

PRINCIPLES OF MACHINING

COURSE DESCRIPTION

Principles of Machining focuses on the essential principles that must be mastered for a person to be effective in manufacturing production work. The course is intended for students who are interested in production that integrates machining and engineering. The course covers professional communications with customers, quality principles and processes, systems, information in the workplace, the process of product design to machine parts, and statistical process control. The course is contextual by design. It connects what is being learned to the learner's current experience, past knowledge, and future conduct. Wherever possible, real-world or simulation hands-on experiences become the context in which instruction is delivered.

It is strongly recommended that administration and guidance follow the scope and sequence course recommendations as listed.

Recommended Credits: 1

Recommended Grade Level(s): 9th or 10th

Number of Competencies in Course: 46

PRINCIPLES OF MACHINING

STANDARDS

- 1.0** Students will perform safety examinations and maintain safety records.
- 2.0** Students will demonstrate leadership, citizenship, and teamwork skills required for success in the school, community, and workplace.
- 3.0** Students will integrate reading, writing, math, and science skills and understand the impact of academic achievement in the workplace.
- 4.0** Students will investigate the evolution of machine technology and determine the influences and effects of technology on the workforce.
- 5.0** Students will demonstrate safe practices and environmental hazard prevention and treatment in a machining environment.
- 6.0** Students will calculate and interpret measurements commonly required in the machining process.
- 7.0** Students will read, analyze, and interpret blueprints.
- 8.0** Students will demonstrate the appropriate use of technologies used in the machining processes.

PRINCIPLES OF MACHINING

STANDARD 1.0

Students will perform safety examinations and maintain safety records.

LEARNING EXPECTATIONS

The student will:

- 1.1** Demonstrate a positive attitude regarding safety practices and issues.
- 1.2** Use and inspect personal protective equipment.
- 1.3** Inspect, maintain, and employ safe operating procedures with tools and equipment, such as hand and power tools, ladders, scaffolding, and lifting equipment.
- 1.4** Demonstrate continuous awareness of potential hazards to self and others and respond appropriately.
- 1.5** Assume responsibilities under HazCom (Hazard Communication) regulations.
- 1.6** Adhere to responsibilities, regulations, and Occupational Safety & Health Administration (OSHA) policies to protect coworkers and bystanders from hazards.
- 1.7** Adhere to responsibilities, regulations, and Occupational Safety & Health Administration (OSHA) policies regarding reporting of accidents and observed hazards, and regarding emergency response procedures.
- 1.8** Demonstrate appropriate related safety procedures.
- 1.9** Pass with 100 % accuracy a written examination relating to safety issues
- 1.10** Pass with 100% accuracy a performance examination relating to safety.
- 1.11** Maintain a portfolio record of written safety examinations and equipment examinations for which the student has passed an operational checkout by the instructor.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student:

- 1.1A** Is attentive during safety discussions.
- 1.1B** Actively seeks information about safe procedures.
- 1.1C** Responds positively to instruction, advice, and correction regarding safety issues.
- 1.1D** Does not deliberately create or increase hazards, such as by horseplay, practical jokes, or creating distractions.
- 1.1E** Reports to school or work physically ready to perform to professional standards, such as rested, or not impaired by medications, drugs, alcohol, etc.
- 1.2** Selects, inspects, and uses the correct personal protective equipment for the assigned task.
- 1.3A** Inspects power tools for intact guards, shields, insulation, and other protective devices.
- 1.3B** Inspects extension cords for the presence of a functional ground connection, prior to use.
- 1.3C** Operates and maintains tools in accordance with manufacturer's instructions and as required by regulation or company policy.
- 1.3D** Properly places and secures ladders and scaffolding prior to use.
- 1.4A** Is observant of personnel and activities in the vicinity of the work area.
- 1.4B** Warns nearby personnel, prior to starting potentially hazardous actions.
- 1.5A** When asked to use a new hazardous material, retrieves MSDSs (material safety data sheets), and identifies the health hazards associated with the new material.

