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ABSTRACT

This document is intended to help education and training institutions deliver the Machine Tool Advanced Skills Technology (MAST) curriculum to a variety of individuals and organizations. MAST consists of industry-specific skill standards and model curricula for 15 occupational specialty areas within the U.S. machine tool and metals-related industries. This volume provides the MAST standards and curriculum for the laser machining specialty area. It is organized in the following sections: (1) a profile of Springfield Technical Community College (Massachusetts), the development center that produced these standards and curriculum; (2) a laser machinist technician competency profile of job duties and tasks; (3) a technician duty, task, and subtask outline; (4) a course curriculum outline and course descriptions; (5) a technical workplace competencies and course crosswalk; and (6) a Secretary's Commission on Achieving Necessary Skills (SCANS) proficiencies course crosswalk. Individual syllabi for the following courses are provided: Industrial Mathematics; Fundamentals of Industrial Electronics and Controls; Computer-Aided Design; Computer Numerical Control; Modern Optics; Laser Safety; Industrial Laser Systems; Computer-Aided Manufacturing; Metrology; and Laser Materials Processing. Components of each syllabus are as follows: lecture, lab, and credit hours; course description; prerequisites; course objectives; required course materials; method of instruction; course objectives: technical competencies; and course objectives: SCANS competencies. Appendixes contain the individual competency profiles for each company surveyed by the MAST development center and narrative of the pilot program for this occupational specialty. (YLB)

Machine Tool Advanced Skills Technology

COMMON GROUND: TOWARD A STANDARDS-BASED TRAINING SYSTEM FOR THE U.S. MACHINE TOOL AND METAL RELATED INDUSTRIES

VOLUME 13

LASER MACHINING

of
a 15 volume set of Skills Standards
and
Curriculum Training Materials for the
PRECISION MANUFACTURING INDUSTRY

*Supported by
the Office of Vocational & Adult Education
U.S. Department of Education*

AUGUSTA TECHNICAL INSTITUTE

CACT CENTER FOR APPLIED COMPETITIVE TECHNOLOGIES

San Diego City College

ITAWAMBA COMMUNITY COLLEGE 1948

Moraine Valley Community College

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

Texas State Technical College Waco

*M*achine Tool *A*dvanced *S*kills *T*echnology Program

MAST

VOLUME 13

-- LASER MACHINING --

Supported by
The Office of Vocational and Adult Education
U.S. Department of Education

September, 1996

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- U.S. Department of Education, Office of Vocational & Adult Education
- MAST Consortia of Employers and Educators

MAST DEVELOPMENT CENTERS
Augusta Technical Institute - Itawamba Community College - Moraine Valley Community College - San Diego City College (CACT) - Springfield Technical Community College - Texas State Technical College

INDUSTRIES
AB Lasers - AIRCAP/MTD - ALCOA - American Saw - AMOCO Performance Products - Automatic Switch Company - Bell Helicopter - Bowen Tool - Brunner - Chrysler Corp. - Chrysler Technologies - Conveyor Plus - Darr Caterpillar - Davis Technologies - Delta International - Devon - D. J. Plastics - Eaton Leonard - EBTEC - Electro-Motive - Emergency One - Eureka - Foster Mold - GeoDiamond/Smith International - Greenfield Industries - Hunter Douglas - Industrial Laser - ITT Engineered Valve - Kaiser Aluminum - Krueger International. - Laser Fare - Laser Services - Lockheed Martin - McDonnell Douglas - Mercury Tool - NASSCO - NutraSweet - Rapistan DEMAG - Reed Tool - ROHR, International - Searle - Solar Turbine - Southwest Fabricators - Smith & Wesson - Standard Refrigeration - Super Sagless - Taylor Guitars - Tecumseh - Teledyne Ryan - Thermal Ceramics - Thomas Lighting - FMC, United Defense - United Technologies Hamilton Standard

COLLEGE AFFILIATES
Aiken Technical College - Bevil Center for Advanced Manufacturing Technology - Central Florida Community College - Chicago Manufacturing Technology Extension Center - Great Lakes Manufacturing Technology Center - Indiana Vocational Technical College - Milwaukee Area Technical College - Okaloosa-Walton Community College - Piedmont Technical College - Pueblo Community College - Salt Lake Community College - Spokane Community College - Texas State Technical Colleges at Harlington, Marshall, Sweetwater

FEDERAL LABS
Jet Propulsion Lab - Lawrence Livermore National Laboratory - L.B.J. Space Center (NASA) - Los Alamos Laboratory - Oak Ridge National Laboratory - Sandia National Laboratory - Several National Institute of Standards and Technology Centers (NIST) - Tank Automotive Research and Development Center (TARDEC) - Wright Laboratories

SECONDARY SCHOOLS
Aiken Career Center - Chicopee Comprehensive High School - Community High School (Moraine, IL) - Connally ISD - Consolidated High School - Evans High - Greenwood Vocational School - Hoover Sr. High - Killeen ISD - LaVega ISD - Lincoln Sr. High - Marlin ISD - Midway ISD - Moraine Area Career Center - Morse Sr. High - Point Lamar Sr. High - Pontotoc Ridge Area Vocational Center - Putnam Vocational High School - San Diego Sr. High - Tupelo-Lee Vocational Center - Waco ISD - Westfield Vocational High School

ASSOCIATIONS

American Vocational Association (AVA) - Center for Occupational Research and Development (CORD) - CIM in Higher Education (CIMHE) - Heart of Texas Tech-Prep - Midwest (Michigan) Manufacturing Technology Center (MMTC) - National Coalition For Advanced Manufacturing (NACFAM) - National Coalition of Advanced Technology Centers (NCATC) - National Skills Standards Pilot Programs - National Tooling and Machining Association (NTMA) - New York Manufacturing Extension Partnership (NYMEP) - Precision Metalforming Association (PMA) - Society of Manufacturing Engineers (SME) - Southeast Manufacturing Technology Center (SMTC)

MAST PROJECT EVALUATORS

Dr. James Hales, East Tennessee State University and William Ruxton, National Tooling and Machine Association (NTMA)

SPECIAL RECOGNITION

Dr. Hugh Rogers recognized the need for this project, developed the baseline concepts and methodology, and pulled together industrial and academic partners from across the nation into a solid consortium. Special thanks and singular congratulations go to Dr. Rogers for his extraordinary efforts in this endeavor.

This report is primarily based upon information provided by the above companies, schools and labs. We sincerely thank key personnel within these organizations for their commitment and dedication to this project. Including the national survey, more than 3,000 other companies and organizations participated in this project. We commend their efforts in our combined attempt to reach some common ground in precision manufacturing skills standards and curriculum development.

This material may be found on the Internet at **http://machinetool.tstc.edu**

CATALOG OF 15 VOLUMES

VOLUME 13
LASER MACHINING

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FOREWORD

Advanced technology has changed forever the nature of employment in modern manufacturing. Traditional assembly operations are being supplanted by automation or made redundant through streamlining of the manufacturing process. In most industries, fewer low-skilled workers are needed to meet the same or higher production goals, leaving a surplus of workers to fill a smaller number of openings. At the same time, as new employment opportunities in advanced manufacturing begin to appear, finding qualified applicants to fill the positions is often difficult. Traditional candidates coming from crafts-based occupations often lack the education and knowledge of computers to operate modern manufacturing technology and processes.

Recognizing the need to increase the supply of new skilled workers for the metal and metals-related industries, the U.S. Department of Education launched the Cooperative Demonstration Program (Manufacturing Technologies) as part of the National Skills Standards Act of 1994. The goal of the Department initiative was to foster the development and implementation of national skill standards and a training model for certificate and Associate of Science degree programs. In July 1994, a multi-state consortium of community colleges led by Texas State Technical College received a grant awarded by the Department under the initiative. The Machine Tool Advanced Skills Technology (MAST) consortium, which includes six of the nation's leading Advanced Technology Centers (ATCs), was formed to develop, test and disseminate industry-specific skill standards and model curricula for the U.S. machine tool industry over a two year period. As part of the MAST consortium, Springfield Technical Community College in Massachusetts was tasked with developing and piloting skill standards and model curricula in the technical area of <u>Laser Machinist</u>.

Laser machining is a prime example of the trend described above. Two decades ago the cutting and machining of metal was primarily carried out by conventional grinding, milling, turning, and related methods. The introduction of laser technology to machine tooling in the 1960's was driven by the need to increase precision and productivity in sophisticated applications and advanced materials that demanded great accuracy and minimal waste; the inevitable result has been to render conventional machining processes obsolete in certain sectors, and to require major changes in the skills of the machinist. Experts in machining with conventional methods, these workers must learn an entirely new set of skills and knowledge to machine by laser.

The present report presents the products and results of the Springfield project in developing the skill standards and curriculum to guide the education of the modern Laser Machinist. The skill standards and curriculum are the result of numerous interviews with practitioners from industry (see Appendix A) and discussions with educators, managers, supervisors, and others involved with machine-related occupations in general, and sheet metal and composites in particular. Based on discussion with the other MAST consortium partners, the project presents the following definition of the new occupation:

__LASER MACHINIST__: *The laser machinist will have a working knowledge of the principles of electronics, lasers, optics, materials, engineering documentation, CAD/CAM, and systems integration, in order to manufacture products to acceptable engineering standards.*

Topics related to the occupational demands of the laser machinist include computer numerical control, metrology, laser technology and applications, optical systems, and industrial electronics and controls. The ideal candidate for laser machining will have a solid foundation in either mechanical engineering technology, laser electro-optics technology, or a related field. This foundation may be obtained through either a two year associate degree or equivalent industry experience.

The Laser Machinist course of study developed and offered by Springfield Technical Community College is structured as a one-year, 29 credit certificate program. The present volume provides the occupational skill standards, project documentation, and course syllabi for a program of study recommended as minimum preparation for an individual desiring to enter manufacturing as laser machinist.

PARTNER OCCUPATIONAL SPECIALITY ASSIGNMENTS

Although each of the six partner college development centers possessed detailed expertise in each of the MAST 15 occupational specialities, a division of work was still very necessary to ensure completion of the project due to the enormity associated with industrial assessment and complete curriculum revision for each of the areas of investigation.

Each Collegiate Partner was responsible for development of a specialization component of the overall model. Information for the future direction of this specialization area was obtained from NIST Manufacturing Centers and/or national consortia, professional societies, and industrial support groups addressing national manufacturing needs. Each Collegiate Partner tested its specialization model utilizing local campus resources and local industry. Information gained from the local experience was utilized to make model corrections. After testing and modification, components were consolidated into a national model. These events occurred during the first year of the Program. During the second year of the Program, the national model was piloted at each of the Collegiate Partner institutions. Experience gained from the individual pilot programs was consolidated into the final national model.

What follows is a profile of the MAST development center which had primary responsibility for the compilation and preparation of the materials for this occupational specialty area. This college also had the responsibility for conducting the pilot program which was used as one of the means of validation for this program.

MAST DEVELOPMENT CENTER, SPRINGFIELD, MA
Center for Business and Technology
Springfield Technical Community College

Dr. Andrew M. Scibelli, President
Springfield Technical Community College

Dr. Thomas E. Holland, Vice President
Center for Business and Technology

One Armory Square
Springfield, MA 01105
College phone: 413/781-7822, fax: 413/781-5805
Center phone: 413/781-1314, fax:413/739-5066
e-mail: tholland@stccadmin.stcc.mass.edu

Manufacturing in New England

According to a 1994 survey from the U.S. Bureau of Labor Statistics, approximately 17% of the employment in New England is manufacturing-related, 32% is service industry, 22% is trade industry, and 29% are other industries. Recent studies show that there are four major areas of emerging growth in technical employment: (1) telecommuncations, (2) biotechnology, (3) environmental technology, and (4) advanced manufacturing technology. Telecommunications, environmental technology and biotechnology are among the top four new growth industries of the region, now constituting a total of more than 205,000 new jobs (NEBHE, 1994). While manufacturing -- long a primary sector of the New England economy -- has declined in the post-cold war era, it still comprises roughly 20% of the employment base of the six-state region. The nature of manufacturing in New England, however, is changing in terms of the technologies of design and production, the materials used, and the products developed. The application of *photonics*, which includes laser machining, is a key emerging technology inherent in all four of the above industries.

Springfield Technical Community College and the Center for Business and Technology

Springfield Technical Community College (STCC) is a public post-secondary institution located within an hour's drive to over 750 metal-machining, optics and photonics manufacturing firms in Massachusetts and Connecticut. The only technical college among the fifteen community colleges in the Commonwealth of Massachusetts, the College is situated between two large urban, disadvantaged communities and serves a highly diverse student body: over 26% of its students are minority, 52% are female, and the average age of all STCC students is twenty-seven. STCC's Advanced Technology Center (ATC) has close to $8 million in technical facilities and equipment in the areas of laser-electro optics, electronics, mechanical technologies (CAD, CNC, CAM), computer-integrated manufacturing (CIM), environmental technology, and the most current computer hardware and software to support manufacturing-related training. STCC also employs a cadre of faculty experts in these technologies who enable the ATC to conduct industry assessments, technical consulting, and industry-specific contract training for the more than 300 small- and medium-sized companies throughout western Massachusetts and Connecticut. The majority of client companies are primary suppliers to the hundreds of defense contractors in New England, including such major firms as United Technologies, Pratt & Whitney, General Electric, Raytheon, and Lockheed-Martin.

Development Team

- **Project Director:** Thomas E. Holland, Ph.D., Vice President of the STCC Center for Business and Technology, served as overall director for the MAST project.
- **Co-Project Directors**: Gary J. Masciadrelli, MSME, Department Chairman of the STCC Mechanical Engineering Technology Department, and Nicholas M. Massa, MSEE, Program Coordinator for the Laser Electro-Optics Technology program, shared programmatic responsibility for conducting industry assessment, designing curricula, administering the pilot program, and developing skill standards and course/program materials for the Laser Machining component of the MAST project.

THE MAST COMPETENCY PROFILE

Development of Competency Profiles at each of the MAST sites began with visits to representative companies for the purpose of surveying expert workers within the industry and occupational areas under investigation. Each site began the survey process by asking a subject matter expert in the targeted technical area, generally a member of their faculty, to employ a modified version of the generally-accepted DACUM (Developing A Curriculum) method to categorize the major skills needed to work in the selected occupation. As source materials, the college instructors drew on their professional knowledge and experience of current and future industry requirements. The initial skill standards developed by the subject matter experts underwent numerous internal reviews and revisions within each site, assuming final form as a series of structured survey and interview statements designed to elicit a simple yes or no response.

To determine an appropriate survey sample, each site compiled a database of their region's small and medium-sized manufacturers and searched for companies likely to employ workers in the targeted occupational area. The resulting cross-industry samples were sorted further to achieve a balance of technological capability and workforce size; the sample companies within each region were then asked to participate in the project. Willing respondents were scheduled for interviews.

During the company interviews, MAST staff asked expert workers to identify the primary duties and tasks performed by a typical worker and to consider the special skills and knowledge, traits and attitudes, and industry trends that will have an impact on worker training, employability, and performance both now and in the future. The interview results were analyzed to create individual profiles identifying the most common duties and skills required of workers at each company. Copies of individual company competency profiles are provided in Appendix A of this volume. These individual company Competency Profiles served two purposes. First, they showed, in a format that could be easily understood by both industry and educators, a picture of the occupational specialty at a given company at that particular time. Second, these individual company Competency Profiles furnished the company with a document for which they could claim ownership. This, in effect, made them "real" partners in the work of MAST.

Data for all companies were then aggregated to develop a composite Competency Profile of industry skill standards within the selected occupational specialty area of, as shown in the following pages.

These same duties and tasks were then included in both the Texas and National Surveys for further validation (see Volume 1). As a result of the surveys, additional refinements were made to the Competency Profiles. These changes were then incorporated into the individual course syllabi which were used for the pilot program.

The MAST Competency Profile for this occupational specialty area has been included on the following pages.

SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job
Basic Machining Course Prerequisites or CNC Machinist Course Ware

TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Customer Relations
Personal Ethics

TOOLS AND EQUIPMENT

FUTURE TRENDS AND CONCERNS

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
MAST PROGRAM REPRESENTATIVES

DR. THOMAS E. HOLLAND
Director, Center for Business & Technology

GARY J. MASCIADRELLI
Department Chairman
Mechanical Engineering Technology

NICK M. MASSA
Director of Technology Development

ROSE MARY TIMMONS
Senior Secretary/Statistician (TSTC)

Furnished By:

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

COMPETENCY PROFILE

Laser Machinist

Prepared By
M.A.S.T.
Machine Tool Advanced Skills
Technology Program
and
Consortium Partners
(V.199J40008)

Machine Tool Advanced Skills Technology Program

MAST

LASER Machinist ... apply the principles of electronics, lasers, optics, materials, engineering documentation, CAD/CAM, and systems integration to manufacture products to referenced engineering standards.

Duties		Tasks												
A	Apply Mathematical Concepts	A-1 Perform basic math functions	A-2 Perform algebraic functions	A-3 Study exponents and right triangle geometry	A-4 Study elements of plane and solid geometry	A-5 Perform data evaluation and statistical analysis	A-6 Perform proportioning and interpolation	A-7 Perform basic trigonometric functions	A-8 Investigate vectors and vector systems	A-9 Investigate the Cartesian coordinate system				
B	Investigate Fundamentals of Industrial Electronics & Control	B-1 Perform voltage, current, resistance and power measements	B-2 Investigate fundamentals of analog active devices	B-3 Investigate fundamentals of digital logic circuitry	B-4 Investigate operational amplifiers for industrial applications	B-5 Investigate linear IC's for industrial applications	B-6 Investigate electric motors	B-7 Study industrial control systems						
C	Apply Concepts of Modern Optics	C-1 Study reflection at plane and spherical surfaces	C-2 Study refraction at plane surfaces	C-3 Study refraction at spherical surfaces	C-4 Perform imaging with a single lens	C-5 Perform imaging with multiple thin lenses	C-6 Study F-stops and apertures	C-7 Study optical systems	C-8 Study interference	C-9 Study diffraction	C-10 Study polarization	C-11 Investigate radiometry and photometry		
D	Perform CNC Programming	D-1 Apply machine specific (milling and lasers) nomenclature and terminology	D-2 Investigate the Cartesian coordinate system as applied to milling and laser machines	D-3 Apply CNC programming language	D-4 Perform start up, tool changing, and ending of programs	D-5 Perform positioning and basic drilling	D-6 Create a sub-program	D-7 Perform contouring	D-8 Apply tool radius compensation (cutter comp)	D-9 Perform programming preparation	D-10 Apply special laser coding parameters			
E	Investigate Industrial Laser Systems	E-1 Study characteristics of light	E-2 Understand basic laser principles	E-3 Study laser output characteristics	E-4 Investigate output modification	E-5 Apply safety and laboratory procedures	E-6 Perform a laser exposition	E-7 Perform laser alignment, gauging, and inspection	E-8 Investigate holography and applications: non-destructive testing	E-9 Investigate the interaction of high power laser beam with materials	E-10 Perform laser welding and surface treatment	E-11 Perform laser material removal		
F	Perform Computer Aided Drafting (CAD)	F-1 Understand PC basics	F-2 Discuss CAD basics and file management	F-3 Use drawing settings	F-4 Perform basic editing commands	F-5 Create drawings with accuracy	F-6 Organize drawing information	F-7 Control the display of drawings	F-8 Use intermediate drawing commands	F-9 Perform intermediate editing commands	F-10 Create multiview drawings	F-11 Create sectioned drawings	F-12 Investigate basic dimensioning	F-13 Perform advanced dimensioning
		F-14 Use and manipulate blocks	F-15 Use blocks to automate the drawing process											
G	Perform Laser Materials Processing	G-1 Discuss traditional mechanical machining	G-2 Discuss non-traditional methods of machining	G-3 Understand basics of laser heating	G-4 Investigate the effects of laser irradiation on materials	G-5 Demonstrate machine operations	G-6 Study hazards and safety							
H	Perform Computer Aided Manufacturing (CAM)	H-1 Understand the basics of a PC based CAM system	H-2 Discuss basic CAM operations	H-3 Set up cutting tools	H-4 Create part profiles	H-5 Edit part profiles	H-6 Perform advanced editing of part profiles	H-7 Edit tool paths	H-8 Perform drilling and counterboring	H-9 Use construction layers in SmartCAM	H-10 Perform user commands and machine events	H-11 Create families of parts	H-12 Perform CAD/CAM integration	H-13 Perform code generation
I	Practice Laser Safety	I-1 Discuss laser safety basics	I-2 Discuss laser hazards	I-3 Study laser safety standards and hazard classifications (i.e., ANSI Z136.1 standards)	I-4 Investigate controls for surveying, alignment and leveling lasers	I-5 Discuss eye protection								

STCCLAS PM5
MAST/06/022196

Duties		Tasks												
J	Perform Measurement & Inspection	J-1 Study basics of metrology	J-2 Select instruments used for measurement	J-3 Interpret limits and tolerances	J-4 Select gaging tools	J-5 Use CMM for location of features	J-6 Perform surface metrol-ogy	J-7 Perform measurement by comparison	J-8 Perform circularity, cylindricity, profile of a line, and runout measurements	J-9 Investigate advanced metrology topics				

THE MAST TECHNICAL WORKPLACE COMPETENCY OUTLINE

The Competency Profiles derived from the industry survey process were returned to industry and faculty members at each MAST partner college for review. Reviewers were asked to identify specific sub-tasks within each block of Duties and Tasks in the Profile; MAST staff at each college broke the sub-tasks down further into the detailed steps required to actually perform the duties and tasks of the manufacturing process. It is these detailed skill standards that were then incorporated into development of the curriculum and piloted as a training program by each of the MAST colleges. All results for the specific occupational specialty area have been organized as an outline of the duties, tasks, and sub-tasks required to demonstrate technical competency in the workplace, as shown in the following pages.

As a result of the Texas and the National Surveys, additional refinements were made to the Competency Outlines. These changes were then incorporated into the individual course syllabi.

The MAST Technical Workplace Competency Outline for this occupational specialty area has been included on the following pages.

LASER MACHINIST
TECHNICAL WORK PLACE COMPETENCIES

LASER MACHINIST...*The laser machinist will have a working knowledge of the principles of electronics, lasers, optics, materials, engineering documentation, CAD/CAM, systems integration all for the goal of producing products to acceptable engineering standards.*

A. APPLY MATHEMATICAL CONCEPTS

1. Perform Basic Math Functions
   a. Use and manipulate fractions
   b. Use and manipulate decimals
   c. Calculate percentages
   d. Calculate units of length, area, and volume
   e. Convert between SI (metric) and English (inch) units
   f. Use a scientific calculator
2. Perform Algebraic Functions
   a. Identify equations with one unknown
   b. Solve algebraic equations by isolation of the unknown
   c. Identify equations with fractions
   d. Solve equations by cross multiplying
   e. Identify and solve linear equations
   f. Calculate the slope of a line
3. Study Exponents and Right Triangle Geometry
   a. Apply the laws of exponents
   b. Calculate exponentials and roots
   c. Analyze right triangles
   d. Use Pythagorean Theorem
4. Study Elements of Plane and Solid Geometry
   a. Calculate the area and circumference of a circle
   b. Determine angular measurements (degrees and radians)
   c. Establish a tangent to a circle
   d. Analyze parallel lines, transverse lines, and angles
   e. Perform the bisection of an angle
   f. Calculate the sum of the interior angles of a polygon
   g. Calculate the area of a triangle and irregular shapes
   h. Analyze trapezoids
5. Perform Data Evaluation and Statistical Analysis
   a. Analyze and plot data
   b. Create graphs (line, bar, and pie)
   c. Calculate mean, normal, and standard deviation
6. Perform Proportioning and Interpolation
   a. Calculate ratios and proportions
   b. Calculate direct, inverse, and combined variations
   c. Calculate constants of proportionality
   d. Perform tabular interpolation
7. Perform Basic Trigonometric Functions

a. Calculate the trigonometric functions of sine, cosine, and tangent
b. Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
c. Solve a right triangle

8. Investigate Vectors and Vector Systems
   a. Analyze components of vectors
   b. Perform vector addition
   c. Perform vector combination
9. Investigate the Cartesian Coordinate System
   a. Study the X-Y coordinate system
   b. Study the X-Y-Z coordinate system
   c. Calculate the slope of a line in the Cartesian coordinate system

B. INVESTIGATE FUNDAMENTALS OF INDUSTRIAL ELECTRONICS & CONTROL

1. Perform Voltage, Current, Resistance and Power Measurements
   a. Study Ohm's law and power and energy
   b. Analyze series, parallel and series-parallel circuits
   c. Study alternating current and voltage
   d. Study capacitors, inductors and transformers
   e. Analyze RC, RL and RLC circuits
2. Investigate Fundamentals of Analog Active Devices
   a. Study semiconductor theory
   b. Analyze diodes and applications
   c. Analyze transistor circuits
   d. Analyze power supply circuits
3. Investigate Fundamentals of Digital Logic Circuitry
   a. Study number systems and codes
   b. Analyze logic gates, boolean algebra and combinational logic circuits
   c. Analyze flip-flops, arithmetic operations and circuits
   d. Analyze counters, registers and memory
   e. Study IC's and MSI logic circuits
   f. Perform interfacing with A/D and D/A circuits
   g. Study microprocessors, micro controllers and microcomputers
4. Investigate Operational Amplifiers for Industrial Applications
   a. Study comparator applications
   b. Study summing amplifier applications
   c. Study integrator and differentiator applications
   d. Study current to voltage converter applications
   e. Study voltage to current converter applications
   f. Study constant current source applications
5. Investigate Linear IC's for Industrial Applications
   a. Study voltage regulation
   b. Study basic series regulators
   c. Study basic switching regulators
   d. Study instrumentation amplifiers

e. Study isolation amplifiers
f. Study oscillators
g. Study 555 timers
h. Study angle measurement circuits
i. Study temperature measurement circuits
j. Study strain and pressure measuring circuits

6. Investigate Electric Motors
   a. Study wound-field DC motors and generators
   b. Study brushless and stepper DC motors
   c. Study AC motors
7. Study Industrial Control Systems
   a. Analyze motor control circuits
   b. Analyze RMS to DC converters
   c. Discuss industrial telemetry and data communications
   d. Discuss modulation techniques
   e. Use programmable controllers
   f. Perform sequential process control
   g. Perform statistical process control

C. APPLY CONCEPTS OF MODERN OPTICS

1. Study Reflection at Plane and Spherical Surfaces
   a. Demonstrate the law of reflection
   b. Demonstrate ray tracing at a plane reflecting surface
   c. Demonstrate ray tracing at a spherical reflecting survace
2. Study Refraction at Plane Surfaces
   a. Demonstrate refraction of light at a dielectric interface
3. Study Refraction at Spherical Surfaces
   a. Demonstrate refraction at plane surfaces
   b. Demonstrate refraction at spherical surfaces
4. Perform Imaging with a Single Lens
   a. Determine focal points and focal lengths in positive thin lenses
   b. Demonstrate image formation in positive thin lenses
   c. Determine focal points and focal lengths in negative thin lenses
   d. Demonstrate image formation in negative thin lenses
5. Perform Imaging with Multiple Thin Lenses
   a. Set up and demonstrate two converging lenses
   b. Set up and demonstrate a converging and diverging lens
6. Study F-Stops and Apertures
   a. Define field stops and aperture stops
   b. Define entrance and exit pupils
7. Study Optical Systems
   a. Set up and demonstrate astronomical (Keplarian) telescopes
   b. Set up and demonstrate Galilean telescopes
   c. Set up and demonstrate beam-expanding collimators
8. Study Interference
   a. Set up and demonstrate Young's double slit interference

b. Demonstrate thin film interference
c. Determine surface flatness by interference

9. Study Diffraction
   a. Demonstrate Fraunhofer (far field) diffraction
   b. Demonstrate Fresnel (near field) diffraction
   c. Determine the limit of resolution of an optical instrument
   d. Measure beam divergence and spot size
   e. Use diffraction gratings
   f. Discuss light scattering
10. Study Polarization
   a. Determine unknown polarization of light
   b. Generate linearly polarized light
   c. Study the effect of birefringent material on polarized light
   d. Generate circularly polarized light
11. Investigate Radiometry and Photometry
   a. Perform optical power measurements
   b. Perform irradiance measurements
   c. Use photoelectric power meters
   d. Perform ambient light suppression
   e. Use attenuators
   f. Perform wavelength calibration
   g. Use radiometric filters
   h. Use photometric filters
   i. Use disc calorimeters

D. PERFORM CNC PROGRAMMING

1. Apply Machine Specific (Milling and Lasers) Nomenclature and Terminology
   a. Study machine specifications
   b. Start up the machine
   c. Study the machine's keyboard and function keys
   d. Establish radius offsets
   e. Study programming basics at the MCU (machine control unit)
   f. Prove out a program
   g. Load and run a part program
2. Investigate the Cartesian Coordinate System as Applied to Milling and Laser Machines
   a. Study the Cartesian coordinate system
   b. Study the basics of a coordinate measurement system
   c. Plot points in an XYZ coordinate system
   d. Set (G90) and program in absolute coordinates
   e. Set (G91) and program in incremental coordinates
3. Apply CNC Programming Language
   a. Study word-address and variable block formats
   b. Study standard programming formats such as FANUC
   c. Study the concept of model addresses
4. Perform Start Up, Tool Changing, and Ending of Programs

a. Zero the machine to the part
b. Close the shutter, Z axis retract, and gas off (lasers)(M61)

5. Perform Positioning and Basic Drilling
   a. Start and stop the spindle (M03 and M05)
   b. Initiate the drilling cycle (G81)
   c. Program using the "R" level to avoid obstructions
   d. Cancel the drilling cycle (G80)
6. Create a Sub-Program
   a. Study the applications of sub-programming
   b. Study the CNC codes used in sub-programming (M98, P###, L##)
   c. Call a sub-program (M98)
   d. End a sub-program (M99)
7. Perform Contouring
   a. Initiate rapid traverse (G00)
   b. Perform linear cutting (G01)
8. Apply Tool Radius Compensation (Cutter Comp)
   a. Study the purpose and application of tool radius compensation
   b. Turn on cutter comp left (G41)
   c. Turn on cutter comp right (G41)
   d. Cancel cutter comp (G40)
9. Perform Programming Preparation
   a. Identify programming planning steps
   b. Set beam size and power (laser applications)
   c. Determine cutting depth or penetration
   d. Determine cutting speed and feed
   e. Determine and design jigs and fixtures for part holding
10. Apply Special Laser Coding Parameters
   a. Select assist gas-oxygen low (M63)
   b. Select assist gas-oxygen high (M64)
   c. Select assist gas-Nitrogen (M65)
   d. Select assist gas-Air (M67)
   e. Turn on and cancel selected assist gas (M68, M69, M70)
   f. Set continuous wave (M90), gated pulsing (M91), super pulsing (M92), and hyper pulsing (M93)

E. INVESTIGATE INDUSTRIAL LASER SYSTEMS

1. Study Characteristics of Light
   a. Study the general description of light waves
   b. Discuss monochromaticity
   c. Study directionality, coherence and polarization
2. Understand Basic Laser Principles
   a. Discuss optical radiation processes with emphasis on the amplification process
   b. Discuss optical feedback
   c. Discuss optical selection rules, transition lifetimes

d. Study Einstein relations, gain coefficients, three-and-four level pumping systems, and threshold and resonator stability

3. Study Laser Output Characteristics
   a. Discuss active mediums, population inversion and optical feedback
   b. Determine the temporal, spatial, and spectral characteristics of the device
   c. Study line broadening mechanisms, axial and transverse modes
   d. Study pump rate, gain saturation, and power output
4. Investigate Output Modification
   a. Study methods used to modify the spatial and spectral characteristics of a variety of laser systems
5. Apply Safety and Laboratory Procedures
   a. Study proper laboratory practice
   b. Demonstrate safety practices
   c. Keep proper lab records
6. Perform a Laser Exposition
   a. Discuss characteristics and components of commercial lasers
   b. Study Ruby, ND: YAG and other solid state lasers
   c. Study gas, dye, and semiconductor lasers
7. Perform Laser Alignment, Gauging, and Inspection
   a. Study laser scanning techniques
   b. Perform optical alignment and optical triangulation
   c. Discuss the principles of optical detection
   d. Study Charge-Coupled Devices (CCD)
8. Investigate Holography and Applications: Non-Destructive Testing
   a. Study coherent light wave interference
   b. Discuss the principles of Holographic Non-Destructive Testing (HNDT)
9. Investigate the Interaction of High Power Laser Beam with Materials
   a. Study laser-optics and beam characteristics
   b. Discuss Transverse Electromagnetic Modes (TEM)
   c. Calculate spot size and power density
   d. Measure reflectivity and absorption of laser energy
   e. Study thermal diffusivity and thermal time constants
10. Perform Laser Welding and Surface Treatment
   a. Study beam delivery optics
   b. Study the procedure of laser welding
   c. Perform pulsed and continuous-wave (CW) laser welding
11. Perform Laser Material Removal
   a. Study Laser-Supported Absorption (LSA)
   b. Perform laser drilling
   c. Perform laser cutting

F. PERFORM COMPUTER AIDED DRAFTING (CAD)

NOTE: () indicates an AutoCAD® command. AutoCAD® is being used as a typical CAD system

1. Understand PC Basics
   a. Discuss hardware and software basics

b. Study DOS and Windows operating systems
c. Discuss directory structure
d. Manipulate and manage files

2. Discuss CAD Basics and File Management
   a. Save files in CAD (SAVE, SAVE AS, AUTOSAVE)
   b. Study drawing editor, menu structure
   c. Perform basic DRAW commands (LINE, CIRCLE)
   d. Study how to enter new points (coordinate entry)
   e. Perform basic EDIT command (ERASE)
3. Use Drawing Settings
   a. Perform drawing sheet set-up (LIMITS, UNITS, GRID)
   b. Study methods for cursor movement control (ORTHO, SNAP, DDRMODES)
4. Perform Basic Editing Commands
   a. Perform modifications and changes to objects on screen (COPY, MOVE, FILLET, CHAMFER)
   b. Discuss how to group objects for editing (WINDOW, CROSSING, REMOVE, ADD, PREVIOUS)
5. Create Drawings with Accuracy
   a. Draw with object snap enabled (OSNAP, DDOSNAP)
   b. Determine the accuracy of the drawing (DIST, LIST, ID)
6. Organize Drawing Information
   a. Perform layer creation (LAYER, DDLMODES)
   b. Study and identify line styles
   c. Load and use line types (LINETYPE, LTSCALE)
   d. Change properties of objects (CHANGE, CHPROP, DDMODIFY)
7. Control the Display of Drawings
   a. Change magnification of objects (ZOOM WINDOW, PREVIOUS, ALL, EXTENTS, DYNAMIC)
   b. Move the display area (PAN)
   c. Plot drawings to a printer (PLOT)
   d. Plot drawings to a plotter (PLOT)
8. Use Intermediate Drawing Commands
   a. Make parallel copies of objects (OFFSET)
   b. Make multiple copies of objects (MULTIPLE COPY, RECTANGULAR AND POLAR ARRAY)
   c. Create arcs (ARC)
   d. Create text on the drawing (TEXT, DTEXT, STYLE)
   e. Create centermarks and center lines (DIM, CENTER)
   f. Draw an ellipse (ELLIPSE)
   g. Draw polygons (POLYGON)
9. Perform Intermediate Editing Commands
   a. Mirror objects (MIRROR)
   b. Rotate objects (ROTATE)
   c. Change the length of existing objects (STRETCH, EXTEND, TRIM)
   d. Edit text (DDEDIT)

e. Study the use of the non-verb format (GRIPS)

10. Create Multiview Drawings
    a. Study the concept of 3rd angle projection
    b. Create and place appropriate orthogonal views
    c. Draw construction lines from one view to create other views
    d. Use existing geometry to place other views (Point Filters)
11. Create Sectioned Drawings
    a. Create and place appropriate section views
    b. Create section lines on a drawing (HATCH, BHATCH, PLINE)
12. Investigate Basic Dimensioning
    a. Study methods for dimensioning objects (DIM)
    b. Apply methods for changing dimension settings (DIMVARS)
13. Perform Advanced Dimensioning
    a. Create and use dimension styles (DDIM)
    b. Apply geometric dimensioning from ANSI Y14.5
14. Use and Manipulate Blocks
    a. Create a block (BLOCK)
    b. Insert blocks into the drawing (INSERT, DDINSERT)
    c. Make a block available outside the current drawing (WBLOCK)
    d. Assign attributes to blocks (DDATTDEF)
    e. Edit attribute information (DDATTE)
15. Use Blocks to Automate the Drawing Process
    a. Use attributes to create a bill of materials and parts list
    b. Create a standard parts library

G. **PERFORM LASER MATERIALS PROCESSING**

1. Discuss Traditional Mechanical Machining
2. Discuss Non-Traditional Methods of Machining
    a. Investigate mechanical methods
        (1) Discuss abrasive flow machining
        (2) Discuss micro abrasive blasting
        (3) Discuss ultrasonic machining
    b. Investigate electrical methods
        (1) Discuss electrochemical machining
        (2) Discuss electrochemical grinding
    c. Investigate chemical methods
        (1) Discuss photochemical machining
        (2) Discuss photochemical polishing
    d. Investigate thermal methods
        (1) Discuss electron beam machining
        (2) Discuss electrodischarge machining
        (3) Discuss wire electrodischarge machining
        (4) Discuss laser beam machining
3. Understand Basics of Laser Heating
    a. Investigate properties of materials
        (1) Study optical properties including:

(a) Transmission
(b) Absorption
(c) Reflection
(d) Scattering

(2) Study mechanical properties including:
   (a) Hardness
   (b) Tribology
   (c) Strength
   (d) Heat treatments

(3) Study chemical properties including:
   (a) Composition
   (b) Decomposition
   (c) Corrodibility

(4) Study electrical properties including:
   (a) Metallic
   (b) Dielectric
      i. Ceramic
      ii. Polymer
      iii. Glass

(5) Study thermal properties including:
   (a) Heat capacity
   (b) Thermal conductivity
   (c) Thermal expansion

4. Investigate the Effects of Laser Irradiation on Materials including:
   a. Melting
   b. Vaporization
   c. Ablation
   d. Dehydration
   e. Removal method
   f. Mechanism of reaction
5. Study Lasers as Machine Tools including:
   a. C.W. vs. pulsed
   b. Energy balance
   c. Factors affecting removal rate
   d. Beam direction and deflection
   e. Tip design
   f. Focused vs. non-focused
   g. Wavelength/power of laser
6. Demonstrate Machine Operations including:
   a. Drilling
   b. Cutting
   c. Surface modification
   d. Embossing
   e. Marking
   f. Texturing
   g. Hardening

h. Annealing
i. Welding

7. Study Hazards and Safety including:
   a. Skin
   b. Eye
   c. Electrical shocks
   d. Fire threats
   e. Toxic fume production
   f. Unprotected wiring and tubing
   g. Water spills
   h. Warning signs
   i. Safety glasses
   j. Interlocks
   k. ANSI Z-136 and Maximum Permissible Exposure
   l. Saving sight by managing light

H. PERFORM COMPUTER AIDED MANUFACTURING (CAM)

NOTE: () or CAPS indicates a SmartCAM® command. SmartCAM® is being used as a typical CAM system

1. Understand the Basics of a PC Based CAM System
   a. Discuss CNC basics
   b. Study SmartCAM® screen layout
   c. Change the screen layout
   d. Determine how CNC and CAM relate
2. Discuss Basic CAM Operations
   a. Study job plan creation
   b. Study the file structure in CAM
   c. Discuss the difference between tools and layers
3. Set Up Cutting Tools
   a. Determine how to sequence elements
   b. Perform tool offset (OFFSET)
   c. Understand Z axis positions (Z_LEVEL & PROF_TOP)
   d. Understand how to allow clearance for cutting tools (CLEAR)
4. Create Part Profiles
   a. Discuss how to input lines, arcs, and circles
   b. Use trim profiles (GROUP_TRIM and PROFILE_TRIM)
   c. Clean up disconnected elements to an intersection (TRIM_EXTEND)
   d. Change the view of part profile (ZOOM, VIEW_ANGLE, etc.)
5. Edit Part Profiles
   a. Change tool properties (PROPERTY_CHG)
   b. Change geometry values (MODIFY)
   c. Arrange elements sequentially (CHAIN)
   d. Use WALL_OFFSET for roughing cuts
   e. Create blend radii
   f. Create chamfers
   g. Split elements in segments

h. Create symmetrical elements using mirror

6. Perform Advanced Editing of Part Profiles
   a. Move and copy elements
   b. rotate and rotate copy elements
   c. Create symmetrical elements using mirror
7. Edit Tool Paths
   a. Change tool path direction (REV_ORDER)
   b. Change the start of a profile (PROF_START)
   c. Change the order of machining events (SEQUENCE_MOVE)
   d. Arrange elements by tool (TOOL_SORT)
8. Perform Drilling and Counterboring
   a. Setup drills and counterboring tools
   b. Study the difference between full depth, tip depth, and spot diameter
9. Use Construction Layers in SmartCAM®
   a. Discuss the use of layers in profile construction
   b. Establish snap points using layers
   c. Trim profiles to "snapable" configurations
10. Perform User Commands and Machine Events
   a. Create multiple hole patterns using line at angle (LAA)
   b. Create multiple hole patterns using GRID
   c. Change the tool feed rate (FEED_CHG)
11. Create Families of Parts
   a. Discuss the importance of macros
   b. Create variables to represent part geometry
   c. Record a macro
   d. Edit and use a macro
12. Perform CAD/CAM Integration
   a. Create .DXF files in AutoCAD®
   b. Discuss the importance of layers in AutoCAD®
   c. Perform .DXF file translation in SmartCAM®
13. Perform Code Generation
   a. Study how a code generator works
   b. Study the machine file (.SMF)
   c. Study the template file (.TMP)
   d. Study how to modify code generators

I. PRACTICE LASER SAFETY

1. Discuss Laser Safety Basics
2. Discuss Laser Hazards including:
   a. Eye hazards
   b. Skin hazards
   c. Associated hazards from high power lasers
   d. Viewing laser radiation
   e. Laser hazard evaluation
   f. Control of associated hazards
   g. Typical laser calculations and measurements

3. Study Laser Safety Standards and Hazard Classifications (i.e., ANSI Z136.1 Standards)
4. Investigate Controls for Surveying, Alignment and Leveling Lasers
5. Discuss Eye Protection including:
   a. Selection of eye protection
   b. Limitations of eye protection
   c. Laser goggle testing

J. PERFORM MEASUREMENT AND INSPECTION

1. Study Basics of Metrology
   a. discuss the reasons for measurements
   b. Study the language of measurement
   c. Determine how to convert between SI and English systems
   d. Interpret dimensions
   e. Study the use of tolerances
   f. Study the requirements of ANSI Y14.5
   g. Study the three fundamental rules of ANSI Y14.5
   h. Interpret the definition of virtual condition
2. Select Instruments Used for Measurement
   a. Use vernier calipers
   b. use dial calipers
   c. Read scales
   d. Use micrometers
   e. Use hole and depth micrometers
   f. Set up and use dial indicators
3. Interpret Limits and Tolerances
   a. Study the use of datums
   b. Study the three plane system: Primary, Secondary, and Tertiary Datums
   c. Study the use of material condition symbols (MMC, LMC, RFS)
   d. Use target points to define datums
4. Select Gaging Tools
   a. Use gage blocks
   b. Use pin gages
   c. Use a height gage
   d. Use "go/no go" gages
   e. Design and build functional gages
5. Use CMM for Location of Features
   a. Access the importance of Coordinate Measurement Machines (CMM)
   b. Set up and use a CMM
   c. Calibrate a CMM
   d. Set up and measure hole locations with respect to applicable datums
   e. Set up and measure location for non-cylindrical features
   f. Set up and measure location for multiple pattern features
   g. Set up and measure for projected tolerance zone
6. Perform Surface Metrology
   a. Use surface plates

b. Use angle plates, mandrels, and vee blocks
c. Study how surface plates are used to establish datums
d. Set up and measure the flatness of a surface
e. Set up and measure the perpendicularity of two surfaces
f. Set up and measure the angularity of two surfaces
g. Set up and measure the parallelism of two surfaces
h. Set up and measure the profile of a surface
i. Set up and measure the straightness of a feature

7. Perform Measurement by Comparison
   a. Use an optical comparator
   b. Create charts from CAD systems to use on overlays
   c. Determine the scaling principle used in optical comparison
   d. Calibrate an optical comparator
8. Perform Circularity, Cylindricity, Profile of a Line, and Runout Measurements
   a. Set up and measure the circularity of round features
   b. Set up and measure the cylindricity of a feature
   c. Set up and measure the profile of line
   d. Set up and measure runout and total runout of round features
   e. Set up and measure two features for coplanarity, concentricity, or coaxiality
9. Investigate Advanced Metrology Topics
   a. Discuss the purpose and application of laser measurement
   b. Set up and use a laser measurement device
   c. Assess how ISO 9000 affects metrology
   d. Study the fundamentals of Statistical Process Control (SPC)

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THE MAST PILOT PROGRAM CURRICULUM AND COURSE DESCRIPTIONS

After completing the Competency Profile and Technical Workplace Competency Outline for each occupational specialty area, each MAST partner reviewed their existing curricula against the industry-verified skill standards in order to identify a suitable foundation for new pilot training programs. Because each college had to comply with the requirements of its respective college system and appropriate state agency, the resulting pilot curricula for occupational specialty areas tended to vary in format and academic requirements (e.g., some programs were based on the semester system, others on the quarter system). Despite differences in the curricula developed at the partner colleges, each of the pilot programs was designed to achieve the following two goals mandated in the MAST grant proposal:

- Pilot Program: "Conduct a one year pilot program with 25 or more selected applicants at each college or advanced technology center to evaluate laboratory content and effectiveness, as measured by demonstrated competencies and indicators of each program area."

- Student Assessment: "Identify global skills competencies of program applicants both at point of entrance and point of exit for entry level and already-employed technicians."

(Note: All occupational specialty areas were not pilot tested at all Development Centers; however, all partner colleges conducted one or more pilot programs.)

Included on the following pages is the curriculum listing for the pilot program which was used to validate course syllabi for this occupational specialty area. This curriculum listing included course names and numbers from the college which conducted the pilot program. The curriculum also shows the number of hours assigned to each of the courses (lecture, lab and credit hours). Also included is a description of each of the courses.

LASER MACHINING
ONE YEAR CERTIFICATE
CURRICULUM
1995-1996

		LEC	LAB	CR
FIRST SEMESTER				
VN 584	Industrial Mathematics	3	0	3
VN 585	Industrial Electronics & Controls	2	3	3
VN 591	Computer Aided Design (CAD)	2	3	3
VN 589	Computer Numerical Control (CNC)	2	3	3
VN 594	Modern Optics	2	3	3
	Semester Totals	11	12	15
SECOND SEMESTER				
VN 593	Laser Safety	1	0	1
VN 587	Industrial Laser Systems	3	3	4
VN 592	Computer Aided Manufacturing (CAM)	2	3	3
VN 586	Metrology	2	3	3
VN 588	Laser Materials Processing	2	3	3
	Semester Totals	10	12	14
	Certificate Totals	21	24	29

LASER MACHINING
CERTIFICATE PROGRAM
COURSE DESCRIPTIONS 1995-1996

VN 584 — **Industrial Mathematics** (3-0-3) Industrial Mathematics is a broad mathematics course that includes topics related to the machine tool industry. Areas of study include elements of Algebra I, Algebra II, plane and solid geometry, trigonometry, and statistics. Problems are related to industry wherever possible. Calculator use is required throughout.

VN 585 — **Fundamentals of Industrial Electronics and Controls** (2-3-3) This course is for students in the Laser Machining Technology program. It consists of a review of basic electronics theory and then a comprehensive coverage of the control of industrial machinery and processes through the use of electronic circuits and systems. After a review of DC and AC circuit theory, the fundamentals of active devices and digital logic theory, some of the topics covered include: linear integrated circuits, DC and AC motors, industrial control devices, transducers, industrial process control and programmable controllers.

VN 586 — **Metrology** (2-3-3) The intent of this course in metrology is to provide the class with an understanding of the importance of accurate measurement as it relates to the overall world of manufacturing. Within the fifteen week semester, we will discuss the history and language of measurement, various measurement instruments and gages are also discussed. Also covered will be calibration, optical comparators and coordinate measuring machines (CMM). The principles of Geometric Dimensioning and Tolerancing will be discussed throughout the semester to teach the interpretation of Engineering drawings per ANSI Y14.5-1994.

