

Laser Manufacturing Technician Curriculum Development



- Overview -

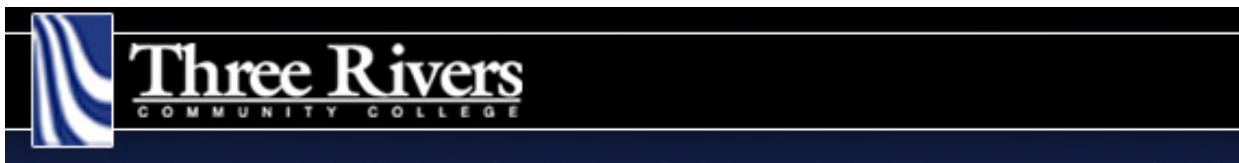
During the Summer/Fall 2005, a skills/needs assessment was conducted with nine laser companies using a modified DACUM (“Developing a Curriculum”) approach. The selected companies represented a cross sectional sample of the laser manufacturing industry in the New England region involved in the manufacturing, use, and/or system integration of lasers (OEMs). These companies included:

JDSU Corporation	Bloomfield, CT
IPG Photonics Corporation	Oxford, MA
Coherent Laser	Bloomfield, CT
Zygo Corporation	Middlefield, CT
OFS Optics	Avon, CT
Photomachining Corporation	Pelham, NH
Rofin-Baasel Corporation	Boxborough, MA
Prima Laser	Springfield, MA
CCAT	East Hartford, CT

Representatives from each company, including engineers, technicians and managers responded either to a DACUM survey, personal interviews, telephone interviews, or a combination thereof, in which they were asked to provide detailed information describing job functions, tasks or duties deemed critical for a laser technician at their particular company. Anecdotal data was also compiled with regard to ancillary tasks and duties required of laser manufacturing technicians at each company in an effort to provide depth and breadth to the survey data. Sample job descriptions from companies that were hiring at the time were also collected. Survey data, interview data, and job descriptions were examined for common core competencies as well as industry-specific knowledge and skill requirements. The results were then integrated into a draft Laser Manufacturing Technician Competency Profile (see attached), in which critical job duties and tasks are tabulated; and a draft Laser Manufacturing Technician Competency Outline, in which detailed and measurable performance indicators (sub-tasks) for each job task were compiled. The draft Competency Profile and Competency Outline were then redistributed to each participating company for validation whereby company representatives were asked to rate the importance of each task and subtask using a 5-point Likert scale (1 = not important; 5= very important). Mean values were computed for all items. Items with an average rating of less than 2.5 were omitted.

In addition to survey and interview data compiled, competencies obtained from the National Skills Standard in Laser Machining (NSF-A TE: Machinetool Advanced Skills Technical Education Resources (MASTER) Project, 1997) as well as the National Photonics Skill Standard for Technicians (CORD Communications, 2003) were used to triangulate the survey data. Both the MASTER Laser Machining Skill Standard and the CORD National Photonics Skills Standard detail the skills and knowledge required of the laser technician resulting from comprehensive DACUMs conducted on a national level with over 100 companies.

The Laser Manufacturing Technician Competency Profile and Outline form the foundation for the Regional Center for Next Generation Manufacturing (RCNGM) Laser Manufacturing Technician AS Degree curriculum (see attached) currently being offered at Three Rivers Community College in Norwich, CT.



Laser Manufacturing Technician

Associate in Applied Science Degree

The Laser Manufacturing Technician program, developed by the Regional Center for Next Generation Manufacturing, is a state-of-the-art industry driven curriculum designed to meet the needs of the 21st century laser manufacturing industry. The Laser Manufacturing Technician is a highly skilled professional with a working knowledge of electronics, lasers, optics, materials, engineering documentation, CAD/CAM, systems integration, and lean manufacturing. The laser manufacturing technician is capable of working productively in industries that manufacture, integrate (OEM) and/or use lasers and laser-based systems in a manufacturing environment.

Students who complete the Laser Manufacturing Technician program may also choose to transfer to Central Connecticut State University where their credits will be accepted into the Industrial Technology bachelor's degree program or to Charter Oak State College. Please check current course schedule for details.