- 1.5B** Reports hazards found on the job site to the supervisor.
- 1.6A** Erects shields, barriers, and signage to protect coworkers and bystanders prior to starting potentially hazardous tasks.
- 1.6B** Provides and activates adequate ventilation equipment as required by the task.
- 1.7A** Reports all injuries to self to the immediate supervisor.
- 1.7B** Reports observed unguarded hazards to their immediate supervisor.
- 1.8** Complies with personal assignments regarding emergency assignments.
- 1.9** Passes with 100% accuracy a written examination relating specifically to content area.
- 1.10** Passes with 100% accuracy a performance examination relating specifically to welding tools, equipment and supplies.
- 1.11** Maintains a portfolio record of written safety examinations and equipment examinations for which the student has passed an operational checkout by the instructor.

SAMPLE PERFORMANCE TASKS

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion.

- Conduct a practice drill simulating a hazardous solvent spill in which an emergency action plan is to be implemented.
- Instruct a visitor to obviously approach the vicinity of a student conducting a hazardous activity and note the level of awareness demonstrated by the student.
- For a project requiring the use of ladders and/or scaffolding, note the proper placement and securing procedures followed by students.

INTEGRATION/LINKAGES

Foundation for Industrial Modernization (FIM). *What Manufacturing Workers Need to Know and Be Able to Do: National Voluntary Skill Standards for Advanced High Performance Manufacturing*. Washington, DC: National Coalition for Advanced Manufacturing, 1995.

International Technology Education Association. *Standards for Technological Literacy: Content for the Study of Technology*. International Technology Education Association. Reston, VA, 2000.

Manufacturing Skill Standards Council. *A Blueprint for Workforce Excellence (draft skill standards for manufacturing.)* Manufacturing Skill Standards Council, 2001.

Ford Academy of Manufacturing Sciences (FAMS curriculum). Project Lead the Way curriculum.

Mathematics/Quality/Teamwork content.

PRINCIPLES OF MACHINING

STANDARD 2.0

Students will demonstrate leadership, citizenship, and teamwork skills required for success in the school, community, and workplace.

LEARNING EXPECTATIONS

The student will:

- 2.1** Cultivate positive leadership skills.
- 2.2** Participate in the student organization directly related to their program of study as an integral part of classroom instruction.
- 2.3** Assess situations, apply problem-solving techniques and decision-making skills within the school, community, and workplace.
- 2.4** Participate as a team member in a learning environment.
- 2.5** Respect the opinions, customs, and individual differences of others.
- 2.6** Build personal career development by identifying career interests, strengths, and opportunities.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student:

- 2.1A** Demonstrate character and leadership using creative and critical thinking skills.
- 2.1B** Uses creative thought process by “thinking outside the box.”
- 2.2A** Relates the creed, purposes, motto, and emblem of their student organization, directly related to personal and professional development.
- 2.2B** Plans and conducts meetings and other business according to accepted rules of parliamentary procedure.
- 2.3A** Makes decisions and assumes responsibilities.
- 2.3B** Analyzes a situation and uses the Professional Development Program or career technical student organization materials directly related to the student’s program of study to resolve it.
- 2.3C** Understands the importance of learning new information for both current and future problem solving and decision making.
- 2.4A** Organizes committees and participates in functions.
- 2.4B** Cooperates with peers to select and organize a community service project.
- 2.5A** Researches different customs and individual differences of others.
- 2.5B** Interacts respectfully with individuals of different cultures, gender, and backgrounds.
- 2.5C** Resolves conflicts and differences to maintain a smooth workflow and classroom environment.
- 2.6A** Creates personal career development by identifying career interests, strengths, and opportunities.
- 2.6B** Identifies opportunities for career development and certification requirements.
- 2.6C** Plans personal educational paths based on available courses and current career goals.
- 2.6D** Creates a resume that reflects student’s skills, abilities, and interests.

SAMPLE PERFORMANCE TASKS

- Create a leadership inventory and use it to conduct a personal assessment.
- Participate in various career technical student organizations' programs and/or competitive events.
- Implement an annual program of work.
- Prepare a meeting agenda for a specific career technical student organization monthly meeting.
- Attend a professional organization meeting.
- Develop a program of study within their career opportunities.
- Participate in the American Spirit Award competition with SkillsUSA.
- Complete *Professional Development Program Level I and Level II*, SkillsUSA.