VN 587 — **Industrial Laser Systems** (3-3-4) This course will provide the student with a basic understanding of industrial lasers, applications, and systems. Course material will include the study of spontaneous and stimulated emission, laser output characteristics and modification, materials, laser safety, laser components, survey of laser types, and industrial laser applications. Among the laser systems to be studied will be gas lasers, semiconductor lasers, solid state lasers, ion lasers, molecular and dye lasers, excimer lasers, free electron lasers, and others. Among the many different uses of lasers to be studied will be laser welding and surface treatment, material removal, laser marking and etching, non-destructive testing, distance measurement, lasers in medicine and surgery, lasers in construction, spectroscopy, communications and others. Classroom lectures will be supplemented with experimental and video demonstrations. Lab included.

VN 588 — **Laser Materials Processing** (2-3-3) The Materials Processing section of the course first provides a basis for comparison between traditional methods and non-traditional methods of machining. By next studying the fundamentals of laser heating, the student is led into the world of laser-material (metals, plastics, ceramics, and composites) interactions, with all of the variables which affect this process. This provides a basis for lasers studied as machine tools and the attendant machine operations, including safety. Demonstration laboratories will be provided after each new concept discussed in class. Video demonstrations will be shown for more elaborate scenarios.

VN 589 <u>Computer Numerical Control (CNC)</u> (2-3-3) This course is an introduction to the fundamental concepts of Computer Numerical Control (CNC). The importance of numerical control to manufacturing and productivity is discussed with different types of CNC systems. Coverage includes writing programs to perform three-axis hole and a verity of milling operations using the various milling machines available in our labs. Students will also create programs for the various lathes in our labs. Turning and facing routines for the lathes as well as the math required to perform all the operations will be covered.

VN 591 <u>Computer Aided Design (CAD)</u> (2-3-3) The purpose of this course is to introduce the student to the terminology, capabilities, and operation of computer-aided drafting hardware and software. The student will be given graphic laboratory problems to create work files and to develop libraries and elementary drawings utilizing lines, rectangles, circles, arcs and ellipses. Using AutoCAD™ as a typical computer-aided drafting and design program, students will also learn scaling, rotations, translations, and projections.

VN 592 <u>Computer Aided Manufacturing</u> (2-3-3) In a laboratory setting, CAM 1 explores machining by utilizing a graphical software package (SmartCAM®) to generate part programs for a CNC mill and laser. Following a review of manual part programming, the emphasis of the course is learning to use the CAM software to select tools, enter part geometry, and convert screen graphics into a CNC program. The student then learns how to communicate the program to the machine and manufacture the part. Intensive work is included in editing the graphics to fully utilize the software. In addition, the student will learn the integration of Computer Aided Design (CAD) with CAM to enhance the understanding of proceeding from the design process through the manufacturing process.

VN 593 <u>Laser Safety</u> (1-0-1) This course is for students in the Laser Machining Technology program. The basic theory of laser operation is presented. With the emphasis on industrial lasers (i.e., higher-power models), various types of lasers and their different uses and applications are covered. Also, the various types of hazards encountered in the use of lasers and the present government safety regulations are discussed.

VN 594 <u>Modern Optics</u> (2-3-3) This course will introduce the student to the basic theories of geometric and wave optics. Topics to be covered will include the rectilinear propagation of light, elementary image formation, lenses, prisms, ray tracing, basic wave theory, interference, diffraction, polarization, and the analysis of optical systems. Classroom lectures will be supplemented with experimental demonstrations.

THE MAST TECHNICAL WORKPLACE COMPETENCY/COURSE CROSSWALK

Upon development of appropriate curricula for the pilot programs, each MAST college began to develop individual course outlines for its assigned specialty area. The skill standards identified in the Competency Profile were cross walked against the technical competencies of the courses in the pilot curriculum. The resulting matrix provided a valuable tool for assessing whether current course content was sufficient or needed to be modified to ensure mastery of entry level technical competencies. Exit proficiency levels for each of the technical competencies were further validated through industry wide surveys both in Texas and across the nation.

The Technical Workplace Competency/Course Crosswalk in the following pages presents the match between industry-identified duties and tasks and the pilot curriculum for . Course titles are shown in columns, duties and tasks in rows. The Exit Level Proficiency Scale, an ascending scale with 5 the highest level of proficiency, includes marked boxes indicating whether the task is covered by the instructor during the course; the numbers 1-5 indicate the degree of attention given to the task and the corresponding proficiency expected on the part of the student. The crosswalk is intended to serve as an aide to other instructional designers and faculty in community college programs across the nation.

Included on the following pages is the Technical Workplace Competency/Course Crosswalk for the pilot program curriculum. This crosswalk validates the fact that the duties and tasks which were identified by industry as being necessary for entry level employees have been incorporated into the development of the course syllabi.

Technical Workplace Competencies/Course

CROSSWALK

TECHNICAL COMPETENCY LASER MACHINIST

TECHNICAL COMPETENCY LASER MACHINIST	Industrial Mathematics	Fundamentals Industrial Electronics/Controls	Computer Numerical Control (CNC)	Modern Optics	Industrial Laser Systems	Computer-Aided Drafting (CAD)	Computer-Aided Manufacturing (CAM)	Laser Materials Processing	Metrology	Laser Safety					EXIT PROFICIENCY LEVEL
A. APPLY MATHEMATICAL CONCEPTS															
A-1 Perform Basic Math Functions	X	X	X	X	X	X	X	X	X	X					4
A-2 Perform Algebra Functions	X	X	X	X	X	X	X	X	X	X					4
A-3 Study Exponents and Right Triangle Geometry	X	X	X	X	X	X	X	X	X	X					4
A-4 Study Elements of Plane and Solid Geometry	X		X	X	X	X	X	X	X						4
A-5 Perform Data Evaluation and Statistical Analysis	X	X							X						4
A-6 Perform Proportioning and Interpolation	X		X			X	X	X	X						4
A-7 Perform Basic Trigonometric Functions	X	X	X	X	X	X	X	X	X	X					4
A-8 Investigate Vectors and Vector Systems	X	X	X	X		X	X		X						4
A-9 Investigate the Cartesian Coordinate System	X	X	X	X	X	X	X	X	X						4
B. INVESTIGATE FUNDAMENTALS OF INDUSTRIAL ELECTRONICS & CONTROL															
B-1 Perform Voltage, Current, Resistance, and Power Measurements		X			X					X					4
B-2 Investigate Fundamentals of Analog Active Devices		X			X										4
B-3 Investigate Fundamentals of Digital Logic Circuitry		X			X										4
B-4 Investigate Operational Amplifiers for Industrial Applications		X			X										4
B-5 Investigate Linear IC's for Industrial Applications		X			X										4
B-6 Investigate Electric Motors		X			X										4
B-7 Study Industrial Control Systems		X													4
C. APPLY CONCEPTS OF MODERN OPTICS															
C-1 Study Reflection at Plane and Spherical Surfaces				X	X			X		X					4
C-2 Study Refraction at Plane Surfaces				X	X			X		X					4
C-3 Study Refraction at Spherical Surfaces				X	X			X		X					4
C-4 Perform Imaging with a Single Lens				X	X			X		X					4
C-5 Perform Imaging with Multiple Thin Lenses				X	X			X		X					4
C-6 Study F-Stops and Apertures				X	X			X		X					4
C-7 Study Optical Systems				X	X			X		X					4
C-8 Study Interference				X	X			X		X					4
C-9 Study Diffraction				X	X			X		X					4
C-10 Study Polarization				X	X			X		X					4
C-11 Investigate Radiometry and Photometry				X	X			X		X					4

Technical Workplace Competencies/Course

CROSSWALK

TECHNICAL COMPETENCY LASER MACHINIST

	Industrial Mathematics	Fundamentals Industrial Electronics/Controls	Computer Numerical Control (CNC)	Modern Optics	Industrial Laser Systems	Computer-Aided Drafting (CAD)	Computer-Aided Manufacturing (CAM)	Laser Materials Processing	Metrology	Laser Safety					EXIT PROFICE
D. PROGRAM CNC MACHINES															
D-1 Apply Machine Specific (Milling and Lasers) Nomenclature and Terminology			X		X		X								4
D-2 Investigate the Cartesian Coordinate System as Applied to Milling and Laser Machines			X		X		X								4
D-3 Apply CNC Programming Language			X												4
D-4 Perform Start Up, Tool Changing, and Ending of Programs			X												4
D-6 Create a Sub-Program			X				X								4
D-7 Perform Contouring			X				X								4
D-8 Apply Tool Radius Compensation (Cutter Comp)			X				X								4
D-9 Perform Programming Preparation			X				X								4
D-10 Apply Special Laser Coding Parameters			X		X		X								4
E. INVESTIGATE INDUSTRIAL LASER SYSTEMS															
E-1 Study Characteristics of Light				X	X			X		X					4
E-2 Understand Basic Laser Principles				X	X			X		X					4
E-3 Study Laser Output Characteristics				X	X			X		X					4
E-4 Investigate Output Modification				X	X			X		X					4
E-5 Apply Safety and Laboratory Procedures				X	X			X		X					4
E-6 Perform a Laser Exposition				X	X			X		X					4
E-7 Perform Laser Alignment, Gauging, and Inspection				X	X			X							4
E-8 Investigate Holography and Applications: Non-Destructive Testing				X	X										4
E-9 Investigate the Interaction of High Power Laser Beam With Materials					X			X		X					4
E-10 Perform Laser Welding and Surface Treatment					X			X		X					4
E-11 Perform Laser Material Removal					X			X		X					4
F. PERFORM COMPUTER AIDED DRAFTING (CAD)															
F-1 Understand PC Basics			X			X	X	X	X						4
F-2 Discuss CAD Basics and File Management						X	X								4
F-3 Use Drawing Settings						X									4
F-4 Perform Basic Editing Commands						X									4
F-5 Create Drawings with Accuracy			X			X	X		X						4
F-6 Organize Drawing Information						X									4
F-7 Control the Display of Drawings						X									4

Technical Workplace Competencies/Course

CROSSWALK

TECHNICAL COMPETENCY LASER MACHINIST

Competency	Industrial Mathematics	Fundamentals Industrial Electronics/Controls	Computer Numerical Control (CNC)	Modern Optics	Industrial Laser Systems	Computer-Aided Drafting (CAD)	Computer-Aided Manufacturing (CAM)	Laser Materials Processing	Metrology	Laser Safety					EXIT PROFICIENCY LEVEL
F-8 Use Intermediate Drawing Commands						X									4
F-9 Perform Intermediate Editing Commands						X									4
F-10 Create Multiview Drawings						X									4
F-11 Create Sectioned Drawings						X									4
F-12 Investigate Basic Dimensioning						X									4
F-13 Perform Advanced Dimensioning						X									4
F-14 Use and Manipulate Blocks						X									4
F-15 Use Blocks to Automate the Drawing Process						X									4
G. PERFORM LASER MATERIALS PROCESSING															
G-1 Discuss Traditional Mechanical Machining			X				X								4
G-2 Discuss Non-Traditional Methods of Machining			X		X	X	X	X							4
G-3 Understand Basics of Laser Heating					X			X							4
G-4 Investigate the Effects of LASER Irradiation on Materials					X			X	X						4
G-5 Study Lasers as Machine Tools			X		X		X	X							4
G-6 Demonstrate Machine Operations			X		X		X	X							4
G-7 Study Hazards and Safety			X	X	X		X	X	X	X					4
H. PERFORM COMPUTER AIDED MANUFACTURING (CAM)															
H-1 Understand the Basics of a PC Based CAM System							X								4
H-2 Discuss Basic CAM Operations							X								4
H-3 Set Up Cutting Tools			X				X								4
H-4 Create Part Profiles						X	X								4
H-5 Edit Part Profiles							X								4
H-6 Perform Advanced Editing of Part Profiles							X								4
H-7 Edit Tool Paths							X								4
H-8 Perform Drilling and Counterboring							X								4
H-9 Use Construction Layers in SmartCAM							X								4
H-10 Perform User Commands and Machine Events							X								4
H-11 Create Families of Parts			X			X	X		X						4
H-12 Perform CAD/CAM Integration						X	X								4
H-13 Perform Code Generation						X	X								4

Technical Workplace Competencies/Course CROSSWALK

TECHNICAL COMPETENCY LASER MACHINIST

	Industrial Mathematics	Fundamentals-Industrial Electronics/Controls	Computer Numerical Control (CNC)	Modern Optics	Industrial Laser Systems	Computer-Aided Drafting (CAD)	Computer-Aided Manufacturing (CAM)	Laser Materials Processing	Metrology	Laser Safety	EXIT PROFIC
I. PRACTICE LASER SAFETY											
I-1 Discuss Laser Safety Basics				X	X	X		X		X	4
I-2 Discuss Laser Hazards				X	X			X		X	4
I-3 Study Laser Safety Standards and Hazard Classifications (i.e., ANSI Z136.1 Standards)				X	X			X		X	4
I-4 Investigate Controls for Surveying, Alignment and Leveling Lasers				X	X			X		X	4
I-5 Discuss Eye Protection			X	X	X		X	X	X	X	4
J. PERFORM MEASUREMENT AND INSPECTION											
J-1 Study Basics of Metrology				X	X	X		X	X	X	4
J-2 Select Instruments Used for Measurement			X	X	X		X	X	X		4
J-3 Interpret Limits and Tolerances	X		X		X	X	X	X	X		4
J-4 Select Gaging Tools			X				X		X		4
J-5 Use CMM for Location Features	X								X		4
J-6 Perform Surface Metrology									X		4
J-7 Perform Measurement by Comparison									X		4
J-8 Perform Circularity, Cylindricity, Profile of a Line, and Runout Measurements									X		4
J-9 Investigate Advanced Metrology Topics			X			X	X	X	X		4

LASER MACHINIST
TECHNICAL WORKPLACE COMPETENCIES
EXIT LEVEL PROFICIENCY MATRIX

Laser Machinist: The laser machinist will have a working knowledge of the principles of electronics, lasers, optics, materials, engineering documentation, CAD/CAM, systems integration all for the goal of producing products to acceptable engineering standards.

The following matrix identifies the five exit levels of technical workplace competencies for the Laser Machinist Certificate at Springfield Technical Community College in Springfield, Massachusetts.

EXIT LEVEL OF PROFICIENCY					
Technical Workplace Competency	**1**	**2**	**3**	**4**	**5**
	rarely	routinely with supervision	routinely with limited supervision	routinely without supervision	initiates/ improves/ modifies and supervises others

THE MAST SCANS/COURSE CROSSWALK

The Secretary's Commission on Achieving Necessary Skills (SCANS), U. S. Department of Labor, has identified in its "AMERICA 2000 REPORT' the following five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance:

COMPETENCIES:

Resources:	Identifies, organizes, plans, and allocates resources
Interpersonal:	Works with others
Information:	Acquires and uses information
Systems:	Understands complex inter-relationships
Technology:	Works with a variety of technologies

FOUNDATION SKILLS:

Basic Skills:	Reads, writes, performs arithmetic and mathematical operations, listens and speaks
Thinking Skills:	Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons
Personal Qualities:	Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

Recognizing the value of SCANS proficiencies to job performance, as well as the growing mandate in many states to include SCANS activities in course curricula, MAST asked survey respondents to review the SCANS skill sets in the context of the draft skill standards for each occupational specialty area. MAST also incorporated evaluation of SCANS competencies and foundation skills into its assessment of the pilot training curricula. The results were summarized in a crosswalk that allowed MAST staff to modify course content where needed to strengthen achievement of SCANS competencies.

The following pages present the SCANS/Course Crosswalk for the pilot curriculum in Courses are listed along the top and SCANS competencies and foundations are shown along the left side of the matrix. An exit level proficiency matrix for SCANS competencies and foundation skills is provided as well.

As "soft" skills, the SCANS competencies are inherently difficult to quantify. MAST realizes that some faculty will emphasize the SCANS more or less than others. The SCANS/Course Crosswalk matrix has been included with this course documentation to show the importance of these "soft skills" and the importance of their being addressed in the classroom (particularly in technical classes). In time, faculty will learn to make these types of SCANS activities an integral and important part of the teaching process.

Included on the following pages is the SCANS/Course Crosswalk for the pilot program curriculum. This crosswalk validates the fact that the "soft skills" (SCANS) which were identified by industry as being necessary for entry level employees have been incorporated into the development of the course syllabi. Also included is a matrix which defines the exit level of proficiency scale (1-5).

SCANS/Course
CROSSWALK
LASER MACHINIST: CERTIFICATE

COMPETENCY	Industrial Mathematics	Fundamentals-Industrial Electronics/Controls	Computer Numerical Control (CNC)	Modern Optics	Industrial Laser Systems	Computer-Aided Drafting (CAD)	Computer-Aided Manufacturing (CAM)	Laser Materials Processing	Metrology	Laser Safety					EXIT PROFICIENCY LEVEL
(RS) RESOURCES:															
A. Allocates time	X	X	X	X	X	X	X	X	X	X					3
B. Allocates money		X	X		X	X	X	X	X	X					2
C. Allocates material and facility resources		X	X		X	X	X	X	X	X					4
D. Allocates human resources		X	X		X	X	X	X	X	X					1
(IN) INTERPERSONAL SKILLS:															
A. Participates as a member of a team	X	X	X	X	X	X	X	X	X	X					4
B. Teaches others	X	X	X	X	X	X	X	X	X	X					3
C. Serves clients/customers		X	X	X	X	X	X	X	X	X					2
D. Exercises leadership		X	X		X	X	X	X	X	X					4
E. Negotiates		X	X		X	X	X	X	X	X					1
F. Works with cultural diversity	X	X	X	X	X	X	X	X	X	X					4
(IF) INFORMATION SKILLS:															
A. Acquires and evaluates information	X	X	X	X	X	X	X	X	X	X					4
B. Organizes and maintains information	X	X	X	X	X	X	X	X	X	X					4
C. Interprets and communicates information	X	X	X	X	X	X	X	X	X	X					4
D. Uses computers to process information	X	X	X	X	X	X	X	X	X	X					4
(SY) SYSTEMS:															
A. Understands systems	X	X	X	X	X	X	X	X	X	X					4
B. Monitors and corrects performance	X	X	X	X	X	X	X	X	X	X					4
C. Improves and designs systems	X	X	X	X	X	X	X	X	X	X					4
(TE) TECHNOLOGY:															
A. Selects technology	X	X	X	X	X	X	X	X	X	X					3
B. Applies technology to task	X		X	X	X	X	X	X	X	X					4
C. Maintains and troubleshoots technology		X	X		X	X	X	X	X	X					4

SCANS/Course CROSSWALK

LASER MACHINIST: CERTIFICATE

FOUNDATION SKILLS

	Industrial Mathematics	Fundamentals-Industrial Electronics/Controls	Computer Numerical Control (CNC)	Modern Optics	Industrial Laser Systems	Computer-Aided Drafting (CAD)	Computer-Aided Manufacturing (CAM)	Laser Materials Processing	Metrology	Laser Safety	Exit Proficiency Level
(BS) BASIC SKILLS:											
A. Reading	X	X	X	X	X	X	X	X	X	X	4
B. Writing	X	X	X	X	X	X	X	X	X	X	4
C. Arithmetic and mathematics	X	X	X	X	X	X	X	X	X		4
D. Listening	X	X	X	X	X	X	X	X	X	X	4
E. Speaking	X	X	X	X	X	X	X	X	X	X	4
(TS) THINKING SKILLS:											
A. Creative thinking	X	X	X	X	X	X	X	X	X	X	4
B. Decision making	X	X	X	X	X	X	X	X	X	X	4
C. Problem solving	X	X	X	X	X	X	X	X	X	X	4
D. Seeing things in the mind's eye	X	X	X	X	X	X	X	X	X	X	4
E. Knowing how to learn	X	X	X	X	X	X	X	X	X	X	4
F. Reasoning	X	X	X	X	X	X	X	X	X	X	4
(PQ) PERSONAL QUALITIES:											
A. Responsibility	X	X	X	X	X	X	X	X	X	X	4
B. Self-esteem	X	X	X	X	X	X	X	X	X	X	4
C. Social	X	X	X	X	X	X	X	X	X	X	4
D. Self-management	X	X	X	X	X	X	X	X	X	X	4
E. Integrity/honesty	X	X	X	X	X	X	X	X	X	X	4

SCANS
COMPETENCIES AND FOUNDATION SKILLS
EXIT LEVEL PROFICIENCY MATRIX

The Secretary's Commission on Achieving Necessary Skills (SCANS), U. S. Department of Labor, has identified in it's "AMERICA 2000 REPORT' the following five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance:

COMPETENCIES:

Resources:	Identifies, organizes, plans, and allocates resources
Interpersonal:	Works with others
Information:	Acquires and uses information
Systems:	Understands complex inter-relationships
Technology:	Works with a variety of technologies

FOUNDATION SKILLS:

Basic Skills:	Reads, writes, performs arithmetic and mathematical operations, listens and speaks
Thinking Skills:	Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons
Personal Qualities:	Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.

The following matrix identifies the five exit levels of proficiency that are needed for solid job performance.

EXIT LEVEL OF PROFICIENCY					
SCANS Competencies and Foundation Skills	**1**	**2**	**3**	**4**	**5**
	rarely	routinely with supervision	routinely with limited supervision	routinely without supervision	initiates/ improves/ modifies and supervises others

MAST/01/012296

THE MAST COURSE SYLLABI
"PILOT PROGRAM"

MAST has produced a very unique set of course outlines, driven and validated by industry and encompassing the broad range of technologies covered by the MAST grant. The course outlines also include proposed SCANS activities that will be useful to an instructor in preparing students to enter the workforce of the future.

Included in the following pages are final course outlines developed and refined in the process of piloting the MAST training programs. The outlines include a brief course description; required course materials (e.g., textbook, lab manual, and tools, if available); proposed method of instruction; proposed lecture and lab outlines; and detailed course objectives for both Technical Workplace Competencies and SCANS Competencies.

These outlines were completed and revised during the second year of MAST, following completion of the pilot phase. The outlines are intended to serve as an aide to other instructional designers and faculty in community college programs across the nation.

Included on the following pages are the Course Syllabi for each of the courses which were taught during the pilot program.

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

INDUSTRIAL MATHEMATICS

MAST PROGRAM
COURSE SYLLABUS
INDUSTRIAL MATHEMATICS

Lecture hours/week: 3 **Lab hours/week: 0** **Credit hours: 3**

COURSE DESCRIPTION:

Industrial Mathematics is a broad mathematics course that includes topics related to the machine tool industry. Areas of study include elements of Algebra I, Algebra II, plane and solid geometry, trigonometry, and statistics. Problems are related to industry wherever possible. Calculator use is required throughout.

PREREQUISITES: Satisfactory performance on math placement test, or permission of the instructor

REQUIRED COURSE MATERIALS:

Textbook: Basic Technical Mathematics, C. T. Olivo and T. P. Olivo, 6th Edition, Delmar Publishers, Inc., 1992; or other equivalent text

Lab Manual: **None**

Supplementary Materials: Handouts, worksheets, scientific calculator, and class problems

METHOD OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, handouts, worksheets, and class problems.

Method of Evaluation: The purpose of this course is to develop the math skills required in a laser machining manufacturing environment where problem solving and independent analysis are expected. A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills where problem solving and independent analysis are expected, and will include evaluation of the student's ability to:

1. understand scientific notation and conversion of units
2. use a hand calculator for trigonometric, statistical, and exponential functions
3. understand various equations relating to plane and solid geometry, and use algebraic techniques to solve for the unknown variable
4. perform basic statistical analysis including the plotting and analysis of bar graphs and charts
5. understand linear equations, proportioning, and interpolation
6. use trigonometry in right and oblique triangles, and vector analysis
7. satisfactorily perform on written, oral, and practical examinations
8. contribute to class discussions

9. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Introduction, Class Procedures	---	
BASIC MATH REVIEW		
Fractions, Decimals, Percentages	12-16	
Units of Length, Area, Volume	23-24	
Conversion of Units to S.I.	32-35	
Use of Calculator		
ALGEBRA REVIEW		
Solving Equations with One Unknown	50-52	
Isolation of One Unknown	Handout	
Cross Multiplication	Handout	
Equations with Fractions	Handout	
Linear Equations, Slope of a Line	Handout	
EXPONENTS & RIGHT TRIANGLE GEOMETRY		
Law of Exponents	58-61	
Exponentials and Roots	63-64	
Right Triangle and Pythagorean Theorem	76	
ELEMENTS OF PLANE AND SOLID GEOMETRY		
Circle - Area, Circumference, Angular Measurement	18-21, 76	
(Degree and Radian)	Handout	
Establish Tangent to Circle		
Parallel Lines, Transverse Lines and Angles	71-74	
Bisecting Angles	79	
Sum of Interior Angles of Polygon	Handout	
Areas of Triangles, Trapezoid	76-77	
Areas of Irregular Shapes	Handout	
Hourly Exam 1		
Volume of Regular and Irregular Solids	73-78	
Specific Gravity of Materials	Handout	
Weight (English, S.I.)	Handout	
Review Exam		
DATA EVALUATION AND STATISTICAL ANALYSIS		
Plotting Data, Bar Graphs, Pie Charts	27-30	
Mean, Normal Distribution, Standard Dev.	Handout	
PROPORTIONING AND INTERPOLATION		
Ratios and Proportions	54-83	
Direct, Inverse, Combined Variation	Handout	
Constants of Proportionality	Handout	
Tabular Interpolation	Handout	

INTRODUCTION TO TRIGONOMETRY	
Trigonometric Functions	82-83
Inverse Functions	Handout
Solving Right Triangles	Handout
TRIGONOMETRY	
Trigonometric functions (values) of angles > 90	Handout
Solving Right Triangles	83
Exam 2	
Review Exam	
Applications of Trigonometry	Handout
OBLIQUE TRIANGLE GEOMETRY, VECTORS	
Law of Sines, Law of Cosines	84-86
Introduction to Vectors	Handout
Adding Vectors	Handout
Components of Vectors	Handout
VECTOR SYSTEMS AND ANALYSIS	
Combining Vectors	Handout
CARTESIAN COORDINATE SYSTEM	
Coordinates, 2 and 3 Dimensions	
Linear Equation, Slope of Line in Coordinate System	Handout
Exam 3 and Review	
COMPREHENSIVE FINAL EXAM	

Total Lecture Hours 45

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

After the successful completion of this course, the student will be able to:

A. APPLY MATHEMATICAL CONCEPTS

1. Perform Basic Math Functions
   a. Use and manipulate fractions
   b. Use and manipulate decimals
   c. Calculate percentages
   d. Calculate units of length, area, and volume
   e. Convert between S.I. (metric) and English (inch) units
   f. Use a scientific calculator
2. Perform Algebraic Functions
   a. Identify equations with one unknown
   b. Solve algebraic equations by isolation of the unknown
   c. Identify equations with fractions
   d. Solve equations by cross multiplying
   e. Identify and solve linear equations
   f. Calculate the slope of a line
3. Study Exponents and Right Triangle Geometry

a. Apply the laws of exponents
b. Calculate exponentials and roots
c. Analyze right triangles
d. Use Pythagorean Theorem

4. Study Elements of Plane and Solid Geometry
   a. Calculate the area and circumference of a circle
   b. Determine angular measurements (degrees and radians)
   c. Establish a tangent to a circle
   d. Analyze parallel lines, transverse lines, and angles
   e. Perform the bisection of an angle
   f. Calculate the sum of the interior angles of a polygon
   g. Calculate the area of a triangle and irregular shapes
   h. Analyze trapezoids
5. Perform Data Evaluation and Statistical Analysis
   a. Analyze and plot data
   b. Create graphs (line, bar, and pie)
   c. Calculate mean, normal, and standard deviation
6. Perform Proportioning and Interpolation
   a. Calculate ratios and proportions
   b. Calculate direct, inverse, and combined variations
   c. Calculate constants of proportionality
   d. Perform tabular interpolation
7. Perform Basic Trigonometric Functions
   a. Calculate the trigonometric functions of sine, cosine, and tangent
   b. Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
   c. Solve a right triangle
8. Investigate Vectors and Vector Systems
   a. Analyze components of vectors
   b. Perform vector addition
   c. Perform vector combination
9. Investigate the Cartesian Coordinate System
   a. Study the X-Y coordinate system
   b. Study the X-Y-Z coordinate system
   c. Calculate the slope of a line in the Cartesian coordinate system

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. *Resources: Identifies, organizes, plans, and allocates resources*

1. follows a schedule to complete assigned tasks on time

B. *Interpersonal: Works with others*

1. complete assigned responsibilities within the classroom serving as a member of the team
2. provide individual assistance/direction to peers as requested
3. works well with all members of the class

C *Information: Acquires and uses information*

1. reads and interprets handouts and assignments
2. systematic organization of training materials.
3. complete assignments and produce required results
4. uses a scientific calculator

D. *Systems: Understands complex inter-relationships*

1. demonstrates knowledge of the following systems:
   a. Classroom organization structure.
   b. Systematic approach to problem solving
2. monitors and corrects performance during analysis
3. constantly evaluating the quality of work to achieve acceptable standards.

E. *Technology: Works with a variety of technologies*

1. chooses a scientific calculator
2. applies appropriate procedures and commands to produce required results

II. FOUNDATION SKILLS

A. *Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*

1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
   a. studies instructor handouts
   b. read/studies textbook
   c. read/study calculator manual
2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. outline the steps necessary to solve mathematical problems
   b. maintain a lecture notebook
   c. submit written responses to chapter question assignments
   d. complete all written assignments
3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. completes mathematical problems as part of assignments.
4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
   a. assimilate classroom instruction

b. seek and receive individualized instruction in the classroom

5. *Speaking: Organizes ideas and communicates orally*
   a. participates in classroom discussions
   b. organize ideas and communicate specific questions to the instructor
   c. verbally affirms understanding of a concept, procedure, or required skill
   d. communicates with peers to ensure the smooth and safe operation of the classroom

B. *Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. *Creative Thinking: Generates new ideas.*
   a. develops new ideas for approaching problem solving
   b. participates in the "brainstorming" process
   c. participates in group problem solving process
2. *Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   a. identifies personal goals
   b. identifies actions required to accomplish personal goals
3. *Problem Solving: Recognizes problems and devises and implements plan of action*
   a. makes daily accommodations to stay on schedule
   b. seeks additional instruction/clarification for assignment completion
   c. balances social and academic life/responsibilities
   d. accepts responsibility
4. *Seeing Things In the Mind's Eye: Organizes, and processes symbols, pictures, graphs, objects, and other information*
   a. understands both written and verbal instructions
   b. assimilates process during instructor demonstrations
5. *Knowing How to Learn: Use efficient learning techniques to acquire and apply new knowledge and skills*
   a. demonstrate mastery of the basic skills and techniques
   b. use these sequential skills to support mastery of new skills
   c. understand the sequential nature of acquired skills and the subsequent knowledge application of new skills and techniques
6. *Reasoning: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   a. understands that practice is vital to improving the skill of the student
   b. understands that the quality of the results is a function of the effort, the attitude, and skill of the student

C. *Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
   a. develops an understanding that in order to be successful you must be a "good" student
   b. develops an understanding that a "good" student is the one who is prompt to every class and has prepared for the day's work

c. develops an understanding good students know what they are going to do in class and does not waste time
d. develops a fine work-ethic

2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
   a. learns to take pride in his or her work through positive reinforcement
   b. sees himself or herself as an asset to the class through continued contributions to the group and a shared common goal
   c. understands that an individual with a positive attitude and the belief in their own abilities will systematically seek solutions and be a valuable employee
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   a. assist classmates in improving skills
   b. assist students with special needs as a peer mentor
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. maintain a record of academic achievement (individual grade book)
   b. accept the responsibility for self-management
5. *Integrity/Honesty: Chooses ethical courses of action*
   a. accept the responsibility for own actions
   b. exhibit personal honesty at all times
   c. accept the challenge of doing your own work in the classroom, during examination, and on outside assignments
   d. understand the consequences of unethical behaviors

Appropriate Reference Materials:

1. Calculator Reference Manual

VN584
06/081196

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

FUNDAMENTALS OF INDUSTRIAL ELECTRONICS AND CONTROLS

MAST PROGRAM
COURSE SYLLABUS
FUNDAMENTALS OF INDUSTRIAL ELECTRONICS AND CONTROLS

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

This course is for students in the Laser Machining Technology program. It consists of a review of basic electronics theory and then a comprehensive coverage of the control of industrial machinery and processes through the use of electronic circuits and systems. After a review of DC and AC circuit theory, the fundamentals of active devices and digital logic theory, some of the topics covered include: linear integrated circuits, DC and AC motors, industrial control devices, transducers, industrial process control, and programmable controllers.

PREREQUISITES: Algebra & Trigonometry

REQUIRED COURSE MATERIALS:

Textbook:	Industrial Electronics, Humphries and Sheets, Latest Edition, Delmar Publishers, Inc.
Lab Manual:	**None**
Supplementary Materials:	Instructor's Lecture & Laboratory Handouts

METHOD OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, handouts, and class problems.

Laboratory: Laboratory will be "hands-on" activities.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The course is designed to provide the student with an understanding of the basic components and systems used in industrial electronics, and will include evaluation of the student's ability to:

1. become familiar with basic DC and AC circuit theory
2. become familiar with the fundamentals of analog active devices: diodes and transducers
3. become familiar with the fundamentals of digital logic circuitry and microprocessor control
4. become familiar with linear integrated circuits and their functions
5. become familiar with the operation of DC and AC motors
6. become familiar with industrial control devices and power control circuits
7. become familiar with industrial process control and how it relates to laser machining

8. become familiar with industrial telemetry and data communication
9. become familiar with sequential process control and programmable controllers
10. satisfactorily perform on written, oral, and practical examinations
11. contribute to class discussions
12. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
DC and AC Circuit Theory		
Voltage, Current, Resistance and Power		
Ohm's Law and Power and Energy		
Series, Parallel and Series-Parallel Circuits		
Alternating Current and Voltage		
Capacitors, Inductors and Transformers		
RC, RL and RLC Circuits		
Polyphase Systems		
Fundamentals of Analog Active Devices		
Introduction to Semiconductors		
Diodes and Applications		
Transistors		
Power Supply Circuits		
Fundamentals of Digital Logic Circuitry and Microprocessors		
Number Systems and Codes		
Logic Gates, Boolean Algebra and Combinational Logic		
Flip-Flops, Arithmetic Operations and Circuits		
Counters, Registers and Memory		
IC's and MSI Logic Circuits		
Interfacing with A/D and D/A Circuits		
Microprocessors, Microcontrollers and Microcomputers		
Operational Amplifiers for Industrial Applications		
Linear IC's for Industrial Applications		
Motors and Industrial Control Devices		
Wound-Field DC Motors and Generators		
Brushless and Stepper DC Motors		
AC Motors		
Industrial Control Devices		
Industrial and Power Control Devices		
Transducers and Industrial Process Control		
Pulse Modulation		

Industrial Telemetry and Data Communications
Sequential Process Control
Programmable Controllers 1
Programmable Controllers 2
FINAL EXAM

Total Lecture Hours	**30**

LAB OUTLINE:

Lab Topics	Contact Hrs.
DC and AC Circuit Analysis	6
Diodes and Applications	3
Transistors	3
Power Supply Circuits	3
Digital Logic Circuitry	3
Operational Amplifiers	3
Linear IC's for Industrial Applications	3
Motors and Industrial Control Devices	6
Transducers and Industrial Process Control	3
Industrial Telemetry and Data Communications	3
Programmable Controllers	6
Total Lab Hours	**45**

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

After the successful completion of this course, the student will be able to:

A. APPLY MATHEMATICAL CONCEPTS
1. Perform Basic Math Functions
    a. Use and manipulate fractions
    b. Use and manipulate decimals
    c. Calculate percentages
    d. Calculate units of length, area, and volume
    e. Convert between S.I. (metric) and English (inch) units
    f. Use a scientific calculator
2. Perform Algebraic Functions
    a. Identify equations with one unknown
    b. Solve algebraic equations by isolation of the unknown
    c. Identify equations with fractions
    d. Solve equations by cross multiplying
    e. Identify and solve linear equations
    f. Calculate the slope of a line
3. Study Exponents and Right Triangle Geometry
    a. Apply the laws of exponents
    b. Calculate exponentials and roots
    c. Analyze right triangles
    d. Use Pythagorean Theorem

4. Study Elements of Plane and Solid Geometry
    a. Calculate the area and circumference of a circle
    b. Determine angular measurements (degrees and radians)
    c. Establish a tangent to a circle
    d. Analyze parallel lines, transverse lines, and angles
    e. Perform the bisection of an angle
    f. Calculate the sum of the interior angles of a polygon
    g. Calculate the area of a triangle and irregular shapes
    h. Analyze trapezoids
5. Perform Data Evaluation and Statistical Analysis
    a. Analyze and plot data
    b. Create graphs (line, bar, and pie)
    c. Calculate mean, normal, and standard deviation
6. Perform Proportioning and Interpolation
    a. Calculate ratios and proportions
    b. Calculate direct, inverse, and combined variations
    c. Calculate constants of proportionality
    d. Perform tabular interpolation
7. Perform Basic Trigonometric Functions
    a. Calculate the trigonometric functions of sine, cosine, and tangent
    b. Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
    c. Solve a right triangle
8. Investigate Vectors and Vector Systems
    a. Analyze components of vectors
    b. Perform vector addition
    c. Perform vector combination
9. Investigate the Cartesian Coordinate System
    a. Study the X-Y coordinate system
    b. Study the X-Y-Z coordinate system
    c. Calculate the slope of a line in the Cartesian coordinate system

B. INVESTIGATE FUNDAMENTALS OF INDUSTRIAL ELECTRONICS & CONTROL

1. Perform Voltage, Current, Resistance and Power Measurements
    a. Study Ohm's law and power and energy
    b. Analyze series, parallel and series-parallel circuits
    c. Study alternating current and voltage
    d. Study capacitors, inductors and transformers
    e. Analyze RC, RL and RLC circuits
2. Investigate Fundamentals of Analog Active Devices
    a. Study semiconductor theory
    b. Analyze diodes and applications
    c. Analyze transistor circuits
    d. Analyze power supply circuits
3. Investigate Fundamentals of Digital Logic Circuitry
    a. Study number systems and codes
    b. Analyze logic gates, boolean algebra and combinational logic circuits
    c. Analyze flip-flops, arithmetic operations and circuits

d. Analyze counters, registers and memory
e. Study IC's and MSI logic circuits
f. Perform interfacing with A/D and D/A circuits
g. Study microprocessors, micro controllers and microcomputers

4. Investigate Operational Amplifiers for Industrial Applications
   a. Study comparator applications
   b. Study summing amplifier applications
   c. Study integrator and differentiator applications
   d. Study current to voltage converter applications
   e. Study voltage to current converter applications
   f. Study constant current source applications
5. Investigate Linear IC's for Industrial Applications
   a. Study voltage regulation
   b. Study basic series regulators
   c. Study basic switching regulators
   d. Study instrumentation amplifiers
   e. Study isolation amplifiers
   f. Study oscillators
   g. Study 555 timers
   h. Study angle measurement circuits
   i. Study temperature measurement circuits
   j. Study strain and pressure measuring circuits
6. Investigate Electric Motors
   a. Study wound-field DC motors and generators
   b. Study brushless and stepper DC motors
   c. Study AC motors
7. Study Industrial Control Systems
   a. Analyze motor control circuits
   b. Analyze RMS to DC converters
   c. Discuss industrial telemetry and data communications
   d. Discuss modulation techniques
   e. Use programmable controllers
   f. Perform sequential process control
   g. Perform statistical process control

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. *Resources: Identifies, organizes, plans, and allocates resources*

1. follows a schedule to complete assigned tasks on time

B. *Interpersonal: Works with others*

1. complete assigned responsibilities within the classroom serving as a member of the team
2. provide individual assistance/direction to peers as requested
3. provides professional and courteous service to customers/clients
4. works well with all members of the class

C. *Information: Acquires and uses information*

1. reads and interprets schematic diagrams and layouts
2. organize and maintain accurate laboratory log books
3. performs laboratory assignments and disseminates results
4. uses computer to analyze and present experimental results

D. *Systems: Understands complex inter-relationships*

1. understands complex electronic systems and interrelated technologies
2. monitors and corrects for flaws and system inaccuracies

E. *Technology: Works with a variety of technologies*

1. chooses procedure, components, and equipment required to perform specific task
2. applies appropriate procedures and uses appropriate components to produce desired results

II. FOUNDATION SKILLS

A. *Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*

1. Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules

a. studies student laboratory manual
b. interprets laboratory procedures and schematics
c. read/studies textbook

2. Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts

a. outlines steps necessary to produce desired experimental results
b. maintain a lecture notebook
c. submit written responses to chapter question assignments
d. complete all written assignments

3. Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques

a. applies mathematical operations required to assess experimental results
b. uses computer to assist in data analysis and reduction
c. keeps a running computation of individual grade

d. performs statistical data interpolation

4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
   a. assimilate classroom instruction
   b. interpolate and assimilate video instruction
   c. observe laboratory demonstrations
   d. seek and receive individualized instruction in the classroom
5. *Speaking: Organizes ideas and communicates orally*
   a. participates in classroom discussions
   b. organize ideas and communicate specific questions to the instructor
   c. verbally affirms understanding of a concept, procedure, or required skill
   d. communicates with peers to ensure the smooth and safe operation of the classroom

B. *Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. *Creative Thinking: Generates new ideas*
   a. develops new ideas for problem solving ·
   b. participates in the "brain storming" process
   c. participates in the group problem solving process
2. *Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   a. identifies personal goals
   b. identifies actions required to accomplish personal goals
3. *Problem Solving: Recognizes problems and devises and implements plan of action*
   a. makes daily accommodations to stay on schedule
   b. seeks additional instruction/clarification for assignment completion
   c. balances social and academic life/responsibilities
   d. accepts responsibility
4. *Seeing Things In the Mind's Eye: Organizes, and processes symbols, pictures, graphs, objects, and other information*
   a. interprets technical drawings
   b. interprets technical illustrations and symbols
   c. understands both written and verbal instructions
   d. assimilates process during instructor demonstrations
5. *Knowing How to Learn: Use efficient learning techniques to acquire and apply new knowledge and skills*
   a. demonstrate mastery of the basic skills and techniques
   b. use these sequential skills to support mastery of new skills
   c. understand the sequential nature of acquired skills and the subsequent knowledge application of new skills and techniques
6. *Reasoning: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   a. understands that practice is vital to improving the skill of the student
   b. understands that the quality of the product is a function of the time of the operation and the attitude and skill of the student

c. understand the complex interaction between optical components

C. *Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
    a. develops an understanding that in order to be successful you must be a "good" student
    b. develops an understanding that a "good" student is the one who is prompt to every class and has prepared for the day's work
    c. develops an understanding good students know what they are going to do in class and does not waste time
    d. develops a fine work-ethic
2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
    a. learns to take pride in his or her work through positive reinforcement
    b. sees himself or herself as an asset to the class through continued contributions to the group and a shared common goal
    c. understands that an individual with a positive attitude and the belief in their own abilities will systematically seek solutions and be a valuable employee
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. assist classmates in improving technical skills
    b. assist students with special needs as a peer mentor
    c. interacts with peers and listens effectively and provides constructive criticism
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. monitors/assesses personal goal progress
    b. maintain a record of academic achievement (individual grade book)
    c. accept the responsibility for self-management
5. *Integrity/Honesty: Chooses ethical courses of action*
    a. accept the responsibility for own actions
    b. exhibit personal honesty at all times
    c. accept the challenge of doing your own work in the classroom, during examination, and on outside assignments
    d. understand the consequences of unethical behaviors

Appropriate Reference Materials:

1. Fundamentals of Linear Circuits, Floyd, Latest Edition, Merrill Publishers
2. Principles of Electric Circuits, Floyd, Latest Edition, Merrill Publishers
3. Digital Systems, Floyd, Latest Edition, Merrill Publishers

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

COMPUTER AIDED DESIGN (CAD)

MAST PROGRAM
COURSE SYLLABUS
COMPUTER-AIDED DESIGN (CAD)

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

The purpose of this course is to introduce the student to the terminology, capabilities, and operation of computer-aided drafting hardware and software. The student will be given graphic laboratory problems to create work files and to develop libraries and elementary drawings utilizing lines, rectangles, circles, arcs and ellipses. Using AutoCAD® as typical computer-aided drafting and design program, students will also learn scaling, rotations, translations, and projections.

PREREQUISITES: Mechanical Drawing, or equivalent

REQUIRED COURSE MATERIALS:

Textbook: Discovering Auto CAD r. 12, Dix and Riley, Prentice-Hall, Inc., 1994
Lab Manual: None

Supplementary Materials: Handouts, Computer Diskettes: 3.5 inch 1.44 meg HD, DS

METHOD OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, handouts, and demonstrations.

Laboratory: Laboratory will be a "hands on" process using the AutoCAD software.