General Education Courses

<u>Course ID</u>	<u>Title</u>	<u>Credits</u>
ENG 101	Composition	3
ENG 202	Technical Writing OR	
ENG 102	Lit and Comp (for transfer students)	3
MAT 137	Intermediate Algebra	3
MAT 186	Pre-Calculus	4
MAT 163	Statistics	3
PHY 121	General Physics I	4
PHY 140	Introduction to Optics	4
	Humanities Elective	3
	Fine Arts Elective	3
	Social Science Elective	3
Credits		33

Technical Core Courses

<u>Course ID</u>	<u>Title</u>	<u>Credits</u>
PHO 240	Introduction to Lasers	4
PHO 230	Laser Electronics	4
CSA 105	Introduction to Software Applications	3
CAD1200/1201	Computer Aided Drafting	3
EE'TXXX	Electric Circuits and Systems (new course)	4 (3+2)
PHO XXX	Opto-electronics (new course)	3 (2+2)
EE'TXXX	Data Acquisition and Control (new course)	3 (1+4)
MFGXXX	Next Generation Manufacturing (new course)	3
MFGXXX	Metrology	4 (3+2)
MFGXXX	CNC Laser Materials Processing	4
Credits		35
Total Credits		68

Competency Profile

Laser Manufacturing Technician

The Laser Manufacturing Technician will have a working knowledge of electronics, lasers, optics, materials, engineering documentation, CAD/CAM, systems integration, and lean manufacturing and will be capable of working productively in industries that manufacture, integrate (OEM) and/or use lasers and laser-based systems in a manufacturing environment.



Duty	Task						
A. Apply Math To Solve Problems	A1. Perform basic math functions	A2. Solve simple algebraic equations	A3. Apply principles of geometry	A4. perform statistical data analysis	A5. Perform proportioning and interpolation	A6. Perform basic trigonometric functions	A7. Perform vector analysis
B. Use A Computer	B1. Navigate Windows® Operating System	B2. Use Microsoft Word®	B3. Use Microsoft Excel®	B4. Use Microsoft PowerPoint®	B5. Program LabView® to acquire and analyze data		
C. Build, Test, and Analyze Electronic Circuits	C1. Build, analyze, test & troubleshoot analog and digital circuits & systems	C1. Build, analyze, test & troubleshoot opto-electronic devices, circuits & systems	C3. Use an AC function generator	C4. Build, analyze, test, & troubleshoot laser supplies			
D. Perform 2D & 3D CAD Operations	D1. Create and edit basic 2D CAD drawings	D2. Create and edit 3D solid models	D3. Create and edit sheet metal parts	D4. Create 3D models using rapid prototyping			
E. Perform CNC & CAM Programming	E1. Use machine specific nomenclature and terminology	E2. Apply Cartesian coordinate system to machine operations	E3. Perform program preparation	E4. Perform basic CNC programming	E5. Perform basic CAM operations	E6. Perform CAD/CAM integration.	E7. Apply laser coding parameters
F. Build, Analyze & Test Laser Systems	F1. Select, clean, install, and align optical components	F2. Identify, install and test laser electrical and cooling system	F3. Measure and adjust laser output parameters	F4. Assemble and wire laser systems			
G. Perform Laser Materials Processing	G1. Perform laser welding	G2. Perform laser cutting	G3. Perform laser hole drilling	G4. Perform laser marking & scribing	G5. Perform laser surface treatment		
H. Perform Dimensional Metrology	H1. Use proper metrology nomenclature	H2. Select instruments used for measurement	H3. Interpret limits and tolerances	H4. Select gauging tools	H5. Use CMM for location of features	H6. Perform surface metrology	
	H7. Perform measurement by comparison	H8. Perform circularity, cylindricity, profile of a line, and runout measurements.	H9. Apply advanced metrology methods				
I. Apply Next Generation Manufacturing Principles & Methods	I1. Demonstrate knowledge of basic materials	I2. Demonstrate knowledge of traditional and non-traditional machine operations and manufacturing processes	I3. Perform production planning and control	I4. Demonstrate knowledge of value-stream mapping and process mapping	I5. Demonstrate knowledge of six-sigma	I6. Demonstrate knowledge of lean manufacturing principles	

Laser Manufacturing Technician Competency Profile Subtask Outline



The Laser Manufacturing Technician will have a working knowledge of electronics, lasers, optics, materials, engineering documentation, CAD/CAM, systems integration, and lean manufacturing and will be capable of working productively in industries that manufacture, integrate (OEM) and/or use lasers and laser-based systems in a manufacturing environment.

