours of RSI broken down:

Q2/Course 1:	**Introduction to Robotics & Automation**	**Planned Hours:**	**10**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: Introduction to Robotics and Automation is an overview of state-of-the art robotics and automation in manufacturing. It includes examination of power and drive systems, vision systems, axes and pathways, and collaborative robots. A strong emphasis is placed on the safety precautions that need to be taken when working with or around robots and/or automated systems.

Students will explore the different characteristics and components of industrial robots, be able to describe the different degrees of freedom that enable robotic movement and apply coordinate systems to use for programmed movements. Students will evaluate types of joints found in robots including categories and arms of robotics, the different applications robots perform in industry including welding, material-handling, artificial intelligence, and other programming options. Robot and personal safety will be explained, and National Institute of Safety and Hazards (NIOSH) guidelines followed. Students will also demonstrate their understanding of robot and personal safety and how human error affects robot safety. Topics include how to safely install and maintain robots; different types and causes of robot accidents; and robot safety systems. Students will demonstrate how to use lockout/tagout; use safety barriers; and complete an emergency stop. Students will also be asked to describe how timed events impact robot safety.

Students will demonstrate an understanding of different robot applications such as welding, laser and plasma; dispensing and spraying; assembly; machining; processing; and finishing. Students will distinguish between various advanced applications for robots and inspection applications. Students will also demonstrate understanding the different drives and motors associated with robots including hydraulic, pneumatic, electric drives, servo and stepper motors; robotic gears, transmission and drive systems; sensors, and motion control within those systems. Students will articulate different robot movements along linear, rotational and joint axes, coordinate systems, path projections, and trajectory generation.

After completing this course, students will understand how to program basic commands for manufacturing applications; distinguish between different vision systems in factory automation and manufacturing applications; discuss differences between scan and vision system technologies; and the impact of light on system imaging, acquisition and analysis. They will be able to identify and list the four types of human-robot collaboration (co-bots) and the collaborative applications in material handling, machine tending, process tasks, finishing tasks, and discuss applications for quality inspection. Students will also be able to identify processes compatible with collaborative robots and discuss how technological advances impact collaborative robotics.

Topics include: Intro to Robotics 201, Robot Safety 211, Robot Applications 215, End Effectors 225, Robot Power and Drive Systems 265, Intro to Collaborative Robots 275, Robot Axes and Pathways 280, Vision Systems 320, and Intro to Automation 291

Q2/Course 2: Machine Maintenance	Planned Hours: 20
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	

Description of course: Machine Maintenance is an introductory course in the upkeep of manufacturing machinery such as manual and CNC machines. High levels of equipment maintenance are an important part of reducing operating costs since they increase equipment uptime and help to maintain quality of the finished product. And machinists are increasingly involved in machine maintenance through an approach called Total Productive Maintenance (TPM).

In this course, students will familiarize themselves with the mechanical and electrical systems commonly found in manufacturing equipment. Students will be introduced to the function and maintenance of bearings; springs; belt drives; gears and clutches; brakes; distribution systems; motor drive and electrical systems. Students will also learn about systems of fatigue and failure analysis of parts; and about the critical role played by lubrication and the different types of lubricants typically used in machine tools.

The course will describe common faults in electrical systems, how to calculate electrical imbalance percentages and harmonic values, and how to distinguish between common insulation resistance testing methods; common causes of thermal abnormalities in motor drive systems; and how to perform inspection and proactive maintenance on electrical systems. The course will emphasize the ability to describe proactive maintenance inspection aspects and testing tools, including how to distinguish between measurement categories; understanding typical motor drive systems; inspection routes; proactive maintenance; power quality; best practices for measuring input power; single and multi-phasing inspection techniques. Students will also learn how to apply the 8 pillars of TPM – Autonomous Maintenance, Focused Improvement, Planned Maintenance, Quality Maintenance, Early Equipment Management, Training and Education, Safety Health & Environment, and TPM in Administration.

After completing this course, students will be able to contrast operational and shutdown inspections; describe the responsibilities of various members of a proactive maintenance team; the importance of maintenance; reactive and corrective maintenance. They will be able to discuss the benefits and limitations of TPM approaches and the significance of planned downtime, and identify the factors involved in selecting the best maintenance approach.