Method of Evaluation: The purpose of this course is to acquaint the student with the terminology, capabilities and operation of computer-aided drafting and hardware and software. Most CAD systems operate in basically the same way. The drawing concepts are the same, only some commands may differ. This course is geared to providing enough familiarity so students will be able to easily adapt to any CAD system they may encounter in a design and drafting career. A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. understand the commands and parameters of the AutoCAD system required to create orthographic drawings electronically
2. create elementary drawings using lines, arcs, circles and ellipses
3. understand how to develop drawing libraries for the purpose of automating the drawing process
4. understand how to create multiview drawings

5. satisfactorily perform on written, oral, and practical examinations
6. contribute to class discussions
7. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Introduction to PCs	**Chapter 1; Handout**	
- Hardware and Software Basics		
- Understand the Operating System		
- Understand Directory Structure and How to Manage Files		
Introduction to AutoCAD and File Management	**Chapter 1, 2; Handout**	
- Understand How to Save Files in AutoCAD (SAVE, SAVE AS, AUTOSAVE)		
- Understand the Drawing Editor, Menu Structure		
- Understand Basic DRAW Commands (LINE, CIRCLE)		
- Understand How to Enter New Points (Coordinate entry)		
- Understand Basic EDIT Command (ERASE)		
Drawing Settings	**Chapter 2, 4**	
- Understand How to Set up the Drawing Sheet (LIMITS, UNITS, GRID)		
- Understand How to Control Cursor Movement (ORTHO, SNAP, DDRMODES)		
More Basic Editing Commands	**Chapter 2, 3, 4**	
- Understand How to Make Changes to Objects on Screen (COPY, MOVE, FILLET, CHAMFER)		
- Understand How to Group Objects for Editing (WINDOW, CROSSING, REMOVE, ADD, PREVIOUS)		
Drawing With Accuracy	**Chapter 2, 6, 10**	
- Understand How to Draw With Object Snap Enabled (OSNAP, DDOSNAP)		
- Understand how to check the accuracy of the drawing (DIST, LIST, ID)		

Organizing Drawing Information **Chapter 3**
- Understand how to create layers (LAYER, DDLMODES)
- Understand and identify line styles
- Understand how to load and use line types (LINETYPE, LTSCALE)
- Understand how to change properties of objects (CHANGE, CHPROP, DDMODIFY)

Controlling the Display of Drawings **Chapter 3, 15**
- Understand How to Change Magnification of Objects (ZOOM Window, Previous, All, Extents, Dynamic)
- Understand How to Move the Display Area (PAN)
- Understand How to Plot Drawings to a Printer (PLOT)
- Understand How to Plot Drawings to a Plotter (PLOT)

Intermediate Drawing Commands **Chapter 4, 5, 7, 9**
- Understand How to Make Parallel Copies of Objects (OFFSET)
- Understand How to Make Multiple Copies of Objects (Multiple COPY, Rectangular and Polar ARRAY)
- Understand How to Create Arcs (ARC)
- Understand How to Put Text on the Drawing (TEXT, DTEXT, STYLE)
- Understand How to Draw Centermarks (DIM, CENTER)
- Understand How to Draw an Ellipse (ELLIPSE)
- Understand How to Draw Polygons (POLYGONS)

MIDTERM EXAM

Intermediate Editing Commands **Chapter 5, 6, 7**
- Understand How to Mirror Objects (MIRROR)
- Understand How to Rotate

Objects (ROTATE)
- Understand How to Change the Length of Existing Objects (STRETCH, EXTEND, TRIM)
- Understand How to Edit Text (DDEDIT)
- Understand How to Use Noun-Verb Format (GRIPS)

REVIEW EXAM

Creating Multi view Drawings	**Chapter 12**
- Understand the Concept of 3rd Angle Projections	
- Understand How to Create and Place Appropriate Orthogonal Views	
- Understand How to Draw Construction Lines From One View to Create Other Views	
- Understand How to Use Existing Geometry to Place Other Views (Point Filters)	
Creating Sectioned Drawings	**Chapter 8, 9**
- Understand How to Create and Place Appropriate Section Views	
- Understand How to Put Section Lines on a Drawing (HATCH, BHATCH, PLINE)	
Basic Dimensioning	**Chapter 8**
- Understand How to Dimension Objects (DIM)	
- Understand How to Change Direction Settings (DIMVARS)	
Advanced Dimensioning	**Chapter 8**
- Understand How to Create and Use Dimension Styles (DDIM)	
- Understand How to Apply Geometric Dimensioning from ANSI Y14.5	
Grouping Objects Together as Blocks	**Chapter 10**
- Understand How to Create a Block (BLOCK)	

- Understand How to Bring Blocks Into the Drawing (INSERT, DDINSERT)
- Understand How to Make a Block Available Outside the Current Drawing (WBLOCK)
- Understand How to Assign Attributes to Blocks (DDATTDEF)
- Understand How to Edit Attribute Information (DDATTE)

Using Blocks to Automate the Drawing Process **Chapter 10; Handout**

- Understand How to Use Attributes to Create a Bill of Materials and Parts List
- Understand How to Create a Standard Parts Library

FINAL COMPREHENSIVE EXAM

Total Lecture Hours **30**

LAB OUTLINE:

Lab Topics	Contact Hrs.
AutoCAD basics: line command, absolute and relative coordinates	3
Line & Circle commands -- polar coordinates	3
Drawing setup commands. Creating Arcs	3
Basic editing: Copy, Fillet, and Chamfer	3
Drawing with accuracy: Object Snaps	3
Layers and Linetypes. Changing objects	3
Printing and plotting	3
Multiple copies: Array. Text commands	3
Symmetrical parts: Mirror Rotating, extending, and stretching objects	3
Creating and placing orthogonal views	3
Section views: Hatch command	3
Dimensioning commands	3
Dimension styles & ANSI Y14.5	3
Grouping objects together: Blocks	3
Using blocks for Bills of Material & libraries	3
Total Lab Hours	**45**

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

After the successful completion of this course the student will be able to:

A. APPLY MATHEMATICAL CONCEPTS

1. Perform Basic Math Functions

a. Use and manipulate fractions
b. Use and manipulate decimals
c. Calculate percentages
d. Calculate units of length, area, and volume
e. Convert between S.I. (metric) and English (inch) units
f. Use a scientific calculator

2. Perform Algebraic Functions
    a. Identify equations with one unknown
    b. Solve algebraic equations by isolation of the unknown
    c. Identify equations with fractions
    d. Solve equations by cross multiplying
    e. Identify and solve linear equations
    f. Calculate the slope of a line
3. Study Exponents and Right Triangle Geometry
    a. Apply the laws of exponents
    b. Calculate exponentials and roots
    c. Analyze right triangles
    d. Use Pythagorean Theorem
4. Study Elements of Plane and Solid Geometry
    a. Calculate the area and circumference of a circle
    b. Determine angular measurements (degrees and radians)
    c. Establish a tangent to a circle
    d. Analyze parallel lines, transverse lines, and angles
    e. Perform the bisection of an angle
    f. Calculate the sum of the interior angles of a polygon
    g. Calculate the area of a triangle and irregular shapes
    h. Analyze trapezoids
5. Perform Basic Trigonometric Functions
    a. Calculate the trigonometric functions of sine, cosine, and tangent
    b. Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
    c. Solve a right triangle
6. Investigate the Cartesian Coordinate System
    a. Study the X-Y coordinate system
    b. Study the X-Y-Z coordinate system
    c. Calculate the slope of a line in the Cartesian coordinate system

B. PERFORM COMPUTER AIDED DRAFTING (CAD)

<u>NOTE</u>: () indicates an AutoCAD® command. AutoCAD® is being used as a typical CAD system

1. Understand PC Basics
    a. Discuss hardware and software basics
    b. Study DOS and Windows operating systems
    c. Discuss directory structure
    d. Manipulate and manage files
2. Discuss CAD Basics and File Management
    a. Save files in CAD (SAVE, SAVE AS, AUTOSAVE)
    b. Study drawing editor, menu structure
    c. Perform basic DRAW commands (LINE, CIRCLE)

d. Study how to enter new points (coordinate entry)
e. Perform basic EDIT command (ERASE)

3. Use Drawing Settings
   a. Perform drawing sheet set-up (LIMITS, UNITS, GRID)
   b. Study methods for cursor movement control (ORTHO, SNAP, DDRMODES)
4. Perform Basic Editing Commands
   a. Perform modifications and changes to objects on screen (COPY, MOVE, FILLET, CHAMFER)
   b. Discuss how to group objects for editing (WINDOW, CROSSING, REMOVE, ADD, PREVIOUS)
5. Create Drawings with Accuracy
   a. Draw with object snap enabled (OSNAP, DDOSNAP)
   b. Determine the accuracy of the drawing (DIST, LIST, ID)
6. Organize Drawing Information
   a. Perform layer creation (LAYER, DDLMODES)
   b. Study and identify line styles
   c. Load and use line types (LINETYPE, LTSCALE)
   d. Change properties of objects (CHANGE, CHPROP, DDMODIFY)
7. Control the Display of Drawings
   a. Change magnification of objects (ZOOM WINDOW, PREVIOUS, ALL, EXTENTS, DYNAMIC)
   b. Move the display area (PAN)
   c. Plot drawings to a printer (PLOT)
   d. Plot drawings to a plotter (PLOT)
8. Use Intermediate Drawing Commands
   a. Make parallel copies of objects (OFFSET)
   b. Make multiple copies of objects (MULTIPLE COPY, RECTANGULAR AND POLAR ARRAY)
   c. Create arcs (ARC)
   d. Create text on the drawing (TEXT, DTEXT, STYLE)
   e. Create centermarks and center lines (DIM, CENTER)
   f. Draw an ellipse (ELLIPSE)
   g. Draw polygons (POLYGON)
9. Perform Intermediate Editing Commands
   a. Mirror objects (MIRROR)
   b. Rotate objects (ROTATE)
   c. Change the length of existing objects (STRETCH, EXTEND, TRIM)
   d. Edit text (DDEDIT)
   e. Study the use of the non-verb format (GRIPS)
10. Create Multi view Drawings
   a. Study the concept of 3rd angle projection
   b. Create and place appropriate orthogonal views
   c. Draw construction lines from one view to create other views
   d. Use existing geometry to place other views (Point Filters)
11. Create Sectioned Drawings
   a. Create and place appropriate section views

b. Create section lines on a drawing (HATCH, BHATCH, PLINE)

12. Investigate Basic Dimensioning
    a. Study methods for dimensioning objects (DIM)
    b. Apply methods for changing dimension settings (DIMVARS)
13. Perform Advanced Dimensioning
    a. Create and use dimension styles (DDIM)
    b. Apply geometric dimensioning from ANSI Y14.5
14. Use and Manipulate Blocks
    a. Create a block (BLOCK)
    b. Insert blocks into the drawing (INSERT, DDINSERT)
    c. Make a block available outside the current drawing (WBLOCK)
    d. Assign attributes to blocks (DDATTDEF)
    e. Edit attribute information (DDATTE)
15. Use Blocks to Automate the Drawing Process
    a. Use attributes to create a bill of materials and parts list
    b. Create a standard parts library

C. PERFORM COMPUTER AIDED MANUFACTURING (CAM)

NOTE: () or CAPS indicates a SmartCAM® command. SmartCAM® is being used as a typical CAM system

1. Perform CAD/CAM Integration
    a. Create .DXF files in AutoCAD®
    b. Discuss the importance of layers in AutoCAD®
    c. Perform .DXF file translation in SmartCAM®

D. PERFORM MEASUREMENT AND INSPECTION

1. Study Basics of Metrology
    a. discuss the reasons for measurements
    b. Study the language of measurement
    c. Determine how to convert between SI and English systems
    d. Interpret dimensions
    e. Study the use of tolerances
    f. Study the requirements of ANSI Y14.5
    g. Study the three fundamental rules of ANSI Y14.5
    h. Interpret the definition of virtual condition
2. Interpret Limits and Tolerances
    a. Study the use of datums
    b. Study the three plane system: Primary, Secondary, and Tertiary Datums
    c. Study the use of material condition symbols (MMC, LMC, RFS)
    d. Use target points to define datums
3. Use CMM for Location of Features
    a. Set up and measure hole locations with respect to applicable datums
    b. Set up and measure location for non-cylindrical features
    c. Set up and measure location for multiple pattern features
    d. Set up and measure for projected tolerance zone
4. Perform Surface Metrology

a. Use surface plates
b. Use angle plates, mandrels, and vee blocks
c. Study how surface plates are used to establish datums
d. Set up and measure the flatness of a surface
e. Set up and measure the perpendicularity of two surfaces
f. Set up and measure the angularity of two surfaces
g. Set up and measure the parallelism of two surfaces
h. Set up and measure the profile of a surface
I. Set up and measure the straightness of a feature

5. Perform Measurement by Comparison
   a. Use an optical comparator
   b. Create charts from CAD systems to use on overlays
   c. Determine the scaling principle used in optical comparison
   d. Calibrate an optical comparator
6. Perform Circularity, Cylindricity, Profile of a Line, and Runout Measurements
   a. Set up and measure the circularity of round features
   b. Set up and measure the cylindricity of a feature
   c. Set up and measure the profile of line
   d. Set up and measure runout and total runout of round features
   e. Set up and measure two features for coplanarity, concentricity, or coaxiality

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. **COMPETENCIES**

A. ***Resources:** Identifies, organizes, plans, and allocates resources*
   1. follows a schedule to complete assigned tasks on time
   2. determines and justifies the cost of CAD software and peripherals
   3. identifies and selects proper materials for product design
   4. provide a self-evaluation of performance based on the time and quality of work

B. ***Interpersonal:** Works with others*
   1. complete assigned responsibilities within the classroom serving as a member of the team
   2. provide individual assistance/direction to peers as requested

3. provides professional and courteous service to customers/clients
4. provides leadership to peers as required
5. accepts constructive criticism
6. works well with all members of the class

C. *Information: Acquires and uses information*
1. organizes and applies drafting protocol and ANSI standards
2. systematic organization of training materials
3. perform laboratory assignments and produce required results
4. uses AutoCAD system to deliver design and drafting solutions

D. *Systems: Understands complex inter-relationships*
1. demonstrates knowledge of the following systems:
   a. personal computers
   b. laboratory organization structure: physical and social
   c. organization of personnel and facilities in the CAD laboratory
   d. dimensioning and measurement systems
2. monitors and corrects performance during CAD drawing creation
3. constantly evaluating the quality of work to achieve acceptable standards

E. *Technology: Works with a variety of technologies*
1. chooses procedure and required CAD commands to produce a drawing
2. applies appropriate procedures and commands to produce a drawing
3. maintains and troubleshoots computer equipment as required

II. FOUNDATION SKILLS

A. *Basic Skills:* Reads, *writes, performs arithmetic and mathematical operations, listens and speaks.*
1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
   a. studies instructor handouts
   b. interprets technical sketches and drawings
   c. read/study text book
2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. outline the necessary views to complete a drawing
   b. maintain a lecture notebook
   c. complete all written assignments
3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. understands geometrical relationships: Tangent, Perpendicular, Parallel, Quadrants
   b. uses the Cartesian coordinate system
   c. keeps a running computation of individual grade
   d. interconverts fractions to decimal expressions
   e. use trigonometry to solve angle calculations
4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
   a. assimilate classroom instruction

b. observe laboratory demonstrations
c. seek and receive individualized instruction in the classroom

5. *Speaking: Organizes ideas and communicates orally*
   a. participates in classroom discussions
   b. organize ideas and communicate specific questions to the instructor
   c. verbally affirms understanding of a concept, procedure, or required skill
   d. communicates with peers to ensure the smooth and safe operation of the classroom and laboratory

B. ***Thinking Skills:*** Thinks *creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. **Creative Thinking:** Generates new ideas.
   a. develops new ideas for approaching problem solving
   b. participates in the "brainstorming" process
   c. participates in group problem solving process
2. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   a. identifies personal goals
   b. identifies actions required to accomplish personal goals
3. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
   a. makes daily accommodations to stay on schedule
   b. seeks additional instruction/clarification for assignment completion
   c. balances social and academic life/responsibilities
   d. accepts responsibility
4. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
   a. interprets technical drawings
   b. interprets technical illustrations and symbols
   c. understands both written and verbal instructions
   d. assimilates process during instructor demonstrations
5. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
   a. demonstrate mastery of the basic skills and techniques
   b. use these sequential skills to support mastery of new skills
   c. understand the sequential nature of acquired skills and the subsequent knowledge application of new skills and techniques
6. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   a. understands that practice is vital to improving the skill of the student
   b. understands that the quality of the product is a function of the time of the operation and the attitude and skill of the student
   c. understands the relationship between CAD theory and drafting principles

C. ***Personal Qualities:*** Displays *responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
    a. develops an understanding that in order to be successful you must be a "good" student
    b. develops an understanding that a "good" student is the one who is prompt to every class and has prepared for the day's work
    c. develops an understanding good students know what they are going to do in class and does not waste time
    d. develops a fine work-ethic
2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
    a. learns to take pride in his or her work through positive reinforcement
    b. sees himself or herself as an asset to the class through continued contributions to the group and a shared common goal
    c. understands that an individual with a positive attitude and the belief in their own abilities will systematically seek solutions and be a valuable employee
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. assist classmates in improving technical skills
    b. assist students with special needs as a peer mentor
    c. shares laboratory resources (computers, and instructor's individual attention)
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. constantly evaluating CAD procedures and results for acceptability.
    b. maintain a record of academic achievement (individual grade book)
    c. make accommodations due to computer availability.
    d. accept the responsibility for self-management
5. *Integrity/Honesty: Chooses ethical courses of action*
    a. accept the responsibility for own actions
    b. exhibit personal honesty at all times
    c. accept the challenge of doing your own work in the classroom, during examination, and on outside assignments
    d. understand the consequences of unethical behaviors

Appropriate Reference Materials:

1. ANSI Y14.5 - 1994 (Dimensioning and Tolerancing)
2. Any text on Drafting
3. AutoCAD Reference Manual

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

COMPUTER NUMERICAL CONTROL

MAST PROGRAM
COURSE SYLLABUS
COMPUTER NUMERICAL CONTROL

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

This course is an introduction to the fundamental concepts of Computer Numerical Control (CNC). The importance of numerical control to manufacturing and productivity is discussed with different types of CNC systems. Special emphasis will be placed on programming laser CNC equipment. Coverage includes writing programs to perform three-axis hole and a variety of milling and cutting operations using the equipment available in our labs.

PREREQUISITES: **Machine Tool Techniques 1, or permission from the professor**

REQUIRED COURSE MATERIALS:

Textbook: Learning Computer Numerical Control, Michael Janke, Delmar Publishers, Inc., 1992

Lab Manual: None

Supplementary Materials:
Instructor Handouts
2" three ring binder
Computer Diskettes, 3.5 inch 1.44 meg, high density
Safety Glasses

METHOD OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, handouts, and demonstrations.

Laboratory: Laboratory will be a "hands on" CNC programming and machining process.

Method of Evaluation: A student's grade will be based on multiple measures of performance. Given many appropriate demonstrations, lectures, reading assignments, and supervised performance opportunities on the lab equipment, the assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. understand the significance of lab safety
2. understand the Cartesian coordinate system as employed in CNC machining
3. understand how a part is processed for CNC application
4. understand basic part geometry and tool action statements in programming
5. use multiple tooling in the machining center
6. manufacture parts on the school's milling machine
7. perform taping operations on the milling machine

8. satisfactorily perform on written, oral, and practical examinations
9. contribute to class discussions
10. maintain attendance per current policy

LECTURE OUTLINE:

This course will be taught using weekly handouts in conjunction with assignments from the text.

Programming, Setup and Operations *via*
Matsuura MC-500V2 with Yasnac MX1 Controls

Lecture Topics	Text Reference Page	Contact Hrs.
Nomenclature/Terminology via Operations		
(Students *observe* in the Lab)		
Part A: Machine Specifications		
Part B: Machine Start Up		
Part C: Function Keys and Other Keyboard Components		
Part D: Mounting Tools		
Part E: Establishing Origin Point (Part Zero)		
Part F: Establishing Tool Length Offsets		
Part G: Establishing Radius Offsets		
Part H: Programming (Specifics of test program shall not be emphasized at this time, but only the mechanics at machine Control Unit)		
Part I: Proving the Program		
Part J: Running the Part		
Cartesian Coordinate System as Applied to Milling		
Part A: Definitions		
Part B: Videotape: Coordinate Measurement System		
Part C: Instructor's Review		
Part D: Programming Practice		
Programming Language		
Part A: Commonly Used Letter Addresses that are Modal		
Part B: "Word-Address, Variable Block" Format		
Part C: Standard Programming Format		
Positioning and Basic Drilling		
Part A: Typical Steps Leading to Parts Production (abbreviated-more on this in Lesson 10)		

Part B: Program 01-Positioning and Drilling with "R" Level to Avoid Obstructions
Part C: Program 02-Positioning and Drilling
Part D: Program 03-Positioning and Drilling

Sub-Programming

Part A: General Information
Part B: Program 01, Revisited-Rewrite with Sub-Program
Part C: Program 02, Revisited-Rewrite with Sub-Program
Part D: Program 03, Revisited-Rewrite with Sub-Program

Position and Fixed Cycle Exercise

Part A: Synchronous Tapping (G93)
Part B: Right-Hand Tapping Cycle (G84)
Part C: Chip-Break Peck Drilling Cycle (G73)
Part D: Deep Hole Peck-Drilling Cycle (G83)
Part E: Program 04

Contouring

Part A: Rapid Traverse, Linear Cutting, Circular Cutting (G00, G01, G03, G17, G18, G19, I, J, R)
Part B: Program 05A
Part C: Program 05B

Tool Radius Compensation

Part A: Purpose and Application
Part B: Program 05A, Revisited!-Rewrite with T.R.C.
Part C: Program 05A-Rewrite with T.R.C. and Sub-Program
Part D: Program 06A-Write with T.R.C. and Sub-Program
Part E: Program 07A-Write with T.R.C. and Sub-Program

Special Contouring Cycle

Part A: Program 06-Using Tool Radius Compensation
Part B: CW Circle Cutting-360 I.D Only (G12) CCW Circle Cutting-360 I.D. Only (G13)
Part C: Rewrite Program 06 Using T.R.C. and G13

Program Preparation

Part A: Identify Program Planning Steps

Part B: Selecting Tooling
01. Tool Geometry
02. Insert Size and Shape
03. Insert Grade
Part C: Cutting Depth, Speeds and Feeds
Lab Assignment/Program 07
Part A: Write Program 07
Part B: Mount Tools
Part C: Establish Part Zero, Tool Length Offsets, and Radius Offsets
Part D: Enter Program at Machine Control Unit
Part E: Prove and Edit
Part F: Run the Part
Program Exercise 08
Part A: Select the Machine to be Used and the Operations to be Performed on the Machine
Part B: Plan for Jigs or Fixtures That May Be Necessary to Hold the Part
Part C: Select the Tooling Needed to Machine the Part
Part D: Write a Program Plan or Outline For the Program
Part E: Write the Actual Program
Part F: Mount Tools
Part G: Establish Part Zero, Tool Length Offsets, and Radius Offsets
Part H: Enter Program at Machine Control Unit
Part I: Prove and Edit
Part J: Run the Part
Program Exercise 09
Part A: "M" Code Listing for Laser Applications
Part B: "M 63" Assist Gas-Oxygen (02) Low
Part C: "M 64" Assist Gas-Oxygen (02) High
Part D: "M 65" Assist Gas-Nitrogen
Part E: "M 90" Continuous Wave
Part F: "M 92" Super Pulsing

Mid-term and Final examinations at weeks 7 and 16 respectively

Total Lecture Hours **30**

LAB OUTLINE:

Lab Topics	Contact Hrs.
Machine Specifications	2
Matsuura controls and operations	2
Cartesian coordinate system	2
G and M codes	2
Positioning and Drilling Programs	3
Positioning and Drilling using Sub-Programs	3
Tapping and deep hole drilling	3
Rapid traverse -- Linear and circular cutting	3
Contour programming	3
Contour programming with Tool Radius Compensation (TRC)	3
Contour programming with TRC and Sub-Programming	3
Contour programming with TRC and Sub-Programming, continued	3
Drilling and milling using Sub-Programming and TRC	3
Programming using TRC and G13 (circular cutting 360°)	3
Putting it all together: A final program	7
Total Lab Hours	45

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

After the successful completion of this course the student will be able to:

A. APPLY MATHEMATICAL CONCEPTS
1. Perform Basic Math Functions
   a. Use and manipulate fractions
   b. Use and manipulate decimals
   c. Calculate percentages
   d. Calculate units of length, area, and volume
   e. Convert between S.I. (metric) and English (inch) units
   f. Use a scientific calculator
2. Perform Algebraic Functions
   a. Identify equations with one unknown
   b. Solve algebraic equations by isolation of the unknown
   c. Identify equations with fractions
   d. Solve equations by cross multiplying
   e. Identify and solve linear equations
   f. Calculate the slope of a line
3. Study Exponents and Right Triangle Geometry
   a. Apply the laws of exponents
   b. Calculate exponentials and roots
   c. Analyze right triangles
   d. Use Pythagorean Theorem
4. Study Elements of Plane and Solid Geometry
   a. Calculate the area and circumference of a circle
   b. Determine angular measurements (degrees and radians)
   c. Establish a tangent to a circle
   d. Analyze parallel lines, transverse lines, and angles
   e. Perform the bisection of an angle

f. Calculate the sum of the interior angles of a polygon
g. Calculate the area of a triangle and irregular shapes
h. Analyze trapezoids

5. Perform Basic Trigonometric Functions
   a. Calculate the trigonometric functions of sine, cosine, and tangent
   b. Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
   c. Solve a right triangle
6. Investigate the Cartesian Coordinate System
   a. Study the X-Y coordinate system
   b. Study the X-Y-Z coordinate system
   c. Calculate the slope of a line in the Cartesian coordinate system

B. PERFORM CNC PROGRAMMING

1. Apply Machine Specific (Milling and Lasers) Nomenclature and Terminology
   a. Study machine specifications
   b. Start up the machine
   c. Study the machine's keyboard and function keys
   d. Establish radius offsets
   e. Study programming basics at the MCU (machine control unit)
   f. Prove out a program
   g. Load and run a part program
2. Investigate the Cartesian Coordinate System as Applied to Milling and Laser Machines
   a. Study the Cartesian coordinate system
   b. Study the basics of a coordinate measurement system
   c. Plot points in an XYZ coordinate system
   d. Set (G90) and program in absolute coordinates
   e. Set (G91) and program in incremental coordinates
3. Apply CNC Programming Language
   a. Study word-address and variable block formats
   b. Study standard programming formats such as FANUC
   c. Study the concept of model addresses
4. Perform Start Up, Tool Changing, and Ending of Programs
   a. Zero the machine to the part
   b. Close the shutter, Z axis retract, and gas off (lasers)(M61)
5. Perform Positioning and Basic Drilling
   a. Start and stop the spindle (M03 and M05)
   b. Initiate the drilling cycle (G81)
   c. Program using the "R" level to avoid obstructions
   d. Cancel the drilling cycle (G80)
6. Create a Sub-Program
   a. Study the applications of sub-programming
   b. Study the CNC codes used in sub-programming (M98, P###, L##)
   c. Call a sub-program (M98)
   d. End a sub-program (M99)
7. Perform Contouring
   a. Initiate rapid traverse (G00)
   b. Perform linear cutting (G01)

8. Apply Tool Radius Compensation (Cutter Comp)
    a. Study the purpose and application of tool radius compensation
    b. Turn on cutter comp left (G41)
    c. Turn on cutter comp right (G41)
    d. Cancel cutter comp (G40)
9. Perform Programming Preparation
    a. Identify programming planning steps
    b. Set beam size and power (laser applications)
    c. Determine cutting depth or penetration
    d. Determine cutting speed and feed
    e. Determine and design jigs and fixtures for part holding
10. Apply Special Laser Coding Parameters
    a. Select assist gas-oxygen low (M63)
    b. Select assist gas-oxygen high (M64)
    c. Select assist gas-Nitrogen (M65)
    d. Select assist gas-Air (M67)
    e. Turn on and cancel selected assist gas (M68, M69, M70)
    f. Set continuous wave (M90), gated pulsing (M91), super pulsing (M92), and hyper pulsing (M93)

C. **INVESTIGATE INDUSTRIAL LASER SYSTEMS**
1. Perform Laser Material Removal
    a. Study Laser-Supported Absorption (LSA)
    b. Perform laser drilling
    c. Perform laser cutting

D. **PERFORM LASER MATERIALS PROCESSING**
1. Discuss Traditional Mechanical Machining
2. Discuss Non-Traditional Methods of Machining
    a. Investigate mechanical methods
        (1) Discuss abrasive flow machining
        (2) Discuss micro abrasive blasting
        (3) Discuss ultrasonic machining
    b. Investigate electrical methods
        (1) Discuss electrochemical machining
        (2) Discuss electrochemical grinding
    c. Investigate chemical methods
        (1) Discuss photochemical machining
        (2) Discuss photochemical polishing
    d. Investigate thermal methods
        (1) Discuss electron beam machining
        (2) Discuss electrodischarge machining
        (3) Discuss wire electrodischarge machining
        (4) Discuss laser beam machining
3. Understand Basics of Laser Heating
    a. Investigate properties of materials
        (1) Study optical properties including:
            (a) Transmission
            (b) Absorption
            (c) Reflection
            (d) Scattering

(2) Study mechanical properties including:
    (a) Hardness
    (b) Tribology
    (c) Strength
    (d) Heat treatments
(3) Study chemical properties including:
    (a) Composition
    (b) Decomposition
    (c) Corrodibility
(4) Study electrical properties including:
    (a) Metallic
    (b) Dielectric
        i. Ceramic
        ii. Polymer
        iii. Glass
(5) Study thermal properties including:
    (a) Heat capacity
    (b) Thermal conductivity
    (c) Thermal expansion

4. Investigate the Effects of Laser Irradiation on Materials including:
    a. Melting
    b. Vaporization
    c. Ablation
    d. Dehydration
    e. Removal method
    f. Mechanism of reaction
5. Study Lasers as Machine Tools including:
    a. C.W. vs. pulsed
    b. Energy balance
    c. Factors affecting removal rate
    d. Beam direction and deflection
    e. Tip design
    f. Focused vs. non-focused
    g. Wavelength/power of laser
6. Demonstrate Machine Operations including:
    a. Drilling
    b. Cutting
    c. Surface modification
    d. Embossing
    e. Marking
    f. Texturing
    g. Hardening
    h. Annealing
    i. Welding
7. Study Hazards and Safety including:
    a. Skin
    b. Eye
    c. Electrical shocks
    d. Fire threats

e. Toxic fume production
f. Unprotected wiring and tubing
g. Water spills
h. Warning signs
i. Safety glasses
j. Interlocks
k. ANSI Z-136 and Maximum Permissible Exposure
l. Saving sight by managing light

E. **PRACTICE LASER SAFETY**
1. Discuss Laser Safety Basics
2. Discuss Laser Hazards including:
   a. Eye hazards
   b. Skin hazards
   c. Associated hazards from high power lasers
   d. Viewing laser radiation
   e. Laser hazard evaluation
   f. Control of associated hazards
   g. Typical laser calculations and measurements
3. Study Laser Safety Standards and Hazard Classifications (i.e., ANSI Z136.1 Standards)
4. Investigate Controls for Surveying, Alignment and Leveling Lasers
5. Discuss Eye Protection including:
   a. Selection of eye protection
   b. Limitations of eye protection
   c. Laser goggle testing

F. **PERFORM MEASUREMENT AND INSPECTION**
1. Study Basics of Metrology
   a. discuss the reasons for measurements
   b. Study the language of measurement
   c. Determine how to convert between SI and English systems
   d. Interpret dimensions
   e. Study the use of tolerances
   f. Study the requirements of ANSI Y14.5
   g. Study the three fundamental rules of ANSI Y14.5
2. Select Instruments Used for Measurement
   a. Use vernier calipers
   b. use dial calipers
   c. Read scales
   d. Use micrometers
   e. Use hole and depth micrometers
   f. Set up and use dial indicators
3. Interpret Limits and Tolerances
   a. Study the use of datums
   b. Study the three plane system: Primary, Secondary, and Tertiary Datums
   c. Study the use of material condition symbols (MMC, LMC, RFS)
   d. Use target points to define datums
4. Use CMM for Location of Features
   a. Access the importance of Coordinate Measurement Machines (CMM)

b. Set up and use a CMM
c. Calibrate a CMM
d. Set up and measure hole locations with respect to applicable datums
e. Set up and measure location for non-cylindrical features
f. Set up and measure location for multiple pattern features
g. Set up and measure for projected tolerance zone

5. Investigate Advanced Metrology Topics
   a. Discuss the purpose and application of laser measurement
   b. Set up and use a laser measurement device
   c. Assess how ISO 9000 affects metrology
   d. Study the fundamentals of Statistical Process Control (SPC)

COURSE OBJECTIVES: SCANS COMPETENCIES

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The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. Resources: Identifies, organizes, plans, and allocates resources
1. follows a schedule to complete assigned tasks on time
2. determines the initial cost of materials and "value added" as a result of machining
3. identifies and selects proper materials and appropriate machining process
4. provide a self-evaluation of performance based on the time and quality of work

B. Interpersonal: Works with others
1. complete assigned responsibilities within the classroom serving as a member of the team
2. provide individual assistance/direction to peers as requested
3. provides professional and courteous service to customers/clients
4. provides leadership to peers as required
5. accepts constructive criticism
6. works well with all members of the class

C. Information: Acquires and uses information
1. reads and interprets blueprints
2. systematic organization of training materials
3. perform laboratory assignments and produce required results
4. uses Machine Control Unit to enter CNC program

D. Systems: Understands complex inter-relationships

1. demonstrates knowledge of the following systems:
    a. Laboratory organization structure: physical and social
    b. Organization of personnel and facilities on the shop floor
    c. Dimensioning and measurement systems
2. monitors and corrects performance during the programming and machining processes
3. constantly evaluating the quality of work to achieve acceptable standards

E. *Technology: Works with a variety of technologies*
1. chooses procedure, tools and equipment to produce part
2. applies appropriate procedures and uses appropriate tools and equipment to produce a machined part to acceptable standards
3. maintains and troubleshoots equipment as required

II. FOUNDATION SKILLS

A. ***Basic Skills:*** *Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*

1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
    a. studies instructor handouts
    b. reads and interprets blueprints
    c. read/studies textbook

2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    a. outline the steps necessary to create a CNC program
    b. maintain a lecture notebook
    c. submit written responses to chapter question assignments
    d. complete all written assignments

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. determines optimum machining speeds, feeds, and depths of cut
    b. calculates "value added" to part
    c. keeps a running computation of individual grade
    d. interconverts fractions to decimal expressions
    e. use trigonometry to solve angle calculations

4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
    a. assimilate classroom instruction
    b. observe laboratory demonstrations
    c. interpret and assimilate video instruction
    d. seek and receive individualized instruction in the classroom

5. ***Speaking:*** *Organizes ideas and communicates orally*
    a. participates in classroom discussions
    b. organize ideas and communicate specific questions to the instructor
    c. verbally affirms understanding of a concept, procedure, or required skill
    d. communicates with peers to ensure the smooth and safe operation of the classroom and laboratory

B. *Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. *Creative Thinking: Generates new ideas*
    a. develops new ideas for approaching problem solving
    b. participates in the "brainstorming" process
    c. participates in group problem solving process
2. *Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. identifies personal goals
    b. identifies actions required to accomplish personal goals
3. *Problem Solving: Recognizes problems and devises and implements plan of action*
    a. makes daily accommodations to stay on schedule
    b. seeks additional instruction/clarification for assignment completion
    c. balances social and academic life/responsibilities
    d. accepts responsibility
4. *Seeing Things In the Mind's Eye: Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. interprets technical drawings
    b. interprets technical illustrations and symbols
    c. understands both written and verbal instructions
    d. assimilates process during instructor demonstrations
5. *Knowing How to Learn: Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. demonstrate mastery of the basic skills and techniques
    b. use these sequential skills to support mastery of new skills
    c. understand the sequential nature of acquired skills and the subsequent knowledge application of new skills and techniques
6. *Reasoning: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. understands that practice is vital to improving the skill of the student
    b. understands that the quality of the product is a function of the time of the operation and the attitude and skill of the student
    c. understands the relationship between different materials and the tool applied to the material surface and adjusts machining parameters accordingly

C. *Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
    a. develops an understanding that in order to be successful you must be a "good" student
    b. develops an understanding that a "good" student is the one who is prompt to every class and has prepared for the day's work
    c. develops an understanding good students know what they are going to do in class and does not waste time
    d. develops a fine work-ethic

2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
    a. learns to take pride in his or her work through positive reinforcement
    b. sees himself or herself as an asset to the class through continued contributions to the group and a shared common goal
    c. understands that an individual with a positive attitude and the belief in their own abilities will systematically seek solutions and be a valuable employee
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. assist classmates in improving technical skills
    b. assist students with special needs as a peer mentor
    c. shares laboratory resources (machines, tools, and instructor's individual attention)
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. perform in-process quality checks on machined parts
    b. maintain a record of academic achievement (individual gradebook)
    c. make accommodations to laboratory schedules due to broken machines
    d. accept the responsibility for self-management
5. *Integrity/Honesty: Chooses ethical courses of action*
    a. accept the responsibility for own actions
    b. exhibit personal honesty at all times
    c. accept the challenge of doing your own work in the classroom, during examination, and on outside assignments
    d. understand the consequences of unethical behaviors

Appropriate Reference Materials:

1. Matsuura Reference Manual
2. Yasnac MX1 Reference Manual

VN589
06/081196

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

MODERN OPTICS

MAST PROGRAM
COURSE SYLLABUS
MODERN OPTICS

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

This course will introduce the student to the basic theories of geometric and wave optics. Topics to be covered will include the rectilinear propagation of light, elementary image formation, lenses, prisms, ray tracing, basic wave theory, interference, diffraction, polarization, and the analysis of optical systems. Classroom lectures will be supplemented with experimental demonstrations.

PREREQUISITES: Algebra I and II; Trigonometry

REQUIRED COURSE MATERIALS:

Textbook:	Introduction to Classical and Modern Optics, Meyer-Arendt, Prentice-Hall, Fourth Edition Geometric Optics, CORD Communications, Laser Electro-Optics Series, 1987 Light Sources and Wave Optics, CORD Communications, Laser Electro-Optics Series, 1987
Lab Manual:	None
Supplementary Materials:	Instructor's Notes & Laboratory Handouts

METHOD OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, handouts, and demonstrations.

Laboratory: Laboratory will be "hands-on" and will be on selected experiments in geometric and physical optics as well as radiometry and photometry.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The objective of this course is to give students a thorough understanding of light and optics with special emphasis on the practical applications to modern industry. Upon completion of this course, students will be well prepared to move on to more advanced topics such as laser theory, electro-optics, and optical systems design. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. understand basic theory of light including reflection & refraction
2. understand geometric optics including optical components, hardware, and systems.
3. understand physical optics including the wave nature of light, polarization, diffraction and interference

4. understand basic principles of radiometry and photometry including measurement techniques
5. satisfactorily perform on written, oral, and practical examinations
6. contribute to class discussions
7. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Introduction to Light		
- What is Light?		
- Propagation of Light		
- The Electromagnetic Spectrum		
- Reflection and Refraction		
- Index of Refraction		
- Snell's Law		
Geometric Optics		
- Prisms		
- Thin Lenses		
- Thin Lens Equations		
- Thick Lenses		
- Geometric Ray Tracing		
- Magnification		
- Mirrors		
- Telescopes		
Review and Midterm Exam		
Wave Optics		
- Light as a Wave Phenomenon		
- Simple Harmonic Motion		
- Polarization		
- Interference		
- Coherence		
- Diffraction		
Radiometry and Photometry		
- Absorption of Light		
- Optical Density		
- Optical Filters		
- Optical Power Meters		
- Irradiance Measurement		
Review and Final Exam		
	Total Lecture Hours	**30**

LAB OUTLINE:

Lab Topics	Contact Hrs.
Reflection at Plane and Spherical Surfaces	3
Refraction at Plane Surfaces	3
Refraction at Spherical Surfaces	3

Imaging with a Single Lens	3
Imaging with Multiple Thin Lenses	3
F-Stops and Apertures	3
Beam-Expanding Collimators	3
Young's Double Slit Interference	3
Thin Film Interference	3
Determine Surface Flatness by Interference	3
Fraunhofer (Far Field) Diffraction	3
Fresnel (Near Field) Diffraction	3
Measure Beam Divergence and Spot Size	3
Diffraction Gratings	3
Polarization	3
Total Lab Hours	**45**

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

After the successful completion of this course the student will be able to:

A. **APPLY MATHEMATICAL CONCEPTS**

1. Perform Basic Math Functions
   a. Use and manipulate fractions
   b. Use and manipulate decimals
   c. Calculate percentages
   d. Calculate units of length, area, and volume
   e. Convert between S.I. (metric) and English (inch) units
   f. Use a scientific calculator
2. Perform Algebraic Functions
   a. Identify equations with one unknown
   b. Solve algebraic equations by isolation of the unknown
   c. Identify equations with fractions
   d. Solve equations by cross multiplying
   e. Identify and solve linear equations
   f. Calculate the slope of a line
3. Study Exponents and Right Triangle Geometry
   a. Apply the laws of exponents
   b. Calculate exponentials and roots
   c. Analyze right triangles
   d. Use Pythagorean Theorem
4. Study Elements of Plane and Solid Geometry
   a. Calculate the area and circumference of a circle
   b. Determine angular measurements (degrees and radians)
   c. Establish a tangent to a circle
   d. Analyze parallel lines, transverse lines, and angles
   e. Perform the bisection of an angle
   f. Calculate the sum of the interior angles of a polygon
   g. Calculate the area of a triangle and irregular shapes
   h. Analyze trapezoids
5. Perform Data Evaluation and Statistical Analysis

a. Analyze and plot data
b. Create graphs (line, bar, and pie)
c. Calculate mean, normal, and standard deviation

6. Perform Proportioning and Interpolation
   a. Calculate ratios and proportions
   b. Calculate direct, inverse, and combined variations
   c. Calculate constants of proportionality
   d. Perform tabular interpolation
7. Perform Basic Trigonometric Functions
   a. Calculate the trigonometric functions of sine, cosine, and tangent
   b. Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
   c. Solve a right triangle
8. Investigate Vectors and Vector Systems
   a. Analyze components of vectors
   b. Perform vector addition
   c. Perform vector combination
9. Investigate the Cartesian Coordinate System
   a. Study the X-Y coordinate system
   b. Study the X-Y-Z coordinate system
   c. Calculate the slope of a line in the Cartesian coordinate system

B. APPLY CONCEPTS OF MODERN OPTICS

1. Study Reflection at Plane and Spherical Surfaces
   a. Demonstrate the law of reflection
   b. Demonstrate ray tracing at a plane reflecting surface
   c. Demonstrate ray tracing at a spherical reflecting surface
2. Study Refraction at Plane Surfaces
   a. Demonstrate refraction of light at a dielectric interface
3. Study Refraction at Spherical Surfaces
   a. Demonstrate refraction at plane surfaces
   b. Demonstrate refraction at spherical surfaces
4. Perform Imaging with a Single Lens
   a. Determine focal points and focal lengths in positive thin lenses
   b. Demonstrate image formation in positive thin lenses
   c. Determine focal points and focal lengths in negative thin lenses
   d. Demonstrate image formation in negative thin lenses
5. Perform Imaging with Multiple Thin Lenses
   a. Set up and demonstrate two converging lenses
   b. Set up and demonstrate a converging and diverging lens
6. Study F-Stops and Apertures
   a. Define field stops and aperture stops
   b. Define entrance and exit pupils
7. Study Optical Systems
   a. Set up and demonstrate astronomical (Keplarian) telescopes
   b. Set up and demonstrate Galilean telescopes
   c. Set up and demonstrate beam-expanding collimators
8. Study Interference
   a. Set up and demonstrate Young's double slit interference

b. Demonstrate thin film interference
c. Determine surface flatness by interference

9. Study Diffraction
   a. Demonstrate Fraunhofer (far field) diffraction
   b. Demonstrate Fresnel (near field) diffraction
   c. Determine the limit of resolution of an optical instrument
   d. Measure beam divergence and spot size
   e. Use diffraction gratings
   f. Discuss light scattering
10. Study Polarization
   a. Determine unknown polarization of light
   b. Generate linearly polarized light
   c. Study the effect of birefringent material on polarized light
   d. Generate circularly polarized light
11. Investigate Radiometry and Photometry
   a. Perform optical power measurements
   b. Perform irradiance measurements
   c. Use photoelectric power meters
   d. Perform ambient light suppression
   e. Use attenuators
   f. Perform wavelength calibration
   g. Use radiometric filters
   h. Use photometric filters
   i. Use disc calorimeters

C. PRACTICE LASER SAFETY

1. Discuss Laser Safety Basics
2. Discuss Laser Hazards including:
   a. Eye hazards
   b. Skin hazards
   c. Associated hazards from high power lasers
   d. Viewing laser radiation
   e. Laser hazard evaluation
   f. Control of associated hazards
   g. Typical laser calculations and measurements
3. Study Laser Safety Standards and Hazard Classifications (i.e., ANSI Z136.1 Standards)
4. Investigate Controls for Surveying, Alignment and Leveling Lasers
5. Discuss Eye Protection including:
   a. Selection of eye protection
   b. Limitations of eye protection
   c. Laser goggle testing

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life.

These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. **COMPETENCIES**

A. ***Resources:*** *Identifies, organizes, plans, and allocates resources*

1. follows a schedule to complete assigned tasks on time

B. ***Interpersonal:*** *Works with others*

1. complete assigned responsibilities within the classroom serving as a member of the team
2. provide individual assistance/direction to peers as requested
3. provides professional and courteous service to customers/clients
4. works well with all members of the class

C. ***Information:*** *Acquires and uses information*

1. reads and interprets schematic diagrams and layouts
2. organize and maintain accurate laboratory log books
3. performs laboratory assignments and disseminates results
4. uses computer to analyze and present experimental results

D. ***Systems:*** *Understands complex inter-relationships*

1. understands complex optical systems and interrelated technologies
2. monitors and corrects for flaws and system inaccuracies

E. ***Technology:*** *Works with a variety of technologies*

1. chooses procedure, components, and equipment required to perform specific task
2. applies appropriate procedures and uses appropriate components to produce desired results

II. **FOUNDATION SKILLS**

A. ***Basic Skills:*** *Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*

1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*

a. studies student laboratory manual
b. interprets laboratory procedures and schematics
c. read/studies textbook

2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*

a. outlines steps necessary to produce desired experimental results
b. maintain a lecture notebook
c. submit written responses to chapter question assignments
d. complete all written assignments

3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. applies mathematical operations required to assess experimental results
    b. uses computer to assist in data analysis and reduction
    c. keeps a running computation of individual grade
    d. performs statistical data interpolation
4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
    a. assimilate classroom instruction
    b. interpolate and assimilate video instruction
    c. observe laboratory demonstrations
    d. seek and receive individualized instruction in the classroom
5. *Speaking: Organizes ideas and communicates orally*
    a. participates in classroom discussions
    b. organize ideas and communicate specific questions to the instructor
    c. verbally affirms understanding of a concept, procedure, or required skill
    d. communicates with peers to ensure the smooth and safe operation of the classroom

B. *Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. *Creative Thinking: Generates new ideas*
    a. develops new ideas for problem solving
    b. participates in the "brain storming" process
    c. participates in the group problem solving process
2. *Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. identifies personal goals
    b. identifies actions required to accomplish personal goals
3. *Problem Solving: Recognizes problems and devises and implements plan of action*
    a. makes daily accommodations to stay on schedule
    b. seeks additional instruction/clarification for assignment completion
    c. balances social and academic life/responsibilities
    d. accepts responsibility
4. *Seeing Things In the Mind's Eye: Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. interprets technical drawings
    b. interprets technical illustrations and symbols
    c. understands both written and verbal instructions
    d. assimilates process during instructor demonstrations
5. *Knowing How to Learn: Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. demonstrate mastery of the basic skills and techniques
    b. use these sequential skills to support mastery of new skills

c. understand the sequential nature of acquired skills and the subsequent knowledge application of new skills and techniques

6. *Reasoning: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   a. understands that practice is vital to improving the skill of the student
   b. understands that the quality of the product is a function of the time of the operation and the attitude and skill of the student
   c. understand the complex interaction between optical components

C. *Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
   a. develops an understanding that in order to be successful you must be a "good" student
   b. develops an understanding that a "good" student is the one who is prompt to every class and has prepared for the day's work
   c. develops an understanding good students know what they are going to do in class and does not waste time
   d. develops a fine work-ethic
2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
   a. learns to take pride in his or her work through positive reinforcement
   b. sees himself or herself as an asset to the class through continued contributions to the group and a shared common goal
   c. understands that an individual with a positive attitude and the belief in their own abilities will systematically seek solutions and be a valuable employee
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   a. assist classmates in improving technical skills
   b. assist students with special needs as a peer mentor
   c. interacts with peers and listens effectively and provides constructive criticism
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. monitors/assesses personal goal progress
   b. maintain a record of academic achievement (individual gradebook)
   c. accept the responsibility for self-management
5. *Integrity/Honesty: Chooses ethical courses of action*
   a. accept the responsibility for own actions
   b. exhibit personal honesty at all times
   c. accept the challenge of doing your own work in the classroom, during examination, and on outside assignments
   d. understand the consequences of unethical behaviors

Appropriate Reference Materials:

1. ANSI-Z136.1, "Safe use of Lasers"
2. Laser Institute of America (LIA) "Introduction to Laser Safety and Laser Hazards - Video Training Module"

VN594
06/081196

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

LASER SAFETY

MAST PROGRAM
COURSE SYLLABUS
LASER SAFETY

Lecture hours/week: 1 **Lab hours/week: 0** **Credit hours: 1**

COURSE DESCRIPTION:

This course is for students in the Laser Machining Technology program. The basic theory of laser operation is presented. With the emphasis on industrial lasers (i.e., higher-power models), various types of lasers and their different uses and applications are covered. Also, the various types of hazards encountered in the use of lasers and the present government safety regulations are discussed.