A. Apply Math to Solve Problems

A1. Perform Basic Math Functions

1. Use and manipulate fractions.
2. Use and manipulate decimals.
3. Calculate percentages.
4. Calculate units of length, area, and volume.
5. Convert between SI (metric) and English (inch) units.
6. Use a scientific calculator

A2. Solve Simple Algebraic Equations

1. Identify equations with one unknown.
2. Solve algebraic equations by isolation of the unknown.
3. Identify equations with fractions.
4. Solve equations by cross-multiplying.
5. Identify and solve linear equations.
6. Calculate the slope of a line.

A3. Apply Principles of Geometry

1. Apply the laws of exponents
2. Calculate exponentials and roots
3. Analyze right triangles
4. Use Pythagorean theorem
5. Calculate the area and circumference of a circle
6. Determine angular measurements (degrees and radians)
7. Establish a tangent to a circle
8. Analyze parallel lines, transverse lines, and angles
9. Perform bisection of an angle
10. Calculate the sum of the interior angles of a polygon
11. Calculate the area of a triangle and irregular shapes
12. Analyze trapezoids

A4. Perform Statistical Data Analysis

1. Collect, screen, analyze and plot data
2. Create graphs (line, bar, and pie)
3. Calculate mean, median, and standard deviation.

A5. Perform Proportioning and Interpolation

1. Calculate ratios and proportions.

2. Calculate direct, inverse, and combined variations
3. Calculate constants of proportionality
4. Perform tabular interpolation

A6. Perform Basic Trigonometric Functions

1. Calculate the trigonometric functions of sine, cosine, and tangent
2. Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
3. Solve a right triangle

A7. Perform Vector Analysis

1. Analyze components of vectors
2. Perform vector addition
3. Perform vector combination
4. Plot data in the X-Y coordinate system
5. Plot data in the X -Y-Z coordinate system
6. Calculate the slope of a line in the Cartesian coordinate system

B. Use a Computer

B1. Navigate Windows® Operating System

1. Create a file
2. Create a directory or folder
3. Manage file folders
4. Open and save files
5. Use Windows Explorer
6. Use Internet explorer
7. Create and/or open a Zip file

B2. Use Microsoft Word®

1. Create, format and edit a document
2. Cut and paste text, data and graphics
3. Save a document
4. Create and format a table
5. Format bullets and numbering
6. Format borders and shading
7. Create and format letters and envelopes
8. Print a document
9. Insert drawings and/or pictures into a document
10. Convert a Word document into Adobe .pdf file
11. Use drawing features to enhance documents
12. Apply footers and headers
13. Set page margins and print parameters
14. Change fonts and symbols
15. Use spell-check
16. Create and use macros
17. Track, highlight, and accept/reject comments and changes

B3. Use Microsoft Excel®

1. Create a spreadsheet file

2. Save a spreadsheet file
3. Create, format and edit cell data
4. Create data tables
5. Sort data
6. Cut and paste text, data and graphics
7. Apply mathematical functions
8. Perform statistical data analysis
9. Create pivot tables
10. Create plots and graphs

B4. Use Microsoft PowerPoint®

1. Organize and create a PPT presentation
2. Edit and save a PPT presentation
3. Create, format and edit bullet list presentation
4. Create, format and edit 2D & 3D graphics
5. Insert and format Excel chart and/or table
6. Format slide and object transitions
7. Create and/or apply presentation templates
8. Insert and format clip art and other digital images
9. Insert and format hyperlinks
10. Apply shading to drawing elements

B7. Program LabView® to acquire and analyze data

1. Set up GPIB Interface
2. Interface electronic test and measurement equipment with LabView
3. Create, test, and debug virtual instruments (VI)
4. Create VI and sub-VI libraries
5. Create structured control programs
6. Create cluster controls & indicators
7. Create visual displays (charts and graphs)
8. Set up and perform real-time data acquisition and instrument control
9. Perform file I/O, printing and reporting

