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**Text of Adopted 19 TAC**

# Chapter 130. Texas Essential Knowledge and Skills for Career and Technical Education

## Subchapter M. Manufacturing

### §130.321. Implementation of Texas Essential Knowledge and Skills for Manufacturing.

The provisions of this subchapter shall be implemented by school districts beginning with the 2010-2011 school year.

### §130.322. Principles of Manufacturing (One-Half to One Credit).

(a) General requirements. This course is recommended for students in Grades 9-12. Recommended prerequisite: Algebra I or Geometry.

(b) Introduction. In Principles of Manufacturing, students gain knowledge and skills in the application, design, production, and assessment of products, services, and systems and how those knowledge and skills are applied to manufacturing. Knowledge and skills in the proper application of principles of manufacturing, the design of technology, the efficient production of technology, and the assessment of the effects of manufacturing production technology prepare students for success in the modern world. The study of manufacturing technology allows students to reinforce, apply, and transfer academic knowledge and skills to a variety of interesting and relevant activities, problems, and settings in a manufacturing setting. In addition to general academic and technical knowledge and skills, students gain an understanding of career opportunities available in manufacturing and what employers require to gain and maintain employment in these careers.

(c) Knowledge and skills.

(1) The student describes the importance of teamwork, leadership, integrity, honesty, work habits, and organizational skills. The student is expected to:

(A) describe how teams function;

(B) use teamwork to solve problems;

(C) distinguish team roles such as team leaders and team members;

(D) identify characteristics of good leaders;

(E) identify employers' work expectations;

(F) discuss Equal Employment Opportunity law in the workplace;

(G) use time-management techniques to develop work schedules;

(H) describe how teams measure results; and

(I) develop a method to reward team performance.

(2) The student explores the employability characteristics of a successful worker in the global economy. The student is expected to:

(A) explore academic knowledge and skills required for postsecondary education;

(B) identify employers' expectations to foster positive customer satisfaction;

(C) demonstrate the skills required in the workplace such as interviewing skills, flexibility, willingness to learn new skills and acquire knowledge, self-discipline, self-worth, positive attitude, and integrity in a work situation;

(D) evaluate personal career goals;

(E) communicate effectively with others to clarify objectives; and

(F) demonstrate skills related to health and safety in the workplace, as specified by appropriate government regulations.

(3) The student describes how a systems model can be used to describe manufacturing and technological activities. The student is expected to:

(A) identify the manufacturing processes such as input, output, and feedback;

(B) describe system differences such as open and closed; and

(C) describe how technological systems interact to achieve common goals.

(4) The student applies manufacturing concepts to specific problems. The student is expected to:

(A) distinguish between disciplines such as engineering, science, and technology;

(B) analyze engineering concepts to solve practical problems;

(C) use problem-solving tools such as calculators and computers;

(D) evaluate computers for simulation tasks;

(E) use tools for laboratory equipment testing;

(F) use precision measuring instruments; and

(G) evaluate software to design quality assurance models.

(5) The student designs products or systems using appropriate processes and techniques. The student is expected to:

(A) improve a product that meets a specified need;

(B) identify system improvements such as quality, reliability, and safety;

(C) produce engineering drawings using standard technical communication techniques; and

(D) research the patenting process.

(6) The student investigates emerging and innovative applications of technology in engineering. The student is expected to:

(A) report on innovative applications of technology in engineering; and

(B) experiment with new technologies.

(7) The student describes quality and how it is measured in manufacturing. The student is expected to:

(A) evaluate different quality control applications in manufacturing; and

(B) research how the quality of products and services affects engineering decisions.

(8) The student manufactures products or systems using the appropriate tools, equipment, machines, materials, and technical processes. The student is expected to:

(A) analyze engineering properties such as chemical, mechanical, and physical;

(B) analyze the processes needed to complete a project;

(C) use a variety of tools such as equipment and machines; and

(D) produce an item that is student designed.

(9) The student practices safe work habits. The student is expected to:

(A) master relevant safety tests;

(B) analyze hazardous materials; and

(C) safely dispose of hazardous materials.

(10) The student describes the importance of maintenance. The student is expected to:

(A) perform maintenance on selected equipment;

(B) store materials correctly; and

(C) analyze the results of improper maintenance.

(11) The student manages a manufacturing project. The student is expected to:

(A) participate in the operation of a manufacturing project; and

(B) develop a plan for completing an individual project.