PREREQUISITES: NONE

REQUIRED COURSE MATERIALS:

Textbook: Laser Safety Guide, by the LIA, Ninth Edition

Supplementary Materials: Instructor Handouts

METHOD OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, handouts, and demonstrations.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The objective of this course is to introduce the Laser Machining student to the potential hazards of lasers and equipment which uses laser light in its operation, as well as to familiarize the student with the various government regulations concerning laser safety and hence the proper and safe operation of lasers. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. become familiar with basic laser operation
2. become familiar with the various types of lasers with emphasis on those with industrial applications
3. become familiar with the various classifications of lasers
4. become familiar with the present government safety rules, specifically, ANSI Z136.1 (1993), regarding laser operation
5. become familiar with the various types of laser safety eye wear available
6. satisfactorily perform on written, oral, and practical examinations
7. contribute to class discussions
8. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Introduction and Theory of Laser Operation		
Types of Lasers and Laser Hazards		
Laser Characteristics and Classes of Lasers		
Laser Safety Standards		
Eye Protection and Hazard Evaluation		
Laser Calculations and Measurements		
ANSI Z136.1 (1993) Standards		
FINAL EXAM		
	Total Lecture Hours	**15**

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

After the successful completion of this course, the student will be able to:

A. APPLY MATHEMATICAL CONCEPTS
1. Perform Basic Math Functions
   a. Use and manipulate fractions
   b. Use and manipulate decimals
   c. Calculate percentages
   d. Calculate units of length, area, and volume
   e. Convert between S.I. (metric) and English (inch) units
   f. Use a scientific calculator
2. Perform Algebraic Functions
   a. Identify equations with one unknown
   b. Solve algebraic equations by isolation of the unknown
   c. Identify equations with fractions
   d. Solve equations by cross multiplying
   e. Identify and solve linear equations
   f. Calculate the slope of a line
3. Study Exponents and Right Triangle Geometry
   a. Apply the laws of exponents
   b. Calculate exponentials and roots
   c. Analyze right triangles
   d. Use Pythagorean Theorem
4. Study Elements of Plane and Solid Geometry
   a. Calculate the area and circumference of a circle
   b. Determine angular measurements (degrees and radians)
   c. Establish a tangent to a circle
   d. Analyze parallel lines, transverse lines, and angles
   e. Perform the bisection of an angle
   f. Calculate the sum of the interior angles of a polygon
   g. Calculate the area of a triangle and irregular shapes
   h. Analyze trapezoids
5. Perform Data Evaluation and Statistical Analysis

a. Analyze and plot data
b. Create graphs (line, bar, and pie)
c. Calculate mean, normal, and standard deviation
6. Perform Proportioning and Interpolation
a. Calculate ratios and proportions
b. Calculate direct, inverse, and combined variations
c. Calculate constants of proportionality
d. Perform tabular interpolation
7. Perform Basic Trigonometric Functions
a. Calculate the trigonometric functions of sine, cosine, and tangent
b. Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
c. Solve a right triangle
8. Investigate Vectors and Vector Systems
a. Analyze components of vectors
b. Perform vector addition
c. Perform vector combination
9. Investigate the Cartesian Coordinate System
a. Study the X-Y coordinate system
b. Study the X-Y-Z coordinate system
c. Calculate the slope of a line in the Cartesian coordinate system

B. INVESTIGATE FUNDAMENTALS OF INDUSTRIAL ELECTRONICS & CONTROL

1. Perform Voltage, Current, Resistance and Power Measurements
a. Study Ohm's law and power and energy
b. Analyze series, parallel and series-parallel circuits
c. Study alternating current and voltage
d. Study capacitors, inductors and transformers
e. Analyze RC, RL and RLC circuits
2. Investigate Fundamentals of Analog Active Devices
a. Study semiconductor theory
b. Analyze diodes and applications
c. Analyze transistor circuits
d. Analyze power supply circuits

C. APPLY CONCEPTS OF MODERN OPTICS

1. Study Reflection at Plane and Spherical Surfaces
a. Demonstrate the law of reflection
b. Demonstrate ray tracing at a plane reflecting surface
c. Demonstrate ray tracing at a spherical reflecting surface
2. Study Refraction at Plane Surfaces
a. Demonstrate refraction of light at a dielectric interface
3. Study Refraction at Spherical Surfaces
a. Demonstrate refraction at plane surfaces
b. Demonstrate refraction at spherical surfaces
4. Perform Imaging with a Single Lens
a. Determine focal points and focal lengths in positive thin lenses
b. Demonstrate image formation in positive thin lenses
c. Determine focal points and focal lengths in negative thin lenses

        d. Demonstrate image formation in negative thin lenses
5. Perform Imaging with Multiple Thin Lenses
    a. Set up and demonstrate two converging lenses
    b. Set up and demonstrate a converging and diverging lens
6. Study F-Stops and Apertures
    a. Define field stops and aperture stops
    b. Define entrance and exit pupils
7. Study Optical Systems
    a. Set up and demonstrate astronomical (Keplarian) telescopes
    b. Set up and demonstrate Galilean telescopes
    c. Set up and demonstrate beam-expanding collimators
8. Study Interference
    a. Set up and demonstrate Young's double slit interference
    b. Demonstrate thin film interference
    c. Determine surface flatness by interference
9. Study Diffraction
    a. Demonstrate Fraunhofer (far field) diffraction
    b. Demonstrate Fresnel (near field) diffraction
    c. Determine the limit of resolution of an optical instrument
    d. Measure beam divergence and spot size
    e. Use diffraction gratings
    f. Discuss light scattering
10. Study Polarization
    a. Determine unknown polarization of light
    b. Generate linearly polarized light
    c. Study the effect of birefringent material on polarized light
    d. Generate circularly polarized light
11. Investigate Radiometry and Photometry
    a. Perform optical power measurements
    b. Perform irradiance measurements
    c. Use photoelectric power meters
    d. Perform ambient light suppression
    e. Use attenuators
    f. Perform wavelength calibration
    g. Use radiometric filters
    h. Use photometric filters
    i. Use disc calorimeters

D. INVESTIGATE INDUSTRIAL LASER SYSTEMS

1. Study Characteristics of Light
    a. Study the general description of light waves
    b. Discuss monochromaticity
    c. Study directionality, coherence and polarization
2. Understand Basic Laser Principles
    a. Discuss optical radiation processes with emphasis on the amplification process
    b. Discuss optical feedback
    c. Discuss optical selection rules, transition lifetimes

d. Study Einstein relations, gain coefficients, three-and-four level pumping systems, and threshold and resonator stability

3. Study Laser Output Characteristics
   a. Discuss active mediums, population inversion and optical
   b. Determine the temporal, spatial, and spectral characteristics of the device
   c. Study line broadening mechanisms, axial and transverse modes
   d. Study pump rate, gain saturation, and power output
4. Investigate Output Modification
   a. Study methods used to modify the spatial and spectral characteristics of a variety of laser systems
5. Apply Safety and Laboratory Procedures
   a. Study proper laboratory practice
   b. Demonstrate safety practices
   c. Keep proper lab records
6. Perform a Laser Exposition
   a. Discuss characteristics and components of commercial lasers
   b. Study Ruby, ND: YAG and other solid state lasers
   c. Study gas, dye, and semiconductor lasers
7. Perform Laser Alignment, Gauging, and Inspection
   a. Study laser scanning techniques
   b. Perform optical alignment and optical triangulation
   c. Discuss the principles of optical detection
   d. Study Charge-Coupled Devices (CCD)
8. Investigate the Interaction of High Power Laser Beam with Materials
   a. Study laser-optics and beam characteristics
   b. Discuss Transverse Electromagnetic Modes (TEM)
   c. Calculate spot size and power density
   d. Measure reflectivity and absorption of laser energy
   e. Study thermal diffusivity and thermal time constants
9. Perform Laser Welding and Surface Treatment
   a. Study beam delivery optics
   b. Study the procedure of laser welding
10. Perform Laser Material Removal
    a. Study Laser-Supported Absorption (LSA)

E. PRACTICE LASER SAFETY

1. Discuss Laser Safety Basics
2. Discuss Laser Hazards including:
   a. Eye hazards
   b. Skin hazards
   c. Associated hazards from high power lasers
   d. Viewing laser radiation
   e. Laser hazard evaluation
   f. Control of associated hazards
   g. Typical laser calculations and measurements
3. Study Laser Safety Standards and Hazard Classifications (i.e., ANSI Z136.1 Standards)
4. Investigate Controls for Surveying, Alignment and Leveling Lasers
5. Discuss Eye Protection including:

a. Selection of eye protection
b. Limitations of eye protection
c. Laser goggle testing

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES
   A. Resources: Identifies, organizes, plans, and allocates resources
      1. follows a schedule to complete assigned tasks on time
   B. Interpersonal: Works with others
      1. complete assigned responsibilities within the classroom serving as a member of the team
      2. provide individual assistance/direction to peers as requested
      3. provides professional and courteous service to customers/clients
      4. works well with all members of the class
   C. Information: Acquires and uses information
      1. reads and interprets schematic diagrams and layouts
      2. organize and maintain accurate laboratory log books
      3. performs laboratory assignments and disseminates results
      4. uses computer to analyze and present experimental results
   D. Systems: Understands complex inter-relationships
      1. understands complex optical systems and interrelated technologies
      2. monitors and corrects for flaws and system inaccuracies
   E. Technology: Works with a variety of technologies
      1. chooses procedure, components, and equipment required to perform specific task
      2. applies appropriate procedures and uses appropriate components to produce desired results

II. FOUNDATION SKILLS
   A. Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks.
      1. Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules
         a. studies student laboratory manual
         b. interprets laboratory procedures and schematics

c. read/studies textbook

2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. outlines steps necessary to produce desired experimental results
   b. maintain a lecture notebook
   c. submit written responses to chapter question assignments
   d. complete all written assignments
3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. applies mathematical operations required to assess experimental results
   b. uses computer to assist in data analysis and reduction
   c. keeps a running computation of individual grade
   d. performs statistical data interpolation
4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
   a. assimilate classroom instruction
   b. interpolate and assimilate video instruction
   c. observe laboratory demonstrations
   d. seek and receive individualized instruction in the classroom
5. *Speaking: Organizes ideas and communicates orally*
   a. participates in classroom discussions
   b. organize ideas and communicate specific questions to the instructor
   c. verbally affirms understanding of a concept, procedure, or required skill
   d. communicates with peers to ensure the smooth and safe operation of the classroom

B. *Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. *Creative Thinking: Generates new ideas*
   a. develops new ideas for problem solving
   b. participates in the "brain storming" process
   c. participates in the group problem solving process
2. *Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   a. identifies personal goals
   b. identifies actions required to accomplish personal goals
3. *Problem Solving: Recognizes problems and devises and implements plan of action*
   a. makes daily accommodations to stay on schedule
   b. seeks additional instruction/clarification for assignment completion
   c. balances social and academic life/responsibilities
   d. accepts responsibility
4. *Seeing Things In the Mind's Eye: Organizes, and processes symbols, pictures, graphs, objects, and other information*
   a. interprets technical drawings

b. interprets technical illustrations and symbols
c. understands both written and verbal instructions
d. assimilates process during instructor demonstrations

5. *Knowing How to Learn: Use efficient learning techniques to acquire and apply new knowledge and skills*
   a. demonstrate mastery of the basic skills and techniques
   b. use these sequential skills to support mastery of new skills
   c. understand the sequential nature of acquired skills and the subsequent knowledge application of new skills and techniques
6. *Reasoning: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   a. understands that practice is vital to improving the skill of the student
   b. understands that the quality of the product is a function of the time of the operation and the attitude and skill of the student
   c. understand the complex interaction between optical components

C. *Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
   a. develops an understanding that in order to be successful you must be a "good" student
   b. develops an understanding that a "good" student is the one who is prompt to every class and has prepared for the day's work
   c. develops an understanding good students know what they are going to do in class and does not waste time
   d. develops a fine work-ethic
2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
   a. learns to take pride in his or her work through positive reinforcement
   b. sees himself or herself as an asset to the class through continued contributions to the group and a shared common goal
   c. understands that an individual with a positive attitude and the belief in their own abilities will systematically seek solutions and be a valuable employee
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   a. assist classmates in improving technical skills
   b. assist students with special needs as a peer mentor
   c. interacts with peers and listens effectively and provides constructive criticism
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. monitors/assesses personal goal progress
   b. maintain a record of academic achievement (individual gradebook)
   c. accept the responsibility for self-management
5. *Integrity/Honesty: Chooses ethical courses of action*

a. accept the responsibility for own actions
b. exhibit personal honesty at all times
c. accept the challenge of doing your own work in the classroom, during examination, and on outside assignments
d. understand the consequences of unethical behaviors

Appropriate Reference Materials:

1. Safe Use of Lasers, ANSI-Z136.1,
2. Introduction to Laser Safety and Laser Hazards - Video Training Module, Laser Institute of America (LIA)
3. Guide to the Selection of Laser Eye Protection by LIA, Third Edition
4. Industrial Lasers and Their Applications, Luxon and Parker, Latest Edition, Prentice-Hall

VN593
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*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

INDUSTRIAL LASER SYSTEMS

MAST PROGRAM
COURSE SYLLABUS
INDUSTRIAL LASER SYSTEMS

Lecture hours/week: 3 **Lab hours/week: 3** **Credit hours: 4**

COURSE DESCRIPTION:

This course will provide the student with a basic understanding of industrial lasers, applications, and systems. Course material will include the study of spontaneous and stimulated emission, laser output characteristics and modification, materials, laser safety, laser components, survey of laser types, and industrial laser applications. Among the laser systems to be studied will be gas lasers, semiconductor lasers, solid state lasers, ion lasers, molecular and dye lasers, excimer lasers, free electron lasers, and others. Among the many different uses of lasers to be studied will be laser welding and surface treatment, material removal, laser marking and etching, non-destructive testing, distance measurement, lasers in medicine and surgery, lasers in construction, spectroscopy, communications and others. Classroom lectures will be supplemented with experimental and video demonstrations. Lab included.

PREREQUISITES: Senior standing in Laser Electro-Optics Technology or permission of the instructor

REQUIRED COURSE MATERIALS:

Textbook: Industrial Lasers and Their Applications, Luxon/Parker, Prentice Hall
Lab Manual: Notebook

Supplementary Materials: Instructor's Notes and Handouts

METHOD OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, handouts, and demonstrations.

Laboratory: Laboratory will be a "hands-on" process.

Method of Evaluation: A student's grade will be based on multiple measures of performance. Upon completion of the course, the student should be familiar with the basic workings of an industrial laser system and its inherent advantages and limitations. The student will understand various applications of industrial laser systems. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. understand basic characteristics of light including directionality, coherence properties, polarization, and monochromaticity
2. understand basic laser principles.
3. understand laser output characteristics

4. understand laser output modification techniques
5. apply proper laboratory safety procedures
6. understand a broad range of laser and laser systems
7. perform laser alignment, guaging and inspection
8. understand holography and its applications
9. understand the interaction of high energy laser beams with various materials
10. understand laser welding and surface treatment
11. understand laser material removal
12. satisfactorily perform on written, oral, and practical examinations
13. contribute to class discussions
14. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Characteristics of Light		
-General Description of Light Waves		
-Understand Monochromaticity		
-Understand Directionality, Coherence and Polarization		
Basic Laser Principles		
-Optical Radiation Processes with Emphasis on the Amplification Process		
-Understand Optical Feedback		
-Discussion of Optical Selection Rules, Transition Lifetimes		
-Understand Einstein Relations, Gain Coefficients Three-and-Four Level Pumping Systems, and Threshold and Resonator Stability		
Laser Output Characteristics		
-Discussion of the Active Medium, Population Inversion And Optical Feedback Determine the Temporal, Spatial, and Spectral Characteristics of the Device		
-Understand Line Broadening Mechanisms, Axial and Transverse Modes		
-Understand Pump Rate, Gain Saturation, and Power Output		
Output Modification		
-Discussion on Methods Used to Modify the Spatial and		

Spectral Characteristics of
a Variety of Laser Systems
-Understand Q-Switching
-Understand Electro-Optic Modulation
and Acousto-Optic Modulation

Safety and Laboratory Procedures
-Discussion of Proper Laboratory Practice
-Live Demonstrations of Practices

A Laser Exposition
-General Description of Characteristics
and Component of Commercial
Lasers
-Understand Ruby, Nd: YAG and Other
Solid State Lasers
-Understand Gas, Dye, and Semiconductor
Lasers

Laser Alignment, Gauging, and Inspection
-Discussion of Laser Scanning Techniques
-Understand Optical Alignment and Optical
Triangulation
-Understand the Principles of Optical
Detection
-General Treatment of Charge-Coupled
Devices (CCD)

**Holography and Applications:
Non-Destructive Testing**
-General Discussion of Light Wave
Interference
-Understand the Principles of Holographic
Non-Destructive Testing (HNDT)
-Understand the Set-Up and Operation of
Holographic Recording System
-Understand the Set-Up and Operation
of HNDT

**Interaction of High Power Laser Beam
With Materials**
-Understand Laser-Optics and Beam
Characteristics
-Discussion of Transverse Electromagnetic
Modes (TEM)
-Understand Spot Size and Power Density
-Understand Reflectivity and Absorption
of Laser Energy
-Discussion of Thermal Diffusivity and
Thermal Time Constants

Laser Welding and Surface Treatment
-Discussion of Beam Delivery Optics
-Understand the Procedure of Laser

Welding
-Understand Pulsed and Continuous-
Wave (CW) Laser Welding
Laser Material Removal
-Discussion of Laser-Supported
Absorption (LSA)
-Understand Laser Drilling
-Understand Laser Cutting
Miscellaneous Applications
-Discussion of Spectroscopy
-Discussion of Spectroscopic Systems
Final Exam

Total Lecture Hours **45**

LAB OUTLINE:

Lab Topics	Contact Hrs.
Alignment Procedures	3
Divergence, Beam-Collimation, and Spatial-Filtering	3
Absorption and Reflection Measurements	3
Power and Energy Measurements	3
CW and Pulsed Power Supply Design & Test	6
Alignment and Operation of an Argon Laser System	6
Alignment and Operation of a CW Nd:YAG Laser System	6
Alignment and Operation of a CW CO_2 Laser System	6
Operation of a GaAs Semiconductor Diode Laser	3
Alignment and Operation of a CW Nd:YAG Laser System	6
Total Lab Hours	**45**

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

After the successful completion of this course the student will be able to:

A. **APPLY MATHEMATICAL CONCEPTS**
1. Perform Basic Math Functions
   a. Use and manipulate fractions
   b. Use and manipulate decimals
   c. Calculate percentages
   d. Calculate units of length, area, and volume
   e. Convert between S.I. (metric) and English (inch) units
   f. Use a scientific calculator
2. Perform Algebraic Functions
   a. Identify equations with one unknown
   b. Solve algebraic equations by isolation of the unknown
   c. Identify equations with fractions
   d. Solve equations by cross multiplying
   e. Identify and solve linear equations
   f. Calculate the slope of a line

3. Study Exponents and Right Triangle Geometry
    a. Apply the laws of exponents
    b. Calculate exponentials and roots
    c. Analyze right triangles
    d. Use Pythagorean Theorem
4. Study Elements of Plane and Solid Geometry
    a. Calculate the area and circumference of a circle
    b. Determine angular measurements (degrees and radians)
    c. Establish a tangent to a circle
    d. Analyze parallel lines, transverse lines, and angles
    e. Perform the bisection of an angle
    f. Calculate the sum of the interior angles of a polygon
    g. Calculate the area of a triangle and irregular shapes
    h. Analyze trapezoids
5. Perform Data Evaluation and Statistical Analysis
    a. Analyze and plot data
    b. Create graphs (line, bar, and pie)
    c. Calculate mean, normal, and standard deviation
6. Perform Proportioning and Interpolation
    a. Calculate ratios and proportions
    b. Calculate direct, inverse, and combined variations
    c. Calculate constants of proportionality
    d. Perform tabular interpolation
7. Perform Basic Trigonometric Functions
    a. Calculate the trigonometric functions of sine, cosine, and tangent
    b. Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
    c. Solve a right triangle
8. Investigate Vectors and Vector Systems
    a. Analyze components of vectors
    b. Perform vector addition
    c. Perform vector combination
9. Investigate the Cartesian Coordinate System
    a. Study the X-Y coordinate system
    b. Study the X-Y-Z coordinate system
    c. Calculate the slope of a line in the Cartesian coordinate system

B. INVESTIGATE FUNDAMENTALS OF INDUSTRIAL ELECTRONICS & CONTROL

1. Perform Voltage, Current, Resistance and Power Measurements
    a. Study Ohm's law and power and energy
    b. Analyze series, parallel and series-parallel circuits
    c. Study alternating current and voltage
    d. Study capacitors, inductors and transformers
    e. Analyze RC, RL and RLC circuits
2. Investigate Fundamentals of Analog Active Devices
    a. Study semiconductor theory
    b. Analyze diodes and applications
    c. Analyze transistor circuits

d. Analyze power supply circuits

3. Investigate Fundamentals of Digital Logic Circuitry
   a. Study number systems and codes
   b. Analyze logic gates, boolean algebra and combinational logic circuits
   c. Analyze flip-flops, arithmetic operations and circuits
   d. Analyze counters, registers and memory
   e. Study IC's and MSI logic circuits
   f. Perform interfacing with A/D and D/A circuits
   g. Study microprocessors, micro controllers and microcomputers
4. Investigate Operational Amplifiers for Industrial Applications
   a. Study comparator applications
   b. Study summing amplifier applications
   c. Study integrator and differentiator applications
   d. Study current to voltage converter applications
   e. Study voltage to current converter applications
   f. Study constant current source applications
5. Investigate Linear IC's for Industrial Applications
   a. Study voltage regulation
   b. Study basic series regulators
   c. Study basic switching regulators
   d. Study instrumentation amplifiers
   e. Study isolation amplifiers
   f. Study oscillators
   g. Study 555 timers
   h. Study angle measurement circuits
   i. Study temperature measurement circuits
   j. Study strain and pressure measuring circuits
6. Investigate Electric Motors
   a. Study wound-field DC motors and generators
   b. Study brushless and stepper DC motors
   c. Study AC motors
7. Study Industrial Control Systems
   a. Analyze motor control circuits
   b. Analyze RMS to DC converters
   c. Discuss industrial telemetry and data communications
   d. Discuss modulation techniques
   e. Use programmable controllers
   f. Perform sequential process control
   g. Perform statistical process control

C. APPLY CONCEPTS OF MODERN OPTICS

1. Study Reflection at Plane and Spherical Surfaces
   a. Demonstrate the law of reflection
   b. Demonstrate ray tracing at a plane reflecting surface
   c. Demonstrate ray tracing at a spherical reflecting surface
2. Study Refraction at Plane Surfaces
   a. Demonstrate refraction of light at a dielectric interface
3. Study Refraction at Spherical Surfaces
   a. Demonstrate refraction at plane surfaces

b. Demonstrate refraction at spherical surfaces

4. Perform Imaging with a Single Lens
    a. Determine focal points and focal lengths in positive thin lenses
    b. Demonstrate image formation with a positive thin lens
    c. Determine focal points and focal lengths in negative thin lenses
    d. Demonstrate image formation with a negative thin lens
5. Perform Imaging with Multiple Thin Lenses
    a. Set up and demonstrate two converging lenses
    b. Set up and demonstrate a converging and diverging lens
6. Study F-Stops & Apertures
    a. Define field stops and aperture stops
    b. Define entrance and exit pupils
7 Study Optical Systems
    a. Set-up and demonstrate astronomical (keplerian)telescopes
    b. Set-up and demonstrate galilean telescopes
    c. Set-up and demonstrate beam-expanding collimators
8 Study Interference
    a. Set-up and demonstrate Young's double slit interference
    b. Demonstrate thin film interference
    c. Determine surface flatness by interference
9 Study Diffraction
    a. Demonstrate Fraunhofer (Far Field) Interference
    b. Demonstrate Fresnel (Near Field) Interference
    c. Determine the limit of resolution of an optical instrument
    d. Measure beam divergence and spot size
    e. Use diffraction gratings
    f. Discuss light scattering
10 Study Polarization
    a. Determine unknown polarization of light
    b. Generate linearly polarized light
    c. Study the effect of birefringent materials on polarized light
    d. Generate circularly polarized light
11. Investigate Radiometry & Photometry
    a. Perform optical power measurements
    b. Perform irradiance measurements
    c. Use photoelectric power meters
    d. Perform ambient light suppression
    e. Use attenuators
    f. Perform wavelength calibration
    g. Use radiometric filters
    h. Use photometric filters
    i. Use disc calorimeters

D. INVESTIGATE INDUSTRIAL LASER SYSTEMS

1. Study Characteristics of Light
    a. Study the general description of light waves
    b. Discuss monochromaticity
    c. Study directionality, coherence and polarization
2. Understand Basic Laser Principles

a. Discuss optical radiation processes with emphasis on the amplification process
b. Discuss optical feedback
c. Discuss optical selection rules, transition lifetimes
d. Study Einstein relations, gain coefficients, three-and-four level pumping systems, and threshold and resonator stability

3. Study Laser Output Characteristics
   a. Discuss active mediums, population inversion and optical feedback
   b. Determine the temporal, spatial, and spectral characteristics of the device
   c. Study line broadening mechanisms, axial and transverse modes
   d. Study pump rate, gain saturation, and power output
4. Investigate Output Modification
   a. Study methods used to modify the spatial and spectral characteristics of a variety of laser systems
5. Apply Safety and Laboratory Procedures
   a. Study proper laboratory practice
   b. Demonstrate safety practices
   c. Keep proper lab records
6. Perform a Laser Exposition
   a. Discuss characteristics and components of commercial lasers
   b. Study Ruby, ND: YAG and other solid state lasers
   c. Study gas, dye, and semiconductor lasers
7. Perform Laser Alignment, Gauging, and Inspection
   a. Study laser scanning techniques
   b. Perform optical alignment and optical triangulation
   c. Discuss the principles of optical detection
   d. Study Charge-Coupled Devices (CCD)
8. Investigate Holography and Applications: Non-Destructive Testing
   a. Study coherent light wave interference
   b. Discuss the principles of Holographic Non-Destructive Testing (HNDT)
9. Investigate the Interaction of High Power Laser Beam with Materials
   a. Study laser-optics and beam characteristics
   b. Discuss Transverse Electromagnetic Modes (TEM)
   c. Calculate spot size and power density
   d. Measure reflectivity and absorption of laser energy
   e. Study thermal diffusivity and thermal time constants
10. Perform Laser Welding and Surface Treatment
    a. Study beam delivery optics
    b. Study the procedure of laser welding
    c. Perform pulsed and continuous-wave (CW) laser welding
11. Perform Laser Material Removal
    a. Study Laser-Supported Absorption (LSA)
    b. Perform laser drilling
    c. Perform laser cutting

E. PERFORM LASER MATERIALS PROCESSING

1. Understand Basics of Laser Heating
   a. Investigate properties of materials
      (1) Study optical properties including:

(a) Transmission
(b) Absorption
(c) Reflection
(d) Scattering

(2) Study mechanical properties including:
(a) Hardness
(b) Tribology
(c) Strength
(d) Heat treatments

(3) Study electrical properties including:
(a) Metallic
(b) Dielectric
i. Ceramic
ii. Polymer
iii. Glass

(4) Study thermal properties including:
(a) Heat capacity
(b) Thermal conductivity
(c) Thermal expansion

2. Investigate the Effects of Laser Irradiation on Materials including:
a. Melting
b. Vaporization
c. Ablation
d. Dehydration
e. Removal method
f. Mechanism of reaction

3. Study Lasers as Machine Tools including:
a. C.W. vs. pulsed
b. Energy balance
c. Factors affecting removal rate
d. Beam direction and deflection
e. Tip design
f. Focused vs. non-focused
g. Wavelength/power of laser

4. Demonstrate Machine Operations including:
a. Drilling
b. Cutting
c. Surface modification
d. Embossing
e. Marking
f. Texturing
g. Hardening
h. Annealing
i. Welding

5. Study Hazards and Safety including:
a. Skin
b. Eye
c. Electrical shocks

d. Fire threats
e. Toxic fume production
f. Unprotected wiring and tubing
g. Water spills
h. Warning signs
i. Safety glasses
j. Interlocks
k. ANSI Z-136 and Maximum Permissible Exposure
l. Saving sight by managing light

F. **PRACTICE LASER SAFETY**
1. Discuss Laser Safety Basics
2. Discuss Laser Hazards including:
   a. Eye hazards
   b. Skin hazards
   c. Associated hazards from high power lasers
   d. Viewing laser radiation
   e. Laser hazard evaluation
   f. Control of associated hazards
   g. Typical laser calculations and measurements
3. Study Laser Safety Standards and Hazard Classifications (i.e., ANSI Z136.1 Standards)
4. Investigate Controls for Surveying, Alignment and Leveling Lasers
5. Discuss Eye Protection including:
   a. Selection of eye protection
   b. Limitations of eye protection
   c. Laser goggle testing

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. **COMPETENCIES**

A. *Resources: Identifies, organizes, plans, and allocates resources*
1. follows a schedule to complete assigned tasks on time

B. *Interpersonal: Works with others*
1. complete assigned responsibilities within the classroom serving as a member of the team
2. provide individual assistance/direction to peers as requested

3. provides professional and courteous service to customers/clients
4. works well with all members of the class

C. *Information: Acquires and uses information*
1. reads and interprets schematic diagrams and layouts
2. organize and maintain accurate laboratory log books
3. performs laboratory assignments and disseminates results
4. uses computer to analyze and present experimental results

D. *Systems: Understands complex inter-relationships*
1. understands complex laser and optical systems and interrelated technologies
2. monitors and corrects for flaws and system inaccuracies

E. *Technology: Works with a variety of technologies*
1. chooses procedure, components, and equipment required to perform specific task
2. applies appropriate procedures and uses appropriate components to produce desired results

II. FOUNDATION SKILLS

A. *Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*

1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
   a. studies student laboratory manual
   b. interprets laboratory procedures and schematics
   c. read/studies textbook
2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. outlines steps necessary to produce desired experimental results
   b. maintain a lecture notebook
   c. submit written responses to chapter question assignments
   d. complete all written assignments
3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. applies mathematical operations required to assess experimental results
   b. uses computer to assist in data analysis and reduction
   c. keeps a running computation of individual grade
   d. performs statistical data interpolation
4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
   a. assimilate classroom instruction
   b. interpolate and assimilate video instruction
   c. observe laboratory demonstrations
   d. seek and receive individualized instruction in the classroom
5. *Speaking: Organizes ideas and communicates orally*
   a. participates in classroom discussions

b. organize ideas and communicate specific questions to the instructor
c. verbally affirms understanding of a concept, procedure, or required skill
d. communicates with peers to ensure the smooth and safe operation of the classroom

B. *Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. *Creative Thinking: Generates new ideas*
   a. develops new ideas for problem solving
   b. participates in the "brain storming" process
   c. participates in the group problem solving process
2. *Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   a. identifies personal goals
   b. identifies actions required to accomplish personal goals
3. *Problem Solving: Recognizes problems and devises and implements plan of action*
   a. makes daily accommodations to stay on schedule
   b. seeks additional instruction/clarification for assignment completion
   c. balances social and academic life/responsibilities
   d. accepts responsibility
4. *Seeing Things In the Mind's Eye: Organizes, and processes symbols, pictures, graphs, objects, and other information*
   a. interprets technical drawings
   b. interprets technical illustrations and symbols
   c. understands both written and verbal instructions
   d. assimilates process during instructor demonstrations
5. *Knowing How to Learn: Use efficient learning techniques to acquire and apply new knowledge and skills*
   a. demonstrate mastery of the basic skills and techniques
   b. use these sequential skills to support mastery of new skills
   c. understand the sequential nature of acquired skills and the subsequent knowledge application of new skills and techniques
6. *Reasoning: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   a. understands that practice is vital to improving the skill of the student
   b. understands that the quality of the product is a function of the time of the operation and the attitude and skill of the student
   c. understand the complex interaction between optical components

C. *Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
   a. develops an understanding that in order to be successful you must be a "good" student
   b. develops an understanding that a "good" student is the one who is prompt to every class and has prepared for the day's work

c. develops an understanding good students know what they are going to do in class and does not waste time

d. develops a fine work-ethic

2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*

   a. learns to take pride in his or her work through positive reinforcement

   b. sees himself or herself as an asset to the class through continued contributions to the group and a shared common goal

   c. understands that an individual with a positive attitude and the belief in their own abilities will systematically seek solutions and be a valuable employee

3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*

   a. assist classmates in improving technical skills

   b. assist students with special needs as a peer mentor

   c. interacts with peers and listens effectively and provides constructive criticism

4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*

   a. monitors/assesses personal goal progress

   b. maintain a record of academic achievement (individual grade book)

   c. accept the responsibility for self-management

5. *Integrity/Honesty: Chooses ethical courses of action*

   a. accept the responsibility for own actions

   b. exhibit personal honesty at all times

   c. accept the challenge of doing your own work in the classroom, during examination, and on outside assignments

   d. understand the consequences of unethical behaviors

Appropriate Reference Materials:

1. Industrial Lasers and Their Applications, Luxon and Parker, Latest Edition, Prentice-Hall
2. ANSI Z136.1 (1993) Safe Use of Lasers by ANSI
3. Guide to the Selection of Laser Eye Protection by LIA, Third Edition

VN587
06/081196

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

COMPUTER AIDED MANUFACTURING (CAM)

MAST PROGRAM
COURSE SYLLABUS
COMPUTER-AIDED MANUFACTURING (CAM)

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

In a laboratory setting, CAM 1 explores machining by utilizing a graphical software package (SmartCAM®) to generate part programs for a CNC mill and laser. Following a review of manual part programming, the emphasis of the course is learning to use the CAM software to select tools, enter part geometry, and convert screen graphics into a CNC program. The student then learns how to communicate the program to the machine and manufacture the part. Intensive work is included in editing the graphics to fully utilize the software.

In addition, the student will learn the integration of Computer Aided Design (CAD) with CAM to enhance the understanding of proceeding from the design process through the manufacturing process.

PREREQUISITES: Metal Machining I, CNC Programming, or permission of the instructor

REQUIRED COURSE MATERIALS:

Textbook: None
Lab Manual: None

Supplementary Materials: Instructor Handouts
2 Computer Diskettes (3.5 inch, High Density)

METHOD OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, handouts, and demonstrations.

Laboratory: Laboratory will be a "hands-on" process using the SmartCAM software.

Method of Evaluation: The purpose of this course is to train the student in the utilization of computer generated graphical programs to model and create machine code for manufacturing engineering. The course will begin preparing the student for filling the growing demand for highly skilled technicians or junior level manufacturing engineers in state-of-the-art industrial environments. A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. understand how to create and edit part profiles using CAM software

2. understand how to optimize CNC technology using CAM programming
3. understand how to integrate CAD drawings into CAM files
4. understand how to create families of parts.
5. understand how to manufacture parts using a CNC mill and CNC laser
6. satisfactorily perform on written, oral, and practical examinations
7. contribute to class discussions
8. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Introduction		
- Review of CNC Basics		
- Understand the SmartCAM® Screen Layout		
- Understand How to Change the Screen Layout		
- Understand How CNC and CAM Relate		
CAM Basics		
- Understand Job Plan Creation		
- Understand the File Structure in CAM		
- Understand the Difference Between Tools and Layers		
Setting Up Cutting Tools		
- Understand How to Sequence Elements		
- Understand Tool Offset (OFFSET)		
- Understand Z Axis Positions (Z_LEVEL and PROF_TOP)		
- Understand How to Allow Clearance for Cutting Tools (CLEAR)		
Creating Part Profiles		
- Understand How to Input Lines, Arcs, and Circles		
- Understand How to Trim Profiles (GROUP-TRIM and PROFILE_TRIM)		
- Understand How to Clean Up Disconnected Elements to an Intersection (TRIM_EXTEND)		
- Understand How to Change the View of Part Profile (ZOOM, VIEW_ANGLE, etc.)		
Editing Part Profiles		
- Understand How to Change Tool Properties (PROPERTY_CHG)		
- Understand How to Change Geometry Values (MODIFY)		

- Understand How to Arrange Elements Sequentially (CHAIN)
- Understand How to Use WALL_OFFSET for Roughing Cuts

Editing Part Profiles (continued)
- Understand How to Create Blend Radii
- Understand How to Create Chamfers
- Understand How to Split Elements in Segments
- Understand How to Create Lead In and Out Moves

Advanced Editing of Part Profiles
- Understand How to Move and Copy Elements
- Understand How to Rotate and Rotate Copy Elements
- Understand How to Create Symmetrical Elements Using Mirror

Editing Tool Paths
- Understand How to Change Tool Path Direction (REV_ORDER)
- Understand How to Change the Start of a Profile (PROF_START)
- Understand How to Change the Order of Machining Events (SEQUENCE_MOVE)
- Understand How to Arrange Elements by Tool (TOOL_SORT)

Midterm Exam

Roughing, Drilling and Counterboring
- Understand How to perform face roughing
- Understand How to perform pocket roughing
- Understand How to avoid islands in roughing
- Understand How to Set Up Drills and Counterboring Tools
- Understand the Difference Between Full Depth, Tip Depth, and Spot Diameter

Using Construction Layers in SmartCAM®
- Understand the Use of Layers in Profile Construction
- Understand How to Establish Snap Points Using Layers

- Understand How to Trim Profiles to "Snapable" Configurations

Using User and Machine Events

- Understand How to Create Multiple Hole Patterns Using Line At Angle (LAA)
- Understand How to Create Multiple Hole Patterns Using GRID
- Understand How to Change the Tool Feed Rate (FEED_CHG)

Family of Parts

- Understand the Importance of Macros
- Understand How to Create Variables to Represent Part Geometry
- Understand How to Record a Macro
- Understand How to Edit and Use a Macro

CAD/CAM Integration

- Understand How to Create .DXF Files in AutoCAD®
- Understand the Importance of Layers in AutoCAD®
- Understand How to Perform .DXF File Translation in SmartCAM®

Code Generation

- Understand How a Code Generator Works
- Understand the Machine File (.SMF)
- Understand the Template File (.TMP)
- Understand How to Modify Code Generators

Final Exam

Total Lecture Hours **30**

LAB OUTLINE:

Lab Topics	Contact Hrs.
SmartCAM basics and simply geometry	4
Creating and editing part profiles	5
Advanced creating & editing part profiles	5
Roughing and Machine events	5
Construction Layers	4
Symmetrical Parts	4
Multiple hole drilling	4
Families of parts	5
CAD/CAM integration	5
Code generators	4
Total Lab Hours	**45**

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

After the successful completion of this course the student will be able to:

A. APPLY MATHEMATICAL CONCEPTS
   1. Perform Basic Math Functions
      a. Use and manipulate fractions
      b. Use and manipulate decimals
      c. Calculate percentages
      d. Calculate units of length, area, and volume
      e. Convert between S.I. (metric) and English (inch) units
      f. Use a scientific calculator
   2. Study Exponents and Right Triangle Geometry
      a. Apply the laws of exponents
      b. Calculate exponentials and roots
      c. Analyze right triangles
      d. Use Pythagorean Theorem
   3. Study Elements of Plane and Solid Geometry
      a. Calculate the area and circumference of a circle
      b. Determine angular measurements (degrees and radians)
      c. Establish a tangent to a circle
      d. Analyze parallel lines, transverse lines, and angles
      e. Perform the bisection of an angle
      f. Calculate the sum of the interior angles of a polygon
      g. Calculate the area of a triangle and irregular shapes
      h. Analyze trapezoids
   4. Perform Basic Trigonometric Functions
      a. Calculate the trigonometric functions of sine, cosine, and tangent
      b. Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
      c. Solve a right triangle
   5. Investigate the Cartesian Coordinate System
      a. Study the X-Y coordinate system
      b. Study the X-Y-Z coordinate system
      c. Calculate the slope of a line in the Cartesian coordinate system

B. PERFORM CNC PROGRAMMING
   1. Apply Machine Specific (Milling and Lasers) Nomenclature and Terminology
      a. Study machine specifications
      b. Start up the machine
      c. Study the machine's keyboard and function keys
      d. Establish radius offsets
      e. Study programming basics at the MCU (machine control unit)
      f. Prove out a program
      g. Load and run a part program
   2. Investigate the Cartesian Coordinate System as Applied to Milling and Laser Machines
      a. Study the Cartesian coordinate system
      b. Study the basics of a coordinate measurement system

c. Plot points in an XYZ coordinate system
d. Set (G90) and program in absolute coordinates
e. Set (G91) and program in incremental coordinates

3. Apply CNC Programming Language
   a. Study word-address and variable block formats
   b. Study standard programming formats such as FANUC
   c. Study the concept of model addresses
4. Perform Start Up, Tool Changing, and Ending of Programs
   a. Zero the machine to the part
   b. Close the shutter, Z axis retract, and gas off (lasers)(M61)
5. Perform Positioning and Basic Drilling
   a. Start and stop the spindle (M03 and M05)
   b. Initiate the drilling cycle (G81)
   c. Program using the "R" level to avoid obstructions
   d. Cancel the drilling cycle (G80)
6. Perform Contouring
   a. Initiate rapid traverse (G00)
   b. Perform linear cutting (G01)
7. Apply Tool Radius Compensation (Cutter Comp)
   a. Study the purpose and application of tool radius compensation
   b. Turn on cutter comp left (G41)
   c. Turn on cutter comp right (G41)
   d. Cancel cutter comp (G40)
8. Perform Programming Preparation
   a. Identify programming planning steps
   b. Set beam size and power (laser applications)
   c. Determine cutting depth or penetration
   d. Determine cutting speed and feed
   e. Determine and design jigs and fixtures for part holding
9. Apply Special Laser Coding Parameters
   a. Select assist gas-oxygen low (M63)
   b. Select assist gas-oxygen high (M64)
   c. Select assist gas-Nitrogen (M65)
   d. Select assist gas-Air (M67)
   e. Turn on and cancel selected assist gas (M68, M69, M70)
   f. Set continuous wave (M90), gated pulsing (M91), super pulsing (M92), and hyper pulsing (M93)

C. **INVESTIGATE INDUSTRIAL LASER SYSTEMS**

1. Perform Laser Material Removal
   a. Study Laser-Supported Absorption (LSA)
   b. Perform laser drilling
   c. Perform laser cutting

D. **PERFORM COMPUTER AIDED DRAFTING (CAD)**

NOTE: () indicates an AutoCAD® command. AutoCAD® is being used as a typical CAD system

1. Understand PC Basics
   a. Discuss hardware and software basics
   b. Study DOS and Windows operating systems

c. Discuss directory structure
d. Manipulate and manage files

2. Discuss CAD Basics and File Management
   a. Save files in CAD (SAVE, SAVE AS, AUTOSAVE)
   b. Study drawing editor, menu structure
   c. Perform basic DRAW commands (LINE, CIRCLE)
   d. Study how to enter new points (coordinate entry)
   e. Perform basic EDIT command (ERASE)
3. Use Drawing Settings
   a. Perform drawing sheet set-up (LIMITS, UNITS, GRID)
   b. Study methods for cursor movement control (ORTHO, SNAP, DDRMODES)
4. Perform Basic Editing Commands
   a. Perform modifications and changes to objects on screen (COPY, MOVE, FILLET, CHAMFER)
   b. Discuss how to group objects for editing (WINDOW, CROSSING, REMOVE, ADD, PREVIOUS)
5. Create Drawings with Accuracy
   a. Draw with object snap enabled (OSNAP, DDOSNAP)
   b. Determine the accuracy of the drawing (DIST, LIST, ID)
6. Organize Drawing Information
   a. Perform layer creation (LAYER, DDLMODES)
   b. Study and identify line styles
   c. Load and use line types (LINETYPE, LTSCALE)
   d. Change properties of objects (CHANGE, CHPROP, DDMODIFY)
7. Control the Display of Drawings
   a. Change magnification of objects (ZOOM WINDOW, PREVIOUS, ALL, EXTENTS, DYNAMIC)
   b. Move the display area (PAN)
   c. Plot drawings to a printer (PLOT)
   d. Plot drawings to a plotter (PLOT)
8. Use Intermediate Drawing Commands
   a. Make parallel copies of objects (OFFSET)
   b. Make multiple copies of objects (MULTIPLE COPY, RECTANGULAR AND POLAR ARRAY)
   c. Create arcs (ARC)
   d. Create text on the drawing (TEXT, DTEXT, STYLE)
   e. Create centermarks and center lines (DIM, CENTER)
   f. Draw an ellipse (ELLIPSE)
   g. Draw polygons (POLYGON)
9. Perform Intermediate Editing Commands
   a. Mirror objects (MIRROR)
   b. Rotate objects (ROTATE)
   c. Change the length of existing objects (STRETCH, EXTEND, TRIM)
   d. Edit text (DDEDIT)
   e. Study the use of the non-verb format (GRIPS)

E. PERFORM LASER MATERIALS PROCESSING

1. Study Lasers as Machine Tools including:

a. C.W. vs. pulsed
b. Energy balance
c. Factors affecting removal rate
d. Beam direction and deflection
e. Tip design
f. Focused vs. non-focused
g. Wavelength/power of laser

2. Demonstrate Machine Operations including:
   a. Drilling
   b. Cutting
   c. Surface modification
   d. Embossing
   e. Marking
   f. Texturing
   g. Hardening
   h. Annealing
   i. Welding
3. Study Hazards and Safety including:
   a. Skin
   b. Eye
   c. Electrical shocks
   d. Fire threats
   e. Toxic fume production
   f. Unprotected wiring and tubing
   g. Water spills
   h. Warning signs
   i. Safety glasses
   j. Interlocks
   k. ANSI Z-136 and Maximum Permissible Exposure
   l. Saving sight by managing light

F. **PERFORM COMPUTER AIDED MANUFACTURING (CAM)**

NOTE: () or CAPS indicates a SmartCAM® command. SmartCAM® is being used as a typical CAM system

1. Understand the Basics of a PC Based CAM System
   a. Discuss CNC basics
   b. Study SmartCAM® screen layout
   c. Change the screen layout
   d. Determine how CNC and CAM relate
2. Discuss Basic CAM Operations
   a. Study job plan creation
   b. Study the file structure in CAM
   c. Discuss the difference between tools and layers
3. Set Up Cutting Tools
   a. Determine how to sequence elements
   b. Perform tool offset (OFFSET)
   c. Understand Z axis positions (Z_LEVEL & PROF_TOP)
   d. Understand how to allow clearance for cutting tools (CLEAR)
4. Create Part Profiles

a. Discuss how to input lines, arcs, and circles
b. Use trim profiles (GROUP_TRIM and PROFILE_TRIM)
c. Clean up disconnected elements to an intersection (TRIM_EXTEND)
d. Change the view of part profile (ZOOM, VIEW_ANGLE, etc.)