Topics include: Total Productive Maintenance 141, Intro to Mechanical Systems 101, Forces of Machines 121, Bearing Applications 221, Spring Applications 231, Belt Drive Applications 241, Gear Applications 251, Clutch and Brake Applications 271, Distribution Systems 221, Motor Drive Systems and Maintenance 348, Electrical Maintenance for Motor Drive Systems 348, Approaches to Maintenance 131, and Robot Maintenance 170

Q2/Course 3: Introduction to PLCs	Planned Hours: 20
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	

Description of course: Introduction to Programmable Logic Controllers (PLCs) provides an overview of components of PLCs and their functions, provides basic information on the ladder logic programming language used in PLCs, and gives an overview of common internal relay instructions used in PLC programs. Manufacturers use PLCs to control automated processes and machines. As Industry 4.0 and smart manufacturing are gaining widespread use, PLCs are more important than ever. Having a foundational knowledge of the basic functions of a PLC helps to increase productivity and efficiency. Students will gain an overview of the basic principles, structure, and symbols of ladder logic programming, including the components of ladder logic programming language used in PLCs; their functions; ladder diagrams; logic gates; and common input and output instructions used in PLC programs. PLC-based automation is continually growing, and ladder logic is the most common language used in PLC programming. Having foundational knowledge of basic ladder logic components and functions will help students improve efficiency and familiarity with PLC programs.

Students will distinguish and identify between different types of PLCs and describe what the central processing unit is; the I/O module; I/O devices; steps in a CPU operating cycle; standardization; ladder diagrams; ladder diagram symbols; logic gates; internal relays; counter, timer, and sequencer instructions in a PLC program. They will identify PLC hardware; distinguish between PLC types, and locate power supplies for a PLC. Students will describe the process of installing and maintaining PLC hardware, including how to troubleshoot errors in a PLC operation.
Students will distinguish between sealing and latching instructions and detail the difference between industrial local area networks and wireless local area networks. They will differentiate between common network transmission media for wired networks; interconnecting devices; routers; and gateway devices.

At the completion of this course, students will be familiar with how to install PLCs; factors to consider before installation; criteria for choosing PLC hardware; precautions to take against humidity, heat, noise, shock, vibration, electrostatic discharges, and voltage spikes. They will demonstrate how to mount a PLC with fixed I/Os; the criteria for selecting; network cable installation practices; and how to turn on and observe a PLC after installation. Students will evaluate automated systems; computer-integrated manufacturing (CIM); information technology (IT); relay ladder logic; management information systems (MIS); manufacturing execution systems (MES); and enterprise resource planning (ERP). **Topics include:** Intro to PLCs 201, Hardware for PLCs 211, Reversing Motor Circuits 341, Basics for Ladder Logic 221, Numbering Systems and Codes 222, PLC Inputs and Outputs 231, Basic Programming for PLCs 241, PLC counters and Timers 251, Networking for PLCs 261, Overview of PLC Registers 305, Math for PLCs 320, PLC Installation Practices 340, Data Manipulation 360, Shift Registers 370, Robot Control Systems 317, Automated Systems and Control 135

Q2/Course 4: Robotics/Automation in Machining - Project	**Planned Hours: 10**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	
Description of course: The use of automation and robotic technology to complement conventional and CNC machining operations is becoming commonplace. Machine tending robot cells can be used to automate repetitive tasks, move goods automatically onto pallets for shipping, eliminating potential for workplace injury, and operation in confined spaces that would be inaccessible to human workers. These technologies can be implemented as part of new production facility design, be added to existing production systems or existing machine tool automation (EMTA) or a hybrid of the two. This advanced course focuses on the integration of advanced automation and robotics technology with machine tools in a manufacturing facility. Students will apply the knowledge, skills and abilities taught and assembled from previous courses to complete a project defined by the instructor. Focus will be placed on safety, and on designing systems for high levels of reliability and maintainability. Instructor-led projects are designed to extend knowledge, skills, and abilities in manual and/or CNC machines, G & M code programming, CAD/CAM simulation, verification and optimization processes. The focus of these assignments is on how each student learns to model and machine simple or complex free-form surfaces; and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams. **Topics include:** Instructor-determined Assignments/Projects	

Element/Course: Year 4 / Quarter 3 Machining 4.0 Smart Manufacturing	**Planned Hours: 60**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	
Description of element/course: In this final sequence of machining 4.0, students are required to complete a capstone project using hybrid or reverse engineering. The course includes a leadership and career exploration component related to workplace leadership and opportunities for career growth. Instruction will include a mix of classroom, virtual and lab. **Topics include:** **1. Smart Manufacturing** **2. Machine Shop Leadership 2** **3. Career Opportunities - Mentor, Supervisor, Programmer, QA, Estimating, Planning** **The above courses are described in detail as follows with the 60 hours of RSI broken down:**	