INTEGRATION/LINKAGES

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International Technology Education Association. *Standards for Technological Literacy: Content for the Study of Technology*. International Technology Education Association. Reston, VA, 2000.

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PRINCIPLES OF MACHINING

STANDARD 3.0

Students will integrate reading, writing, math, and science skills and understand the impact of academic achievement in the work place.

LEARNING EXPECTATIONS

The student will:

- 3.1** Assume responsibility for accomplishing classroom assignments and workplace goals within accepted time frames.
- 3.2** Develop advanced study skills.
- 3.3** Demonstrate and use written and verbal communication skills so others can understand.
- 3.4** Read and understand technical documents such as regulations, manuals, reports, forms, graphs, charts, and tables.
- 3.5** Apply the foundations of mathematical principles such as algebra, geometry, and advanced math to solve problems.
- 3.6** Apply basic scientific principles and methods to solve problems and complete tasks.
- 3.7** Understand computer operations and related applications to input, store, retrieve, and output information as it relates to the course.
- 3.8** Research, recognize, and understand the interactions of the environment and *green* issues as they relate to the course work and to a global economy.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student:

- 3.1A** Uses appropriate time management to achieve goals.
- 3.1B** Arrives at school on time each day.
- 3.1C** Completes assignments and meets deadlines.
- 3.2A** Assesses current personal study skills.
- 3.2B** Demonstrates advanced note-taking ability.
- 3.2C** Formulates appropriate study strategies for given tasks.
- 3.3A** Communicates ideas, information, and messages in a logical manner.
- 3.3B** Fills out forms, time sheets, reports, logs, and documents to comply with class and project requirements.
- 3.4A** Reads and understands technical documents and uses industry jargon, acronyms, and terminology related to machining appropriately.
- 3.4B** Recognizes the meaning of specialized words or phrases unique to the career and machining industry.
- 3.5A** Utilizes computation in adding, subtracting, multiplying, and dividing of whole numbers, fractions, decimals, and percents.
- 3.5B** Chooses the right mathematical method or formula to solve a problem.
- 3.5C** Performs math operations accurately to complete classroom and lab tasks.
- 3.6A** Understands scientific principles critical to the course.
- 3.6B** Applies scientific principles and technology to solve problems and complete tasks.
- 3.6C** Has knowledge of the scientific method (e.g., identifies the problem, collects information, forms opinions, and draws conclusions).

- 3.7A** Uses basic computer hardware (e.g., PCs, printers) and software to perform tasks as required for the course work.
- 3.7B** Understands capabilities of computers and common computer terminology (e.g, program, operating system).
- 3.7C** Applies the appropriate technical solution to complete tasks.
- 3.7D** Inputs data and information accurately for the course requirements.
- 3.8A** Researches and recognizes *green* trends in career area and industry.
- 3.8B** Examines current environmentally friendly trends.
- 3.8C** Applies sustainability practices by understanding processes that are non-polluting, conserving of energy and natural resources, and economically efficient.

SAMPLE PERFORMANCE TASKS

- Examine and compile different learning styles for portfolios.
- Create calendars containing all activities and obligations for one month. Discusses how to handle conflicting or competing obligations then complete daily and weekly plans showing tasks, priorities, and scheduling.
- Complete self-assessments of study habits.
- Compute precise and exact measurements.
- Explore study strategies for different subjects and tasks then analyze two homework assignments and select the best strategies for completing them.
- Create “life maps” showing necessary steps or “landmarks” along the path to personal, financial, educational, and career goals.
- Take notes during counselor classroom visits and work in small groups to create flow charts of the path options.
- List attitudes that lead to success then rate individually in these areas. Work together to suggest strategies for overcoming the weaknesses identified own and partners’ self-assessments then share with the class the strategies developed.
- Research the Internet and other technology to collect and analyze data concerning climate change.
- Keep a data file of alternative energy sources and the sources’ impact on the environment.
- Develop a recycling project at home or for the school environment.

INTEGRATION/LINKAGES

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International Technology Education Association. *Standards for Technological Literacy: Content for the Study of Technology*. International Technology Education Association. Reston, VA, 2000.