5. Edit Part Profiles
   a. Change tool properties (PROPERTY_CHG)
   b. Change geometry values (MODIFY)
   c. Arrange elements sequentially (CHAIN)
   d. Use WALL_OFFSET for roughing cuts
   e. Create blend radii
   f. Create chamfers
   g. Split elements in segments
   h. Create symmetrical elements using mirror
6. Perform Advanced Editing of Part Profiles
   a. Move and copy elements
   b. rotate and rotate copy elements
   c. Create symmetrical elements using mirror
7. Edit Tool Paths
   a. Change tool path direction (REV_ORDER)
   b. Change the start of a profile (PROF_START)
   c. Change the order of machining events (SEQUENCE_MOVE)
   d. Arrange elements by tool (TOOL_SORT)
8. Perform Roughing, Drilling and Counterboring
   a. Understand how to perform face roughing.
   b. Understand how to perform pocket roughing.
   c. Understand how to avoid islands in roughing.
   d. Setup drills and counterboring tools
   e. Study the difference between full depth, tip depth, and spot diameter
9. Use Construction Layers in SmartCAM®
   a. Discuss the use of layers in profile construction
   b. Establish snap points using layers
   c. Trim profiles to "snapable" configurations
10. Perform User Commands and Machine Events
    a. Create multiple hole patterns using line at angle (LAA)
    b. Create multiple hole patterns using GRID
    c. Change the tool feed rate (FEED_CHG)
11. Create Families of Parts
    a. Discuss the importance of macros
    b. Create variables to represent part geometry
    c. Record a macro
    d. Edit and use a macro
12. Perform CAD/CAM Integration
    a. Create .DXF files in AutoCAD®
    b. Discuss the importance of layers in AutoCAD®
    c. Perform .DXF file translation in SmartCAM®
13. Perform Code Generation
    a. Study how a code generator works
    b. Study the machine file (.SMF)

c. Study the template file (.TMP)
d. Study how to modify code generators

G. **PRACTICE LASER SAFETY**

1. Discuss Laser Safety Basics
2. Discuss Laser Hazards including:
   a. Eye hazards
   b. Skin hazards
   c. Associated hazards from high power lasers
   d. Viewing laser radiation
   e. Laser hazard evaluation
   f. Control of associated hazards
   g. Typical laser calculations and measurements
3. Study Laser Safety Standards and Hazard Classifications (i.e., ANSI Z136.1 Standards)
4. Investigate Controls for Surveying, Alignment and Leveling Lasers
5. Discuss Eye Protection including:
   a. Selection of eye protection
   b. Limitations of eye protection
   c. Laser goggle testing

H. **PERFORM MEASUREMENT AND INSPECTION**

1. Interpret Limits and Tolerances
   a. Study the use of datums
   b. Study the three plane system: Primary, Secondary, and Tertiary Datums
   c. Study the use of material condition symbols (MMC, LMC, RFS)
   d. Use target points to define datums
2. Use CMM for Location of Features
   a. Access the importance of Coordinate Measurement Machines (CMM)
   b. Set up and use a CMM
   c. Calibrate a CMM
   d. Set up and measure hole locations with respect to applicable datums
   e. Set up and measure location for non-cylindrical features
   f. Set up and measure location for multiple pattern features
   g. Set up and measure for projected tolerance zone
3. Perform Measurement by Comparison
   a. Use an optical comparator
   b. Create charts from CAD systems to use on overlays
   c. Determine the scaling principle used in optical comparison
   d. Calibrate an optical comparator

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. *Resources: Identifies, organizes, plans, and allocates resources*
   1. follows a schedule to complete assigned tasks on time
   2. determines the initial cost of materials and "value added" as a result of machining
   3. identifies and selects proper materials and appropriate machining process
   4. provide a self-evaluation of performance based on the time and quality of work

B. *Interpersonal: Works with others*
   1. complete assigned responsibilities within the classroom serving as a member of the team
   2. provide individual assistance/direction to peers as requested
   3. provides professional and courteous service to customers/clients
   4. provides leadership to peers as required
   5. accepts constructive criticism
   6. works well with all members of the class

C. *Information: Acquires and uses information*
   1. reads and interprets blueprints
   2. systematic organization of training materials
   3. perform laboratory assignments and produce required results
   4. uses SmartCAM system to deliver CNC solutions

D. *Systems: Understands complex inter-relationships*
   1. demonstrates knowledge of the following systems:
      a. personal computers
      b. laboratory organization structure: physical and social
      c. organization of personnel and facilities in the CAM laboratory
      d. dimensioning and measurement systems
   2. monitors and corrects performance during CNC process modeling
   3. constantly evaluating the quality of work to achieve acceptable standards

E. *Technology: Works with a variety of technologies*
   1. chooses procedure and required CAM commands to produce a CNC process model
   2. applies appropriate procedures and commands to produce a CNC process model
   3. maintains and troubleshoots computer equipment as required

II. FOUNDATION SKILLS

A. *Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*
   1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
      a. studies instructor handouts

b. reads and interprets blueprints

2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. outline the steps necessary to create a CNC process model
   b. maintain a lecture notebook
   c. complete all written assignments
3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. determines optimum machining speeds, feeds, and depths of cut
   b. calculates "value added" to part
   c. keeps a running computation of individual grade
   d. interconverts fractions to decimal expressions
   e. use trigonometry to solve angle calculations
4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
   a. assimilate classroom instruction
   b. observe laboratory demonstrations
   c. seek and receive individualized instruction in the classroom
5. *Speaking: Organizes ideas and communicates orally*
   a. participates in classroom discussions
   b. organize ideas and communicate specific questions to the instructor
   c. verbally affirms understanding of a concept, procedure, or required skill
   d. communicates with peers to ensure the smooth and safe operation of the classroom and laboratory

B. *Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. *Creative Thinking: Generates new ideas*
   a. develops new ideas for approaching problem solving
   b. participates in the "brainstorming" process
   c. participates in group problem solving process
2. *Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   a. identifies personal goals
   b. identifies actions required to accomplish personal goals
3. *Problem Solving: Recognizes problems and devises and implements plan of action*
   a. makes daily accommodations to stay on schedule
   b. seeks additional instruction/clarification for assignment completion
   c. balances social and academic life/responsibilities
   d. accepts responsibility
4. *Seeing Things In the Mind's Eye: Organizes, and processes symbols, pictures, graphs, objects, and other information*
   a. interprets technical drawings
   b. interprets technical illustrations and symbols
   c. understands both written and verbal instructions

d. assimilates process during instructor demonstrations

5. *Knowing How to Learn: Use efficient learning techniques to acquire and apply new knowledge and skills*
   a. demonstrate mastery of the basic skills and techniques
   b. use these sequential skills to support mastery of new skills
   c. understand the sequential nature of acquired skills and the subsequent knowledge application of new skills and techniques
6. *Reasoning: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   a. understands that practice is vital to improving the skill of the student
   b. understands that the quality of the product is a function of the time of the operation and the attitude and skill of the student
   c. understands the relationship between CAM theory and CNC practice

C. *Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
   a. develops an understanding that in order to be successful you must be a "good" student
   b. develops an understanding that a "good" student is the one who is prompt to every class and has prepared for the day's work
   c. develops an understanding good students know what they are going to do in class and does not waste time
   d. develops a fine work-ethic
2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
   a. learns to take pride in his or her work through positive reinforcement
   b. sees himself or herself as an asset to the class through continued contributions to the group and a shared common goal
   c. understands that an individual with a positive attitude and the belief in their own abilities will systematically seek solutions and be a valuable employee
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   a. assist classmates in improving technical skills
   b. assist students with special needs as a peer mentor
   c. shares laboratory resources (computers, machines, tools, and instructor's individual attention)
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. constantly evaluating CAM procedures and results for acceptability
   b. maintain a record of academic achievement (individual gradebook)
   c. make accommodations due to computer availability
   d. accept the responsibility for self-management
5. *Integrity/Honesty: Chooses ethical courses of action*

a. accept the responsibility for own actions
b. exhibit personal honesty at all times
c. accept the challenge of doing your own work in the classroom, during examination, and on outside assignments
d. understand the consequences of unethical behaviors

Appropriate Reference Materials:

Any text on CNC programming
SmartCAM Advanced 3D Machining Manual

VN592
06/081196

Machine Tool Advanced Skills
Technology Program

MAST

COURSE SYLLABUS

METROLOGY

MAST PROGRAM
COURSE SYLLABUS
METROLOGY

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

The intent of this course in metrology is to provide the class with an understanding of the importance of accurate measurement as it relates to the overall world of manufacturing. Within the fifteen week semester, we will discuss the history and language of measurement. Various measurement instruments and gages are also discussed. Also covered will be calibration, optical comparators and coordinate measuring machines (CMM). The principles of Geometric Dimensioning and Tolerancing will be discussed throughout the semester to teach the interpretation of engineering drawings per ANSI Y14.5.

PREREQUISITES: NONE

REQUIRED COURSE MATERIALS:

Textbook:	Fundamentals of Dimensional Metrology, Bush, T. (1989), Albany, NY
Lab Manual:	**NONE**
Supplementary Materials:	Delmar pocket calculator Note book

METHOD OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, handouts, and demonstrations.

Laboratory: Laboratory will be a "hands on" inspection and measurement process.

Method of Evaluation: Metrology practices and measurement are an important component of any manufacturing concern, regardless of the product. This course will introduce the students to the many methods available for the measurement of quality products. As design and manufacturing methods become more complex and precise, so must the methods used to measure them if the high quality standards we set are to be met. A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. demonstrate an understanding of the ANSI standard.
2. demonstrate proper use of calipers and micrometers.
3. demonstrate proper use of gage blocks and pin gages.
4. demonstrate how to use a Coordinate Measurement Machine.

5. demonstrate how to use an optical comparator.
6. satisfactorily perform on written, oral, and practical examinations
7. contribute to class discussions
8. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Introduction of Course	**Chapter 1**	
- Syllabus and Pretest		
- Reasons for Measurement		
- Understanding How Measurement Developed		
- Metrology as a Science		
- Why Do We Measure?		
Language of Measurement	**Chapter 2, 3**	
- Understanding How Measurement is a Universal Language		
- Understanding the Terms Precision, Accuracy and Reliability		
- Units Used in Measurement		
- What is a Standard and How They Evolved		
- Origins of the Inch and Metric Systems		
- The Language of Geometric Dimensioning and Tolerancing (ANSI Y14.5)		
- Gaging vs. Measuring		
Vernier and Micrometer Measurement	**Chapter 5, 6, 7**	
- How Does a Vernier Scale Work		
- What Accuracy Does a Vernier Provide		
- QUIZ #1 on Measurement		
G.D.&T. Per ANSI Y14.5		
- What Are Datums and How Are They Used		
- How Are Modifiers Used		
- Limits and tolerances		
- What is Profile, Form, Orientation, Position, and Runout		
Gage Blocks and Datums	**Chapter 8, 9, 10**	
- Use and Develop of Gage Blocks		
- The Use of Datums in Manufacturing		
- Go/No Go and the Taylor Principle		
Calibration	**Chapter 13**	
- Why is Calibration Necessary		
- What Controls Are Required		
True Position and Modifiers	**Chapter 13**	

- What is True Position and Why Is It Important to Manufacturing
- Composite Positioning of Patterns
- What are Modifiers M.M.C., L.M.C., R.F.S. and Projected Tolerance Zone
- How is Bonus Tolerance Calculated
- Review For Midterm Exam

MIDTERM EXAM (All Previous Chapters)

Coordinate Measuring Machines (CMM)	**Chapter 19**
- Understanding the Advantages of CMM - Setup and calibration of a CMM. - Measurement of hole locations with respect to Datums.	
Optical Flats and Orientation	**Chapter 14** (15, 16 and 17 for reference)
- What is Helium Light Band - Using Light for Measurement - How is Orientation Measured - Perpendicularity - Parallelism - Angularity	
Perform Circularity, Cylindricity, Profile of a Line, and Runout Measurements	
- Set up and measure the circularity of round features - Set up and measure the cylindricity of a feature - Set up and measure the profile of line - Set up and measure runout and total runout of round features - Set up and measure two features for coplanarity, concentricity, or coaxiality	
Surface Metrology and Profile	**Chapter 18**
- Why is Surface Metrology Important - Methods Used to Evaluate Surface Texture - What Is the Difference Between Surface Metrology and Dimensional Metrology - How Manufacturing Processes Affect the Surface Texture of Parts	

Open Discussion Week

- Open Discussion About Metrology

- Open Discussion About G.D.&T.
- Metrology and ISO 9000
- Controlling and Measuring the Form of a Part

Optical Metrology — **Chapter 20, 21, 22, 23**

- Optical Magnification for Inspection
- Four Principal Applications of Optics in Metrology
- The Microscope-High Power Magnification
- Measurement by Comparison
- Measuring Contours and Shapes With Optical Comparators
- Making Comparator Charts For Easy Inspection
- Principles of Optical Alignment

Review for Final Exam (All of Above Chapters)

- Post Test Evaluation
- Review for Final Exam

Final Exam (Comprehensive of Semester's Work)

Total Lecture Hours **30**

LAB OUTLINE:

Lab Topics	Contact Hrs.
Verniers and micrometer measurement	5
Gage blocks and Pin gages.	5
Functional gages: Go/No Go gages	5
CMM and true position	5
Bonus tolerances	5
Measurement of Perpendicularity, Parallelism, Angularity	5
Measurement of Circularity, Cylindricity, Runout	5
Surface metrology: Measurement of Flatness and Profile	5
Optical metrology: Measurement of profile using an optical comparator	5
Total Lab Hours	**45**

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

After the successful completion of this course the student will be able to:

A. APPLY MATHEMATICAL CONCEPTS

1. Perform Basic Math Functions
   a. Use and manipulate fractions
   b. Use and manipulate decimals

c. Calculate percentages
d. Calculate units of length, area, and volume
e. Convert between S.I. (metric) and English (inch) units
f. Use a scientific calculator

2. Perform Algebraic Functions
   a. Identify equations with one unknown
   b. Solve algebraic equations by isolation of the unknown
   c. Identify equations with fractions
   d. Solve equations by cross multiplying
   e. Identify and solve linear equations
   f. Calculate the slope of a line
3. Study Exponents and Right Triangle Geometry
   a. Apply the laws of exponents
   b. Calculate exponentials and roots
   c. Analyze right triangles
   d. Use Pythagorean Theorem
4. Study Elements of Plane and Solid Geometry
   a. Calculate the area and circumference of a circle
   b. Determine angular measurements (degrees and radians)
   c. Establish a tangent to a circle
   d. Analyze parallel lines, transverse lines, and angles
   e. Perform the bisection of an angle
   f. Calculate the sum of the interior angles of a polygon
   g. Calculate the area of a triangle and irregular shapes
   h. Analyze trapezoids
5. Perform Data Evaluation and Statistical Analysis
   a. Analyze and plot data
   b. Create graphs (line, bar, and pie)
   c. Calculate mean, normal, and standard deviation
6. Perform Proportioning and Interpolation
   a. Calculate ratios and proportions
   b. Calculate direct, inverse, and combined variations
   c. Calculate constants of proportionality
   d. Perform tabular interpolation
7. Perform Basic Trigonometric Functions
   a. Calculate the trigonometric functions of sine, cosine, and tangent
   b. Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
   c. Solve a right triangle
8. Investigate the Cartesian Coordinate System
   a. Study the X-Y coordinate system
   b. Study the X-Y-Z coordinate system
   c. Calculate the slope of a line in the Cartesian coordinate system

B. APPLY CONCEPTS OF MODERN OPTICS

1. Study Reflection at Plane and Spherical Surfaces
   a. Demonstrate the law of reflection
   b. Demonstrate ray tracing at a plane reflecting surface

c. Demonstrate ray tracing at a spherical reflecting surface

2. Study Refraction at Plane Surfaces
   a. Demonstrate refraction of light at a dielectric interface
3. Study Refraction at Spherical Surfaces
   a. Demonstrate refraction at plane surfaces
   b. Demonstrate refraction at spherical surfaces
4. Perform Imaging with a Single Lens
   a. Determine focal points and focal lengths in positive thin lenses
   b. Demonstrate image formation with a positive thin lens
   c. Determine focal points and focal lengths in negative thin lenses
   d. Demonstrate image formation with a negative thin lens
5. Perform Imaging with Multiple Thin Lenses
   a. Set up and demonstrate two converging lenses
   b. Set up and demonstrate a converging and diverging lens
6. Study F-Stops & Apertures
   a. Define Field stops and aperture stops
   b. Define Entrance and exit pupils
7. Study Optical Systems
   a. Set-up and demonstrate astronomical (Keplerian) telescopes
   b. Set-up and demonstrate Galilean telescopes
   c. Set-up and demonstrate beam-expanding collimators
8. Study Interference
   a. Set-up and demonstrate Young's double slit interference
   b. Demonstrate thin film interference
   c. Determine surface flatness by interference
9. Study Diffraction
   a. Demonstrate Fraunhofer (far field) interference
   b. Demonstrate Fresnel (near field) interference
   c. Determine the Limit of resolution of an optical instrument
   d. Measure beam divergence and spot size
   e. Use diffraction gratings
   f. Discuss light scattering
10. Study Polarization
    a. Determine unknown polarization of light
    b. Generate linearly polarized light
    c. Study the effect of birefringent materials on polarized light
    d. Generate circularly polarized light
11. Investigate Radiometry & Photometry
    a. Perform optical power measurements
    b. Perform irradiance measurements
    c. Use photoelectric power meters
    d. Perform ambient light suppression
    e. Use attenuators
    f. Perform Wavelength calibration
    g. Use radiometric filters

C. INVESTIGATE INDUSTRIAL LASER SYSTEMS

1. Perform Laser Alignment, Gauging, and Inspection

a. Study laser scanning techniques
b. Perform optical alignment and optical triangulation
c. Discuss the principles of optical detection
d. Study Charge-Coupled Devices (CCD)

2. Perform Laser Material Removal
   a. Study Laser-Supported Absorption (LSA)
   b. Perform laser drilling
   c. Perform laser cutting

D. PERFORM COMPUTER AIDED DRAFTING (CAD)

<u>NOTE</u>: () indicates an AutoCAD® command. AutoCAD® is being used as a typical CAD system

1. Create Multiview Drawings
   a. Study the concept of 3rd angle projection
   b. Create and place appropriate orthogonal views
   c. Draw construction lines from one view to create other views
   d. Use existing geometry to place other views (Point Filters)
2. Create Sectioned Drawings
   a. Create and place appropriate section views
   b. Create section lines on a drawing (HATCH, BHATCH, PLINE)
3. Investigate Basic Dimensioning
   a. Study methods for dimensioning objects (DIM)
   b. Apply methods for changing dimension settings (DIMVARS)
4. Perform Advanced Dimensioning
   a. Create and use dimension styles (DDIM)
   b. Apply geometric dimensioning from ANSI Y14.5

E. PERFORM LASER MATERIALS PROCESSING

1. Investigate the Effects of Laser Irradiation on Materials including:
   a. Melting
   b. Vaporization
   c. Ablation
   d. Dehydration
   e. Removal method
   f. Mechanism of reaction
2. Study Lasers as Machine Tools including:
   a. C.W. vs. pulsed
   b. Energy balance
   c. Factors affecting removal rate
   d. Beam direction and deflection
   e. Tip design
   f. Focused vs. non-focused
   g. Wavelength/power of laser
3. Demonstrate Machine Operations including:
   a. Drilling
   b. Cutting
   c. Surface modification
   d. Embossing

e. Marking
f. Texturing
g. Hardening
h. Annealing
i. Welding

4. Study Hazards and Safety including:
   a. Skin
   b. Eye
   c. Electrical shocks
   d. Fire threats
   e. Toxic fume production
   f. Unprotected wiring and tubing
   g. Water spills
   h. Warning signs
   i. Safety glasses
   j. Interlocks
   k. ANSI Z-136 and Maximum Permissible Exposure
   l. Saving sight by managing light

F. **PRACTICE LASER SAFETY**

1. Discuss Laser Safety Basics
2. Discuss Laser Hazards including:
   a. Eye hazards
   b. Skin hazards
   c. Associated hazards from high power lasers
   d. Viewing laser radiation
   e. Laser hazard evaluation
   f. Control of associated hazards
   g. Typical laser calculations and measurements
3. Study Laser Safety Standards and Hazard Classifications (i.e., ANSI Z136.1 Standards)
4. Investigate Controls for Surveying, Alignment and Leveling Lasers
5. Discuss Eye Protection including:
   a. Selection of eye protection
   b. Limitations of eye protection
   c. Laser goggle testing

G. **PERFORM MEASUREMENT AND INSPECTION**

1. Study Basics of Metrology
   a. Discuss the reasons for measurements
   b. Study the language of measurement
   c. Determine how to convert between SI and English systems
   d. Interpret dimensions
   e. Study the use of tolerances
   f. Study the requirements of ANSI Y14.5
   g. Study the three fundamental rules of ANSI Y14.5
   h. Interpret the definition of virtual condition
2. Select Instruments Used for Measurement
   a. Use vernier calipers

b. Use dial calipers
c. Read scales
d. Use micrometers
e. Use hole and depth micrometers
f. Set up and use dial indicators

3. Interpret Limits and Tolerances
   a. Study the use of datums
   b. Study the three plane system: Primary, Secondary, and Tertiary Datums
   c. Study the use of material condition symbols (MMC, LMC, RFS)
   d. Use target points to define datums
4. Select Gaging Tools
   a. Use gage blocks
   b. Use pin gages
   c. Use a height gage
   d. Use "go/no go" gages
   e. Design and build functional gages
5. Use CMM for Location of Features
   a. Access the importance of Coordinate Measurement Machines (CMM)
   b. Set up and use a CMM
   c. Calibrate a CMM
   d. Set up and measure hole locations with respect to applicable datums
   e. Set up and measure location for non-cylindrical features
   f. Set up and measure location for multiple pattern features
   g. Set up and measure for projected tolerance zone
6. Perform Surface Metrology
   a. Use surface plates
   b. Use angle plates, mandrels, and vee blocks
   c. Study how surface plates are used to establish datums
   d. Set up and measure the flatness of a surface
   e. Set up and measure the perpendicularity of two surfaces
   f. Set up and measure the angularity of two surfaces
   g. Set up and measure the parallelism of two surfaces
   h. Set up and measure the profile of a surface
   i. Set up and measure the straightness of a feature
7. Perform Measurement by Comparison
   a. Use an optical comparator
   b. Create charts from CAD systems to use on overlays
   c. Determine the scaling principle used in optical comparison
   d. Calibrate an optical comparator
8. Perform Circularity, Cylindricity, Profile of a Line, and Runout Measurements
   a. Set up and measure the circularity of round features
   b. Set up and measure the cylindricity of a feature
   c. Set up and measure the profile of line
   d. Set up and measure runout and total runout of round features
   e. Set up and measure two features for coplanarity, concentricity, or coaxiality

9. Investigate Advanced Metrology Topics
    a. Discuss the purpose and application of laser measurement
    b. Set up and use a laser measurement device
    c. Assess how ISO 9000 affects metrology
    d. Study the fundamentals of Statistical Process Control (SPC)

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. **COMPETENCIES**
    A. Resources: Identifies, organizes, plans, and allocates resources
        1. follows a schedule to complete assigned tasks on time
        2. determines and justifies the cost of inspection equipment
        3. identifies and selects appropriate inspection resources
        4. provide a self-evaluation of performance based on the time and quality of work
    B. Interpersonal: Works with others
        1. complete assigned responsibilities within the classroom serving as a member of the team
        2. provide individual assistance/direction to peers as requested
        3. provides professional and courteous service to customers/clients
        4. provides leadership to peers as required
        5. accepts constructive criticism
        6. works well with all members of the class
    C. Information: Acquires and uses information
        1. reads and interprets blueprints
        2. systematic organization of training materials
        3. perform laboratory assignments and produce required results
        4. uses a CMM and SPC software
    D. Systems: Understands complex inter-relationships
        1. demonstrates knowledge of the following systems:
            a. laboratory organization structure: physical and social
            b. organization of personnel and facilities in the inspection department
            c. dimensioning and measurement systems
        2. monitors and corrects performance during the inspection process
        3. constantly evaluating the quality of work to achieve acceptable standards

E. *Technology: Works with a variety of technologies*
   1. chooses appropriate device and procedures to inspect a part
   2. applies appropriate procedures and uses appropriate equipment to produce an inspection report
   3. maintains and troubleshoots equipment as required

II. **FOUNDATION SKILLS**

A. *Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*
   1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
      a. studies instructor handouts
      b. reads and interprets blueprints
      c. read/studies textbook
   2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
      a. outline the steps necessary to setup and inspect a part
      b. maintain a lecture notebook
      c. submit written responses to chapter question assignments
      d. complete all written assignments
   3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
      a. determines application of bonus tolerance
      b. calculates bonus tolerance
      c. keeps a running computation of individual grade
      d. interconverts fractions to decimal expressions
      e. use trigonometry to solve angle calculations
      f. uses statistics for SPC
   4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*
      a. assimilate classroom instruction
      b. observe laboratory demonstrations
      c seek and receive individualized instruction in the classroom
   5. *Speaking: Organizes ideas and communicates orally*
      a. participates in classroom discussions
      b. organize ideas and communicate specific questions to the instructor
      c. verbally affirms understanding of a concept, procedure, or required skill
      d. communicates with peers to ensure the smooth and safe operation of the classroom and laboratory

B. *Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*
   1. *Creative Thinking: Generates new ideas*
      a. develops new ideas for approaching problem solving
      b. participates in the "brainstorming" process
      c. participates in group problem solving process

2. *Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   a. identifies personal goals
   b. identifies actions required to accomplish personal goals
3. *Problem Solving: Recognizes problems and devises and implements plan of action*
   a. makes daily accommodations to stay on schedule
   b. seeks additional instruction/clarification for assignment completion
   c. balances social and academic life/responsibilities
   d. accepts responsibility
4. *Seeing Things In the Mind's Eye: Organizes, and processes symbols, pictures, graphs, objects, and other information*
   a. interprets technical drawings
   b. interprets technical illustrations and symbols
   c. understands both written and verbal instructions
   d. assimilates process during instructor demonstrations
5. *Knowing How to Learn: Use efficient learning techniques to acquire and apply new knowledge and skills*
   a. demonstrate mastery of the basic skills and techniques
   b. use these sequential skills to support mastery of new skills
   c. understand the sequential nature of acquired skills and the subsequent knowledge application of new skills and techniques
6. *Reasoning: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   a. understands that practice is vital to improving the skill of the student
   b. understands that the quality of the product is a function of the time of the operation and the attitude and skill of the student
   c. understands the value of quality parts and assemblies as they relate to the success of a company

C. *Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*
1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
   a. develops an understanding that in order to be successful you must be a "good" student
   b. develops an understanding that a "good" student is the one who is prompt to every class and has prepared for the day's work
   c. develops an understanding good students know what they are going to do in class and does not waste time
   d. develops a fine work-ethic
2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
   a. learns to take pride in his or her work through positive reinforcement
   b. sees himself or herself as an asset to the class through continued contributions to the group and a shared common goal

c. understands that an individual with a positive attitude and the belief in their own abilities will systematically seek solutions and be a valuable employee

3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   a. assist classmates in improving technical skills
   b. assist students with special needs as a peer mentor
   c. shares laboratory resources (machines, inspection equipment, and instructor's individual attention)
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. evaluates and validates results of the inspection process
   b. maintain a record of academic achievement (individual gradebook)
   c. make accommodations to laboratory schedules
   d. accept the responsibility for self-management
5. *Integrity/Honesty: Chooses ethical courses of action*
   a. accept the responsibility for own actions
   b. exhibit personal honesty at all times
   c. accept the challenge of doing your own work in the classroom, during examination, and on outside assignments
   d. understand the consequences of unethical behaviors

Appropriate Reference Materials:

1. CMM Reference Manual
2. Individual inspection equipment Reference Manuals
3. ANSI Y14.5 - 1994

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*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

LASER MATERIALS PROCESSING

MAST PROGRAM
COURSE SYLLABUS
LASER MATERIALS PROCESSING

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

The Materials Processing section of the course first provides a basis for comparison between traditional methods and non-traditional methods of machining. By next studying the fundamentals of laser heating, the student is led into the world of laser-material (metals, plastics, ceramics, and composites) interactions, with all of the variables which affect this process. This provides a basis for lasers studied as machine tools and the attendant machine operations, including safety. Demonstration laboratories will be provided after each new concept discussed in class. Video demonstrations will be shown for more elaborate scenarios.

PREREQUISITES: **Algebra and Trigonometry, a basic knowledge of standard machining operations, basic laser theory and systems.**

REQUIRED COURSE MATERIALS:

Textbook: Practical Laser Safety, D. C. Winburn, Marcel Dekker, Inc., 1985
Lab Manual: **NONE**

Supplementary Materials: **Instructor Handouts**

METHOD OF INSTRUCTION:

Lecture: Didactic presentations will include lecture, videos, handouts, and demonstrations.

Laboratory: Laboratory will be a "hands-on" process.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The functionality of laser-materials interactions depends on a well established basis of materials and optical sciences. The purpose of this section of the course is to learn basics of materials science in the light of laser surface and bulk effects and to apply these principles to machining materials of various types, where conventional and even other non-traditional methods fall short. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. understand the basics of materials science
2. understand the basics of laser interactions with materials
3. understand the basic mathematics for estimating processes prior to performing the operations

4. be able to differentiate between the actions of various lasers at different wave lengths on a wide variety of materials
5. perform simple machining operations on at least four different classes of materials
6. satisfactorily perform on written, oral, and practical examinations
7. contribute to class discussions
8. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Traditional Mechanical Machining		
Non-Traditional Methods of Machining		
Mechanical		
Abrasive Flow Machining		
Microabrasive Blasting		
Ultrasonic Machining		
Electrical		
Electrochemical Machining		
Electrochemical Grinding		
Chemical		
Photochemical Machining		
Photochemical Polishing		
Thermal		
Electron Beam Machining		
Electrodischarge Machining		
Wire Electrodischarge Machining		
Laser Beam Machining		
Basics of Laser Heating		
Properties of Materials		
Optical		
Transmission		
Absorption		
Reflection		
Scattering		
Mechanical		
Hardness		
Tribology		
Strength		
Heat Treatments		
Chemical		
Composition		
Decomposition		
Corrodibility		
Electrical		
Metallic		
Dielectric		
Ceramic		
Polymer		

Glass
Thermal
Heat Capacity
Thermal Conductivity
Thermal Expansion Coefficient
Phase Changes
Laboratory
Effects of Laser Irradiation on Materials
Melting
Vaporization
Ablation
Dehydration
Removal Method
Mechanism of Reaction
Laboratory
Lasers as Machine Tools
C.W. vs. Pulsed
Energy Balance
Factors Affecting Removal Rate
Beam Direction and Deflection
Tip Design
Focused vs. Non-Focused
Wave Length/Power of Laser
Laboratory
Machine Operations
Drilling
Cutting
Surface Modification
Embossing
Marking
Texturing
Hardening
Annealing
Welding
Laboratory
Hazards and Safety
Skin
Eye
Electrical Shocks
Fire Threats
Toxic Fume Production
Unprotected Wiring and Tubing
Water Spills
Warning Signs
Safety Glasses
Interlocks
ANSI Z-136 and Maximum Permissible

Exposure
Saving Sight by Managing Light
Summary
What Has Been Learned?....Let's Do It!

Total Lecture Hours **30**

LAB OUTLINE:

Lab Topics	Contact Hrs.
Material Cutting with CO_2 and Nd:YAG Lasers	9
Seam Welding using CO_2 and Nd:YAG Lasers	9
Spot Welding using CO_2 and Nd:YAG Lasers	9
Surface Hardening using CO_2 and Nd:YAG Lasers	6
Material Scribing with CO_2 and Nd:YAG Lasers	6
Laser Marking & Etching	6
Total Lab Hours	**45**

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

After the successful completion of this course the student will be able to:

A. APPLY MATHEMATICAL CONCEPTS
1. Perform Basic Math Functions
   a. Use and manipulate fractions
   b. Use and manipulate decimals
   c. Calculate percentages
   d. Calculate units of length, area, and volume
   e. Convert between S.I. (metric) and English (inch) units
   f. Use a scientific calculator
2. Perform Algebraic Functions
   a. Identify equations with one unknown
   b. Solve algebraic equations by isolation of the unknown
   c. Identify equations with fractions
   d. Solve equations by cross multiplying
   e. Identify and solve linear equations
   f. Calculate the slope of a line
3. Study Exponents and Right Triangle Geometry
   a. Apply the laws of exponents
   b. Calculate exponentials and roots
   c. Analyze right triangles
   d. Use Pythagorean Theorem
4. Study Elements of Plane and Solid Geometry
   a. Calculate the area and circumference of a circle
   b. Determine angular measurements (degrees and radians)
   c. Establish a tangent to a circle
   d. Analyze parallel lines, transverse lines, and angles
   e. Perform the bisection of an angle
   f. Calculate the sum of the interior angles of a polygon

g. Calculate the area of a triangle and irregular shapes
h. Analyze trapezoids

5. Perform Data Evaluation and Statistical Analysis
   a. Analyze and plot data
   b. Create graphs (line, bar, and pie)
   c. Calculate mean, normal, and standard deviation
6. Perform Proportioning and Interpolation
   a. Calculate ratios and proportions
   b. Calculate direct, inverse, and combined variations
   c. Calculate constants of proportionality
   d. Perform tabular interpolation
7. Perform Basic Trigonometric Functions
   a. Calculate the trigonometric functions of sine, cosine, and tangent
   b Calculate the inverse trigonometric functions of arcsine, arccosine, and arctangent
   c. Solve a right triangle
8. Investigate Vectors and Vector Systems
   a. Analyze components of vectors
   b. Perform vector addition
   c. Perform vector combination
9. Investigate the Cartesian Coordinate System
   a. Study the X-Y coordinate system
   b. Study the X-Y-Z coordinate system
   c. Calculate the slope of a line in the Cartesian coordinate system

B. INVESTIGATE FUNDAMENTALS OF INDUSTRIAL ELECTRONICS & CONTROL

1. Perform Voltage, Current, Resistance and Power Measurements
   a. Study Ohm's law and power and energy
   b. Analyze series, parallel and series-parallel circuits
   c. Study alternating current and voltage
   d. Study capacitors, inductors and transformers
   e. Analyze RC, RL and RLC circuits
2. Investigate Fundamentals of Analog Active Devices
   a. Study semiconductor theory
   b. Analyze diodes and applications
   c. Analyze transistor circuits
   d. Analyze power supply circuits
3. Investigate Fundamentals of Digital Logic Circuitry
   a. Study number systems and codes
   b. Analyze logic gates, boolean algebra and combinational logic circuits
   c. Analyze flip-flops, arithmetic operations and circuits
   d. Analyze counters, registers and memory
   e. Study IC's and MSI logic circuits
   f. Perform interfacing with A/D and D/A circuits
   g. Study microprocessors, micro controllers and microcomputers
4. Investigate Operational Amplifiers for Industrial Applications
   a. Study comparator applications
   b. Study summing amplifier applications

c. Study integrator and differentiator applications
d. Study current to voltage converter applications
e. Study voltage to current converter applications
f. Study constant current source applications

5. Investigate Linear IC's for Industrial Applications
   a. Study voltage regulation
   b. Study basic series regulators
   c. Study basic switching regulators
   d. Study instrumentation amplifiers
   e. Study isolation amplifiers
   f. Study oscillators
   g. Study 555 timers
   h. Study angle measurement circuits
   i. Study temperature measurement circuits
   j. Study strain and pressure measuring circuits
6. Investigate Electric Motors
   a. Study wound-field DC motors and generators
   b. Study brushless and stepper DC motors
   c. Study AC motors
7. Study Industrial Control Systems
   a. Analyze motor control circuits
   b. Analyze RMS to DC converters
   c. Discuss industrial telemetry and data communications
   d. Discuss modulation techniques
   e. Use programmable controllers
   f. Perform sequential process control
   g. Perform statistical process control

C. APPLY CONCEPTS OF MODERN OPTICS

1. Study Reflection at Plane and Spherical Surfaces
   a. Demonstrate the law of reflection
   b. Demonstrate ray tracing at a plane reflecting surface
   c. Demonstrate ray tracing at a spherical reflecting surface
2. Study Refraction at Plane Surfaces
   a. Demonstrate refraction of light at a dielectric interface
3. Study Refraction at Spherical Surfaces
   a. Demonstrate refraction at plane surfaces
   b. Demonstrate refraction at spherical surfaces
4. Perform Imaging with a Single Lens
   a. Determine focal points and focal lengths in positive thin lenses
   b. Demonstrate image formation with a positive thin lens
   c. Determine focal points and focal lengths in negative thin lenses
   d. Demonstrate image formation with a negative thin lens
5. Perform Imaging with Multiple Thin Lenses
   a. Set up and demonstrate two converging lenses
   b. Set up and demonstrate a converging and diverging lens
6. Study F-Stops & Apertures
   a. Define field stops and aperture stops
   b. Define entrance and exit pupils

7. Study Optical Systems
    a. Set-up and demonstrate astronomical (Keplerian) telescopes
    b. Set-up and demonstrate Galilean telescopes
    c. Set-up and demonstrate beam-expanding collimators
8. Study Interference
    a. Set-up and demonstrate Young's double slit interference
    b. Demonstrate Thin film interference
    c. Determine surface flatness by interference
9. Study Diffraction
    a. Demonstrate Fraunhofer (far field) interference
    b. Demonstrate Fresnel (near field) interference
    c. Determine the limit of resolution of an optical instrument
    d. Measure beam divergence and spot size
    e. Use Diffraction gratings
    f. Discuss light scattering
10. Study Polarization
    a. Determine unknown polarization of light
    b. Generate Linearly polarized light
    c. Study the effect of birefringent materials on polarized light
    d. Generate circularly polarized light
11. Investigate Radiometry & Photometry
    a. Perform optical power measurements
    b. Perform Irradiance measurements
    c. Use photoelectric power meters
    d. Perform ambient light suppression
    e. Use attenuators
    f. Perform wavelength calibration
    g. Use radiometric filters

D. INVESTIGATE INDUSTRIAL LASER SYSTEMS

1. Study Characteristics of Light
    a. Study the general description of light waves
    b. Discuss monochromaticity
    c. Study directionality, coherence and polarization
2. Understand Basic Laser Principles
    a. Discuss optical radiation processes with emphasis on the amplification process
    b. Discuss optical feedback
    c. Discuss optical selection rules, transition lifetimes
    d. Study Einstein relations, gain coefficients, three-and-four level pumping systems, and threshold and resonator stability
3. Study Laser Output Characteristics
    a. Discuss active mediums, population inversion and optical feedback
    b. Determine the temporal, spatial, and spectral characteristics of the device
    c. Study line broadening mechanisms, axial and transverse modes
    d. Study pump rate, gain saturation, and power output
4. Investigate Output Modification
    a. Study methods used to modify the spatial and spectral characteristics of a variety of laser systems

5. Apply Safety and Laboratory Procedures
    a. Study proper laboratory practice
    b. Demonstrate safety practices
    c. Keep proper lab records
6. Perform a Laser Exposition
    a. Discuss characteristics and components of commercial lasers
    b. Study Ruby, ND: YAG and other solid state lasers
    c. Study gas, dye, and semiconductor lasers
7. Perform Laser Alignment, Gauging, and Inspection
    a. Study laser scanning techniques
    b. Perform optical alignment and optical triangulation
    c. Discuss the principles of optical detection
    d. Study Charge-Coupled Devices (CCD)
8. Investigate Holography and Applications: Non-Destructive Testing
    a. Study coherent light wave interference
    b. Discuss the principles of Holographic Non-Destructive Testing (HNDT)
9. Investigate the Interaction of High Power Laser Beam with Materials
    a. Study laser-optics and beam characteristics
    b. Discuss Transverse Electromagnetic Modes (TEM)
    c. Calculate spot size and power density
    d. Measure reflectivity and absorption of laser energy
    e. Study thermal diffusivity and thermal time constants
10. Perform Laser Welding and Surface Treatment
    a. Study beam delivery optics
    b. Study the procedure of laser welding
    c. Perform pulsed and continuous-wave (CW) laser welding
11. Perform Laser Material Removal
    a. Study Laser-Supported Absorption (LSA)
    b. Perform laser drilling
    c. Perform laser cutting

E. **PERFORM LASER MATERIALS PROCESSING**

1. Discuss Traditional Mechanical Machining
2. Discuss Non-Traditional Methods of Machining
    a. Investigate mechanical methods
        (1) Discuss abrasive flow machining
        (2) Discuss micro abrasive blasting
        (3) Discuss ultrasonic machining
    b. Investigate electrical methods
        (1) Discuss electrochemical machining
        (2) Discuss electrochemical grinding
    c. Investigate chemical methods
        (1) Discuss photochemical machining
        (2) Discuss photochemical polishing
    d. Investigate thermal methods
        (1) Discuss electron beam machining
        (2) Discuss electrodischarge machining
        (3) Discuss wire electrodischarge machining
        (4) Discuss laser beam machining

3. Understand Basics of Laser Heating
   a. Investigate properties of materials
      (1) Study optical properties including:
         (a) Transmission
         (b) Absorption
         (c) Reflection
         (d) Scattering
      (2) Study mechanical properties including:
         (a) Hardness
         (b) Tribology
         (c) Strength
         (d) Heat treatments
      (3) Study chemical properties including:
         (a) Composition
         (b) Decomposition
         (c) Corrodibility
      (4) Study electrical properties including:
         (a) Metallic
         (b) Dielectric
            i. Ceramic
            ii. Polymer
            iii. Glass
      (5) Study thermal properties including:
         (a) Heat capacity
         (b) Thermal conductivity
         (c) Thermal expansion
4. Investigate the Effects of Laser Irradiation on Materials including:
   a. Melting
   b. Vaporization
   c. Ablation
   d. Dehydration
   e. Removal method
   f. Mechanism of reaction
5. Study Lasers as Machine Tools including:
   a. C.W. vs. pulsed
   b. Energy balance
   c. Factors affecting removal rate
   d. Beam direction and deflection
   e. Tip design
   f. Focused vs. non-focused
   g. Wavelength/power of laser
6. Demonstrate Machine Operations including:
   a. Drilling
   b. Cutting
   c. Surface modification
   d. Embossing
   e. Marking
   f. Texturing

g. Hardening
h. Annealing
i. Welding

7. Study Hazards and Safety including:
   a. Skin
   b. Eye
   c. Electrical shocks
   d. Fire threats
   e. Toxic fume production
   f. Unprotected wiring and tubing
   g. Water spills
   h. Warning signs
   i. Safety glasses
   j. Interlocks
   k. ANSI Z-136 and Maximum Permissible Exposure
   l. Saving sight by managing light

F. PRACTICE LASER SAFETY

1. Discuss Laser Safety Basics
2. Discuss Laser Hazards including:
   a. Eye hazards
   b. Skin hazards
   c. Associated hazards from high power lasers
   d. Viewing laser radiation
   e. Laser hazard evaluation
   f. Control of associated hazards
   g. Typical laser calculations and measurements
3. Study Laser Safety Standards and Hazard Classifications (i.e., ANSI Z136.1 Standards)
4. Investigate Controls for Surveying, Alignment and Leveling Lasers
5. Discuss Eye Protection including:
   a. Selection of eye protection
   b. Limitations of eye protection
   c. Laser goggle testing

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. *Resources: Identifies, organizes, plans, and allocates resources*

1. follows a schedule to complete assigned tasks on time

B. *Interpersonal: Works with others*

1. complete assigned responsibilities within the classroom serving as a member of the team
2. provide individual assistance/direction to peers as requested
3. provides professional and courteous service to customers/clients
4. works well with all members of the class

C. *Information: Acquires and uses information*

1. reads and interprets schematic diagrams and layouts
2. organize and maintain accurate laboratory log books
3. performs laboratory assignments and disseminates results
4. uses computer to analyze and present experimental results

D. *Systems: Understands complex inter-relationships*

1. understands complex optical systems and interrelated technologies
2. monitors and corrects for flaws and system inaccuracies

E. *Technology: Works with a variety of technologies*

1. chooses procedure, components, and equipment required to perform specific task
2. applies appropriate procedures and uses appropriate components to produce desired results

II. FOUNDATION SKILLS

A. *Basic Skills:* Reads, writes, performs arithmetic and mathematical operations, listens and speaks.

1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
   a. studies student laboratory manual
   b. interprets laboratory procedures and schematics
   c. read/studies textbook
2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. outlines steps necessary to produce desired experimental results
   b. maintain a lecture notebook
   c. submit written responses to chapter question assignments
   d. complete all written assignments
3. *Arithmetic/Mathematics: Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. applies mathematical operations required to assess experimental results
   b. uses computer to assist in data analysis and reduction
   c. keeps a running computation of individual grade
   d. performs statistical data interpolation
4. *Listening: Receives, attends to, interprets, and responds to verbal messages and other cues*

a. assimilate classroom instruction
b. interpolate and assimilate video instruction
c. observe laboratory demonstrations
d. seek and receive individualized instruction in the classroom

5. *Speaking: Organizes ideas and communicates orally*
a. participates in classroom discussions
b. organize ideas and communicate specific questions to the instructor
c. verbally affirms understanding of a concept, procedure, or required skill
d. communicates with peers to ensure the smooth and safe operation of the classroom

B. *Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. *Creative Thinking: Generates new ideas*
a. develops new ideas for problem solving
b. participates in the "brain storming" process
c. participates in the group problem solving process

2. *Decision Making: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
a. identifies personal goals
b. identifies actions required to accomplish personal goals

3. *Problem Solving: Recognizes problems and devises and implements plan of action*
a. makes daily accommodations to stay on schedule
b. seeks additional instruction/clarification for assignment completion
c. balances social and academic life/responsibilities
d. accepts responsibility

4. *Seeing Things In the Mind's Eye: Organizes, and processes symbols, pictures, graphs, objects, and other information*
a. interprets technical drawings
b. interprets technical illustrations and symbols
c. understands both written and verbal instructions
d. assimilates process during instructor demonstrations

5. *Knowing How to Learn: Use efficient learning techniques to acquire and apply new knowledge and skills*
a. demonstrate mastery of the basic skills and techniques
b. use these sequential skills to support mastery of new skills
c. understand the sequential nature of acquired skills and the subsequent knowledge application of new skills and techniques

6. *Reasoning: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
a. understands that practice is vital to improving the skill of the student
b. understands that the quality of the product is a function of the time of the operation and the attitude and skill of the student
c. understand the complex interaction between optical components

C. *Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. *Responsibility: Exerts a high level of effort and perseveres towards goal attainment*
   a. develops an understanding that in order to be successful you must be a "good" student
   b. develops an understanding that a "good" student is the one who is prompt to every class and has prepared for the day's work
   c. develops an understanding good students know what they are going to do in class and does not waste time
   d. develops a fine work-ethic
2. *Self-Esteem: Believes in own self-worth and maintains a positive view of self*
   a. learns to take pride in his or her work through positive reinforcement
   b. sees himself or herself as an asset to the class through continued contributions to the group and a shared common goal
   c. understands that an individual with a positive attitude and the belief in their own abilities will systematically seek solutions and be a valuable employee
3. *Sociability: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   a. assist classmates in improving technical skills
   b. assist students with special needs as a peer mentor
   c. interacts with peers and listens effectively and provides constructive criticism
4. *Self-Management: Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. monitors/assesses personal goal progress
   b. maintain a record of academic achievement (individual gradebook)
   c. accept the responsibility for self-management
5. *Integrity/Honesty: Chooses ethical courses of action*
   a. accept the responsibility for own actions
   b. exhibit personal honesty at all times
   c. accept the challenge of doing your own work in the classroom, during examination, and on outside assignments
   d. understand the consequences of unethical behaviors

Appropriate Reference Materials:

1. Industrial Lasers and Their Applications, Luxon and Parker, Latest Edition, Prentice-Hall
2. ANSI Z136.1 (1993) Safe Use of Lasers by ANSI
3. Guide to the Selection of Laser Eye Protection by LIA, Third Edition

APPENDIX A - INDUSTRY COMPETENCY PROFILES

The following pages contain the individual Competency Profiles for each of the companies surveyed by the MAST development center for the occupational specialty area of . These Competency Profiles/skill standards were used to develop the curriculum for the pilot program.

The participation of the companies as partners in the MAST effort is greatly appreciated. Each company has approved the use of its logo in MAST materials. None of the participating companies shall be held responsible or liable for any of the findings of the project.

SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job
Basic Machining Course Prerequisites or CNC Machinist Course Ware

TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Customer Relations
Personal Ethics

TOOLS AND EQUIPMENT

FUTURE TRENDS AND CONCERNS

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
MAST PROGRAM REPRESENTATIVES

DR. THOMAS E. HOLLAND
Director, Center for Business & Technology

GARY J. MASCIADRELLI
Department Chairman
Mechanical Engineering Technology

NICK M. MASSA
Director of Technology Development

ROSE MARY TIMMONS
Senior Secretary/Statistician (TSTC)

Furnished By:

DANA A. MILLER
Manager, Operations

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

COMPETENCY PROFILE

Laser Machinist

Prepared By
M.A.S.T.
Machine Tool Advanced Skills Technology Program
and
Consortia Partners
(V.199J40008)

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

LASERS
The Mark of Excellence

LASER Machinist ... apply the principles of electronics, lasers, optics, materials, engineering documentation, CAD/CAM, and systems integration to manufacture products to referenced engineering standards.

Duties		Tasks												
A	Apply Mathematical Concepts	A-1 Perform basic math functions	A-2 Perform algebraic functions	A-3 Study exponents and right triangle geometry	A-4 Study elements of plane and solid geometry	A-5 Perform basic trigonometric functions	A-6 Apply oblique triangle geometry	A-7 Investigate vectors and vector systems	A-8 Investigate the Cartesian coordinate system					
B	Investigate Fundamentals of Industrial Electronics & Control	B-1 Perform voltage, current, resistance, and power measements	B-2 Investigate electric motors	B-3 Study industrial control systems										
C	Apply Concepts of Modern Optics	C-1 Study geometric optics	C-2 Study physical optics	C-3 Investigate radiometry and photometry										
D	Perform CNC Programming	D-1 Apply machine specific (milling and lasers) nomenclature and terminology	D-2 Investigate the Cartesian coordinate system as applied to milling and laser machines	D-3 Apply CNC programming language	D-4 Perform start up, tool changing and ending of programs	D-5 Perform positioning and basic drilling	D-6 Create a sub-program	D-7 Use position and fixed cycles	D-8 Perform contouring	D-9 Apply tool radius compensation (cutter comp)	D-10 Perform programming preparation	D-11 Apply special laser coding parameters		
E	Investigate Industrial Laser Systems	E-1 Study characteristics of light	E-2 Understand basic laser principles	E-3 Study laser output characteristics	E-4 Investigate output modification	E-5 Apply safety and laboratory procedures	E-6 Perform a laser exposition	E-7 Perform laser alignment, gauging and inspection	E-8 Investigate the interaction of high power laser beam with materials	E-9 Perform laser welding and surface treatment	E-10 Perform laser material removal			
F	Perform Computer Aided Drafting (CAD)	F-1 Understand PC basics	F-2 Discuss CAD basics and file management	F-3 Use drawing settings	F-4 Perform basic editing commands	F-5 Create drawings with accuracy	F-6 Organize drawing information	F-7 Control the display of drawings	F-8 Use intermediate drawing commands	F-9 Perform intermediate editing commands	F-10 Create multiview drawings	F-11 Create sectioned drawings	F-12 Investigate basic dimensioning	F-13 Use and manipulate blocks
		F-14 Use blocks to automate the drawing process												
G	Perform Laser Materials Processing	G-1 Discuss traditional mechanical machining	G-2 Discuss non-traditional methods of machining	G-3 Understand basics of laser heating	G-4 Investigate the effects of laser irradiation on materials	G-5 Study lasers as machine tools	G-6 Demonstrate machine operations	G-7 Study hazards and safety						
H	Perform Computer Aided Manufacturing (CAM)	H-1 Understand the basics of a PC based CAM system	H-2 Discuss basic CAM operations	H-3 Set up cutting tools	H-4 Create part profiles	H-5 Edit part profiles	H-6 Perform advanced editing of part profiles	H-7 Edit tool paths	H-8 Perform drilling and counterboring	H-9 Use construction layers in SmartCAM	H-10 Perform user commands and machine events	H-11 Create families of parts	H-12 Perform CAD/CAM integration	H-13 Perform code generation
I	Practice Laser Safety	I-1 Discuss laser safety basics	I-2 Discuss laser hazards	I-3 Study laser safety standards and hazard classifications (i.e., ANSI Z136.1 standards)	I-4 Investigate controls for surveying, alignment and leveling lasers	I-5 Discuss eye protection								174

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Duties		Tasks												
J	Perform Measurement & Inspection	J-1 Study basics of metrology	J-2 Select instruments used for measurement	J-3 Interpret limits and tolerances	J-4 Select gaging tools	J-5 Use CMM for location of features	J-6 Perform surface metrol-ogy	J-7 Perform measurement by comparison	J-8 Perform circularity, cylindricity, profile of a line, and runout measurements	J-9 Investigate advanced metrology topics				

SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job
Basic Machining Course Prerequisites or CNC Machinist
Course Ware

TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Customer Relations
Personal Ethics

TOOLS AND EQUIPMENT

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Mechanical Engineering Technology

NICK M. MASSA
Director of Technology Development

ROSE MARY TIMMONS
Senior Secretary/Statistician (TSTC)

Furnished By:

RITA DUCHARME
Director of Human Resources

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

FUTURE TRENDS AND CONCERNS

COMPETENCY PROFILE

Laser Machinist

Prepared By
M.A.S.T.
Machine Tool Advanced Skills
Technology Program
and
Consortia Partners
(V.199J40008)

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

EBTEC

LASER Machinist ... apply the principles of electronics, lasers, optics, materials, engineering documentation, CAD/CAM, and systems integration to manufacture products to referenced engineering standards.