(12) The student applies the appropriate codes, laws, standards, or regulations such as Occupational Safety and Health Administration, National Electrical Code, American Society for Testing Materials, standard symbols, and line weights. The student is expected to:

(A) research the importance of regulations such as codes, laws, and standards; and

(B) follow the appropriate regulations.

(13) The student describes the intended and unintended effects of technological solutions to the manufacturing process. The student is expected to:

(A) evaluate an assessment strategy such as the risks and benefits of engineering activities; and

(B) demonstrate how engineering changes environments.

(14) The student describes the factors that affect the evolution of technology. The student is expected to:

(A) analyze how changes in technology affect manufacturing practices;

(B) evaluate how the development of technology in manufacturing is influenced by past events;

(C) analyze the international effects of technology;

(D) demonstrate how advancements in technology have affected the field of engineering;

(E) evaluate the factors that affect the implementation of new ideas; and

(F) analyze how manufacturing evolves.

(15) The student solves problems, thinks critically, and makes decisions related to manufacturing. The student is expected to:

(A) apply an engineering approach to problem solving to improve a manufactured product;

(B) apply critical-thinking strategies to the analysis of proposed solutions; and

(C) apply decision-making techniques to engineering solutions.

(16) The student identifies the factors that influence the cost of an item or service. The student is expected to:

(A) defend a budget for a project; and

(B) determine the most effective strategies to minimize costs.

(17) The student applies communication, mathematics, and science knowledge and skills to manufacturing activities. The student is expected to:

(A) demonstrate communication techniques consistent with industry standards;

(B) locate relevant information needed to solve problems;

(C) apply mathematics concepts to solve manufacturing problems;

(D) analyze science principles used to solve problems; and

(E) use the appropriate units of measure.

(18) The student describes the relationship between manufacturing and marketing. The student is expected to:

(A) prepare a marketing plan for a product;

(B) analyze the effect of customer satisfaction on the image of a product; and

(C) analyze how customer demands influence the design of an object.

(19) The student selects and reports on career opportunities, requirements, and expectations in engineering and technology. The student is expected to:

(A) investigate an area of interest in manufacturing;

(B) analyze the various specializations in manufacturing; and

(C) describe the functions of engineers, technologists, and technicians.

**§130.323. Welding (One to Two Credits).**

(a) General requirements. This course is recommended for students in Grades 10-12. Recommended prerequisite: Algebra 1.

(b) Introduction. Rapid advances in technology have created new career opportunities and demands in many industries. Welding provides the knowledge, skills, and technologies required for employment in metal technology systems. Students develop knowledge and skills related to this system and apply them to personal career development. This course supports integration of academic and technical knowledge and skills. Students will reinforce, apply, and transfer knowledge and skills to a variety of settings and problems. Knowledge about career opportunities, requirements, and expectations and the development of workplace skills prepare students for future success.

(c) Knowledge and skills.

(1) The student describes the importance of teamwork, leadership, integrity, honesty, work habits, and organizational skills. The student is expected to:

(A) describe how teams function;

(B) use teamwork to solve problems;

(C) distinguish team roles such as team leaders and team members;

(D) identify characteristics of good leaders;

(E) identify employers' work expectations;

(F) discuss Equal Employment Opportunity law in the workplace;

(G) use time-management techniques to develop work schedules;

(H) describe how teams measure results; and

(I) develop a method to reward team performance.

(2) The student explores the employability characteristics of a successful worker in the global economy. The student is expected to:

(A) explore academic knowledge and skills required for postsecondary education;

(B) identify employers' expectations to foster positive customer satisfaction;

(C) demonstrate the skills required in the workplace such as interviewing skills, flexibility, willingness to learn new skills and acquire knowledge, self-discipline, self-worth, positive attitude, and integrity in a work situation;

(D) evaluate personal career goals;

(E) communicate effectively with others in the workplace to clarify objectives; and

(F) demonstrate skills related to health and safety in the workplace, as specified by appropriate government regulations.