Q3/Course 1: Smart Manufacturing	**Planned Hours: 20**
Mode of Instruction (check all that apply) ☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute	

Description of course: The smart manufacturing course introduces students to a broad category of technologies including big data processing and analytics, network-connected devices and services, and advanced robotics. In this course, students will evaluate digital twin functions and uses; how to use digital twin to virtually test a part or machine, and how digital twins are made. Students will explore digital threads and how to use digital twins for digital threads. They will identify common software applications associated with digital threads; their purpose; and challenges associated with implementing digital threads. Students will explore how digital thread connects the supply chain with the manufacturer, and the relationship between digital thread and the end user. Students will be introduced to industrial internet of things (IIoT) and Industry 4.0 as part of smart manufacturing technologies. They will consider data storage and maintenance; how to develop a digital enterprise strategy; how to identify key financial benefits of implementing a digital enterprise strategy; and personnel challenges of digital enterprise strategy adoption.

At the completion of this course, students will identify robot components; applications; automated systems and controls; robot axes; advanced maintenance procedures; safety; drives, hardware, and components. They will learn how to install robots; industrial network integration; and programming. Additionally, students will familiarize themselves with early developments in machine learning and artificial intelligence in manufacturing by exploring machine learning processes; artificial intelligence (AI) and machine learning AI; supervised and unsupervised machine learning; and applications for machine learning AI in manufacturing.

Instructor-led projects are designed to extend knowledge, skills, and abilities in manual and/or CNC machines, G code programming, CAD/CAM simulation, verification and optimization processes. The focus of these assignments is on how each student learns to model and machine simple or complex free form surfaces, and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include: Instructor-determined Assignments/Projects, Introduction to Digital Twin 241, Introduction to Digital Thread 242, and Introduction to Digital Enterprise Strategy 251

Q3/Course 2: Machine Shop Leadership 2	**Planned Hours: 30**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study

Provided by: Machinists Institute

Description of course: Machine Shop Leadership 2 is the second series in leadership development for manufacturing professionals. The class builds on the foundations learned in Machine Shop Leadership 1 to extend students' knowledge and skills for leadership, including communication skills to support mentorship/knowledge transfer from journey to apprentice, conflict resolution, effective team leadership and effective communication skills. Students will apply fundamentals of the human relations and communication processes to personal and workplace relationships. Emphasis on applying communication theory to interviewing, small group communications, and public speaking. Students are required to prepare and give oral presentations, based on instructor-determined assignments and/or projects.

The course includes respectful workplace training such as 'RISE Up' to address anti-harassment training requirements and emphasize the tools and skills necessary to create and maintain a safe, inclusive and productive workplace environment. Other topics include the issues surrounding diversity in the modern workplace as well as employer responsibilities regarding diversity management; how to identify and prevent harassment and discrimination in a diverse workplace; and the basic Federal employment laws that apply to manufacturing. Students will identify the basic responsibilities of a team leader and gives helpful ideas about how to gain the respect and trust of others; key types of communication; and common roadblocks to communication. They will use effective communication as a tool to help build teamwork, manage conflict, and motivate team members. Students will address employee performance issues dealing with a variety of situations in which a conflict may occur, and demonstrate constructive advice for the best approaches to dealing with those conflicts.

Instructor-led projects are designed to extend knowledge, skills, and abilities in leadership, communication and promotion of respectful workplace principles. The focus of these assignments is on how each student demonstrates competency in these areas, and the promotion of independent learning. Course activities will build on previous courses and topics covered and may involve projects that require students to work in teams.

Topics include: Instructor-determined Assignments/Projects, Leadership, and Mentorship Matters for the Mentor

Q3/Course 3: Career Development	**Planned Hours: 10**

Mode of Instruction (check all that apply)

☒ Classroom ☒ Lab ☒ Online ☐ Self-Study Provided by: Machinists Institute
Description of course: Many career positions and opportunities in manufacturing are increasingly going unfilled. This course will expose students to various manufacturing branches such as product lifecycle; supply chain; development and design stages; materials; production processes; assembly; and other important manufacturing tasks. Students will evaluate different career opportunities and pathways that can lead to manufacturing careers. In this course, students will distinguish between common pathways to manufacturing careers such as pathways to development and design; production; programming; quality control (QC); quality assurance (QA); logistics and maintenance; health and safety; sales; and business functions. **Topics include:** Manufacturing 101, Careers in Manufacturing 102, Intro to AI and Machine Learning 301