Duties		Tasks												
A	Apply Mathematical Concepts	A-1 Perform basic math functions	A-2 Perform algebraic functions	A-3 Study exponents and right triangle geometry	A-4 Study elements of plane and solid geometry	A-5 Perform data evaluation and statistical analysis	A-6 Perform proportioning and interpolation	A-7 Perform basic trigonometric functions	A-8 Apply oblique triangle geometry	A-9 Investigate vectors and vector systems	A-10 Investigate the Cartesian coordinate system			
B	Investigate Fundamentals of Industrial Electronics & Control	B-1 Perform voltage, current, resistance, and power measements	B-2 Investigate fundamentals of analog active devices	B-3 Investigate fundamentals of digital logic circuitry	B-4 Investigate operational amplifiers for industrial applications	B-5 Investigate linear IC's for industrial applications	B-6 Investigate electric motors	B-7 Study industrial control systems						
C	Apply Concepts of Modern Optics	C-1 Study geometric optics	C-2 Study physical optics	C-3 Investigate radiometry and photometry										
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F	Perform Computer Aided Drafting (CAD)	F-1 Understand PC basics	F-2 Discuss CAD basics and file management	F-3 Use drawing settings	F-4 Perform basic editing commands	F-5 Create drawings with accuracy	F-6 Organize drawing information	F-7 Control the display of drawings	F-8 Use intermediate drawing commands	F-9 Perform intermediate editing commands	F-10 Create multiview drawings	F-11 Create sectioned drawings	F-12 Investigate basic dimensioning	F-13 Perform advanced dimensioning
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Duties		Tasks												
J	Perform Measurement & Inspection	J-1 Study basics of metrology	J-2 Select instruments used for measurement	J-3 Interpret limits and tolerances	J-4 Select gaging tools	J-5 Use CMM for location of features	J-6 Perform surface metrology	J-7 Perform measurement by comparison	J-8 Perform circularity, cylindricity, profile of a line, and runout measurements	J-9 Investigate advanced metrology topics				

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Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job
Basic Machining Course Prerequisites or CNC Machinist Course Ware

TRAITS AND ATTITUDES
Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Customer Relations
Personal Ethics

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Furnished By:

ROBIN BARBERO
Vice President

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

FUTURE TRENDS AND CONCERNS

COMPETENCY PROFILE

Laser Machinist

Prepared By
M.A.S.T.
Machine Tool Advanced Skills Technology Program
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SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

The Industrial Laser Source

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Duties		Tasks												
J	Perform Measurement & Inspection	J-1 Study basics of metrology	J-2 Select instruments used for measurement	J-3 Interpret limits and tolerances	J-4 Select gaging tools	J-5 Use CMM for location of features	J-6 Perform surface metrol-ogy	J-7 Perform measurement by comparison	J-8 Perform circularity, cylindricity, profile of a line, and runout measurements	J-9 Investigate advanced metrology topics				

SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job
Basic Machining Course Prerequisites or CNC Machinist Course Ware

TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Customer Relations
Personal Ethics

TOOLS AND EQUIPMENT

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE MAST PROGRAM REPRESENTATIVES

DR. THOMAS E. HOLLAND
Director, Center for Business & Technology

GARY J. MASCIADRELLI
Department Chairman
Mechanical Engineering Technology

NICK M. MASSA
Director of Technology Development

ROSE MARY TIMMONS
Senior Secretary/Statistician (TSTC)

Furnished By:

RONALD BENJAMIN
Engineer

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

FUTURE TRENDS AND CONCERNS

COMPETENCY PROFILE

Laser Machinist

Prepared By
M.A.S.T.
Machine Tool Advanced Skills Technology Program
and
Consortia Partners
(V.199J40008)

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

laser fare

LASER Machinist ... apply the principles of electronics, lasers, optics, materials, engineering documentation, CAD/CAM, and systems integration to manufacture products to referenced engineering standards.

Duties		Tasks												
A	Apply Mathematical Concepts	A-1 Perform basic math functions	A-2 Perform algebraic functions	A-3 Study exponents and right triangle geometry	A-4 Study elements of plane and solid geometry	A-5 Perform data evaluation and statistical analysis	A-6 Perform proportioning and interpolation	A-7 Perform basic trigonometric functions	A-8 Investigate the Cartesian coordinate system					
B	Investigate Fundamentals of Industrial Electronics & Control	B-1 Perform voltage, current, resistance, and power measements	B-2 Investigate fundamentals of analog active devices	B-3 Investigate fundamentals of digital logic circuitry	B-4 Investigate operational amplifiers for industrial applications	B-5 Investigate linear IC's for industrial applications	B-6 Investigate electric motors	B-7 Study industrial control systems						
C	Apply Concepts of Modern Optics	C-1 Study geometric optics	C-2 Study physical optics	C-3 Investigate radiometry and photometry										
D	Perform CNC Programming	D-1 Apply machine specific (milling and lasers) nomenclature and terminology	D-2 Investigate the Cartesian coordinate system as applied to milling and laser machines	D-3 Apply CNC programming language	D-4 Perform start up, tool changing and ending of programs	D-5 Create a sub-program	D-6 Perform contouring	D-7 Apply tool radius compensation (cutter comp)	D-8 Perform programming preparation	D-9 Apply special laser coding parameters				
E	Investigate Industrial Laser Systems	E-1 Study characteristics of light	E-2 Understand basic laser principles	E-3 Study laser output characteristics	E-4 Investigate output modification	E-5 Apply safety and laboratory procedures	E-6 Perform a laser exposition	E-7 Perform laser alignment, gauging and inspection	E-8 Investigate holography and applications: non-destructive testing	E-9 Investigate the interaction of high power laser beam with materials	E-10 Perform laser welding and surface treatment	E-11 Perform laser material removal		
F	Perform Computer Aided Drafting (CAD)	F-1 Understand PC basics	F-2 Discuss CAD basics and file management	F-3 Use drawing settings	F-4 Perform basic editing commands	F-5 Create drawings with accuracy	F-6 Organize drawing information	F-7 Control the display of drawings	F-8 Use intermediate drawing commands	F-9 Perform intermediate editing commands	F-10 Investigate basic dimensioning	F-11 Perform advanced dimensioning	F-12 Use and manipulate blocks	F-13 Use blocks to automate the drawing process
G	Perform Laser Materials Processing	G-1 Discuss traditional mechanical machining	G-2 Investigate the effects of laser irradiation on materials	G-3 Study lasers as machine tools	G-4 Demonstrate machine operations	G-5 Study hazards and safety								
H	Perform Computer Aided Manufacturing (CAM)	H-1 Understand the basics of a PC based CAM system	H-2 Create families of parts	H-3 Perform CAD/CAM integration	H-4 Perform code generation									
I	Practice Laser Safety	I-1 Discuss laser safety basics	I-2 Discuss laser hazards	I-3 Study laser safety standards and hazard classifications (i.e., ANSI Z136.1 standards)	I-4 Investigate controls for surveying, alignment and leveling lasers	I-5 Discuss eye protection								
J	Perform Measurement & Inspection	J-1 Study basics of metrology	J-2 Select instruments used for measurement	J-3 Interpret limits and tolerances	J-4 Select gaging tools	J-5 Perform surface metrology	J-6 Perform measurement by comparison	J-7 Perform circularity, cylindricity, profile of a line, and runout measurements	J-8 Investigate advanced metrology topics					

SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job
Basic Machining Course Prerequisites or CNC Machinist Course Ware

TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Customer Relations
Personal Ethics

TOOLS AND EQUIPMENT

FUTURE TRENDS AND CONCERNS

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
MAST PROGRAM REPRESENTATIVES

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ROSE MARY TIMMONS
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Furnished By:

BRUCE N. BEAUCHESNE
President

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

COMPETENCY PROFILE

Laser Machinist

Prepared By
M.A.S.T.
Machine Tool Advanced Skills
Technology Program
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SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

LASER
SERVICES, INC.

LASER Machinist ... apply the principles of electronics, lasers, optics, materials, engineering documentation, CAD/CAM, and systems integration to manufacture products to referenced engineering standards.

Duties		Tasks												
A	Apply Mathematical Concepts	A-1 Perform basic math functions	A-2 Perform algebraic functions	A-3 Study exponents and right triangle geometry	A-4 Study elements of plane and solid geometry	A-5 Perform data evaluation and statistical analysis	A-6 Perform proportioning and interpolation	A-7 Perform basic trigonometric functions	A-8 Apply oblique triangle geometry	A-9 Investigate vectors and vector systems	A-10 Investigate the Cartesian coordinate system			
B	Investigate Fundamentals of Industrial Electronics & Control	B-1 Perform voltage, current, resistance, and power measements	B-2 Investigate fundamentals of analog active devices	B-3 Investigate fundamentals of digital logic circuitry	B-4 Investigate operational amplifiers for industrial applications	B-5 Investigate linear IC's for industrial applications	B-6 Investigate electric motors	B-7 Study industrial control systems						
C	Apply Concepts of Modern Optics	C-1 Study geometric optics	C-2 Study physical optics	C-3 Investigate radiometry and photometry										
D	Perform CNC Programming	D-1 Apply machine specific (milling and lasers) nomenclature and terminology	D-2 Investigate the Cartesian coordinate system as applied to milling and laser machines	D-3 Apply CNC programming language	D-4 Perform start up, tool changing and ending of programs	D-5 Perform positioning and basic drilling	D-6 Create a sub-program	D-7 Use position and fixed cycles	D-8 Perform contouring	D-9 Apply tool radius compensation (cutter comp)	D-10 Perform programming preparation	D-11 Apply special laser coding parameters		
E	Investigate Industrial Laser Systems	E-1 Study characteristics of light	E-2 Understand basic laser principles	E-3 Study laser output characteristics	E-4 Investigate output modification	E-5 Apply safety and laboratory procedures	E-6 Perform a laser exposition	E-7 Perform laser alignment, gauging and inspection	E-8 Investigate holography and applications: non-destructive testing	E-9 Investigate the interaction of high power laser beam with materials	E-10 Perform laser welding and surface treatment	E-11 Perform laser material removal	E-12 Investigate miscellaneous applications	
F	Perform Computer Aided Drafting (CAD)	F-1 Understand PC basics	F-2 Discuss CAD basics and file management	F-3 Use drawing settings	F-4 Perform basic editing commands	F-5 Create drawings with accuracy	F-6 Organize drawing information	F-7 Control the display of drawings	F-8 Use intermediate drawing commands	F-9 Perform intermediate editing commands	F-10 Create multiview drawings	F-11 Create sectioned drawings	F-12 Investigate basic dimensioning	F-13 Perform advanced dimensioning
		F-14 Use and manipulate blocks	F-15 Use blocks to automate the drawing process											
G	Perform Laser Materials Processing	G-1 Discuss traditional mechanical machining	G-2 Discuss non-traditional methods of machining	G-3 Understand basics of laser heating	G-4 Investigate the effects of laser irradiation on materials	G-5 Study lasers as machine tools	G-6 Demonstrate machine operations	G-7 Study hazards and safety						
H	Perform Computer Aided Manufacturing (CAM)	H-1 Understand the basics of a PC based CAM system	H-2 Discuss basic CAM operations	H-3 Set up cutting tools	H-4 Create part profiles	H-5 Edit part profiles	H-6 Perform advanced editing of part profiles	H-7 Edit tool paths	H-8 Perform drilling and counterboring	H-9 Use construction layers in SmartCAM	H-10 Perform user commands and machine events	H-11 Create families of parts	H-12 Perform CAD/CAM integration	H-13 Perform code generation
I	Practice Laser Safety	I-1 Discuss laser safety basics	I-2 Discuss laser hazards	I-3 Study laser safety standards and hazard classifications (i.e., ANSI Z136.1 standards)	I-4 Investigate controls for surveying, alignment and leveling lasers	I-5 Discuss eye protection								

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LSTLAS PMS
MAST/06/692595

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Duties		Tasks												
J	Perform Measurement & Inspection	J-1 Study basics of metrology	J-2 Select instruments used for measurement	J-3 Interpret limits and tolerances	J-4 Select gaging tools	J-5 Use CMM for location of features	J-6 Perform surface metrol-ogy	J-7 Perform measurement by comparison	J-8 Perform circularity, cylindricity, profile of a line, and runout measurements	J-9 Investigate advanced metrology topics				

APPENDIX B - PILOT PROGRAM NARRATIVE

What follows is a narrative of the pilot program which was conducted for this particular occupational specialty.

Table of Contents

MAST PROJECT
LASER MACHINING CERTIFICATE
PILOT PROGRAM NARRATIVE

The Laser Machining Certificate Pilot Program started on September 12, 1995 with 19 students enrolled in the program. There were 30 applicants for the program. The applicants took Math and English placement tests prior to the start of the program. Students with placement scores of Algebra I and English communication skills were eligible to participate in the program. A total of 19 students were initially admitted into the program. The class consisted of six high school students (seniors), two high school faculty (vocational education), and eleven industry representatives with background ranging from simple machine operators to degreed engineers to QC managers. At the end of the program, sixteen student remained which translates into a 84% retention rate.

The Laser Machining Pilot Program was divided into five - six week modules, two courses per module. The courses met on Tuesday and Thursday evenings for 3 hours from 4 - 7 p.m. The course schedule has been included.

Evaluations were administered at the conclusion of each course to provide feedback and suggestions on improving the course (see MAST Overall Pilot-Program Evaluation). In addition, to assess value added for each course, the students were given a pre-test on the first class meeting and a post-test on the last class meeting. A summary of these results is included.

The pilot program included three industry tours: Trumpf Laser, Ebtec Corp., and Laser Services, Inc.. These tours involved a brief lecture relating to laser materials processing specific to that particular company and demonstrations of various industrial laser systems and their applications. A summary of each tour is included.

A National Science Foundation Instrumentation and Laboratory Improvement grant (NSF-ILI) for $150K was awarded to STCC for the development of a Laser Materials Processing Lab to support the program. These funds will allow STCC to purchase a CO_2 cutting laser, a Nd:YAG laser marking/etching system, and several pieces of test and measurement equipment. This lab will enhance the already well-equipped Laser and Mechanical Technology labs.

In conclusion, based on the summarative evaluations from the participants (industry and education):

- approximately 90 percent of respondents said the pilot program overall evaluation was good to excellent.
- approximately 80 percent of respondents said the pilot program content and pedagogy was good to excellent.
- a relatively even distribution of respondents agreed that the hands-on component of the program was adequate. This was expected due to the nature of the accelerated pilot program structure.
- approximately 60 percent of respondents indicated that the level of difficulty was appropriate.

Based on the above assessment, the plans for the full certificate program will reflect the pilot program content and pedagogy, with an increase in the amount of hands-on practice in laser materials processing. The newly acquired laser materials processing lab and full semester-length courses will more than adequately address the lessons learned from the very successful pilot program.

Springfield Technical Community College
and the
Machine Tool Advanced Skills Technology Program
(MAST)

LASER MACHINING PROGRAM

Funded by the U.S. Department of Education

A course in Laser Machining will be offered at Springfield Technical Community College beginning September 12, 1995 running until May 30, 1996. There will be five six-week sessions meeting on Tuesday and Thursday late afternoon from 4 pm to 7 pm at STCC.

The course is free and funded through a grant obtained by the Machine Tool Advanced Skills Technology Program (MAST) from the United States Department of Education.

The purpose of the course is to pilot a national training program model for the advanced training of technicians in the machine tool & precision manufacturing industry.

Math and English placement tests will be given to each applicant during the last week of July and first week of August. **APPLICATIONS MUST BE RECEIVED BY JUNE 30, 1995 TO BE CONSIDERED. ENROLLMENT IS LIMITED TO 20 STUDENTS.** Application does not guarantee enrollment!

For an application, please call or write to:

Brenda Field
MAST Project
One Armory Square
Springfield, MA 01103
(413)781-1315

LASER MACHINING PROGRAM
180 HOURS OF TRAINING

****

DON'T DELAY - SEND FOR APPLICATION TODAY

Springfield Technical Community College
and the
Machine Tool Advanced Skills Technology Program
(MAST)

LASER MACHINING PROGRAM

APPLICATION FORM

****

Please fill out completely and return by June 30, 1995 to:

Brenda Field
MAST Project
One Armory Square
Springfield, MA 01103
FAX (413)739-5066

Name________________________________ Employer________________________________

Home Address________________________________ Employer Address________________________________

________________________________ ________________________________

Home Phone________________________________ ________________________________

Current Occupation________________________________ Company Phone________________________________

Please describe breifly your work history and/or education and training on any industrial machining equipment (laser or conventional), CNC, or computers of any kind. ________________

____

____

Does your company currently use laser machining equipment or plan to in the near future? If so, what type?____

____

LASER MACHINING CERTIFICATE PILOT PROGRAM PARTICIPANT ROSTER

NAME	TITLE	COMPANY or SCHOOL	ADDRESS
Camacho, Antonio	Student	Putnam Vocational High School	Springfield, MA
Duquette, Andre	Student	Chicopee Comprehensive High School	Chicopee, MA
Haarmann, Kevin	Tool Room Supervisor	Specialty Loose Leaf, Inc.	Holyoke, MA
Hussey, Keith	Manager, Maintenance and Training	Hole Specialists, Inc.	Ludlow, MA
Jackson, Brandi	Student	Putnam Vocational High School	Springfield, MA
Katafiasz, Andrew	Faculty	Putnam Vocational High School	Springfield, MA
Massa, Bruno	Machine Operator	Precision EDM	Springfield, MA
Massa, Walter	Self Employed	Self Employed	Springfield, MA
Myers, Allen	Laser Technician	EBTEC Corp.	Agawam, MA
Parnell, Sean	Engineer	Holyoke Machine Co.	Holyoke, MA
Pen, Roum	Student	Chicopee Comprehensive High School	Chicopee, MA
Peroulakis, Nicolaos	QC Manager	Precision EDM	Springfield, MA
Picard, John	EDM Machinist	Precision EDM	Springfield, MA
Ricard, Ronald	Faculty	Putnam Vocational High School	Springfield, MA
Sienkiewicz, Casimir	Machinist	Pride Machining	Westfield, MA
Stefanowicz, Edward	Machinist	American Saw & Mfg. Co.	East Longmeadow, MA
Stone, Curtis	Student	Chicopee Comprehensive High School	Chicopee, MA
Viverito, Paul	Machinist Programmer	Holyoke Machine Co.	Holyoke, MA
Wolan, Andrew	Student	Putnam Vocational High School	Springfield, MA

MAST PROJECT:
LASER MACHINING CERTIFICATE PILOT PROGRAM
TIME SCHEDULE

PERIOD	COURSES	INSTRUCTOR
SESSION 1.	1. Industrial Mathematics 2. Fundamentals of Industrial Electronics and Controls	Bruce Pennino Gary Mullet
SESSION 2.	3. CNC 4. Modern Optics	John LaFrancis Nick Massa
SESSION 3.	5. Industrial Laser Theory 6. CAD	Peter Vangel Diane Gallece
SESSION 4.	7. Industrial Laser Systems 8. CAM	Peter Vangel Gary Masciadrelli
SESSION 5.	9. Materials Processing 10. Metrology	James Masi Mike Rowley
INTERIM SESSION	11. Laser Safety	Gary Mullett

MAST PROJECT STUDENT COURSE EVALUATION INTERIM SURVEY

Dear Student:

Please take a moment to complete the following questions and return this survey to your instructor. Your answers will help us to evaluate how well the course is going so far and to adjust the course to better suit the needs of the class. Thank you.

Yours truly,

Mast Project Staff

Date:
Course: **Instructor:**

Please evaluate the following aspects of the training so far:

	EXCELLENT	GOOD	UNCERTAIN	FAIR	POOR
1. Training course overall.	1	2	3	4	5
2. Course content.	1	2	3	4	5
3. Presentation of course material.	1	2	3	4	5
4. Hands-on instruction.	1	2	3	4	5
5. Hands-on practice.	1	2	3	4	5
6. Training manuals.	1	2	3	4	5
7. Length of course per night.	1	2	3	4	5
8. Availability of instructor for questions or clarification.	1	2	3	4	5
9. Review of materials.	1	2	3	4	5

(continued on next page)

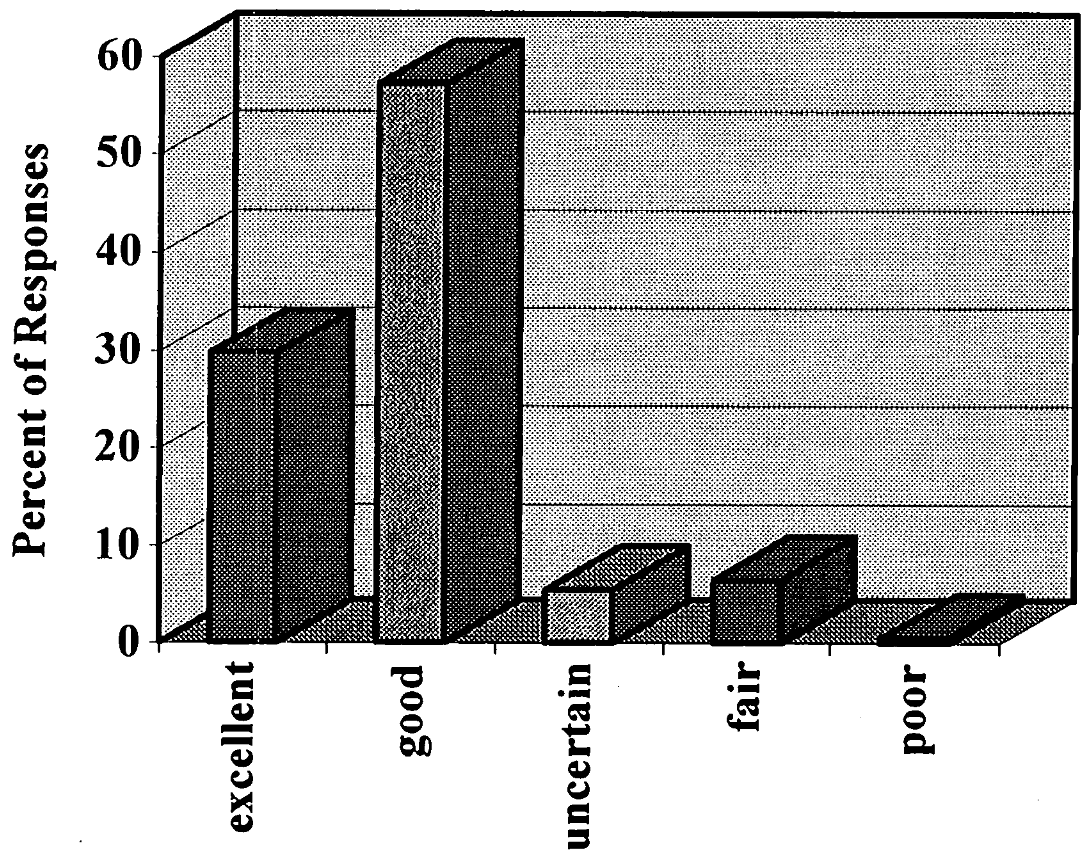
Please circle the number that best describes how you feel about the following statements:

	STRONGLY DISAGREE	DISAGREE	UNSURE	AGREE	STRONGLY AGREE
10. There is enough class time for the instructor to present the material.	1	2	3	4	5
11. There is enough time for hands-on practice.	1	2	3	4	5
12. There is enough time for hands-on instruction.	1	2	3	4	5
13. The course work is at the right level of difficulty for me.	1	2	3	4	5
14. The course work is too easy for me.	1	2	3	4	5
15. I have trouble keeping up with the instructor.	1	2	3	4	5
16. I have trouble keeping up with the class.	1	2	3	4	5
17. I am receiving enough one to one instruction.	1	2	3	4	5
18. The instructor is available to answer questions.	1	2	3	4	5

19. **What suggestions do you have for improving the course?**

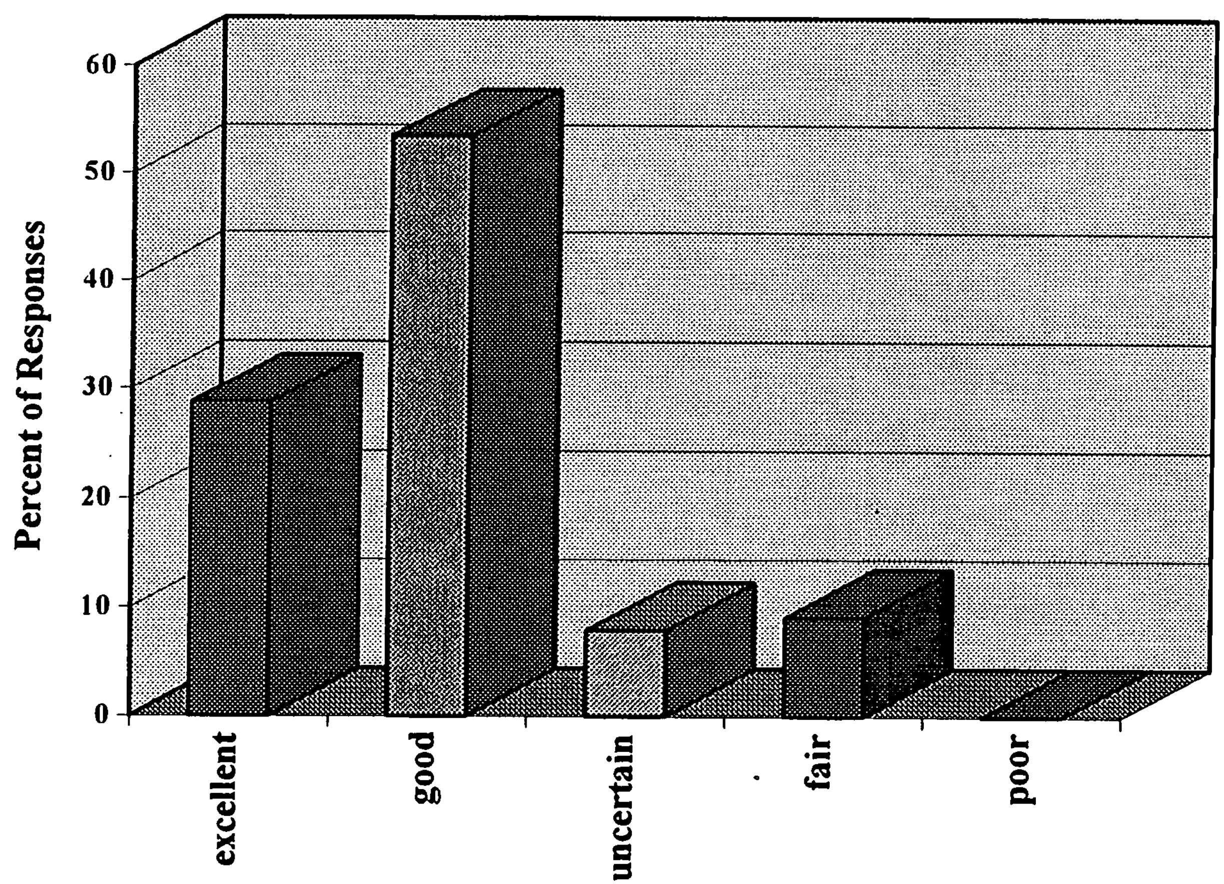
Pilot Program
Evaluation Results

Overall Course Evaluation



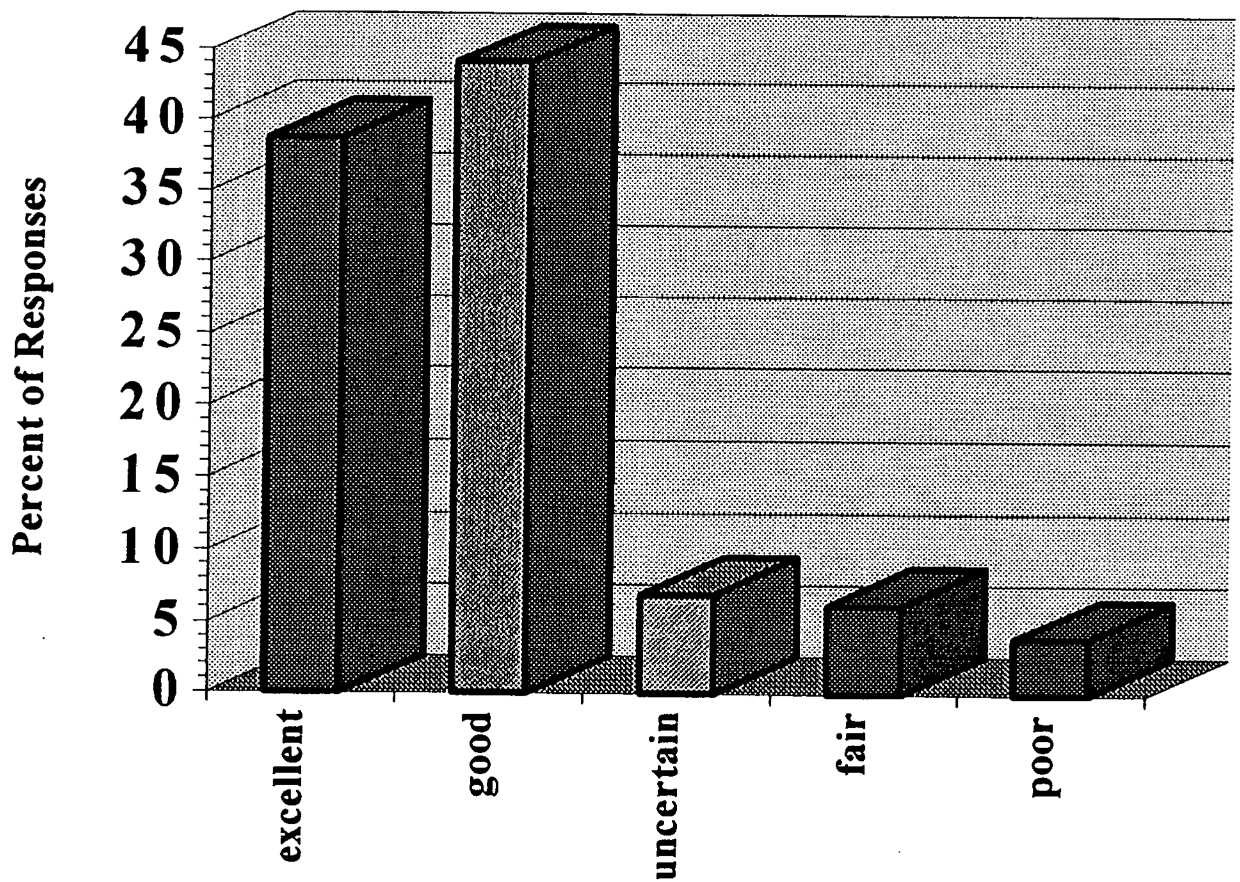
Pilot Program
Evaluation Results

Course Content



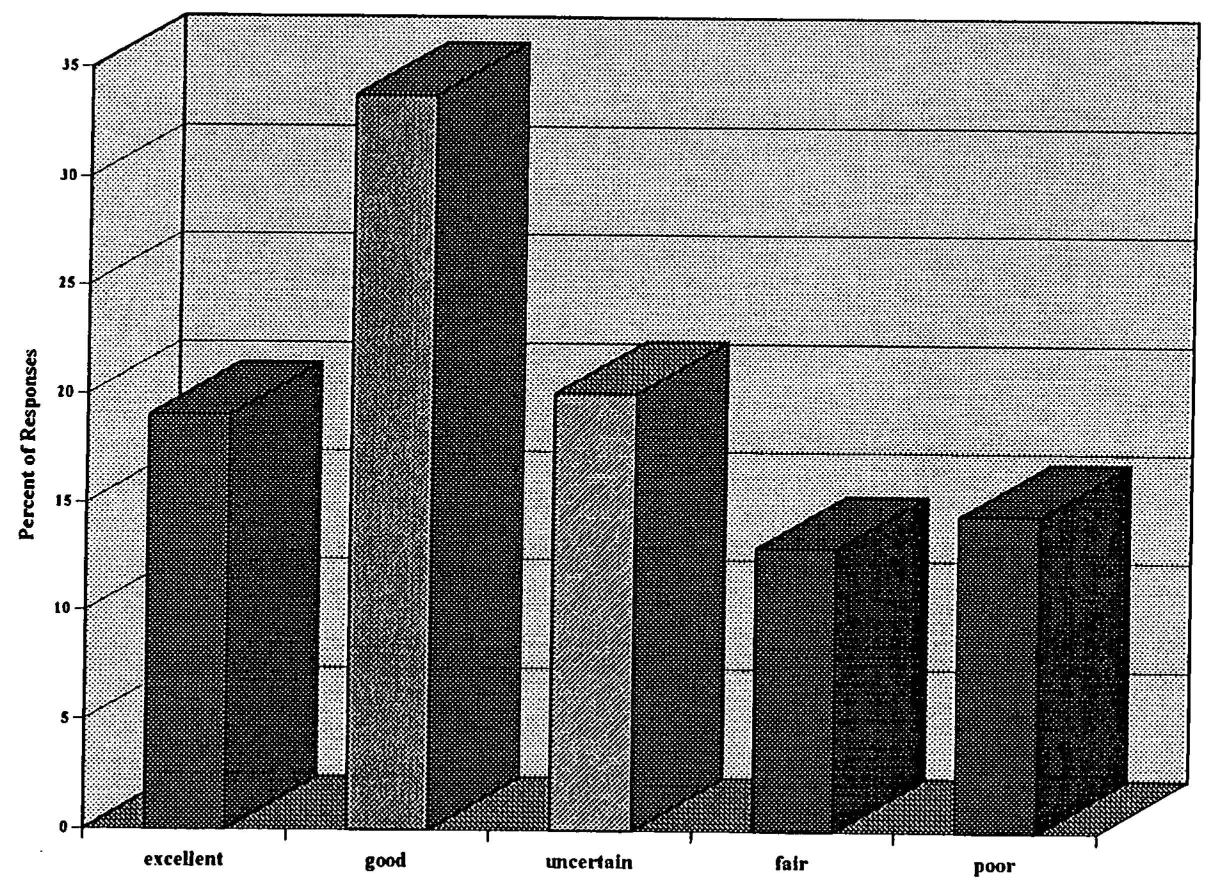
Pilot Program
Evaluation Results

Presentation of Course Material



Pilot Program
Evaluation Results

Hands-On Instruction



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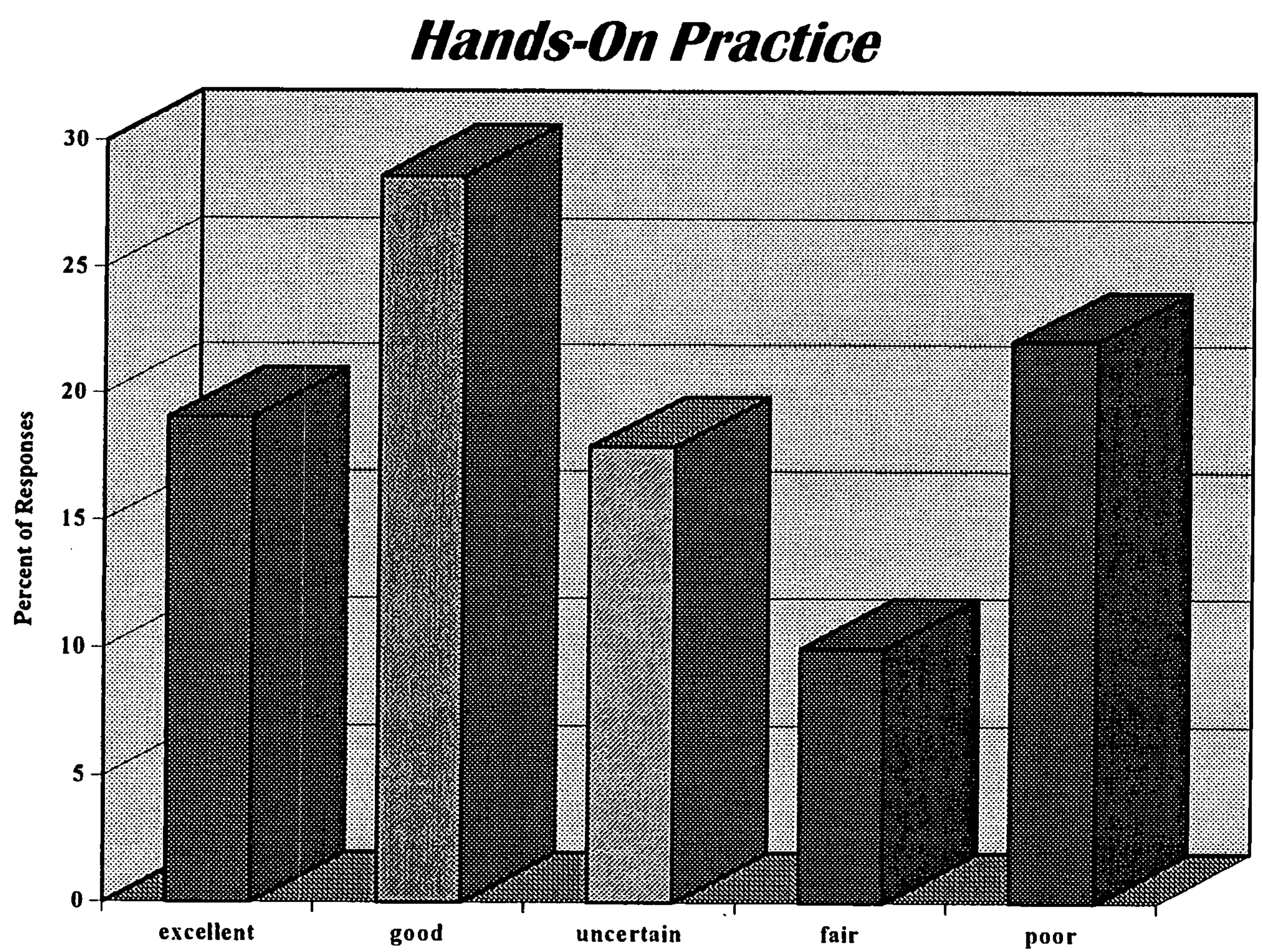
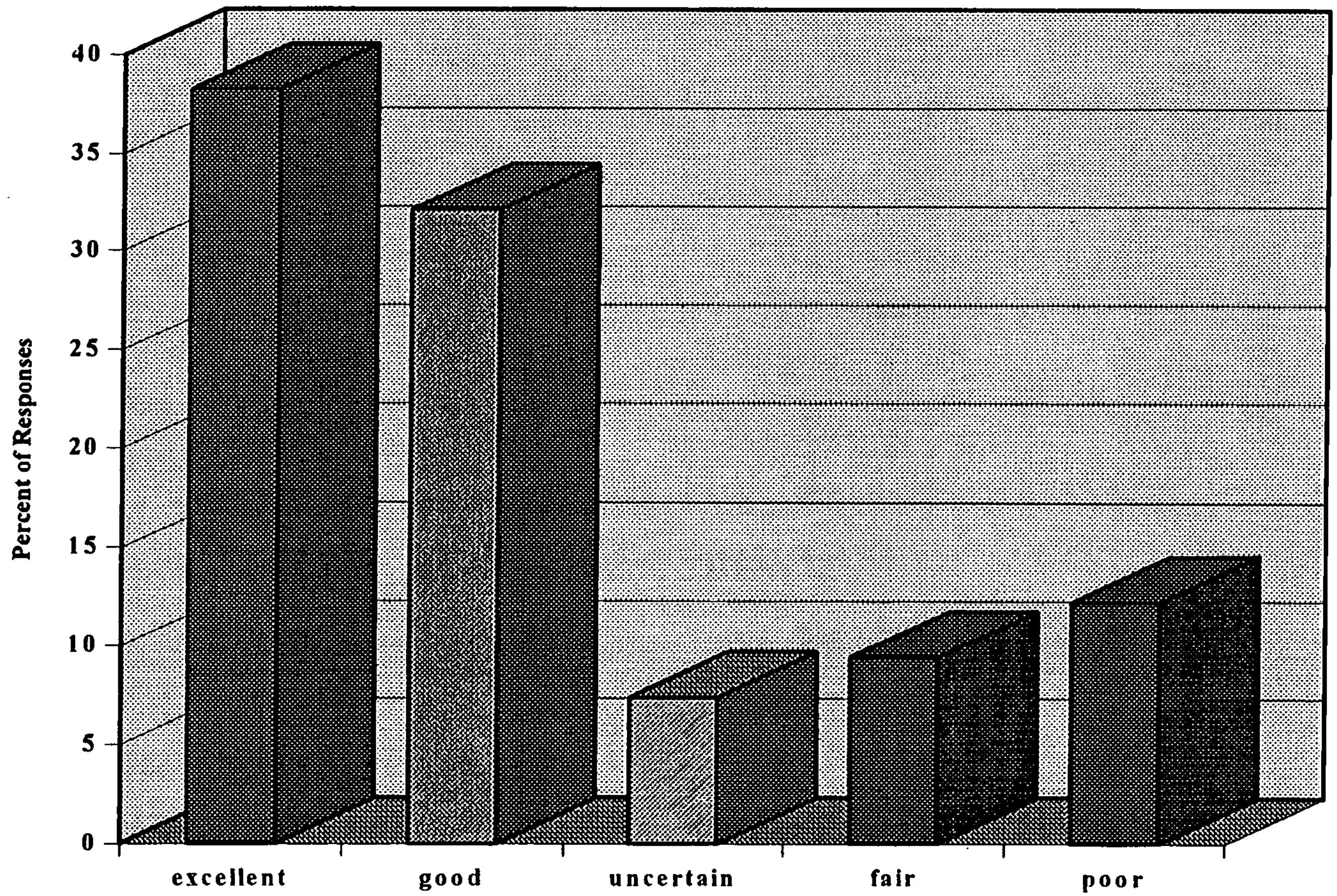
Pilot Program
Evaluation Results



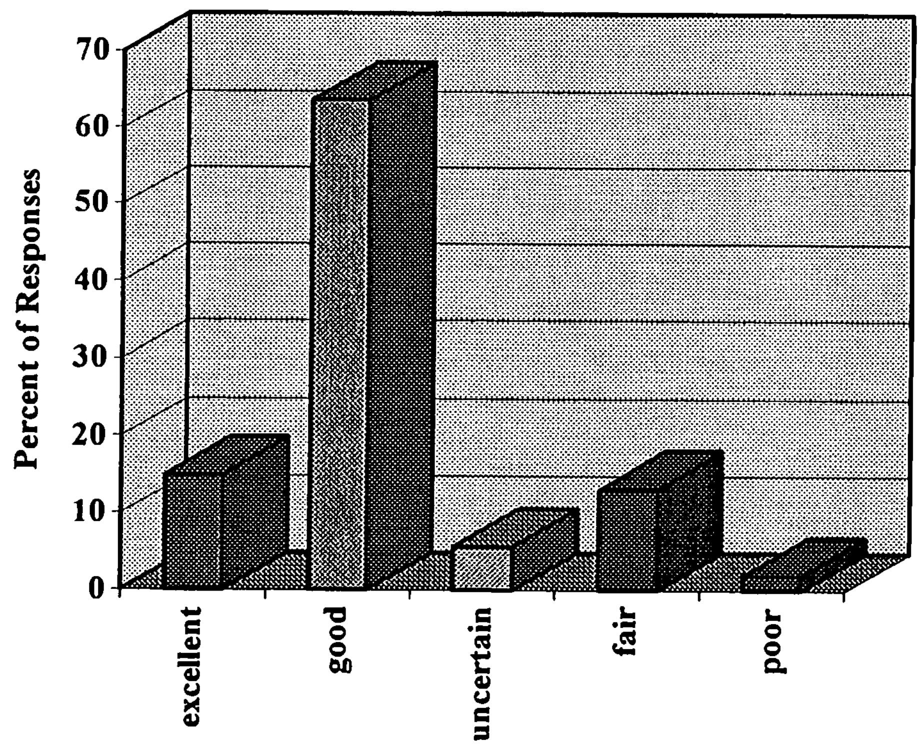
Pilot Program
Evaluation Results

Training Manuals



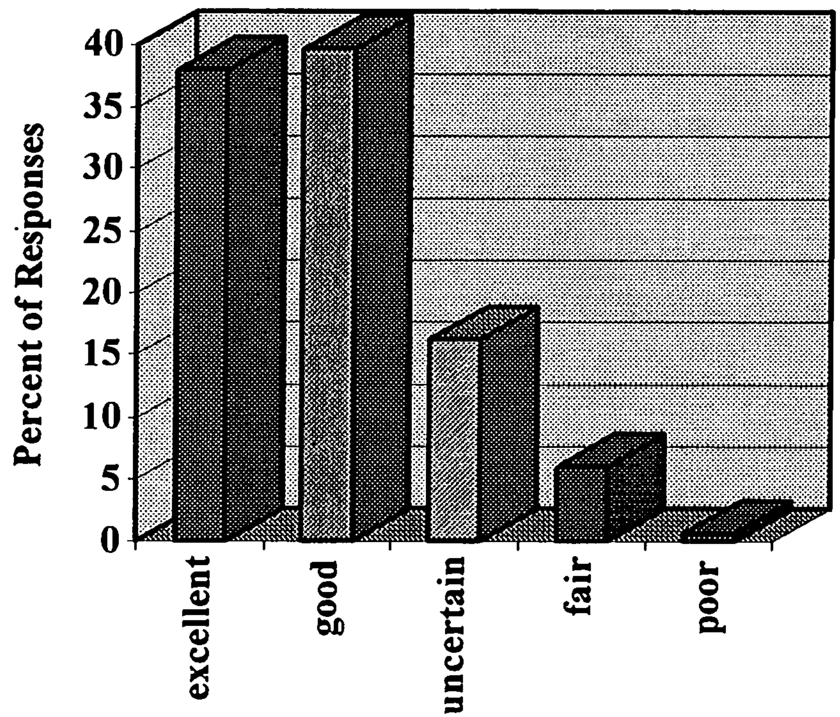
Pilot Program
Evaluation Results

Course Length



Pilot Program
Evaluation Results

Availability of Instructor



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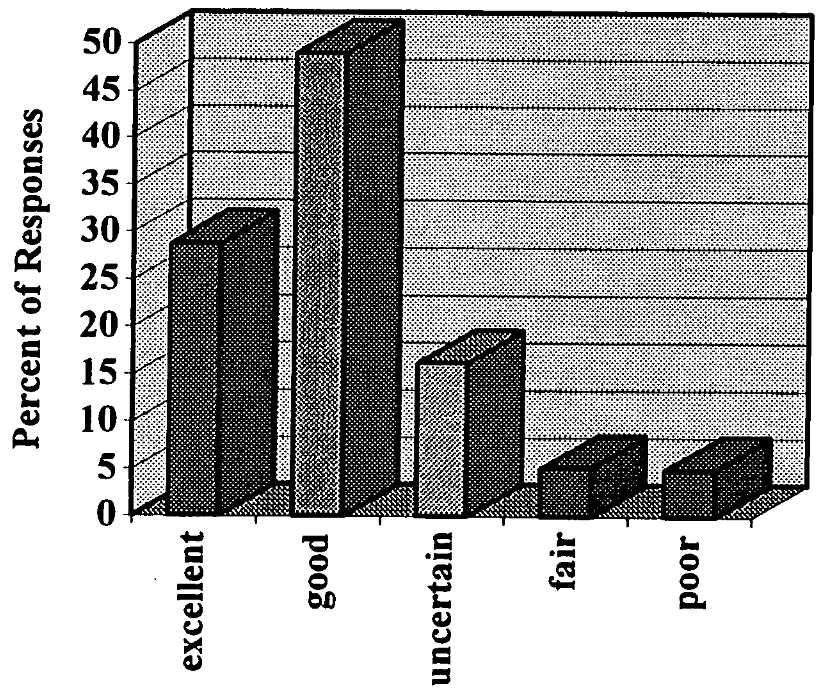
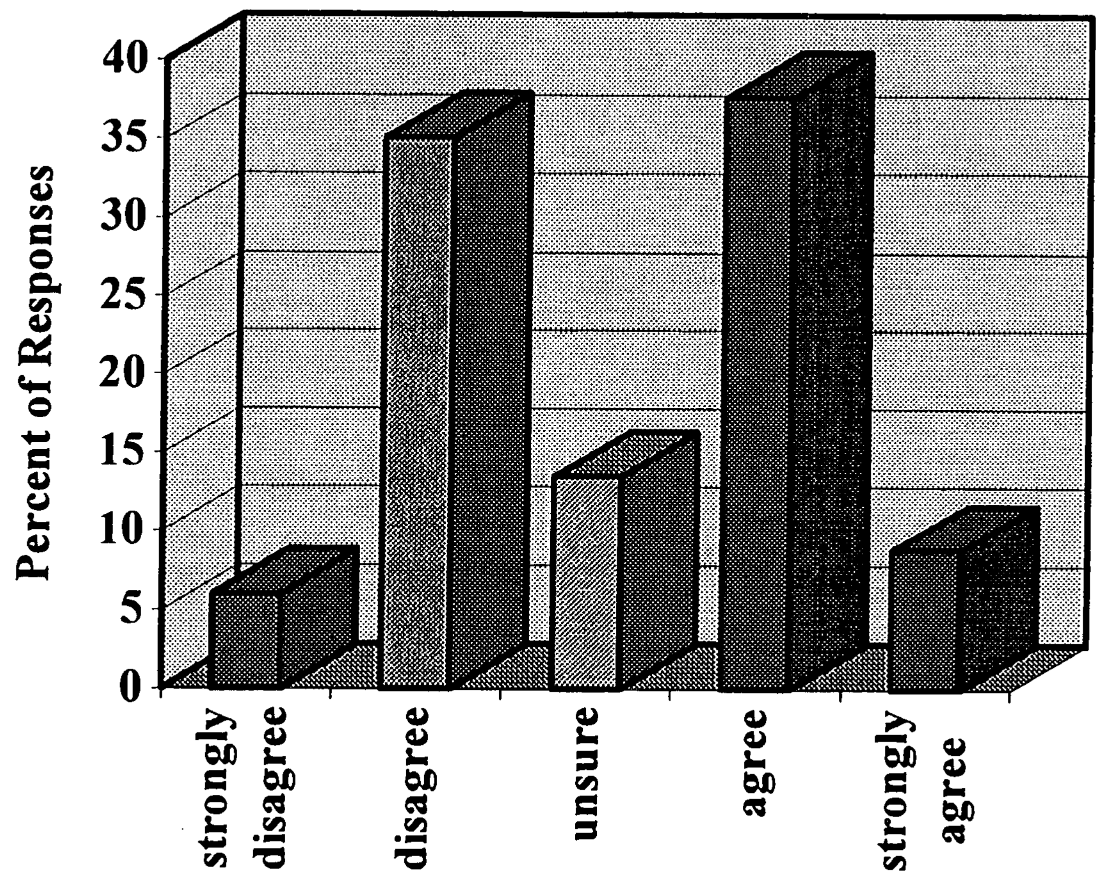
Pilot Program
Evaluation Results

Review of Materials



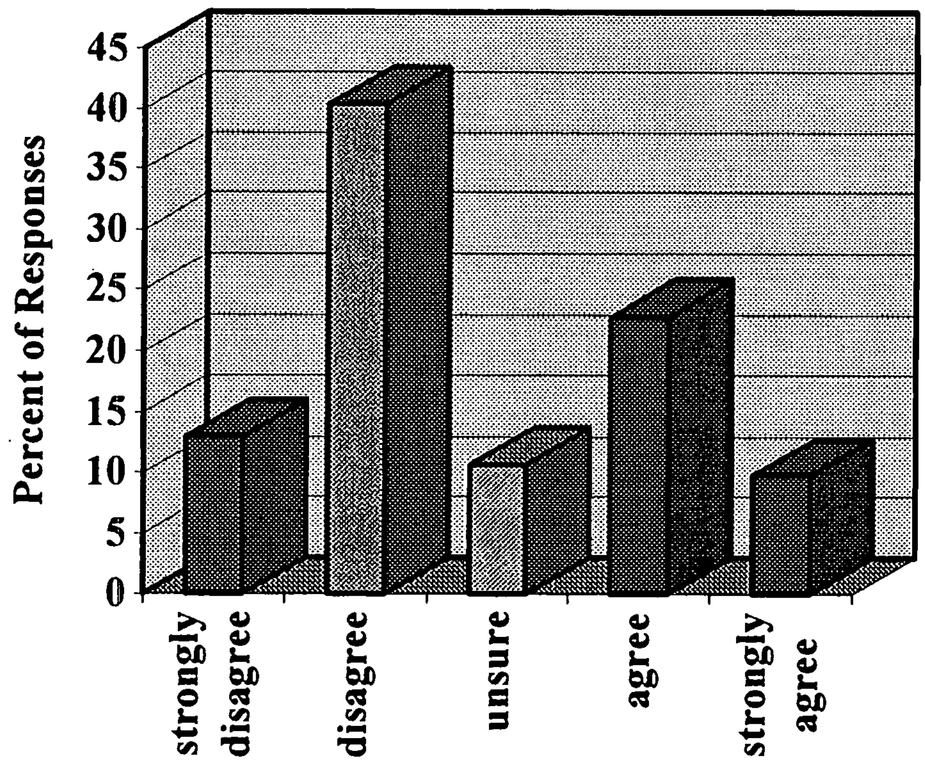
Pilot Program
Evaluation Results

Class Time is Sufficient?