Manufacturing Skill Standards Council. *A Blueprint for Workforce Excellence (draft skill standards for manufacturing.)* Manufacturing Skill Standards Council, 2001. Ford Academy of Manufacturing Sciences (FAMS curriculum). Project Lead the Way curriculum. Mathematics/Reading/Communications content.

PRINCIPLES OF MACHINING

STANDARD 4.0

Students will investigate the evolution of machine technology and determine the influences and effects of technology on the workforce.

LEARNING EXPECTATIONS

The student will:

- 4.1 Describe and illustrate the role of a machinist.
- 4.2 Develop a presentation on the evolution of machine tools.
- 4.3 Formulate a discussion on how modern machines and tools have affected the workforce.
- 4.4 Describe and design a presentation as an overview of machining processes.
- 4.5 Explain and demonstrate the operation of CNC machining equipment.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student:

- 4.1A Research and illustrate the education and training requirements to become a machinist.
- 4.1B Demonstrates character, leadership, and integrity using creative and critical-thinking that is required as a machinist.
- 4.1C Demonstrate the machinist responsibilities and skills that are required in basic bench operations, basic metal operations, and operation quality control functions.
- 4.2A Illustrate and describe the functions of the evolution of machine tools such as a bow drill, bow lathe, spring pole lathe, treadle lathe, great wheel lathe, and thread cutter.
- 4.2B Demonstrate appropriate and accurate measurements using a ruler, micrometer caliper, vernier caliper, feeler gauges, and other gauging tools.
- 4.3A Site the major changes in both global and U.S. industry because of the evolution of machinery.
- 4.3B Identify all major components and functions of the machine tools, and all major hand tools.
- 4.4A Analyzes situations in the workplace of a machine process and uses problem-solving techniques to solve the problem.
- 4.4B Shows the dynamic relationship among organizational units.
- 4.4C Illustrates the communication system used in organizational designs of the machine process system.
- 4.4D Predicts the impact of quality initiatives on the success of an organization.
- 4.5A Apply the principles of three-dimensional coordinate planes in the development of a simple program for the production of the part on a CNC milling machine.

SAMPLE PERFORMANCE TASKS

- Students will define a machinist.
- Students will research and illustrate the responsibilities, educational requirements, and training of a machinist.
- Students will illustrate and explain through a presentation the evolution of machine tools.

- Students will demonstrate through application and classroom presentation the functions of a ruler, micrometer, vernier caliper, gauges, and other measuring devices.
- Students will compare and contrast the components and functions of machine tools and hand tools through demonstration.
- Students will illustrate the organizational structure of a manufacturing company.
- Students will critique the importance of a communication structure in a manufacturing company.

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Mathematics/Reading/Communications content.

PRINCIPLES OF MACHINING

STANDARD 5.0

Students will demonstrate safe practices and environmental hazard prevention and treatment in a machining environment.

LEARNING EXPECTATIONS

The student will:

- 5.1** Use a reference sheet of materials to assess and demonstrate the safety guidelines and regulations for the disposal of waste materials.
- 5.2** Analyze environmental hazards and preventions procedures for the machining industry.
- 5.3** Perform environmental safety evaluations in machining situations.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student:

- 5.1A** Review and implement maintenance, cleaning, and housekeeping checklists to appropriately maintain safety hazards on all hand tools, conventional machines, and CNC machine tools.
- 5.1B** Determines factors that lead to profit and loss.
- 5.2A** Perform assigned responsibilities and document the appropriate handling and disposal of environmental hazard materials according to OSHA requirements.
- 5.2B** Communicate, using written and verbal methods, the actions taken in handling and application of coolant, cutting fluids, and lubricants.
- 5.2C** Handle and store hazardous materials as required as safety practices according to OSHA and EPA requirements.
- 5.3A** Inspect, assess and report to a supervisor the general condition of a given hand tool and machine.
- 5.3B** Perform daily, weekly, and/or monthly routine maintenance on conventional machines and CNC milling machines.
- 5.3C** Compares the costs of accident prevention with the costs of accidents.
- 5.3D** Compares the cost of servicing to keep in good repair versus replacing or repairing.