C. Build, Test, and Analyze Electronic Circuits

C1. Build, analyze, test and troubleshoot analog and digital circuits & systems

1. Calculate AC, DC and RMS voltage, current, resistance and power
2. Measure DC and RMS voltage, current, resistance and power using a digital multimeter
3. Use a digital storage oscilloscope
4. Use programmable function generator
5. Use an RF spectrum analyzer
6. Use a digital logic probe
7. Use a digital logic analyzer
8. Use circuit simulation software (e.g., MultiSim®, Pspice®, Electronics Workbench®, etc)
9. Identify short circuits and open circuits
10. Build, analyze, and test electronic motion control systems (i.e., x-y-z micropositioning system, DC and stepper motor control circuits)
11. Solder according to comply with IPC standards
12. Read component specifications

13. Read wiring schematics
14. Perform basic wiring according to wiring schematics
15. Identify ground loops and RF shielding requirements
16. Comply with OSHA Electrical Safety standards

C2. Build, analyze, test and troubleshoot optoelectronic devices, circuits & systems

1. Use opto-isolators for electrical isolation
2. Build and troubleshoot optical detector circuits
3. Build and troubleshoot LED and laser diode driver circuits
4. Use an optical power meter
5. Use a fiber break indicator
6. Strip, cleave and inspect fiber optic cable
7. Terminate and test fiber optic cable assemblies
8. Determine and measure fiber optic cable characteristics (i.e., tensile strength, circularity, index profile, etc)
9. Install bare fiber connectors
10. Use a fiber optic loss test set
11. Measure insertion loss
12. Use an Optical Time-Domain Reflectometer (OTDR)
13. Install and test mechanical splices
14. Use a fiber optic fusion splicer
15. Use an optical spectrum analyzer
16. Install and operate a thermo-electric (TE) cooler
17. Install and test coherent and incoherent fiber optic bundles
18. Build, operate and test Erbium Doped Fiber Amplifiers (EDFA)
19. Install and test fiber optic couplers and splitters
20. Install and test fiber Bragg gratings
21. Build, operate and test integrated optical modulators
22. Properly dispose of fiber optic waste
23. Clean and handle optic fiber according to industry specifications
24. Ensure adherence to ANSI Z136.1 laser safety standards
25. Comply with OSHA Electrical Safety standards

C3. Build, analyze, test and troubleshoot laser power supplies

1. Build, analyze, test and troubleshoot high voltage neutral gas laser power supplies
2. Build, analyze, test and troubleshoot high voltage ion laser power supplies
3. Build, analyze, test and troubleshoot solid-state diode-pumped laser power supplies
4. Build, analyze, test and troubleshoot laser diode driver circuits
5. Build, analyze, test and troubleshoot solid-state flashlamp-pumped driver circuits
6. Build, analyze, test and troubleshoot high voltage RF power supplies
7. Build, analyze, test and troubleshoot pulsed laser power supplies
8. Build, analyze, test and troubleshoot fiber laser power supplies
9. Comply with OSHA Electrical Safety standards

D. Perform 2D and 3D CAD Operations

D1. Create and edit basic 2D CAD drawings

1. Perform basic 2D CAD file management
2. Apply drawing settings

3. Use basic and advanced editing commands
4. Create drawings with stated accuracy
5. Organize drawing information
6. Control the display of drawings
7. Create multi-view drawings
8. Create orthogonal views.
9. Create sectioned drawings
10. Create and edit electrical wiring and assembly drawings
11. Create drawing annotations including geometric tolerance.
12. Understand and use centerlines.
13. Apply the standards from ASME Y14.5-1994 to dimensions for both English and Metric drawings.
14. Place notes on drawings
15. Use and manipulate blocks

D2. Create and edit 3D solid models

1. Understand how to sketch, refine, and add parametric dimensions and constraints to profiles using a 3D solid modeling system.
2. Create part features for a 3D solid model.
3. Manipulate the view of the part.
4. Create 3D workplanes.
5. Edit part features.

D3. Create and edit sheet metal parts.