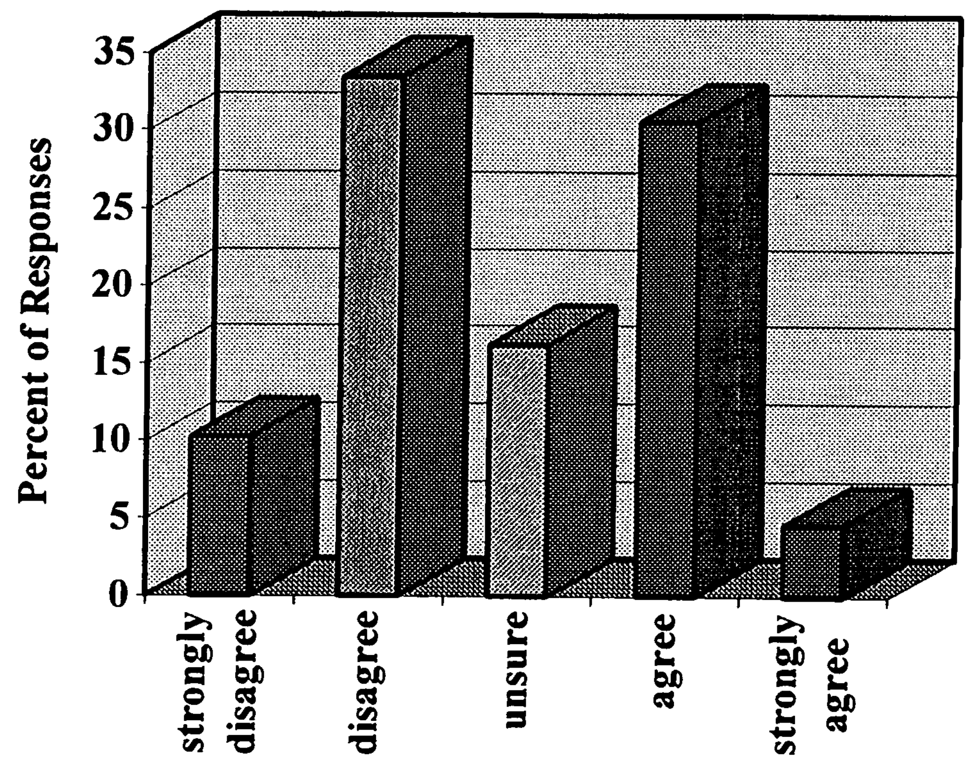
Pilot Program
Evaluation Results

Sufficient Time for Hands-on Practice?



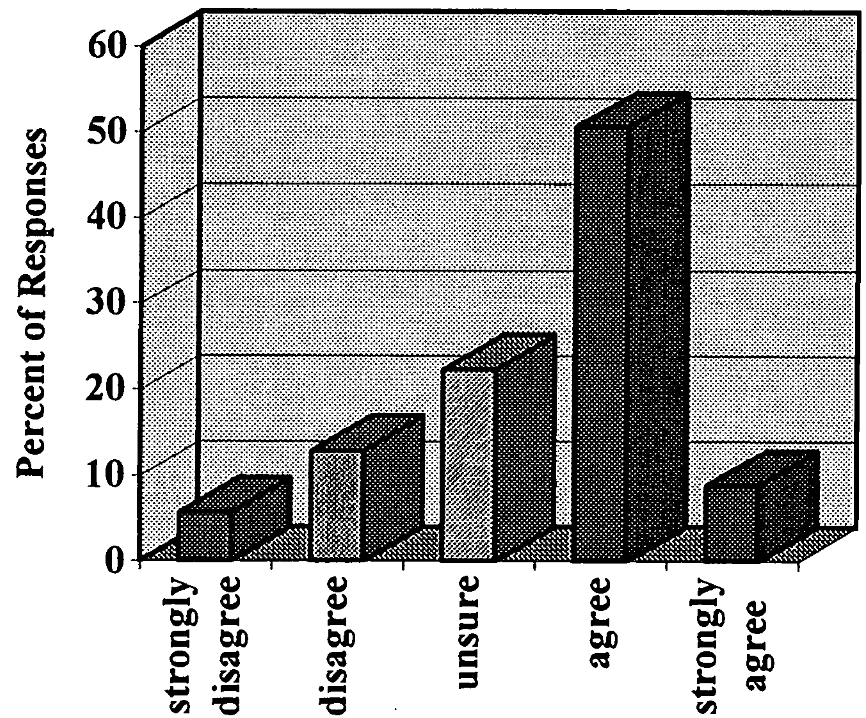
Pilot Program
Evaluation Results

Sufficient Time for Hands-on Instruction?



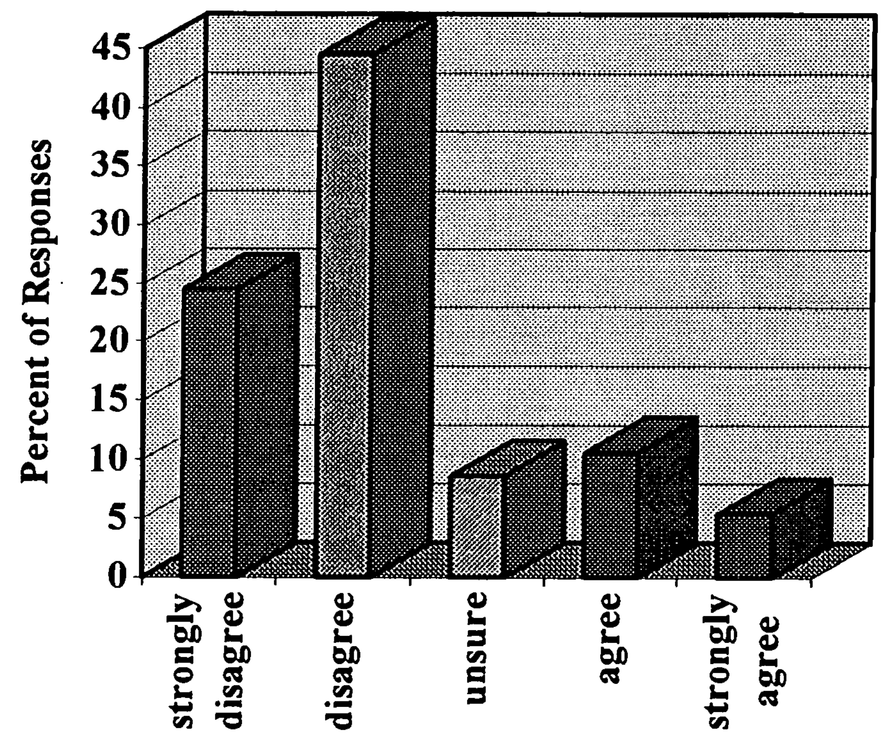
Pilot Program
Evaluation Results

Course Work is at the Right Level of Difficulty?



Pilot Program
Evaluation Results

Course Work is too Easy?



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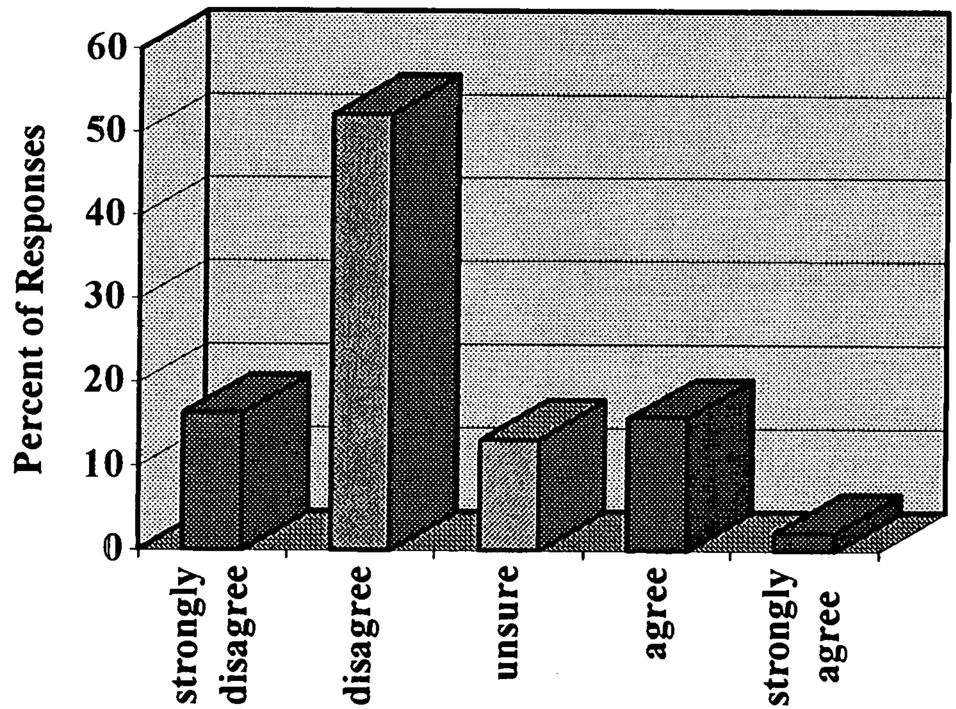
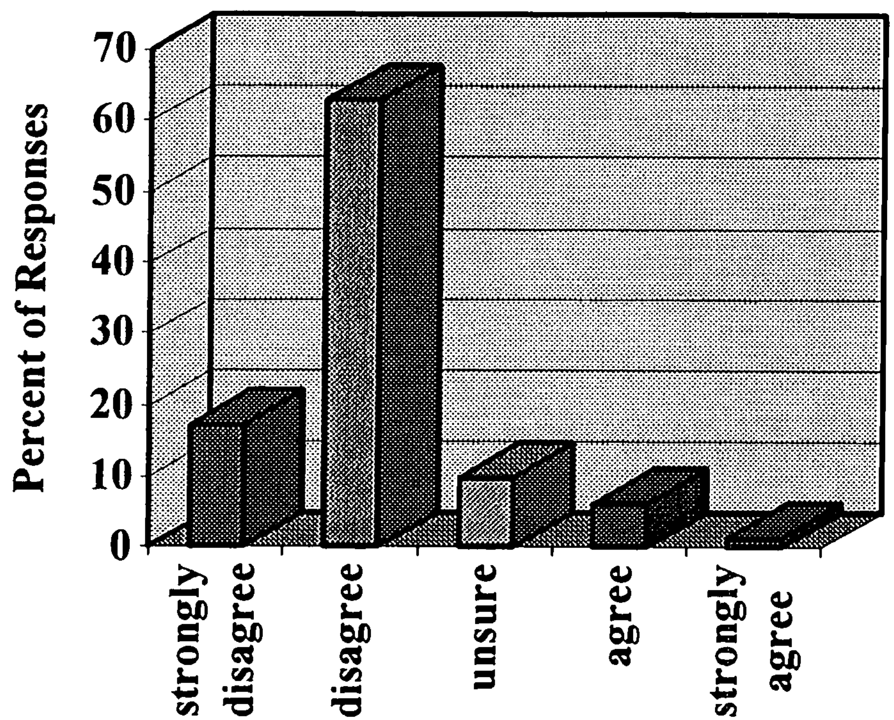
Pilot Program
Evaluation Results

Instructor's Pace is too Fast?



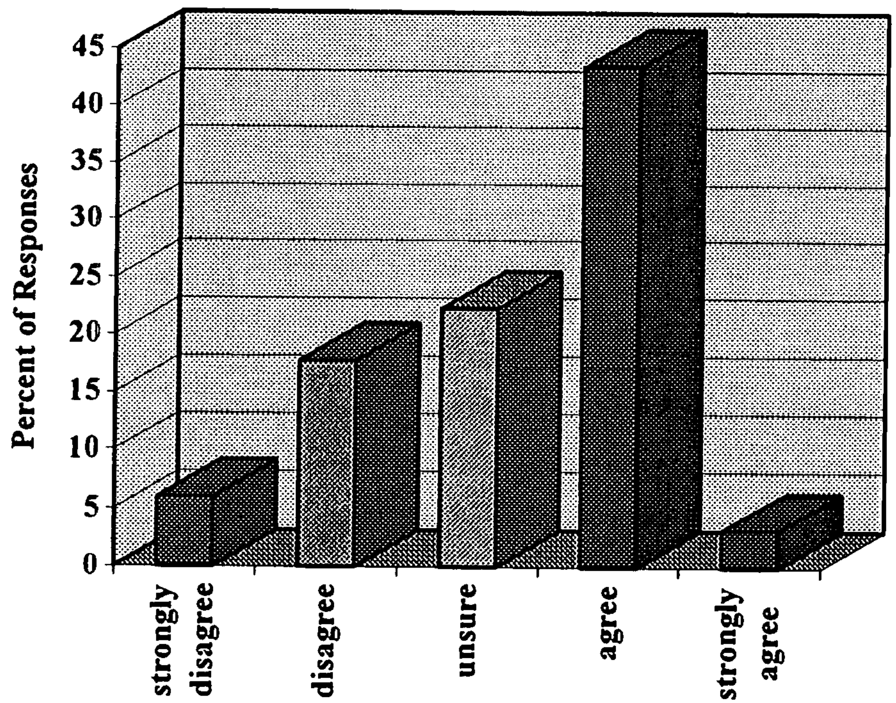
Pilot Program
Evaluation Results

Class Pace is too Fast?



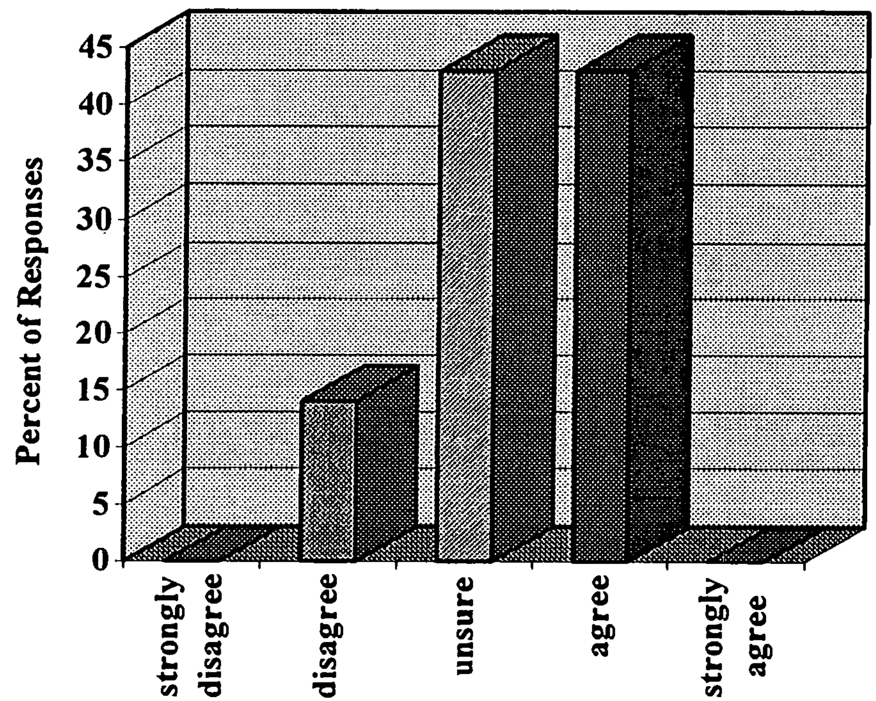
Pilot Program
Evaluation Results

There is Sufficient One-to-One Instruction?



Pilot Program
Evaluation Results

The instructor is Available to Answer Questions?



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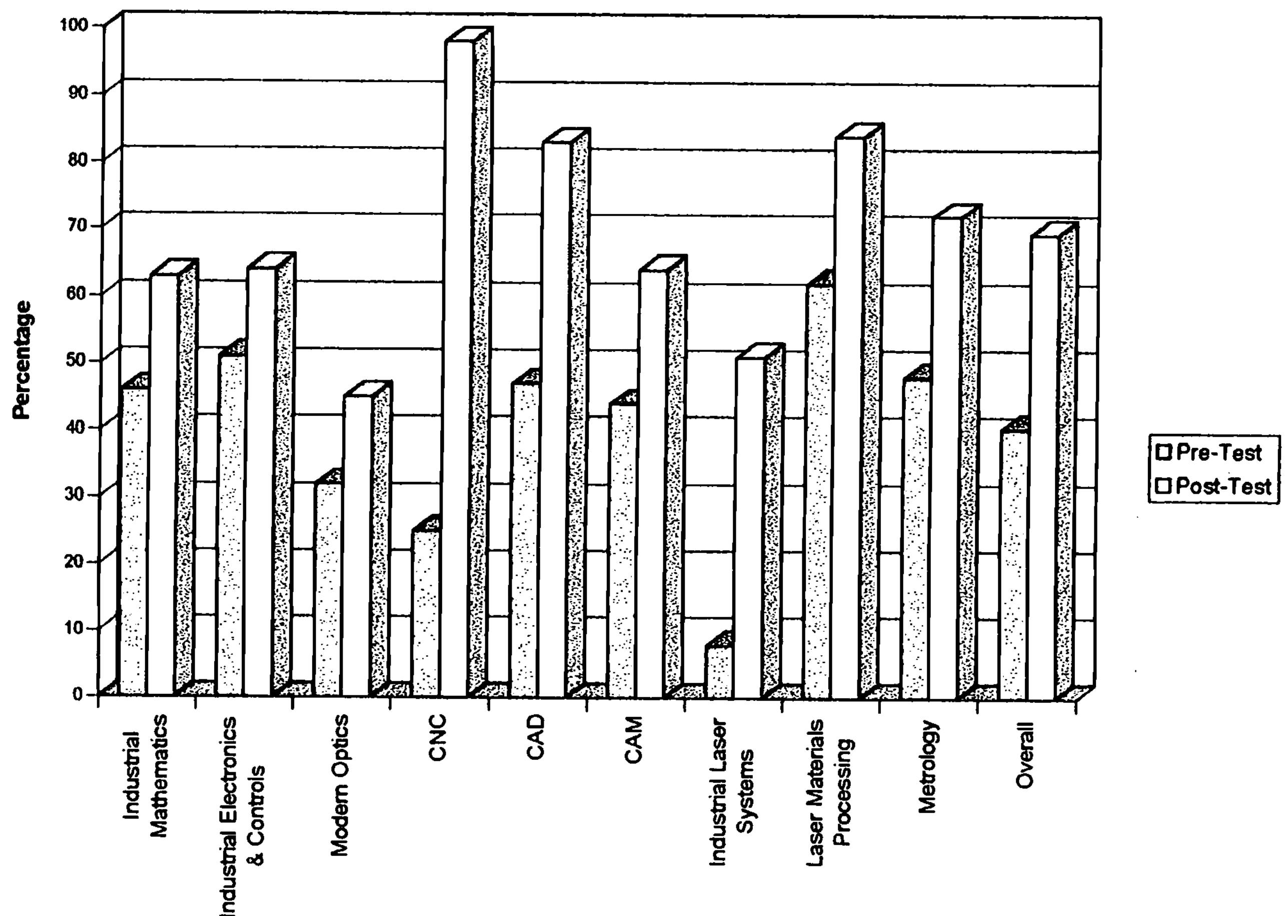
Pilot Program
Evaluation Results

Value Added



SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
SPRINGFIELD, MASSACHUSETTS

LASER-MACHINING GRANT
INDUSTRIAL TOUR

Trip to: Trumpf Laser, Inc, Farmington, CT. on February 13, 1996

Contact: Paul Salvo, Director of Technical Marketing

Trumpf Laser is a worldwide manufacturer of laser and high precision machining equipment consisting of 2500 employees in three countries (US, Canada, & Mexico). The Farmington, CT. facility manufactures machine tools for the metal fabricating industry including laser cutting equipment, punch presses and sheet metal bending equipment. They are the sixth largest machine tool manufacturing company in the world.

The tour began with a two-hour presentation on laser theory and applications specific to Trumpf. The lecture was very well received and was an excellent supplement to the laser Machining program. The lecture was followed by an in-depth tour of the laser manufacturing facility (Turbo Laser®) as well as the customer application center and research and development lab.

Trumpf offers in-house training on their laser cutting equipment and we were fortunate to partake in a live demonstration of a large laser sheet metal cutting demonstration which really helped to solidify the students' understanding of the laser machining process.

The highlight of the tour was observing the lasers being manufactured because of the unique design of the Turbo Laser system. The assembly takes place in a class 100 cleanroom for process integrity and to insure quality and reliability standards.

Trumpf's comments on the laser machining program was very enthusiastic and they seemed genuinely satisfied with the design of the curriculum and looked forward to hiring graduates for the Farmington plant.

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
SPRINGFIELD, MASSACHUSETTS

LASER-MACHINING PILOT PROGRAM
INDUSTRIAL TOUR

Trip to: Laser Services, Inc. Westford MA 01886 on April 4, 1996

Contact: Bruce Beauchene - President, Gary Adams - Manufacturing Manager, & Stephen Knight - Sales & Applications

Laser Services, Inc. is a small job-shop laser machining company. There are about 50 employees. The company was started in 1979, but the owner, Bruce Beauchene, has been involved with machining and manufacturing since 1968. Laser Services' customers vary from the microelectronics industry, NASA, military, and furniture (wood). Their largest work is from the microelectronics industry. In this industry, space can be a difficult requirement, such as hearing aides and pacemakers. Also, reliability enters the design process. Therefore, they perform work in substrate scribing, drilling, cutting, resistor trimming and marking. Their biggest competitor, which was surprising to hear, is Coors, Inc.

On occasion, they also design and build laser processing equipment. The tour included watching their staff retrofitting a turn-key system to meet a customer's manufacturing requirements in a new turn-key product.

The company performs laser machining on a variety of materials including ceramics, nylon, stainless steel, wood, and paper. The tour included some excellent applications of laser machining including laser marking, ceramic cutting, and film resistor trimming. Their trimming process includes in-process testing of the laser trimming. Also, two men were working on a program to perform laser drilling of 50 micron diameter holes into .020 thick stainless steel. One worker was a two year AS graduate while the other was a four year degree engineer.

In all manufacturing operations, the operator monitors the process. The company believes in knowledgeable workers. Their people will set-up, run, and monitor their job. They have found programming to be better as a centralized process. Simply, it is not practical to train every worker in programming. Also, program changes by people not expert in programming can be down right dangerous.

Other operations seen included laser cutting of paper matting for picture frames. These were being done for colleges; presumably to mount pictures. It was amazing that the laser did not burn the paper! It is all in the speed!

The laser machining of ceramics was also seen. They branched a CO_2 laser into 4 beams. Therefore, four parts are cut at the same time. The program was cutting the basic ceramic shape, then providing scribe lines so the parts can be easily snapped off.

Finally, ballistic nylon was being machined to serve as luggage handles. The nice part about this laser application is that the nylon gets its edges sealed, thus preventing fraying.

Their engineering department was small. They are running AutoCAD R12 with their own CAM system. They have hired a Ph.D. from MIT to write the program. Bruce emphasized the cost capital intensity of his business. Turn key laser systems can run $400K.

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
SPRINGFIELD, MASSACHUSETTS

LASER-MACHINING GRANT
INDUSTRIAL TOUR

Trip to: Texcel, Inc. Westfield MA 01085 on April 18, 1996

Contact: Laurence Derose, President; Thomas Marino, VP; and David Thomas, Technician

Texcel is a high technology manufacturing company. The staff are "hands-on", technically competent professionals. Texcel's customers are the medical and aerospace industries. Their products constitute tiny parts which require unique fixturing and manufacturing methods. The majority of their products are assembled with laser welding technology. They also perform laser marking of products utilizing commercially available software (Corel Draw) to facilitate their "print to part" task. They are a small manufacturing facility but stay competitive by accepting more complicated projects.

The people they hire have either a mechanical discipline or an electrical (i.e. laser) discipline. As a result, they must train the new employee in the missing disciplines. They are finding that the best candidates are ex-machinists with CNC background. Therefore, the grant's concept of serving the American Machine tool industry seems right on the mark.

Due to the part sizes, they find their most challenging task is in tooling, fixturing, and materials handling. They have included automation in the form of robotics technology to create manufacturing cells. They require that their employees have PC computer skills including the use of translating files from one format to another (e.g. .DXF to .DWG)

The group was very impressed with the companies dedication to automation and its willingness to accept challenging work to create their "niche" of competitiveness. It seems every manufacturing machine was automated.

The group was very encouraged with their comments on how machinists make the best candidates. A machinist or mechanical technician understands that Texcel is USING lasers not designing them. They understand that the laser is simply another machine tool controlled by a computer. They have a functional understanding of blue prints and CNC codes (G-codes and M-codes). It is truly the time to begin the process for training and educating tomorrow's work force in an interdisciplinary fashion.

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
SPRINGFIELD, MASSACHUSETTS

LASER-MACHINING GRANT
INDUSTRIAL TOUR

Trip to: EBTEC Corporation, Agawam MA , on May 14, 1996

Contact: Rita Ducharme - Human Resources
Mark Hauser - Manufacturing Manager
Lawrence Carlson - Engineering Manager

Ebtec Corporation serves industry with sophisticated services in electron beam welding and laser welding, drilling, and cutting. Ebtec primarily serves the aerospace, military and commercial aircraft, bio-medical and micro-electronics industry. Applications include:

- laser cutting of metals ranging in thickness from .001"- .375" especially hard to machine materials such as inconels and tool steels.
- laser welding of thick or thin materials and circular, flat, tubular, or tapered parts with varying weld joints.
- laser drilling of alloy metals and composites such as super-alloys and Kevlar which cannot be drilled with conventional methods.

Ebtec uses both electron beam welding equipment (9 EB machines) and lasers (11 laser machines) ranging from 350 watts to 1200 watts. Most of the equipment seemed to be less that 10 years old and where controlled with Aerotek programmable controllers. The business is in the process of diversifying its customer base to include more commercial applications such as precision laser processing of automotive panels and cutting of plastics.

Ebtec is also very interested in participating in a co-op arrangement. They were very explicit about what skills they deemed necessary for students interested in laser machining, basically either a machinist experienced in cnc with some laser experience or a laser technician with machining background. In either case, the laser machining program seems to be right on track with their needs.

Industrial Mathematics

MATHEMATICS EVALUATION

LASER MACHINING CERTIFICATE PILOT PROGRAM

Course: Industrial Mathematics

Bruce J. Pennino

Name ______________________________

Directions:

-- Please do as many of the problems as you can. Attempt all problems.
-- Use a calculator.
-- A similar test will be repeated at the end of the program.
-- Do/show all work on these pages.

1. Add: 1/4 + 1/8 + 1/20 + .0235= ________

2. Add: -1 + 2.1 -0.333 -0.3(-.2)= ________

3. Do indicated operations:

   3a. $\frac{20(12)(15)}{15} + \frac{1}{2} =$ ________

   3b. 1/16" = ________FT

   3c. 1" = ________CM

   3d. 2 1/16" = ________MM

   3e. 5.125" = ________M

4. 2X + 3Y - .5X + 2(2Y) = ________

5. $\frac{2a\ (b^2)}{a\ b} =$ ________

6. (X + Y)(X - Y) = ________

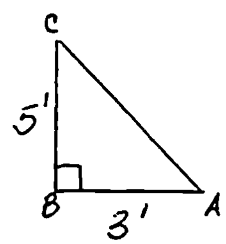
7. A circle has a <u>diameter</u> of 2". Show equations used.

7a. Its circumference is: ________ FT

7b. Its area is: ________ FT^2

7c. Its area is: ________ CM^2

8. For the <u>right</u> triangle shown:



8a. $\measuredangle$ A + B + C = ________ $^\circ$

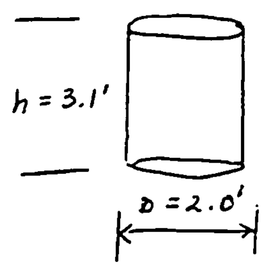
8b. AC(hypotenuse) = ________

8c. $\measuredangle$ A = ________ $^\circ$ = ________ RAD.

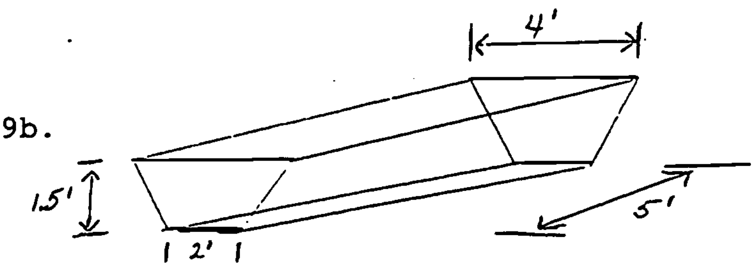
$\measuredangle$ C = ________ $^\circ$

9. Determine the volume of:

9a.



9b.



10. The specific gravity of a metal is 5.0. What is the weight of 5 FT^3.

11. $\frac{A}{B} = \frac{C}{d}$ d= ________

12. $\frac{AB}{XY} = \frac{A}{N-C}$ C= ________

13. 13a. $\sqrt{25} =$ 13b. $(25)^{1/3} =$ 13c. $25^{.25} =$

14. 14a. SIN 10° = ______________

14b. SIN $10^{\circ}\ 23'$ = ______________

14C. SIN $10^{\circ}\ 23'\ 12''$ = ______________

15. 15a. COS θ = .6666

θ = ______________

15b. $\theta = \cos^{-1}$ 0.543

16. You make the following measurements with a micrometer.

0.9994	0.9990	0.9990
0.9992	0.9992	0.9989
0.9996	0.9989	0.9988
0.9995	0.9988	0.9988
0.9990	0.9989	0.9987

16a. What is the mean (average) value?

$\overline{X}$ = ______________

16b. Calculate the standard deviation.

16c. What does standard deviation indicate?

LASER MACHINING CERTIFICATE PILOT PROGRAM

COURSE EVALUATION RESULTS

INDUSTRIAL MATH

1. Training course overall: 6% (2) excellent
   69% (11) good
   19% (3) fair

2. Course content: 13% (2) excellent
   44% (7) good
   25% (4) uncertain
   19% (3) fair

3. Presentation of course material:
   19% (3) excellent
   44% good
   13% (2) uncertain
   25% (4) fair

4. Hands-on instruction:
   13% (2) excellent
   31% (5) good
   25% (4) uncertain
   25% (4) fair
   13% (2) poor
   38% saying either fair or poor

5. Hands on practice: 13% (2) excellent
44% (7) good
6% (1) uncertain
25% (4) fair
6% (1) poor

6. Training manuals: 6% (1) excellent
13% (2) good
38% (6) uncertain
19% (3) fair
25% (4) poor
44% saying either fair or poor

7. Length of course per night:
31% (5) excellent
50% (8) good
6% (1) uncertain
13% (2) fair

8. Availability of instructor for questions or clarification:
38% (6) excellent
25% (4) good
19% (3) uncertain
19% (3) fair

9. Review of materials: 13% (2) excellent
56% (9) good
19% (3) uncertain
13% (2) fair

10. There is enough class time for the instructor to present the material:

13% (2) disagree

6% (1) unsure

75% (12) agree

6% (1) strongly agree

11. There is enough time for hands-on practice:

28% (6) disagree

25% (4) unsure

31% (5) agree

6% (1) strongly agree

12. There is enough time for hands-on instruction:

25% (4) disagree

25%(4) unsure

44% (7) agree

6% (1) strongly agree

13. The course work is at the right level of difficulty for me:

6% (1) strongly disagree

19% (3) disagree

13% (2) unsure

44% (7) agree

19% (3) strongly agree

14. The course work is too easy for me:

31% (5) strongly disagree

44% (7) disagree

13% (2) unsure

13% (2) strongly agree

15. I have trouble keeping up with the instructor:

19% (3) strongly disagree

38% (6) disagree

6% (1) unsure

38% (6) agree

16. I have trouble keeping up with the class:

19% (3) strongly disagree

50% (8) disagree

13% (2) unsure

13% (2) agree

6% (1) strongly agree

17. I am receiving enough one to one instruction:

6% (1) strongly disagree

19% (3) disagree

38% (6) unsure

19% (3) agree

13% (2) strongly agree

18. The instructor is available to answer questions:

25% (4) unsure

50% (8) agree

19% (3) strongly agree

19. SUGGESTIONS FOR IMPROVING THE COURSE

a) Length of time wasn't quite enough to consume enough information.

b) None at this time. Can't evaluate until we find out how this applies to rest of program.

c) Understanding that this was an abbreviated course, the cost of the textbook, the level of math background needed, the quickness of presentation, and the assumption of the instructor that all participants had recent math at the required level, lends me to report that I did not enjoy the math course.

d) I wouldn't change anything but increase the material covered.

e) Better text - example: instructor showed 3 methods of vector analysis, text only showed one. Homework problems were excellent. Instruction was good.

* ( ) number of participants responding

Industrial Electronics & Controls

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

VN585 - FUNDAMENTALS OF INDUSTRIAL ELECTRONICS

Assessment Test - MAST Project

DC Theory

#1. Like charges:

a. Repel b. Attract

#2. When an atom gains or loses an electron, it is called an ion.

a. True b. False

#3. An element is a good conductor when it has:

a. A filled outer shell b. Have a large number of free electrons

c. A half filled outer shell

#4. A battery has:

a. Two terminals b. Separated charge

c. A chemical reaction d. All of the above

#5. The movement of electrons from one point to another is called:

a. EMF b. Current flow c. Resistance

#6. EMF is another name for:

a. Current flow b. Induction c. Potential difference

#7. Four cells, each having an EMF of 2.1 volts are connected in series aiding configuration. The overall EMF is:

a. 2.1 Volts b. 4.0 Volts c. 8.4 Volts

#8. Four cells, each having an EMF of 2.1 volts are connected in a parallel configuration. The overall EMF is:

a. 2.1 Volts b. 4.0 Volts c. 8.4 Volts

#9. Cells can be connected in a series-parallel arrangement so that both the voltage and current capacity increase.

#10. The unit of resistance is the:

a. Watt b. Volt c. Ohm d. Amp

#11. The resistance of 100 feet of wire is 20 Ohms, the resistance of 50 feet of this same wire is:

a. 40 Ohms b. 20 Ohms c. 10 Ohms d. None of the above

#12. The total resistance of resistors in series is equal to:

a. the sum of the resistors b. the largest value resistor

c. the smallest value resistor

#13. The resistance of a Red, Black, Orange resistor is:

a. 200 Ohms b. 20 Ohms c. 20,000 Ohms d. 2,000 Ohms

#14. A voltmater is connected across a circuit:

a. True b. False

#15. An Ohm meter may be used to check a circuit for continuity:

a. True b. False

#16. A short is a:

a. Electronic Malfunction b. A desired circuit

c. When the resistance is infinite

#17. How much current flows through a 10 Ohm resistor when 5 Volts is applied:

a. 2 Amps b. 50 Volts c. 50 mAmps d. 500 mAmps

#18. What is Ohms Law for Voltage:

a. V = I/R b. V = I x R c. V = R/I d. V = I x I x R

#19. What is the value of a resistor which develops a voltage drop of 15 Volts when 1/2 Amp flows through it:

a. 7.5 Ohms   b. 15 Ohms   c. 30 Ohms   d. None of the above

#20. If one has Kilohms of resistance and volts of EMF, one will get:

a. MegAmps   b. Kilowatts   c. Millivolts   d. Milliamps

#21. Power is a measure of:

a. Work   b. Energy   c. Joules   d. Dynes

#22. If in a certain circuit, 100 Volts is applied and 2 Amps flow, the power supplied is:

a. 50 Watts   b. 50 Watt-Hours   c. 200 Watts   d. None of the above

#23. If one knows the current, I, and the resistance, R, one may calculate the power;

a. True   b. False

#24. A parallel circuit is a special form of series circuit:

a. True   b. False

#25. A series-parallel circuit may be simplified to a series circuit:

a. True   b. False

#26. Kirchhoff's Voltage Law states that the sum of the voltage drops in a circuit are equal to the applied voltage:

a. True   b. False

#27. Three wires join together. If 1 Amp of current flows into one wire and 4 Amps of current flow out of another wire. How much current flows into or out of the third wire:

a. 3 Amps out   b. 5 Amps in   c. 3 Amps in   d. 5 Amps out

#28. The total resistance of a parallel circuit is less than the smallest resistor:

a. True   b. False

AC Theory

#1. Magnetism and electricity are not related.

a. True b. False

#2. A magnetic field can induce an EMF in a wire:

a. Sometimes b. Always c. Never

#3. How is electrical energy stored in a capacitor?

a. Magnetic Field b. Electric Field c. EM Field

#4. What happens to the current in a circuit while a capacitor is charging?

a. Increases b. Decreases c. Constant

#5. The rate of charge or discharge of a capacitor or inductor is called the time constant.

a. True b. False

#6. An AC generator produces a Sine Wave output voltage

a. True b. False

#7. What is the unit of measurement for frequency?

a. EMF b. Henry c. Hertz d. Period

#8. A sine wave goes through a 360 degree cycle:

a. True b. False

#9. The peak value of a sign wave occurs at:

a. 45 Degrees b. 120 Degrees c. 90 Degrees d. 240 Degrees

#10. If the frequency of a signal is 5 KHz, what is its period?

a. 10 mSec b. 2 mSec c. 20 mSec d. .2 mSec e. .02 mSec

#11. An Oscilloscope is used to measure or observe:

a. Power b. Signals c. Resistance d. Capacity

#12. A signal takes up 5 squares horizontally, the Time/Cm control is set to 2 mSec. What is the frequency of the waveform?

a. 2 KHz. b. 200 Hz. c. 100 Hz. d. 20 Hz. e. 10 Hz.

#13. The waveform on the screen has a height of 5 squares, the vertical sensitivity is 10 Volts/Division. What is the waveforms peak to peak value?

a. 5 Volts b. 10 Volts c. 2 Volts d. 50 Volts e. 25 Volts

#14. If an AC voltage is applied to a resistor, the current and voltage are in Phase.

a. True b. False

#15. The power supplied by the power company has a frequency of

a. 400 Hz. b. 60 Hz. c. 120 Hz. d. 50 Hz.

#16. How much power is dissipated in a purely capacitive circuit?

a. Depends upon Capacitor Value b. Power = I X V

c. None d. Not Enough Information Given

#17. How does the resistance that a capacitor has to the flow of AC current (reactance) vary with frequency? As the frequency goes up, reactance goes:

a. Up b. Down c. Constant d. Oscillates

#18. What does it mean to attenuate a signal?

a. Raise its Level b. Lower its Level c. Keep it Constant

#19. Inductive reactance behaves just the opposite of capacitive reactance:

a. True b. False

#20. The formular for inductive reactance is:

a. Xl = 1/2*PI*F*L   b. Xl = 2*PI*F*L   c. XL = 2*PI*L

#21. If one uses a capacitor and an inductor together in a circuit, the circuit will exhibit:

a. High Resistance   b. Resonance   c. Low Resistance

#22. One can build a low pass filter from resistors and capacitors:

a. True   b. False

#23. A "Cross-Over" network is a type of Filter:

a. True   b. False

#24. The "Q" of a Band Pass Filter is a measure of its sharpness;

a. True   b. False

#25. What are the two windings of a transformer called?

#26. The voltage ratio between the primary and secondary of a transformer is directly proportional to:

#27. Transformers may be used to step-up or step-down AC voltage:

a. True   b. False

Semiconductor Theory

#1. What are the two semiconductor materials most commonly used to manufacture electronic components?

#2. What are the current carriers in an N-type semiconductor?

#3. Semiconductors are not affected by temperature.

a. True b. False

#4. A diode is formed by combining N-type and P-type semiconductor material.

a. True b. False

#5. A diode will conduct in both directions.

a. True b. False

#6. Diode V-I curves show how a diode functions.

a. True b. False

#7. Figure 19-7 shows the V-I of a silicon diode. Is the diode ON or OFF if the applied voltage is .3 Volts?

a. ON b. OFF c. Not enough information

#8. PIV stands for:

a. P-type InVerter b. Peak Inverse Voltage

c. Positive InVerter d. Positive IV

#9. A Zener Diode is used for:

a. A voltage regulator b. A voltage reference

c. Both a and b d. None of the above

#10. Bipolar Transistors were invented by T. Edison in 1875.

a. True b. False

#11. A transistor has current gain.

a. true b. False

#12. A common-emitter configuration is a type of amplifier.

a. True b. False

#13. A certain Transistor amplifier has an input of 50 mVolts and an output of 5 Volts. It has a gain of:

a. 5 b. 10 c. 50 d. 100 e. 1000

#14. To function correctly a transistor must be biased.

a. True b. False

#15. Two transistor amplifiers with gains of 10 are cascaded together. The total gain is:

a. 20 b. 1000 c. 100 d. none of the above

#16. What does FET stand for?