(3) The student applies academic skills to the requirements of welding. The student is expected to:

(A) demonstrate effective communication skills with individuals from varied cultures such as fellow workers, management, and customers;

(B) demonstrate mathematical skills to estimate costs;

(C) demonstrate technical writing skills related to work orders;

(D) apply accurate readings of measuring devices, both U.S. customary and metric;

(E) accurately use an appropriate tool to make measurements;

(F) compute measurements such as area, surface area, volume, and perimeter;

(G) determine how changes in dimension affect geometric figures;

(H) calculate problems using whole numbers, fractions, mixed numbers, and decimals;

(I) use a calculator to perform computations;

(J) perform conversions between fractions and decimals;

(K) understand the functions of angles;

(L) apply right triangle relationships using the Pythagorean Theorem;

(M) understand the parts of a circle;

(N) identify the most reasonable mathematical solution using estimation;

(O) use cross-sections of three-dimensional figures to relate to plane figures;

(P) describe orthographic views of three-dimensional figures; and

(Q) describe isometric views of three-dimensional figures.

(4) The student knows the function and application of the tools, equipment, technologies, and materials used in welding. The student is expected to:

(A) use welding equipment according to safety standards;

(B) properly dispose of environmentally hazardous materials used in welding; and

(C) use appropriate personal protective equipment as needed to follow safety measures.

(5) The student understands welding joint design, symbols, and welds. The student is expected to:

(A) demonstrate knowledge of a welding blueprint;

(B) interpret blueprints, drawings, charts, and diagrams;

(C) analyze components of the welding symbol;

(D) analyze types of welding joints;

(E) analyze positions of welding; and

(F) identify types of welds such as fillet, groove, spot, plug, and flanged.

(6) The student applies the concepts and skills of welding to simulate actual work situations. The student is expected to:

(A) explore careers in welding;

(B) work independently to fabricate a welded project with minimal assistance;

(C) work collaboratively with other students to complete a relevant project; and

(D) troubleshoot equipment.

(7) The student knows the concepts and intricacies of inspections and related codes. The student is expected to:

(A) evaluate weld inspection processes; and

(B) analyze welding codes.

(8) The student performs oxy-fuel processes on carbon steels. The student is expected to:

(A) observe safe operating practices;

(B) perform safe handling of compressed gases;

(C) identify components of oxy-fuel gas cutting;

(D) demonstrate proper set-up procedures for oxy-fuel process;

(E) distinguish factors affecting base metals;

(F) demonstrate proper cutting techniques such as piercing, straight line, and bevel;

(G) perform welding and brazing; and

(H) identify acceptable cuts.

(9) The student performs plasma arc cutting on metals. The student is expected to:

(A) observe safe operating practices;

(B) demonstrate knowledge of the theories of plasma arc cutting;

(C) apply safe handling of compressed air supply;

(D) identify components of plasma arc cutting;

(E) demonstrate correct set-up procedure for plasma arc cutting;

(F) define cutting terms; and

(G) perform shape cutting.

(10) The student performs shielded metal arc welding principles and practices on metals. The student is expected to:

(A) use safe operating practices;

(B) demonstrate knowledge of the theories of electrical relationships such as alternating current and direct current, heat transfer, and polarity;

(C) apply shielded metal arc welding principles;

(D) demonstrate proper set-up procedure for shielded metal arc welding;

(E) determine appropriate filler for base metal in shielded metal arc welding;

(F) perform welds such as fillet and groove;

(G) perform passes such as root, hot, filler, and cover;

(H) perform plate preparation; and

(I) perform heating processes such as pre-heating and post-heating.

(11) The student performs gas metal arc welding principles and practices. The student is expected to:

(A) use safe operating practices;

(B) demonstrate knowledge of the theories of electrical relationships such as alternating current and direct current, heat transfer, and polarity;

(C) apply gas metal arc welding principles;

(D) demonstrate proper set-up procedure for gas metal arc welding;

(E) determine appropriate filler for base metal in gas metal arc welding; and

(F) perform fillet welds.

(12) The student performs flux cored arc welding principles and practices on metals. The student is expected to:

(A) use safe operating practices;

(B) demonstrate knowledge of the theories of electrical relationships such as alternating current and direct current, heat transfer, and polarity;

(C) apply flux cored arc welding principles;

(D) demonstrate proper set-up procedure for flux cored arc welding;

(E) determine appropriate filler for base metal in flux cored arc welding;

(F) perform fillet welds; and

(G) perform welds in all appropriate positions.

(13) The student performs gas tungsten arc welding on metals. The student is expected to:

(A) use safe operating practices;

(B) demonstrate knowledge of the theories of electrical relationships such as alternating current and direct current, heat transfer, and polarity;

(C) determine the common types of tungsten and filler materials;

(D) demonstrate proper set-up procedure for gas tungsten arc welding;

(E) perform fillet welds;

(F) perform welds in all appropriate positions; and

(G) perform welds on carbon steel.