1. Discuss sheet metal design methods.
2. Discuss and prepare sheet metal styles.
3. Understand and use sheet metal tools.
4. Create sheet metal faces, flanges, cuts, bends, and corner seams.
5. Create a flat pattern from a folded sheet metal part

D4. Create 3D models using rapid prototyping

1. Select the appropriate prototyping technology for a given design application
2. Convert Computer Aided Design (CAD) file to Stereolithography (STL) file.
3. Determine and set physical parameters of rapid prototype model or part
4. Generate machine specific code and process specific parameters for rapid prototyping process and part
5. Prepare rapid prototyping machine according to manufacturer's specifications and the production plan
6. Load proper rapid prototyping materials into machine and set up machine for a test part
7. Identify and assemble proper post processing tools and infusing materials
8. Comply with Material Safety Data Sheets (MSDS) for post production materials
9. Perform procedures appropriate to post processing plan and type of rapid prototyping process.
10. Perform dimensional metrology on created rapid prototype part to assure compliance with design criteria

E. Perform CNC and CAM Programming

E1. Use machine specific nomenclature and terminology

1. Determine machine specifications
2. Identify keyboard and function keys.
3. Establish radius offsets.
4. Perform basic programming of MCU (machine control unit)
5. Prove out a program
6. Load and run a part program

E2. Apply Cartesian coordinate system to machine operations.

1. Study the Cartesian coordinate system.
2. Study the basics of a coordinate measurement system
3. Plot points in an XYZ coordinate system.
4. Understand absolute coordinates
5. Understand incremental coordinates

E3. Perform Programming Preparation

1. Identify programming planning steps
2. Set beam size and power (laser applications)
3. Determine cutting depth or penetration.
4. Determine cutting speed and feed

E4. Perform basic CNC programming

1. Use word-address and variable block formats
2. Understand standard programming formats such as FANUC
3. Understand modal addresses
4. Perform start up, tool changing, and ending of programs
5. Perform positioning and basic drilling
6. Create a sub-program.
7. Perform contouring.
8. Apply tool radius compensation

E5. Perform basic CAM operations

1. Demonstrate an understanding of CAM basics.
2. Create 2D part profiles.
3. Edit 2D part profiles
4. Demonstrate an understanding of CAM tooling
5. Create tool paths
6. Edit tool paths
7. Perform Roughing.
8. Perform drilling, counterboring, and threading

E6. Perform CAD/CAM Integration.

1. Create .DXF files
2. Perform .DXF file translation
3. Manipulate CAD geometry into tool path data.

E7. Apply Laser Coding Parameters

1. Select assist gas-oxygen
2. Select assist gas-Nitrogen

3. Select assist gas-Air
4. Turn on and cancel selected assist gas
5. Determine and set laser output pulse parameters

F. Build, Analyze & Test Laser Systems

F1. Select, clean, and install optical components

1. Comply with industry standards for handling, cleaning and inspecting optical components
2. Select, clean, install and align laser HR mirror and output coupler
3. Select, clean, install, and align focusing optics
4. Select, clean, install, and align solid-state laser rod
5. Select, install, align and test a flashlamp
6. Select, install, align and test a diode laser pump
7. Select, install, align and test a laser Q-switch
8. Select, install, align and test an etalon
9. Select, install, align and test polarizers, quarter-wave & half-wave plates
10. Use and autocollimator to align optical cavity
11. Terminate, splice and test fiber optic beam delivery cable.
12. Identify, install and test laser beam tracer
13. Construct, align and use an interferometer
14. Ensure adherence to ANSI Z136.1 laser safety standards
15. Comply with OSHA Electrical Safety standards

F2. Identify, install and test laser electrical and cooling systems

1. Identify, install and test laser electrical system according to specifications
2. Identify, install and test laser cooling system according to specification
3. Identify, install and test laser gas flow system according to specifications
4. Identify, install and test laser shutter & beam dump system
5. Identify, install and test laser safety interlock system
6. Identify, install and test laser gas assist nozzle
7. Comply with OSHA Electrical Safety standards