SAMPLE PERFORMANCE TASKS

- Students analyze the impact that emerging technologies have made in manufacturing.
- Students will compare and contrast the issues of environmental hazards and material wastes that a business/corporation must consider when organizing a manufacturing system.
- Students will categorize and define the various manufacturing categories in a presentation.
- Students will research chemical hazards and illustrate the appropriate use of a Material Safety Data Sheet.
- Students will be assessed on safety instructions and checklists based on OSHA requirements and guidelines on handling and applications of coolants, cutting fluids, and lubricants.
- Students will be assessed on safety instructions and checklists based on OSHA and EPA requirements and guidelines on handling and storage of hazardous materials.

INTEGRATION/LINKAGES

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Mathematics/Reading/Communications content.

PRINCIPLES OF MACHINING

STANDARD 6.0

Students will calculate and interpret measurements commonly required in the machining processes.

LEARNING EXPECTATIONS

The student will:

- 6.1** Formulate and prove the correct usage of common measurement tools to perform measurements to appropriate standards of accuracy and precision.
- 6.2** Identify, calculate, and apply the English system of measurement.
- 6.3** Identify, calculate, and apply the metric system of measurement.
- 6.4** Interpret measurements encountered in the machining workplace.
- 6.5** Explain, analyze, and calculate tolerances using measurement tools and machines.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student:

- 6.1A** Resolves the problem by applying appropriate problem-solving techniques.
- 6.1B** Selects the appropriate measurement tool for a given task.
- 6.1C** Makes an accurate measurement of a given object using a ruler, micrometer, or other gauging instrument..
- 6.2A** Performs basic mathematical calculations, calibrations, and measurements in English measurement units.
- 6.3A** Performs basic mathematical calculations, calibrations, and measurements in metric measurement units.
- 6.4A** Record measurements with the appropriate number of significant figures.
- 6.4B** Interprets recorded measurements.
- 6.5A** Uses given measurements to set up or adapt a process.

SAMPLE PERFORMANCE TASKS

- Students will identify and explain precision and semi-precision tools.
- Describe and illustrate the implementation of tool selection based on tool characteristics and task.
- Students will use a micrometer to measure various solid shapes or simple parts.
- Students will use a vernier caliper to measure various solid shapes or simple parts.
- Students will use a micrometer to measure various solid shapes or simple parts.
- Students will use transfer measuring instruments (i.e., telescope, gauges, small feeler gauges) to measure various holes and indentions.
- Calculate speeds, feeds, and depth of cut for various machine operations.
- Students will record measurements in English and metric conversions.
- Students will determine the tools needed for the machining operations of a simple part.

INTEGRATION/LINKAGES

Foundation for Industrial Modernization (FIM). *What Manufacturing Workers Need to Know and Be Able to Do: National Voluntary Skill Standards for Advanced High Performance Manufacturing*. Washington, DC: National Coalition for Advanced Manufacturing, 1995.

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Manufacturing Skill Standards Council. *A Blueprint for Workforce Excellence (draft skill standards for manufacturing.)* Manufacturing Skill Standards Council, 2001. Ford Academy of Manufacturing Sciences (FAMS curriculum). Project Lead the Way curriculum. Mathematics content.

PRINCIPLES OF MACHINING

STANDARD 7.0

Students will read, analyze, and interpret blueprints.

LEARNING EXPECTATIONS

The student will:

- 7.1** Define and explain basic blueprint vocabulary.
- 7.2** Classify and compare the different types of dimensions and general note symbols.
- 7.3** Interpret commonly used abbreviations and terminology.
- 7.4** Classify and differentiate types of perspective drawings.
- 7.5** Determine and calculate scale measurements of the view or section of a drawing.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student:

- 7.1A** Sketches parts and assigns measurements to the sketch.
- 7.1B** Interprets blueprint format and vocabulary.
- 7.2A** Interprets machinist's symbol information.
- 7.2B** Identifies symbols commonly used in construction and fabrication drawings, including material, electrical, plumbing, HVAC, and plot plan and survey symbols.
- 7.2C** Distinguishes between object lines, dimension and extension lines, center lines, section lines, and other lines commonly found in construction and fabrication drawings.
- 7.3A** Analyzes, interprets, and compares information on drawings and blueprints.
- 7.4A** Interprets three-dimensional features found in construction and fabrication drawings.
- 7.5A** Uses the scale of a drawing to determine locations not explicitly dimensioned.
- 7.5B** Uses the scale of a drawing to determine dimensions not explicitly shown on drawing.