**§130.324. Advanced Welding (Two to Three Credits).**

(a) General requirements. This course is recommended for students in Grades 11-12. Recommended prerequisites: Algebra I or Geometry and Welding.

(b) Introduction. Advanced Welding builds on knowledge and skills developed in Welding. Students will develop advanced welding concepts and skills as they relate to personal and career development. This course integrates academic and technical knowledge and skills. Students will have opportunities to reinforce, apply, and transfer knowledge and skills to a variety of settings and problems.

(c) Knowledge and skills.

(1) The student describes the importance of teamwork, leadership, integrity, honesty, work habits, and organizational skills. The student is expected to:

(A) analyze how effective teams function;

(B) apply teamwork to solve advanced problems;

(C) distinguish team roles such as team leaders and team members;

(D) evaluate characteristics of good leaders;

(E) use employers' work expectations to measure project success;

(F) evaluate team performance in using time-management techniques to develop work schedules; and

(G) develop a method to evaluate team performance.

(2) The student explores the employability characteristics of a successful worker in the global economy. The student is expected to:

(A) apply academic knowledge and skills required for postsecondary education;

(B) use employers' expectations to evaluate student performance and customer satisfaction;

(C) demonstrate the skills required in the workplace such as interviewing skills, flexibility, willingness to learn new skills and acquire knowledge, self-discipline, self-worth, positive attitude, and integrity in a work situation;

(D) evaluate progress toward personal career goals;

(E) communicate effectively with others in the workplace to clarify objectives; and

(F) apply knowledge and skills related to health and safety in the workplace, as specified by appropriate government regulations.

(3) The student applies academic skills to the requirements of welding. The student is expected to:

(A) differentiate effective communication skills with individuals from varied cultures such as fellow workers, management, and customers;

(B) demonstrate mathematical skills to estimate costs;

(C) determine the impact of inaccurate readings of measuring devices on cost estimates;

(D) justify the selection of a tool to make accurate measurements;

(E) compute measurements such as area, surface area, volume, and perimeter;

(F) calculate problems using whole numbers, fractions, mixed numbers, and decimals;

(G) use a calculator to perform advanced computations;

(H) apply right triangle relationships using the Pythagorean Theorem; and

(I) defend the choice of a mathematical solution using estimation.

(4) The student knows the function and application of the tools, equipment, technologies, and materials used in welding. The student is expected to:

(A) use welding equipment according to safety standards;

(B) dispose of environmentally hazardous materials used in welding;

(C) determine the performance impact of emerging technologies in welding;

(D) use appropriate personal protective equipment to follow safety measures; and

(E) investigate the use of automated welding machines such as numerical control, computer numerical control, and robotics-controlled welding machines.

(5) The student illustrates welding joint design, symbols, and welds. The student is expected to:

(A) use knowledge of welding blueprints to complete an advanced project; and

(B) inspect projects using welding blueprints.

(6) The student applies the concepts and skills of welding to perform tasks. The student is expected to:

(A) work independently to fabricate a welded project;

(B) work collaboratively with other students to complete a real-world application item; and

(C) troubleshoot equipment.

(7) The student knows the concepts and intricacies of inspections and related codes. The student is expected to:

(A) inspect welding projects of team members;

(B) use advanced codes for weld inspections; and

(C) critique welds of team members.

(8) The student performs advanced oxy-fuel processes on carbon steels. The student is expected to:

(A) observe safe operating practices;

(B) apply safe handling of compressed gases; and

(C) perform advanced cutting processes according to accepted welding standards.

(9) The student performs plasma arc cutting on metals. The student is expected to:

(A) observe safe operating practices; and

(B) perform advanced shape cutting processes according to accepted welding standards.

(10) The student performs shielded metal arc welding on metals. The student is expected to:

(A) use safe operating practices; and

(B) demonstrate advanced knowledge of qualified welding positions using accepted welding standards.

(11) The student performs gas metal arc welding. The student is expected to:

(A) use safe operating practices;

(B) perform fillet welds;

(C) perform groove welds; and

(D) perform welds in all appropriate positions according to accepted welding standards.

(12) The student performs advanced flux cored arc welding on metals. The student is expected to:

(A) use safe operating practices;

(B) perform fillet welds;

(C) perform groove welds; and

(D) perform welds in all appropriate positions according to accepted welding standards.