F3. Measure and adjust laser output parameters

1. Measure and adjust laser output power (CW and pulsed)
2. Measure laser output beam divergence
3. Measure and adjust laser output mode profile
4. Measure and adjust laser beam diameter
5. Measure and adjust laser output wavelength spectrum
6. Measure and adjust laser beam polarization
7. Determine laser beam quality factor (M^2 & K)
8. Measure and adjust RF generator output
9. Measure laser beam propagation factor
10. Measure laser coherence length
11. Select, install, and adjust laser beam focusing optics
12. Ensure adherence to ANSI Z136.1 laser safety standards
13. Comply with OSHA Electrical Safety standards

F4. Assemble and wire laser systems

1. Read and understand wiring schematics

2. Operate hand tools (hand drill, screwdrivers etc)
3. Read and understand Assemble Drawings
4. Wire panels per NEC and NFPA guidelines
5. Assemble sheet metal and machined parts
6. Integrate laser system with appropriate enclosure (i.e., Class I)
7. Document assembly and wiring changes.
8. Comply with OSHA Electrical Safety standards

G. Perform Laser Materials Processing

G1. Perform laser welding

1. Evaluate material characteristics & process requirements
2. Determine required laser parameters
3. Select appropriate beam delivery system
4. Determine laser assist-gas requirements
5. Inspect laser-processed materials
6. Ensure adherence to ANSI Z136.1 laser safety standards

G2. Perform laser cutting

1. Evaluate material characteristics & process requirements
2. Determine required laser parameters
3. Select appropriate beam delivery system
4. Determine laser assist-gas requirements
5. Inspect laser-processed materials
6. Ensure adherence to ANSI Z136.1 laser safety standards

G3. Perform laser hole drilling

1. Evaluate material characteristics & process requirements
2. Determine required laser parameters
3. Select appropriate beam delivery system
4. Determine laser assist-gas requirements
5. Inspect laser-processed materials
6. Ensure adherence to ANSI Z136.1 laser safety standards

G4. Perform laser marking & scribing

1. Evaluate material characteristics & process requirements
2. Determine required laser parameters
3. Select appropriate beam delivery system
4. Determine laser assist-gas requirements
5. Inspect laser-processed materials
6. Ensure adherence to ANSI Z136.1 laser safety standards

G5. Perform laser surface treatment

1. Evaluate material characteristics & process requirements
2. Determine required laser parameters
3. Select appropriate beam delivery system
4. Determine laser assist-gas requirements
5. Inspect laser-processed materials
6. Ensure adherence to ANSI Z136.1 laser safety standards

H. Perform Dimensional Metrology

H.1 Use proper metrology nomenclature

1. Discuss the various methods of measurements.
2. Convert between SI and English systems.
3. Interpret dimensions.
4. Apply ANSI Y14.5 requirements for geometric dimensioning and tolerance

H.2 Select instruments used for measurement

1. Use Vernier calipers.
2. Use dial calipers.
3. Read scales.
4. Use micrometers.
5. Use hole and depth micrometers.
6. Set up and use dial indicators.

H.3 Interpret limits and tolerances

1. Discuss the use of datums
2. Discuss the three-plane system: primary, secondary, and tertiary datums
3. Apply material condition symbols (MMC, LMC, RFS)
4. Use target points to define datums

H.4 Select gauging tools

1. Use gauge blocks.
2. Use pin gages.
3. Use a height gauge.
4. Use to “go/no go” gauges.
5. Design and build functional gauges.

H.5 Use CMM for location of features

1. Set up, calibrate and use a Coordinate Measurement Machines (CMM)
2. Set up and measure hole locations with respect to applicable datums.
3. Set up and measure location for non-cylindrical features.
4. Set up and measure location for multiple pattern features.
5. Set up and measure the projected tolerance zone.

H.6 Perform surface metrology

1. Use surface plates.
2. Use of angle plates, mandrels, and V-blocks.
3. Use surface plates to establish datums.
4. Set up and measure the flatness of a surface.
5. Set up and measure the perpendicularity of two surfaces.
6. Set up and measure the angularity of two surfaces.
7. Set up and measure the parallelism of two surfaces.
8. Set up and measure the profile of a surface.
9. Set up and measure the straightness of a feature.

H.7 Perform measurement by comparison

1. Use an optical comparator.
2. Create charts from CAD systems to use as overlays.
3. Determine the scaling principle used in optical comparison.
4. Calibrate an optical comparator.