SAMPLE PERFORMANCE TASKS

- Review, interpret, and sketch isometric and exploded isometric drawings of a simple part.
- Review, interpret, and sketch orthographic drawings of a simple part.
- Differentiate between drawings and blueprints.
- Identify and define basic manufacturing and machining symbols on blueprints.
- Examine and explain parts to determine application of symbols from drawings, sketches, and blueprints of a simple part.
- Examine manufacturing projects to distinguish various types of lines, joints, and materials.
- Participate in job shadowing or internship within the manufacturing industry that integrates emerging technologies and CAD drafting..

INTEGRATION LINKAGES

Foundation for Industrial Modernization (FIM). *What Manufacturing Workers Need to Know and Be Able to Do: National Voluntary Skill Standards for Advanced High Performance Manufacturing*. Washington, DC: National Coalition for Advanced Manufacturing, 1995.

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Mathematics/Quality/Teamwork content.

PRINCIPLES OF MACHINING

STANDARD 8.0

Students will demonstrate the appropriate use of technologies used in the machining processes.

LEARNING EXPECTATIONS

The student will:

- 8.1** Investigate the chemical and physical properties of materials used in the machining process.
- 8.2** Demonstrate the steps involved in the bench layout processes for milling, cutting, welding, and machine operations.
- 8.3** Demonstrate a level of proficiency in common machining operations.

PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET

The student:

- 8.1A** Research and demonstrate the ideas of heat, shock, friction, zone of distortion, cutting interface, and machinability as they relate to machining applications.
- 8.1B** Recognize and apply knowledge of common materials and their principle properties relevant to machining tasks.
- 8.2** Implement a design print detailing a part requiring milling, drilling, turning, and grinding, verbal instructions, and appropriate references; formulate a set of strategies to manufacture the part.
- 8.3** Maintains a portfolio record of written safety examinations, equipment examinations, and completion of machined parts and products that demonstrates students' skills and proficiency level.

SAMPLE PERFORMANCE TASKS

- Research and define the classification systems for metals.
- Describe and illustrate the general characteristics for carbon steels, stainless steel, structural steel, cast iron, aluminum, and other commonly used metals.
- Describe and list the advantages and disadvantages for each of the following: casting, hot working, and cold working processes.
- Research and explain strength and hardness requirements for construction of parts and structures.
- Design a flow process and organize equipment and materials needed for a given cutting, drilling, milling, and/or machining operation to manufacture a simple part.
- Students will organize a plan for the layout, setup, and the performance of these operations: drilling, tapping, countersinking, counterboring, and reaming.
- Calculate speeds, feeds, and depth of cut for various machine operations.
- Students will determine the tools needed for the machining operations of a simple part.
- Students will demonstrate the proper setup and milling procedures on a milling machine.
- Students will demonstrate the proper setup and application of lathe accessories required for lathe operations.

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Mathematics/Quality/Teamwork content.

SAMPLING OF AVAILABLE RESOURCES

CORD. *Necessary Skills Now for Manufacturing*. Waco, TX: CORD Communications, 1999.

Quirk, Michael. *Manufacturing, Teams and Improvement: The Human Art of Manufacturing*. Prentice Hall, 1998.

Wright, R. Thomas. *Exploring Manufacturing*. Tinley Park, IL: Goodheart-Willcox, 1993..

Quirk, Michael. *Manufacturing, Teams and Improvement: The Human Art of Manufacturing*. Prentice Hall, 1998.

Groover, Mikell P. *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*. John Wiley and Sons, 2001.

Amrine, Harold. Ritchey, John. Moodie, Colin. Kmec, Joseph. *Manufacturing Organization and Management*. Prentice Hall, 1992.

Foundation for Industrial Modernization (FIM). *What Manufacturing Workers Need to Know and Be Able to Do: National Voluntary Skill Standards for Advanced High Performance Manufacturing*. Washington, DC: National Coalition for Advanced Manufacturing, 1995.

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