(13) The student performs gas tungsten arc welding on metals. The student is expected to:

(A) use safe operating practices;

(B) perform fillet welds;

(C) perform groove welds;

(D) perform welds in all appropriate positions according to accepted welding standards; and

(E) perform welds on metals such as carbon steel, stainless steel, pipe, and aluminum.

**§130.325. Precision Metal Manufacturing (One to Two Credits).**

(a) General requirements. This course is recommended for students in Grades 10-12. Recommended prerequisites: Principles of Manufacturing and completed or concurrently enrolled in Algebra I or Geometry.

(b) Introduction. Rapid advances in technology have created new career opportunities and demands in many industries. Precision Metal Manufacturing provides the knowledge, skills, and technologies required for employment in metal technology systems. This course may also address a variety of materials in addition to

metal such as plastics, ceramics, and wood. Students develop knowledge of the concepts and skills related to these systems to apply them to personal and career development. This course supports integration of academic and technical knowledge and skills. Students will have opportunities to reinforce, apply, and transfer knowledge and skills to a variety of settings and problems. Knowledge about career opportunities, requirements, and expectations and the development of workplace skills prepare students for success.

(c) Knowledge and skills.

(1) The student knows the importance of teamwork, leadership, integrity, honesty, work habits, and organizational skills. The student is expected to:

(A) describe how teams function;

(B) use teamwork to solve problems;

(C) distinguish team roles such as team leaders and team members;

(D) identify characteristics of good leaders;

(E) identify employers' work expectations;

(F) discuss Equal Employment Opportunity law in the workplace;

(G) use time-management techniques to develop work schedules;

(H) describe how teams measure results; and

(I) develop a method to reward team performance.

(2) The student explores the employability characteristics of a successful worker in the global economy. The student is expected to:

(A) determine academic knowledge and skills required for postsecondary education;

(B) identify employers' expectations to foster positive customer satisfaction;

(C) demonstrate the skills required in the workplace such as interviewing skills, flexibility, willingness to learn new skills and acquire knowledge, self-discipline, self-worth, positive attitude, and integrity in a work situation;

(D) evaluate personal career goals;

(E) communicate effectively with others in the workplace to clarify objectives; and

(F) demonstrate skills related to health and safety in the workplace, as specified by appropriate government regulations.

(3) The student applies advanced academic skills to the requirements of precision metal manufacturing. The student is expected to:

(A) demonstrate effective communication skills with individuals from varied cultures such as fellow workers, management, and customers;

(B) successfully complete work orders;

(C) demonstrate mathematical skills to estimate costs;

(D) interpret blueprints such as schematics, drawings, charts, and diagrams; and

(E) use mathematics as it applies to precision machining operations.

(4) The student knows the concepts and skills that form the technical knowledge required in a machine shop. The student is expected to:

(A) examine the resources found in recognized machinery manufacturing reference materials; and

(B) demonstrate knowledge of the uses of abrasives.

(5) The student knows the function and application of the tools, equipment, technologies, and materials used in a machine shop. The student is expected to:

(A) safely use equipment commonly employed in machine shops;

(B) properly dispose of environmentally hazardous materials used in machine shops;

(C) demonstrate knowledge of numerical control operations; and

(D) demonstrate knowledge of emerging technologies that may affect the machine shop.

(6) The student applies technical knowledge and skills of precision metal manufacturing to simulated and actual work situations. The student is expected to:

(A) demonstrate proficiency in cutting processes such as drilling, turning, boring, milling, and broaching;

(B) use various work mounting procedures on all machines;

(C) properly execute lathe procedures such as threads, turn tapers, polishes, knurls, and bores;

(D) mill flat surfaces, bevels, chamfers, grooves, and key-seats using proper milling procedures;

(E) use proper procedures for surface grinding operations;

(F) accurately machine precision pieces;

(G) demonstrate knowledge of heating metals such as hardening, tempering, annealing, normalizing, and case hardening steel; and

(H) apply technical knowledge and skills in a machine shop to career preparation experiences.

**§130.326. Advanced Precision Metal Manufacturing (Two to Three Credits).**

(a) General requirements. This course is recommended for students in Grades 11-12. Recommended prerequisites: Precision Metal Manufacturing and completed or concurrently enrolled in Algebra II.