#17. The FET is a current amplifier.

a. True b. False

#18. The three leads of an FET are: Gate, Drain, and Emitter.

a. True b. False

#19. Amplifiers are used to change a signal's:

a. Time b. Frequency c. Power d. Delay

#20. There are many types of FETs

a. True b. False

#21. An SCR is a type of control device

a. True b. False

#22. The PUT is a type of Vacuum Tube.

a. True b. False

#23. An LED is a type of Laser.

a. True b. False

#24. A solar cell converts light energy to sound energy.

a. True b. False

#25. What color LED doesn't yet exist?

a. Orange b. Green c. Yellow d. Blue e. Red

#26. What happens to the resistance of a photoconductive cell as light intensity increases?

a. gets smaller b. gets larger c. no change

#27. LCD's are easier to read in bright sun light than LED's.

a. true b. false

#28. Do incandescent lamps have a long life expectancy?

a. Yes b. No

Digital Theory

#1. A quantity having a continuous set of values is called a:

a. a digital quantity
b. an analog quantity
c. a binary quantity
d. a natural quantity

#2. The output of an OR gate is High when:

a. any input is High
b. all inputs are high
c. no inputs are high
d. both a and b

#3. An example of a data storage device is:

a. the logic gate
b. the flip-flop
c. the comparator
d. the register
e. both b and d

#4. The binary number 1101 is equal to the decimal number:

a. 13
b. 49
c. 11
d. 3

#5. The decimal number 17 is equal to the binary number:

a. 10010 b. 11000 c. 10001 d. 01001

#6. The binary number 10001101010001101111 can be written in hexadecimal as:

a. AD467 b. 8C46F c. 8D46F d. AE46F

#7. When the input to an inverter is High (1), the output is

a. High or 1
b. Low or 1
c. High or 0
d. Low or 0

#8. The output of an AND gate with inputs A, B, C is High (1) when:

a. A = 1, B = 1, C = 1
b. A = 1, B = 0, C = 1
c. A = 0, B = 0, C = 0

#9. The TTL family with the fastest switching speed is

a. Standard b. ALS c. AS

#10. All Boolean expressions can be implemented with

a. NAND gates only b. NOR gates only

c. Combinations of NAND and NOR gates

d. combinations of AND gates, OR gates and inverters

e. any of these

#11. A 4-Bit parallel adder can add

a. two 4-bit binary numbers b. two 2-bit binary numbers

c. four bits at a time d. four bits in sequence

#12. A BCD-to-7-segment decoder has 0100 on its inputs. The active outputs are

a. a, c, f, g b. b, c, f, g c. b, c, e, f

d. b, d, e, g

#13. A feature that distinguishes the J-K flip-flop from the S-R flip-flop is the

a. toggle condition b. preset input

c. type of clock d. clear input

#14. A one-shot is a type of

a. monostable multivibrator b. astable multivibrator

c. timer d. both a and c e. both b and c

#15. A four bit binary counter has a maximum count of

a. 16 b. 32 c. 8 d. 4

#16. A stage in a shift register consists of

a. a latch b. a flip-flop c. a byte of storage

#17. A 32-bit data word consists of

a. 2 bytes b. 4 nibbles c. 4 bytes d. 3 bytes

#18. A DRAM must be

a. replaced periodically b. refreshed periodically

c. always enabled d. programmed before each use

#19. An 8-Bit DAC has a resolution of

a. 0.1% b. 0.392% c. 1% d. 3.92%

#20. The RS-232C is

a. a standard interface for parallel data

b. a standard interface for serial data

c. an enhancement of the IEEE-488 interface

d. the same as SCSI

#21. A basic microcomputer does not include

a. an arithmetic unit b. a control unit

c. peripheral units d. a memory unit

#22. A 20-bit address bus supports

a. 100,000 memory addresses b. 1,048,576 addresses

c. 2,097,152 addresses d. 20,000 addresses

#23. DMA stands for

a. digital microprocessor address b. direct memory access

c. data multiplexed access

LASER MACHINING CERTIFICATE PILOT PROGRAM

COURSE EVALUATION RESULTS

INDUSTRIAL ELECTRONICS

1. Training course overall:
   - 11% (2) excellent
   - 61% (11) good
   - 22% (4) uncertain

2. Course content:
   - 22% (4) excellent
   - 50% (9) good
   - 22% (4) uncertain
   - 5% (1) fair

3. Presentation of course material:
   - 22% (4) excellent
   - 50% (9) good
   - 16% (3) uncertain
   - 5% (1) fair
   - 5% (1) poor

4. Hands-on instruction:
   - 16% (3) good
   - 27% (5) uncertain
   - 22% (4) fair
   - 39% (7) poor

5. Hands on practice:
   - 5% (1) good
   - 28% (5) uncertain
   - 11% (2) fair
   - 55% (10) poor

6. Training Manuals: 5% (1) good

22% (4) uncertain

11% (2) fair

61% (11) poor

7. Length of course per night:

5% (1) excellent

78% (14) good

11% (2) uncertain

5% (1) fair

8. Availability of instructor for questions or clarification:

44% (8) excellent

28% (5) good

28% (5) uncertain

9. Review of materials: 22% (4) excellent

22% (4) good

44% (8) uncertain

5% (1) fair

5% (1) poor

10. There is enough class time for the instructor to present the material:

5% (1) strongly disagree

33% (6) disagree

17% (3) unsure

33% (6) agree

5% (1) strongly agree

11. There is enough time for hands-on practice:

39% (7) strongly disagree

33% (6) disagree

11% (2) unsure

11% (2) agree

12. There is enough time for hands-on instruction:

22% (4) strongly disagree

33% (6) disagree

28% (5) unsure

11% (2) agree

13. The course work is at the right level of difficulty for me:

16% (3) disagree

33% (6) unsure

39% (7) agree

5% (1) strongly agree

14. The course work is to easy for me:

16% (3) strongly disagree

44% (8) disagree

5% (1) agree

11% (2) strongly agree

15. I have trouble keeping up with the instructor:

16% (3) strongly disagree

28% (5) disagree

11% (2) unsure

39% (7) agree

16. I have trouble keeping up with the class:

16% (3) strongly disagree

55% (10) disagree

16% (3) unsure

5%(1) agree

17. I am receiving enough one to one instruction:

22% (4) disagree

44% (8) unsure

28% (5) agree

18. The instructor is available to answer questions:

28% unsure

50% agree

16% strongly agree

19. SUGGESTIONS FOR IMPROVING THE COURSE

a) It's difficult. I think we should go at a slower pace but yet there isn't enough time.

b) Continue to develop curriculum.

c) Not enough time to learn what's necessary.

d) None at this time. Can't evaluate until we find out how this applies to rest of program text. Homework might be helpful, we crammed a lot of information into a short period of class time.

e) Ensure course materials and handouts are made available. Ensure course hands-on is available. Ensure course hands-on practice is made available.

f) More hands on.

g) Suggest that students be aware that it's better for them to have some previous experience in electronics.

h) Classes on more days. Need books and manuals.

i) When doing a shortened course like this, it is essential to do a task analysis to determine those key knowledge items required for job success. Don't tell me what your not going to tell me. It results in wasted time and my feeling cheated. Don't promise to give training materials on first day and then fail to deliver. Handouts would have helped greatly. Younger students talk too much among themselves creating a distracting environment.

j) Run this for more than 6 weeks. Need more hands on projects

k) More classes. Need books.

l) After a semester of basic electronics, if possible, I would have a class on trouble shooting industrial electronic equipment. (ie CNC controller)

* ( ) number of participants responding

Modern Optics

*Name*__________________

Laser Machining Program

Modern Optics
Final Exam

Please circle the correct answer. There is only one correct answer per question.

1. Light, as it propagates through space, can be considered to be

a. a ray

b. a wave

c. a particle

d. all of the above

2. The primary colors contained in white light are (in the proper order)

a. red, orange, yellow, green, blue, indigo, violet

b. violet, red, yellow, green, orange, blue, indigo

c. black, brown, red, orange, yellow, green, blue

d. orange, yellow, green, violet, red, white, brown

3. The wavelength range for visible light is

a. 300 to 600 nanometers

b. 400 to 700 meters

c. 1000 to 10000 nanometers

d. 400 to 700 nanometers

4. The infrared portion of the spectrum ranges from

a. 400 to 700 nanometers

b. 1 micrometer to 1 millimeter

c. 10 to 400 nanometers

d. 1000 micrometers to 100 millimeters

5. The ultraviolet portion of the spectrum ranges from

a. 400 to 700 nanometers

b. 1 micrometer to 1 millimeter

c. 10 to 400 nanometers

d. 1000 micrometers to 100 millimeters

6. The velocity of light in a vacuum is

a. 1000 miles/hr

b. 10000 miles/hr

c. 186,000 miles/hr

d. 300,000,000 meters/sec

7. The index of refraction is a measure of ratio of

a. the speed of light in material to the speed of light in a vacuum

b. the speed of light in a vacuum to the speed of light in a material

c. the wavelength of infrared light to the wavelength of visible light

d. the frequency of visible light to the frequency of ultraviolet light

8. The wavelength of light in a material is

a. greater than the wavelength in a vacuum

b. less than the wavelength in a vacuum

c. the same as the wavelength in a vacuum

d. none of the above

9. The frequency of light in a material is

a. greater than the frequency in a vacuum

b. less than the frequency in a vacuum

c. the same as the frequency in a vacuum

d. none of the above

10. *The polarization of light describes*

  a. *the direction in which the light is propagating*

  b. *the orientation of the electric field of the wave*

  c. *the ability of the light to travel through a material*

  d. *its ability to be influenced by outside forces*

11. *Brewster's angle is defined as*

  a. *the angle that light makes as it refracted by glass*

  b. *the direction in which the light is propagating*

  c. *the angle at which 100% of the parallel component of the electric field is transmitted*

  d. *the angle at which total internal reflection occurs*

12. *The critical angle is defined as*

  a. *the angle that light makes as it refracted by glass*

  b. *the direction in which the light is propagating*

  c. *the angle at which 100% of the electric field is transmitted*

  d. *the angle at which total internal reflection occurs*

13. *A quarter waveplate is used*

  a. *to produce plane polarized light*

  b. *the produce circularly polarized light*

  c. *to attenuate light*

  d. *to rotate the plane of polarization*

14. *A half-wave plate is used*

  a. *to produce plane polarized light*

  b. *the produce circularly polarized light*

  c. *to attenuate light*

  d. *to rotate the plane of polarization*

15. *Coherence is a measure of*

a. *the constant phase relationship between two or more waves of light*

b. *the ability of a material to transmit light*

c. *the ability of different wavelengths of light to propagate through space*

d. *the orientation of the electric field of a light wave*

16. *Diffraction is defined as*

a. *the bending of light by a lens*

b. *the phase shift experienced by light as it travels through the atmosphere*

c. *the bending of light as it passes by an obstacle*

d. *the scattering of light by microscopic impurities in a material*

17. *A diffraction-limited optical system is one in which*

a. *the focusing ability is limited only by the size of the aperture*

b. *the intensity of the light is reduced because of diffraction*

c. *the polarization of the light is rotated by the diffracting aperture*

d. *all of the above*

18. *The optical density of a material is a measure of*

a. *the thickness of the material*

b. *the mass of the material*

c. *the absorption of the material*

d. *the ability of a material to absorb water*

19. *A neutral density filter is*

a. *a filter that allows all wavelengths of light to pass*

b. *a filter that allows only a narrow range of wavelengths to pass*

c. *a filter that allows all wavelengths except for a narrow range to pass*

d. *a filter that allows only a certain intensity of light to pass*

20. *Radiometry is defined as the measurement of*

a. *electromagnetic radiation where all wavelengths are treated equally*

b. *electromagnetic radiation limited to the visible portion of the spectrum*

c. *electromagnetic radiation limited to the ultraviolet portion of the spectrum*

d. *electromagnetic radiation limited to the infrared portion of the spectrum*

21. *Photometry is defined as the measurement of*

a. *electromagnetic radiation where all wavelengths are treated equally*

b. *electromagnetic radiation limited to the visible portion of the spectrum*

c. *electromagnetic radiation limited to the ultraviolet portion of the spectrum*

d. *electromagnetic radiation limited to the infrared portion of the spectrum*

22. *A lens focuses light through*

a. *reflection*

b. *diffraction*

c. *refraction*

d. *birefringence*

23. *Which of the following lenses is not a converging lens?*

a. *biconvex*

b. *biconcave*

c. *plano-convex*

d. *positive meniscus*

24. *A positive meniscus focuses light from infinity*

a. *at the front focal point of the lens*

b. *at the back focal point of the lens*

c. *at infinity*

d. *in the center of the lens*

LASER MACHINING CERTIFICATE PILOT PROGRAM

COURSE EVALUATION RESULTS

MODERN OPTICS

1. Training course overall:	29% (4) excellent
	66% (9) good
	14% (2) fair
2. Course content:	14% (2) excellent
	71% (10) good
	7% (1) uncertain
	7%(1) fair
3. Presentation of course material:	14% (2) excellent
	71% (10) good
	14% (2) uncertain
	7% (1) poor
4. Hands-on instruction:	7% (1) excellent
	28% (4) good
	50% (7) uncertain
	14% (2) fair
5. Hands-on practice:	21% (3) good
	36% (5) uncertain
	19% (2) fair
	28% (4) poor

6. Training manuals:
   21% (3) excellent
   57% (8) good
   7% (1) uncertain
   14% (2) fair

7. Length of course per night:
   14% (2) excellent
   57% (8) good
   7% (1) uncertain
   14% (2) fair
   7% (1) poor

8. Availability of instructor for questions or clarification:
   50% (7) excellent
   43% (6) good
   7% (1) uncertain

9. Review of materials:
   7% (1) excellent
   79% (11) good
   14% (2) uncertain
   7% (1) poor

10. There is enough class time for the instructor to present the material:
    14% (2) strongly disagree
    36% (5) disagree
    7% (1) unsure
    43% (6) agree

11. There is enough time for hands-on practice:

29% (4) strongly disagree

43% (6) disagree

14% (2) unsure

14% (2) agree

12. There is enough time for hands-on instruction:

14% (2) strongly disagree

36% (5) disagree

14% (2) unsure

36% (5) agree

13. The course work is at the right level of difficulty for me:

7% (1) disagree

36% (5) unsure

50% (7) agree

7% (1) strongly agree

14. The course work is too easy for me:

21% (3) strongly disagree

71% (10) disagree

7% (1) unsure

15. I have trouble keeping up with the instructor:

43% (6) disagree

29% (4) unsure

21% (3) agree

7% (1) strongly agree

16. I have trouble keeping up with the class:

71% (10) disagree

21% (3) unsure

7% (1) agree

17. I am receiving enough one to one instruction:

7% (1) strongly disagree

21% (3) disagree

21% (3) unsure

50% (7) agree

18. The instructor is available to answer questions:

7% (1) unsure

71% (10) agree

21% (3) strongly agree

19. SUGGESTIONS FOR IMPROVING THE COURSE

a) The demonstrations were nice, but the theory presentations without working problems resulted in my not getting much from the demos.

b) More hands on work.

c) More time and more hands on labs.

d) Was not enough overall time to complete course.

e) More time required for this subject. Most complex course so far.

* ( ) number of participants responding

Computer Aided Design (CAD)

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
SPRINGFIELD, MASSACHUSETTS

INTRODUCTION TO COMPUTER-AIDED DESIGN

Quiz 1

PART I. MULTIPLE CHOICE

1. The file extension ".bak" stands for
   A. backup file.
   B. binary file.
   C. binary attribute file.
   D. backing file.
   E. both B and D.

2. The following are valid systems of units identified in the UNITS command <u>except</u>
   A. Fractional
   B. Decimal
   C. English
   D. Scientific
   E. Engineering

3. The command that sets the paper size is
   A. SETTINGS.
   B. LIMITS.
   C. PSPACE.
   D. GRID.
   E. SCALE.

4. The AutoCAD command that allows you to make multiple copies of existing objects in a rectangular or circular pattern is called
   A. REPEAT
   B. ARRAY
   C. MINSERT
   D. MULTIPLE
   E. MCOPY

5. The command DTEXT is an enhanced TEXT command in that DTEXT:
   A. allows the user to see text as its being typed in
   B. allows the user to enter text with a dialogue box
   C. allows the user to enter multiple lines of text without restarting the command
   D. A and C
   E. A and B

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
SPRINGFIELD, MASSACHUSETTS

INTRODUCTION TO COMPUTER-AIDED DESIGN

Quiz 1

6. Which of the following is not a valid option for creating circles?
   - A. CEN, RAD:
   - B. CEN, DIA:
   - C. 2 POINT:
   - D. TTR:
   - E. CIRCUM:

7. To view a different portion of a drawing without changing its magnification, use
   - A. MOVE.
   - B. VIEW.
   - C. PAN.
   - D. ZOOM.
   - E. none of the above.

8. The setting that forces the cursor in horizontal and vertical movement is
   - A. Axis.
   - B. Ortho.
   - C. Snap.
   - D. Parallel.
   - E. None of the above.

9. The "U" option of the LINE command means
   - A. Unite
   - B. Unit.
   - C. Underline.
   - D. Undo.
   - E. Union.

10. All of the following are valid options of the TEXT and DTEXT commands <u>except</u>
   - A. Above.
   - B. Center.
   - C. Fit.
   - D. Align.
   - E. Middle.

mastqz1.doc

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
SPRINGFIELD, MASSACHUSETTS

INTRODUCTION TO COMPUTER-AIDED DESIGN

Quiz 2

PART I. MULTIPLE CHOICE

1. The file extension ".bak" stands for
   A. backup file.
   B. binary file.
   C. binary attribute file.
   D. backing file.
   E. both B and D.

2. The following are valid systems of units identified in the UNITS command <u>except</u>
   A. Fractional
   B. Decimal
   C. English
   D. Scientific
   E. Engineering

3. The command that sets the paper size is
   A. SETTINGS.
   B. LIMITS.
   C. PSPACE.
   D. GRID.
   E. SCALE.

4. Which method of coordinate entry is the Relative **Polar** coordinate method?
   A. 3,5
   B. @3,4
   C. @3<180
   D. Both B and C
   E. None of the above

5. Which method of coordinate entry is the Relative **Rectangular** coordinate method?
   A. 3,5
   B. @3,4
   C. @3<180
   D. Both B and C
   E. None of the above

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
SPRINGFIELD, MASSACHUSETTS

INTRODUCTION TO COMPUTER-AIDED DESIGN

Quiz 2

6. Which method of coordinate entry is the **Absolute** coordinate method?
   A. 3,5
   B. @3,4
   C. @3<180
   D. Both B and C
   E. None of the above

7. To view a different portion of a drawing without changing its magnification, use
   A. MOVE.
   B. VIEW.
   C. PAN.
   D. ZOOM.
   E. none of the above.

8. The setting that forces the cursor in horizontal and vertical movement is
   A. Axis.
   B. Ortho.
   C. Snap.
   D. Parallel.
   E. None of the above.

9. The "U" option of the LINE command means
   A. Unite
   B. Unit.
   C. Underline.
   D. Undo.
   E. Union.

10. All of the following are valid options of the TEXT and DTEXT commands <u>except</u>
   A. Above.
   B. Center.
   C. Fit.
   D. Align.
   E. Middle.

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LASER MACHINING CERTIFICATE PILOT PROGRAM

COURSE EVALUATION RESULTS

CAD

1. Training course overall: 11% (1) excellent
   66% (6) good
   22% (2) fair

2. Course content: 77% (7) good
   11% (1) uncertain
   11% (1) fair

3. Presentation of course material:
   33% (3) excellent
   55% (5) good
   11% (1) poor

4. Hands-on instruction: 22% (2) excellent
   66% (6) good
   11% (1) poor

5. Hands on practice: 44% (4) excellent
   44% (4) good
   11% (1) poor

6. Training Manuals: 66% (6) excellent
   22% (2) good
   11% (1) poor

7. Length of course per night:

22% (2) excellent

22% (2) good

44% (4) fair

11% (1) poor

8. Availability of instructor for questions or clarification:

22% (2) excellent

44% (4) good

11% (1) uncertain

22% (2) fair

9. Review of materials:

11% (1) excellent

66% (6) good

22% (2) fair

5% (1) fair

10. There is enough class time for the instructor to present the material:

22% (2) strongly disagree

44% (4) disagree

11% (1) unsure

22% (2) agree

11. There is enough time for hands-on practice:

55% (5) disagree

11% (1) unsure

22% (2) agree

11% (1) strongly agree

12. There is enough time for hands-on instruction:

44% (4) disagree

22% (2) unsure

33% (3) agree

13. The course work is at the right level of difficulty for me:

11% (1) strongly disagree

33% (3) disagree

55% (5) agree

14. The course work is to easy for me:

44% (4) disagree

22% (2) unsure

22% (2) agree

11% (1) strongly agree

15. I have trouble keeping up with the instructor:

11% (1) strongly disagree

66% (6) disagree

22% (2) agree

16. I have trouble keeping up with the class:

11% (1) strongly disagree

55% (5) disagree

11% (1) unsure

22% (2) agree

17. I am receiving enough one to one instruction:

33% (3) disagree

22% (2) unsure

44% (4) agree

18. The instructor is available to answer questions:

22% disagree

77% agree

19. SUGGESTIONS FOR IMPROVING THE COURSE

a) Smaller class, more time. Should have a Drawing Interpretation or Mechanical Drawing class as a prerequisite. It would be more important for a technician to be able to properly interpret or work with actual drawings then to be able to generate them with a computer. Divide class into groups based on Autocad experience.

b) Longer classs

c) Maybe this program should be expanded another 2 weeks or so.

ComputerNumerical Control (CNC)

Name______________________________

Quiz for CNC

1. What is the purpose of the G90 code?

2. What is the purpose of the G00 code?

3. What is the purpose of the G01 code?

4. What is the purpose of the G03 code?

5. What is the purpose of the G02 code?

6. What is the purpose of the M06 code?

7. What is the purpose of the M01 code?

8. What is the purpose of the M30 code?

9. What is the purpose of the G91 code?

10. Where is the Machine Home Position?

11. What is the purpose of the M03 code?

12. What does the letter "T" represent in the milling program?

LASER MACHINING CERTIFICATE PILOT PROGRAM

COURSE EVALUATION RESULTS

CNC

1. Training course overall:	42% (5) excellent 58% (7) good
2. Course content:	33% (4) excellent 66% (8)good
3. Presentation of course material:	66% (8) excellent 33% (4) good
4. Hands-on instruction:	58% (7) good 16% (2) uncertain 16% (2) fair 8% (1) poor
5. Hands-on practice:	25% (3) good 42% (5) uncertain 8% (1) fair 25% (3) poor
6. Training manuals:	67% (8) excellent 25% (3) good 8% (1) fair
7. Length of course per night:	92% (11) good 8% (1) fair

8. Availability of instructor for questions or clarification:

33% (4) excellent

42% (5) good

25% (3) uncertain

9. Review of materials:

17% (2) excellent

83% (10) good

10. There is enough class time for the instructor to present the material:

33% (4) disagree

58% (7) agree

8% (1) strongly agree

11. There is enough time for hands-on practice:

8% (1) strongly disagree

58% (7) disagree

25% (3) unsure

8% (1) agree

12. There is enough time for hands-on instruction:

8% (1) strongly disagree

33% (4) disagree

33% (4) unsure

25% (3) agree

13. The course work is at the right level of difficulty for me:

8% (1) disagree

25% (3) unsure

67% (8) agree

14. The course work is too easy for me:

58% (7) disagree

33% (4) agree

8% (1) agree

15. I have trouble keeping up with the instructor:

17% (2) strongly disagree

75% (9) disagree

8% (1) unsure

16. I have trouble keeping up with the class:

25% (3) strongly disagree

75% (9) disagree

17. I am receiving enough one to one instruction:

17% (2) disagree

58% (7) agree

25% (3) unsure

18. The instructor is available to answer questions:

67% (8) agree

33% (4) strongly agree

19. SUGGESTIONS FOR IMPROVING THE COURSE

a) More hands on work with machines; actually run programs.

b) More time should be spent in the machine shop.

c) Try to incorporate more hands-on and projects.

d) Actual on machine time should be included in program/course. Basic and dry discussions of programming lines is fairly boring after a short length of time.

e) Longer course to allow actual programming and testing.

f) More hands-on.

g) More lab work.

* ( ) number of participants responding

Industrial Laser Systems

MAST Laser Machining Program
Industrial Laser Systems Final Exam

1. The word Laser originated as:
   a. a military codeword for a top-secret project.
   b. a trademark.
   c. an acronym for light amplified by the stimulated emission of radiation.
   d. the German word for light emitter.

2. The first laser emitted:
   a. pulses of 694-nm red light.
   b. a continuous red beam.
   c. pulses of white light from a helical flashlamp.
   d. spontaneous emission.

3. Laser light is which of the following:
   a. coherent.
   b. stimulated emission.
   c. spontaneous emission.
   d. monochromatic.
   e. a, b, and d.
   f. c and d.

4. Which important laser emits light in the visible range, 400-700 nm?
   a. Argon-ion.
   b. Nitrogen.
   c. Carbon dioxide.
   d. Neodymium-YAG.
   e. chemical.

5. Which is the proper measurement of average power emitted by a pulsed laser?
   a. energy × time.
   b. pulse energy × repetition rate.
   c. pulse energy ÷ repetition rate.
   d. peak power × pulse length.
   e. none of the above.

6. How do you calculate the radius of a laser spot at a given distance if you know the beam divergence?
   a. multiply the beam divergence in degrees by the distance in milliradians.
   b. divide the beam divergence in degrees by the distance in meters.
   c. measure it with a ruler.
   d. multiply the sine of the beam by the distance in meters.
   e. multiply the power in watts by the beam divergence.

7. What is the major advantage of a four-level laser over a three-level laser?
   a. more levels to excite atoms to.
   b. the lower laser level is not the ground state.
   c. more metastable states.
   d. no advantage.

8. Which of the following resonator types is not a stable resonator?
   a. plane-parallel.
   b. concentric.
   c. confocal.
   d. hemispherical.
   e. hemiconfocal.

9. How many internal minimum-intensity points are there in a TEM_{03} mode beam?
   a. none.
   b. 1.
   c. 2.
   c. 3.
   d. 6.

10. What type of laser cavity could produce a beam with a central dark spot?
   a. plane-parallel.
   b. confocal.
   c. unstable.
   d. stable.
   e. concentric.

11. Which of the following contributes to the broadening of laser emission bandwidth?
   a. Doppler shift of moving atoms and molecules.
   b. amplification within the laser medium.
   c. coherence of the laser light.
   d. optical pumping of the laser transition.
   e. none of the above.

12. How many longitudinal modes can fall within a laser's gain bandwidth?
    a. 1 only.
    b. 2.
    c. 3.
    d. 10.
    e. no fixed limit, dependent on bandwidth and mode spacing.

13. What type of filter would you use to block light from a laser, but let other light through?
    a. neutral-density filter.
    b. interference filter.
    c. color filter.
    d. spatial filter.
    e. any of the above.

14. Which type of laser is the simplest to modulate directly by changing its excitation?
    a. semiconductor.
    b. ruby.
    c. Helium-neon.
    d. Neodymium-YAG.
    e. all equally difficult.

15. A host material for a solid-state laser must meet which of the following criteria?
    a. must be transparent at the pump wavelength.
    b. must be transparent at the laser wavelength.
    c. must be able to conduct away waste heat.
    d. a and b only.
    e. a, b, and c.

16. Which of the following is the best pump source for a solid-state laser?
    a. a flashlight.
    b. a flashlamp.
    c. a helium-neon laser.
    c. an electrical charge.
    d. an electrical discharge.
    e. a fluorescent tube.

17. What type of laser is the most efficient pump for neodymium lasers?
    a. GaA1As semiconductor.
    b. Argon-ion
    c. Helium-neon at 632.8 nm.
    d. Ruby.
    e. InGaAsP semiconductor.

18. What makes it feasible to pump neodymium laser with semiconductor lasers?
   a. high efficiency of semiconductor lasers/
   b. high power available form semiconductor lasers.
   c. pump bands coincide with semiconductor laser output.
   d. a and b.
   e. a, b, and c.

19. In which of the following characteristics is neodymium-doped glass better than Nd-YAG?
   a. thermal characteristics.
   b. higher repetition rate.
   c. ease of producing large blocks.
   d. higher laser gain.
   e. much shorter output wavelength.

20. Which of the following wavelengths cannot be readily generated from an Nd-YAG laser?
   a. 266 nm.
   b. 355 nm.
   c. 477 nm.
   d. 532 nm.
   e. 1064 nm.

21. How does a diffraction grating select a particular wavelength to oscillate in a laser cavity?
   a. it diffracts only one wavelength back in the fight direction to oscillate with the other cavity mirror.
   b. it increases losses at other wavelengths by diffracting them out of the laser cavity.
   c. if reflects only one wavelength and it absorbs the rest.
   d. a and b.
   e. all of the above.

22. Which of the following is not an attraction of high-power lasers?
   a. ability to generate high-powers in very short pulses.
   b. amenable to robotic control.
   c. do not apply physical force to objects.
   d. are extremely efficient.
   e. can focus light energy tightly onto a small spot to generate very high powers.

23. A 1000-W continuous-wave carbon-dioxide laser illuminates a titanium sheet for 1 s. How much energy does the titanium absorb (assuming that absorption does not change with heating)?

a. 100 W.
b. 80 joules.
c. 120 joules.
d. 800 joules.
e. none of the above.

24. Which of the following are desirable for drilling holes in a thick (2-cm) slab of material?

a. short laser pulses.
b. short focal-length lens.
c. long focal-length lens.
d. a and b.
e. a and c.

LASER MACHINING CERTIFICATE PILOT PROGRAM

COURSE EVALUATION RESULTS

INDUSTRIAL LASER SYSTEMS

1. Training course overall:	6% (1) excellent
	53% (8) good
	6% (1) uncertain
	26% (4) fair
	6% (1) poor
2. Course content:	20% (3) excellent
	46% (7) good
	6% (1) uncertain
	26% (4) fair
3. Presentation of course material:	
	13% (2) excellent
	26% (4) good
	20% (3) uncertain
	26% (4) fair
	13% (2) poor
4. Hands-on instruction:	6% (1) good
	20% (3) uncertain
	26% (4) fair
	46% (7) poor

5. Hands on practice: 6% (1) good
20% (3) uncertain
13% (2) fair
60% (9) poor

6. Training Manuals: 6% (1) excellent
46% (7) good
33% (5) fair
13% (2) poor

7. Length of course per night:
6% (1) excellent
53% (8) good
13% (2) uncertain
26% (4) fair

8. Availability of instructor for questions or clarification:
20% (3) excellent
33% (5) good
33% (5) uncertain
13% (2) fair

9. Review of materials: 6% (1) excellent
40% (6) good
13% (2) uncertain
40% (6) fair

10. There is enough class time for the instructor to present the material:

40% (6) strongly disagree

13% (2) disagree

26% (4) unsure

13% (2) agree

6% (1) strongly agree

11. There is enough time for hands-on practice:

60% (7) strongly disagree

13% (2) disagree

26% (4) unsure

12. There is enough time for hands-on instruction:

46% (7) strongly disagree

20% (3) disagree

26% (4) unsure

6% (1) agree

13. The course work is at the right level of difficulty for me:

26% (4) strongly disagree

20% (3) disagree

33% (5) unsure

26% (3) agree

14. The course work is to easy for me:

40% (6) strongly disagree

40% (6) disagree

6% (1) unsure

13% (2) strongly agree

15. I have trouble keeping up with the instructor:

6% (1) strongly disagree

33% (5) disagree

13% (2) unsure

40% (6) agree

6% (1) strongly agree

16. I have trouble keeping up with the class:

13% (2) strongly disagree

33% (5) disagree

46% (7) unsure

6%(1) agree

17. I am receiving enough one to one instruction:

6% (1) strongly disagree

26% (4) disagree

33% (5) unsure

33% (5) agree

18. The instructor is available to answer questions:

20% (3) disagree

20% (3) unsure

40% (6) agree

20% (3) strongly agree

19. SUGGESTIONS FOR IMPROVING THE COURSE

a) No offense, but a different instructor might help.

b) Longer classes.

c) I would make this course more pertainable to the machining industry (laser) working parameters, job development, more practicality instead of theory.

d) Instructor thought he was presenting this mateial to a graduate level class.

e) Choose an instructor who knows the meaning of "introductory level course".

f) More prep courses set for jumping right into industrial laser system.

g) Instructor seemed bothered when asked questions outside of seminar.

h) Very technical area, much more time needed to absorb material.

I) Final exam was much too difficult and did not reflect classroom presentation. Instructor should have put theory lessons together to show applications as was asked on the final exam.

Computer Aided Manufacturing (CAM)

Springfield Technical Community College
and the
Machine Tool Advanced Skills Technology Program
(MAST)

LASER MACHINING PILOT PROGRAM

Module 8: CAM
Pre/Post Test

The following questions reference SmartCAM™ as a typical CAM package. Select the best answer.

1. The primary goal of a CAM system is to:

    a. Create a drawing with dimensions
    b. Create CNC code
    c. Perform Trigonometry to assist CNC programming
    d. None of the above

2. Lines, arcs, and polylines in SmartCAM™ are referred to as:

a. Elements
b. Identities
c. Units
d. Things

3. The term "Level" is best described as

a. The top of the part
b. The location of Z 0 (Z-Zero)
c. The position of the bottom of the endmill during cutting.
d. The length of an endmill

4. The term "Profile Top" is best described as

a. The top of the part
b. The location of Z 0 (Z-Zero)
c. The position of the bottom of the endmill during cutting.
d. a & b only

5. “Clearance” is necessary to ensure:

a. Bolts are easy to assembly.
b. Nothing. It is not a requirement.
c. The tool does not collide with the part.
d. Tools do not wear.

6. A sequencial grouping of lines and/or arcs is referred to as a:

a. Path
b. Cutter path
c. Cutter event
d. Profile

7. The Tool used, Offset, Clearance, and Level are considered:

a. Properties
b. Settings
c. Values
d. None of the above

8. A series of lines and arcs which are NOT sequencial, can be put into sequence using:

a. Chain
b. Sequence Move
c. Reverse Order
d. Tool Sort

9. If the roughing tool is tool 1 and the finish tool is tool 2, but tool 2 is going first, the fastest way to fix this is using:

a. Chain
b. Sequence Move
c. Reverse Order
d. Tool Sort

10. The fastest way to change from climb milling to conventional milling is to use:

a. Chain
b. Sequence Move
c. Reverse Order
d. Tool Sort

11. The most efficient way that overlapping lines may be cleaned to a shart corner is to use:

a. Trim_Extend
b. Tool Sort
c. Modify
d. Delete

12. If a command is "Dimmed out", it typically means that ______________ is required.

a. A group
b. Additional software
c. Re-booting the computer
d. A layer

13. The type CAD of file required for CAD/CAM integration is:

a. DXF
b. IGS
c. TGA
d. GIF
e. a or b only
f. b or c only
e. d or d only

14. Macros are useful in creating:

a. Families of parts
b. CAD drawings
c. CNC code
d. Job plans

15. If a lines end point is incorrect, it can be fixed using:

a. Modify
b. Property Change
c. Tool Sort
d. Sequence Move

16. Each element in SmartCAM has three characteristics:

a. Geometry, Property, and Sequence
b. Path, Property, and Sequence
a. Geometry, Offset, and Sequence

a. Geometry, Property, and Direction

17. If a tool has an improper offset, it can be fixed using:

a. Modify
b. Property Change
c. Tool Sort
d. Sequence Move

18. Unfortunately, one can only work from the top view in SmartCAM™. All other views are for visualizing only.

a. True
b. False

19. With a proper Code generator, SmartCAM™ graphics may be coded for **any** CNC machine.

a. True
b. False

20. When draw in free form geometry, the graphic of the tool can be shut off using the command:

a. Display Modes
b. Element Data
c. Show Path
d. Thickness

21. It is possible to snap to either the Level of a line or its Profile top.

a. True
b. False

22. In order to verify that the machine event will be correct, one uses:

a. Display Modes
b. Element Data
c. Show Path
d. User Event

23. In correct Z levels may not be corrected when viewing in Element Data.

a. True
b. False

24. You have created 4 lines into a rectangle, however, you see two tools in your graphics. The most likely reason is:

a. You have a line on top of a line
b. There is no problem.
c. The second tool indicates clearance
d. The system is telling you to draw a circle

25. Geometry appears on the screen, yet in an isometric view, no thickness is apparent. Select the three possibilities.

a. In Display modes, Thickness not on.
b. Profile Top is OFF and should be ON
c. Tool offset is NONE
d. The thickness must be drawn separately
e. The geometry must be on a layer rather than toolpath.
f. Thicknesses less than .5 inch cannot be seen due to screen resolution.

LASER MACHINING CERTIFICATE PILOT PROGRAM

COURSE EVALUATION RESULTS

CAM

1. Training course overall: 72% (8) excellent
   27% (3) good

2. Course content: 72% (8) excellent
   27% (3) good

3. Presentation of course material:
   82% (9) excellent
   18% (2) good

4. Hands-on instruction: 72% (8) excellent
   27% (3) good

5. Hands on practice: 72% (8) excellent
   27% (3) good

6. Training Manuals: 64% (7) excellent
   36% (4) good

7. Length of course per night:
   27% (3) excellent
   64% (7) good
   9% (1) fair

8. Availability of instructor for questions or clarification:

64% (7) excellent

27% (3) good

9% (1) uncertain

9. Review of materials:

64% (7) excellent

36% (4) good

10. There is enough class time for the instructor to present the material:

45% (5) disagree

9% (1) unsure

45% (5) agree

11. There is enough time for hands-on practice:

25% (3) disagree

10% (2) unsure

33% (4) agree

25% (3) strongly agree

12. There is enough time for hands-on instruction:

33% (4) disagree

18% (2) unsure

41% (5) disagree

9% (1) strongly agree

13. The course work is at the right level of difficulty for me:

25% (3) unsure

59% (7) agree

9% (1) strongly agree

14. The course work is to easy for me:

27% (3) strongly disagree

63% (7) disagree

8% (1) unsure

8% (1) agree

15. I have trouble keeping up with the instructor:

8% (1) strongly disagree

50% (6) disagree

25% (3) unsure

16% (2) agree

16. I have trouble keeping up with the class:

8% (1) strongly disagree

72% (8) disagree

8% (1) unsure

8% (1) agree

17. I am receiving enough one to one instruction:

16% (2) unsure

63% (7) agree

16% (2) strongly agree

18. The instructor is available to answer questions:

8% (1) unsure

33% (4) agree

50% (6) strongly agree

19. SUGGESTIONS FOR IMPROVING THE COURSE

a) Keep it as is

b) Updated computers

c) Get faster computers

d) Lengthen time of course

e) Instructor was very thorough with the little time he had. There's just not enough time in the course

f) Better, faster P.C.'s

g) Run in conjunction with CNC and CAD

Metrology

METROLOGY PRE - TEST

1. METROLOGY IS THE MEASUREMENT OF
   A. MASS
   B. LENGTH
   C. TIME
   D. ALL OF THE ABOVE

2. WHICH MEASUREMENT OF LENGTH IS THE SMALLEST
   A. 3/64 "
   B. 3 MM.
   C. .038

3. THE MICROMETER WAS ORIGINALLY INVENTED FOR USE IN
   A. MACHINING
   B. ASTRONOMY
   C. MEDICINE

4. THE EARLIEST RECORDED LENGTH STANDARD WAS THE:
   A. ULRA
   B. CUBIT
   C. LENGTH OF A MONARCHS FOOT
   D. LENGTH OF A KINGS THUMB

5. A DATUM WHEN USED IN MANUFACTURING IS PRIMARILLY USED FOR ______________________

____

____

____

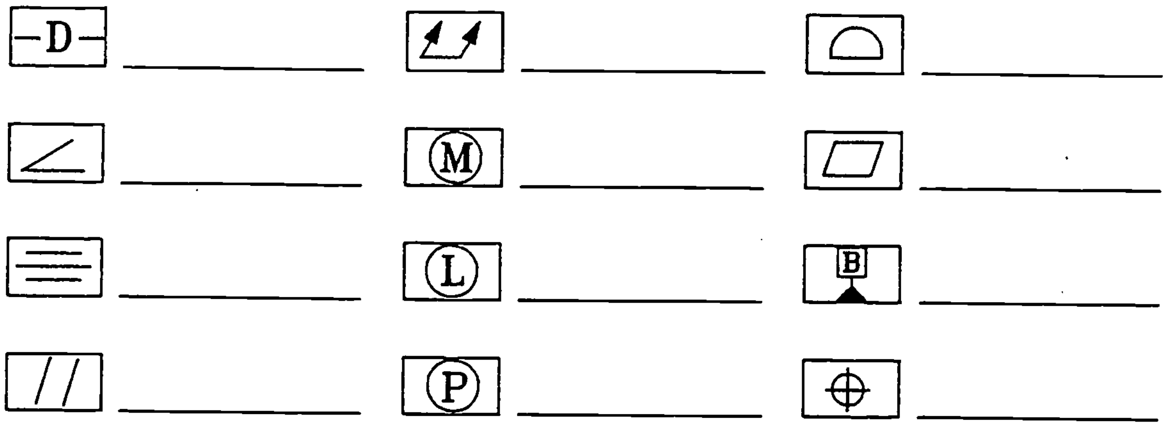
____

____

____

____

6. WHICH OF THE BELOW GEOMETRIC DIMENSIONING AND TOLERANCING SYMBOLS CAN YOU NAME



7. WRITE A BRIEF DESCRIPTION OF THE FOLLOWING:

ACCURACY ______________________________

____

____

____

PRECISION ______________________________

____

____

____

RELIABILITY ______________________________

____

____

____

8. IN SURFACE METROLOGY, WHICH SURFACE IS THE SMOOTHEST.

9. A PROFILOMETER IS USED TO MEASURE:

10. A COORDINATE MEASURING MACHINE (CMM) IS USED FOR :

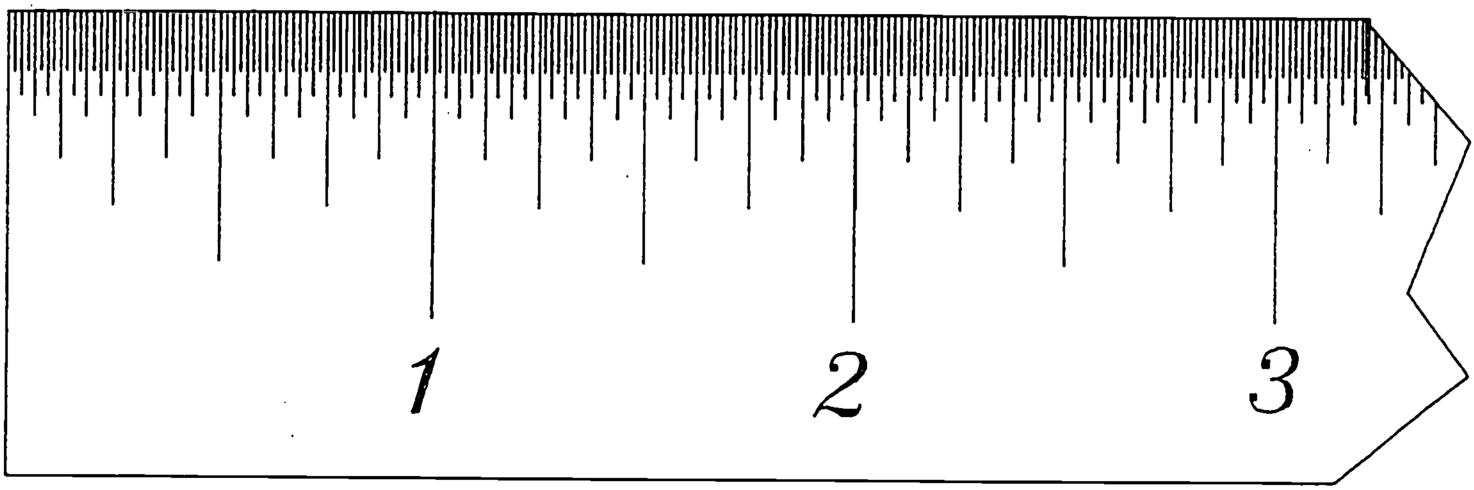
11. OPTICS ARE USED IN METROLOGY FOR:
    A. MAGNIFICATION
    B. ALIGNMENT
    C. MEASUREMENT
    D. STANDARDIZATION
    E. ALL OF THE ABOVE

12. AN OPTICAL COMPARATOR (SHADOWGRAPH) IS USED FOR

13. STONE SURFACE PLATES ARE PRIMARILLY MADE FROM:
    A. GRANITE
    B. MARBLE
    C. SLATE
    D. LIMESTONE
    E. ANY OF THE ABOVE

14. MARK THE FOLLOWING DIMENSIONS AT THE PROPER LOCATION ON THE SCALE

A. 1 1/4"
B. 2 13/16"
C. 1 23/64"
D. 3 5/32"



15. WHICH MANUFACTURING PROCESS WILL PROVIDE THE SMOOTHEST SURFACE FINISH ON ALUMINUM.

A. DRILLING
B. MILLING
C. HONING
D. SAWING

LASER MACHINING CERTIFICATE PILOT PROGRAM

COURSE EVALUATION RESULTS

METROLOGY

1.	Training course overall:	71% (5) excellent
		29% (2) good
2.	Course content:	71% (5) excellent
		29% (2) good
3.	Presentation of course material:	71% (5) excellent
		29% (2) good
4.	Hands-on instruction:	29% (2) excellent
		29% (2) good
		29% (2) uncertain
		14% (1) poor
5.	Hands-on practice:	14% (1) excellent
		43% (3) good
		29% (2) uncertain
		14% (1) poor
6.	Training manuals:	71% (5) excellent
		29% (2) good
7.	Length of course per night:	29% (2) excellent
		57% (4) good
		14% (1) uncertain

8. Availability of instructor for questions or clarification:

71% (5) excellent

29% (2) good

9. Review of materials: 71% (5) excellent

29% (2) good

10. There is enough class time for the instructor to present the material:

57% (4) disagree

29% (2) unsure

14% (1) agree

11. There is enough time for hands-on practice:

14% (1) strongly disagree

57% (4) disagree

29% (2) agree

12. There is enough time for hands-on instruction:

14% (1) strongly disagree

43% (3) disagree

29% (2) agree

13. The course work is at the right level of difficulty for me:

29% (2) unsure

71% (5) agree

14. The course work is too easy for me:

14% (1) strongly disagree

71% (5) disagree

14% (1) unsure

15. I have trouble keeping up with the instructor:

29% (2) strongly disagree

71% (5) disagree

16. I have trouble keeping up with the class:

14% (1) strongly disagree

71% (5) disagree

14% (1) unsure

17. I am receiving enough one to one instruction:

14% (1) strongly disagree

57% (4) agree

29% (2) strongly agree

18. The instructor is available to answer questions:

14% (1) disagree

43% (3) unsure

43% (3) agree

19. SUGGESTIONS FOR IMPROVING THE COURSE

Course instructor is excellent. Don't see how he could improve. Would enjoy taking a full-time course with him.

* ( ) number of participants responding

Laser Materials Processing

PRE-TEST FOR LASER MACHINING COURSE

NAME:______________________________

LASER INTERACTIONS

1. When a laser impinges on a material some of the light is _____________, some is ____________, and the rest is _____________.

2. Metals reflect more light in the visible region of the spectrum because ___________________________________.

3. Window glass reflects about _____% of the light incident on it.

4. When laser light heats a substance the material (a) evaporates; (b) melts; (c) changes hardness; or (d) oxidizes? Explain____.

5. Lasers can do anything that conventional methods can. True or false?

6. Heating in a material is a direct result of the laser light being ____________ in that material.

7. Cutting with a laser depends only on the power of the laser. True or false? Explain____.

8. The principles involved in laser surgery are the dame as those involved in laser machining. True or false? Explain

____.

9. When machining with a laser, one must take care to prevent ______________ light from hitting the operator.

10. Laser safety goggles work well for all lasers. True or False? Explain____.

LASER MACHINING CERTIFICATE PILOT PROGRAM

COURSE EVALUATION RESULTS

LASER MATERIALS PROCESSING

1.	Training course overall:	14% (1) excellent
		86% (6) good
2.	Course content:	14% (1) excellent
		71% (5) good
		14% (1) fair
3.	Presentation of course material:	29% (2) excellent
		71% (5) good
4.	Hands-on instruction:	29% (2) excellent
		43% (3) good
		14% (1) uncertain
		14% (1) fair
5.	Hands-on practice:	29% (2) excellent
		43% (3) good
		14% (1) fair
6.	Training manuals:	43% (3) excellent
		57% (4) good
7.	Length of course per night:	100% (7) good

8. Availability of instructor for questions or clarification:

86% (6) good

14% (1) uncertain

9. Review of materials:

14% (1) excellent

57% (4) good

29% (2) uncertain

10. There is enough class time for the instructor to present the material:

29% (2) disagree

29% (2) unsure

43% (3) agree

11. There is enough time for hands-on practice:

14% (1) strongly disagree

29% (2) disagree

57% (4) agree

12. There is enough time for hands-on instruction:

14% (1) strongly disagree

29% (2) disagree

57% (4) agree

13. The course work is at the right level of difficulty for me:

14% (1) strongly disagree

14% (1) unsure

71% (5) agree

14. The course work is too easy for me:

71% (5) strongly disagree

14% (1) unsure

14% (1) agree

15. I have trouble keeping up with the instructor:

    14% (1) strongly disagree

    86% (6) disagree

16. I have trouble keeping up with the class:

    29% (2) strongly disagree

    71% (5) disagree

17. I am receiving enough one to one instruction:

    14% (1) disagree

    86% (6) agree

18. The instructor is available to answer questions:

    14% (1) strongly disagree

    71% (1) unsure

    71% (5) agree

* ( ) number of participants responding

PRE-TEST FOR LASER MACHINING COURSE

NAME:_______________________________

Dr. J. Masi

FUNDAMENTALS OF LIGHT

1. Light may be thought of as ________________-like motion, or as ____________________ travelling at the speed of light.

2. A quantum of light is called a ____________________.

3. Light is radiant energy in the narrow range from __________ to __________ nanometers, or from _________ to _________ colors, respectively.

4. The central wavelength for the eye is in the ________ color range at 555 nanometers.

5. The unit of power used for light is the __________, which is also another name for _______per___________, a rate of energy expenditure.

6. Most plants are colored green, indicating that they __________ that color light.

7. The most powerful laser is the _______ laser, which emits electromagnetic radiation in the ____________ portion of the spectrum.

8. The sun emits about _________ watts/ sq. meter.

9. Lasers are safe as long as you can't see them. True or False?

10. Eyeglasses are enough protection for working with lasers. True or False?

For more information:

MAST Program Director
Texas State Technical College
3801 Campus Drive
Waco, TX 76705

(817) 867-4849
FAX (817) 867-3380
1-800-792-8784
http://machinetool.tstc.edu