H.8 Perform circularity, cylindricity, profile of a line, and runout measurements.

1. Set up and measure the circularity of round features.
2. Set up and measure the cylindricity of a feature.
3. Set up and measure the profile of line.
4. Set up and measure runout and total runout of round features.
5. Set up and measure two features for co-planarity, concentricity, or coaxiality.

H.9 Apply advanced metrology methods.

1. Evaluate the appropriateness and applications of laser measurement.
2. Set up and use an interferometer-based laser measurement device.
3. Evaluate compliance with ISO9000 metrology requirements
4. Apply statistical process control (SPC) in metrology

I. Apply Next Generation Manufacturing Principles & Methods

I.1 Demonstrate knowledge of basic material properties

1. Describe how metals are classified and characterized:
 - a. Low, medium and high carbon steel
 - b. Alloy steels
 - c. Tool steels
 - d. Stainless steels
 - e. Structural steels
 - f. Cast irons
 - g. Aluminum
 - h. Composites
2. Describe the physical properties of metals including brittleness, ductility, elasticity, hardness, malleability, tensile strength and toughness
3. Discuss electrical properties of materials including resistivity and conductivity
4. Discuss the thermal properties of materials including heat capacity, thermal conductivity, thermal diffusivity, and thermal expansion

I.2 Demonstrate knowledge of traditional and non-traditional machine operations and manufacturing processes.

1. Describe traditional drilling, cutting, welding, and milling processes
2. Determine correct rotational speeds for engine lathe, drill press and milling machine operations
3. Perform and/or describe drilling operations and the use of boring tools and reamers
4. Perform and/or describe milling operations including indexing, calculation of cutter RPM and table feed
5. Perform and/or describe grinding operations including selection of abrasives, grinding wheels and grinding machines
6. Describe metal working processes including rolling, drawing, forging, and extrusion
7. Describe metal shearing, bending and forming

8. Describe fastening processes including fasteners, welding and bonding
 9. List and describe hot & cold working processes
 10. Describe service processes including strength and hardness
 11. Discuss corrosion resistance methods
 12. Describe the heat treating process
 13. Perform Rockwell hardness testing
- I3. Perform production planning & control
1. Identify appropriate production methods and planning methodology
 2. Create Gantt charts, network diagrams, and product structure trees to plan production
 3. Evaluate demand forecasts and forecast accuracy
 4. Develop short, medium and long-term capacity plans
 5. Develop master production schedules
 6. Project material needs and inventory requirements
 7. Use shop floor controls: Precontrols, concurrent controls, and post controls
 9. Perform Materials Requirements Planning (MRP I), Manufacturing Resource Planning (MRP II), and Customer Relations Management (CRM) systems
 8. Apply Kanban system for production control
- I4. Demonstrate knowledge of value stream mapping and process mapping
1. Define a value stream
 2. Describe when and where to use value stream mapping
 3. Describe the twelve steps to value stream mapping
 4. Describe the process of achieving "future state"
 5. Describe how to use value stream mapping to develop a lean strategy.
 6. Identify different types of waste
 7. Provide levels of detail (i.e., Macro, Micro & Sub-Micro)
 8. Describe setups and batches
 9. Describe how to streamline a process and build "future state" maps
- I5. Demonstrate knowledge of Six-Sigma
1. Describe the 5-phase DMAIC continuous improvement model.
 2. Describe the characteristics of an effective team
 3. Develop and analyze process maps.
 4. Interpret customer requirements.
 5. Develop data collection and measurement plans.
 6. Perform process stratification and data analysis
 7. Determine root causes of defects
 8. Implement quality comparative methods
 9. Conduct sources of variation (SOV) studies
 10. Perform statistical analysis by using the MINITAB™ software
 11. Determine if a process is stable & capable
- I6. Demonstrate knowledge of lean manufacturing principles
1. Describe the principles of lean manufacturing.
 2. Identify and define waste.
 3. Describe the attitudes and metrics of lean organizations.
 4. Describe lean as a total system.

5. Explain the role of “cleaning” in maintaining quality and throughput.
6. Describe how a value stream is mapped across a system.
7. Identify and eliminate obstacles to becoming a lean organization.