(b) Introduction. This course is designed to enhance the technical knowledge and skills learned in Precision Metal Manufacturing by allowing students the opportunity to explore career preparation that has resulted from the rapid advances in technology and career demands in high-skill, high-wage opportunities. Advanced Precision Metal Manufacturing provides the knowledge, skills, and technologies required for employment in a globally competitive manufacturing environment. This course may also address a variety of materials in addition to metal such as plastics, ceramics, and wood. Students need to develop concepts and skills related to this system in order to apply them to personal and professional development. Career and technical education supports the integration of academic and career and technical knowledge and skills. Students must have opportunities to reinforce, apply, and transfer knowledge and skills to a variety of settings and problems. Knowledge about career opportunities, requirements, and expectations and the development of workplace skills prepare students for future success.

(c) Knowledge and skills.

(1) The student describes the importance of teamwork, leadership, integrity, honesty, work habits, and organizational skills. The student is expected to:

(A) demonstrate how advanced teams function effectively;

(B) apply effective teamwork strategies to solve problems;

(C) distinguish team roles such as team leaders and team members;

(D) evaluate characteristics of effective team leadership;

(E) identify employers' work expectations;

(F) discuss Equal Employment Opportunity law in the workplace;

(G) evaluate team performance in using time-management techniques to develop work schedules; and

(H) develop a method to evaluate team performance.

(2) The student explores the employability characteristics of a successful worker in the global economy. The student is expected to:

(A) apply academic knowledge and skills required for postsecondary education;

(B) use employers' expectations to evaluate student performance and customer satisfaction;

(C) demonstrate the skills required in the workplace such as interviewing skills, flexibility, willingness to learn new skills and acquire knowledge, self-discipline, self-worth, positive attitude, and integrity in a work situation;

(D) evaluate progress toward personal career goals;

(E) communicate effectively with others in the workplace to clarify objectives; and

(F) apply skills related to health and safety in the workplace, as specified by appropriate government regulations.

(3) The student applies the technical knowledge and skills of Advanced Precision Metal Manufacturing. The student is expected to:

(A) apply the technical knowledge and skills found in The Machinery's Handbook resource; and

(B) demonstrate knowledge of the uses of abrasives.

(4) The student learns about advanced numerical control machinery. The student is expected to:

(A) research the history of numerical control machines;

(B) distinguish among different types of computer numerical control machines used in the industry;

(C) demonstrate safety rules for numerical control operation;

(D) demonstrate the use of binary numbers to control computer numerical control machines;

(E) demonstrate the methods by which programs can be entered into a controller; and

(F) use appropriate machining terminology to enhance computer numerical control vocabulary.

(5) The student experiences advanced numerical control systems development and implementation. The student is expected to:

(A) demonstrate the types of drive motors used on numerical control machinery;

(B) display the types of loop systems;

(C) explain the Cartesian coordinate system;

(D) differentiate between absolute and incremental positioning; and

(E) illustrate the difference between datum and delta dimensioning.

(6) The student learns the process planning and tool selection within a computer numerical control lab environment. The student is expected to:

(A) develop a process plan;

(B) demonstrate proper numerical control setup;

(C) demonstrate use of tools for hole operations;

(D) perform milling operations;

(E) apply the proper grade of carbide insert for a given material;

(F) use common numerical control turning tool types;

(G) determine the proper spindle revolutions per minute; and

(H) execute proper feed rates on a product.

(7) The student evaluates tool changing and tool registers in the computer numerical control lab environment. The student is expected to:

(A) perform various types of tool changes;

(B) demonstrate quick change tooling used on computer numerical control mills;

(C) demonstrate appropriate tool storage;

(D) demonstrate the proper use of tool registers;

(E) determine tool offset length; and

(F) enter tool offsets for a set up.

(8) The student learns to program coordinates for all computer numerical control machinery in the computer control lab environment. The student is expected to:

(A) explain the program coordinates for hole operations such as drilling, reaming, boring, and tapping;

(B) program hole operation coordinates such as absolute and incremental positioning; and

(C) program milling coordinates such as absolute and incremental positioning.

(9) The student learns two-axis programming for all computer numerical control machinery in the computer numerical control lab environment. The student is expected to:

(A) identify the parts of the computer numerical control program;

(B) describe the word address code format;

(C) write a simple two-axis program using word addresses to perform hole operations; and

(D) write a simple two-axis program using word addresses to perform hole operations and milling operations combined.

(10) The student learns three-axis programming for all computer numerical control machinery in the computer numerical control lab environment. The student is expected to:

(A) write a simple program to perform hole operations using a three-axis machine;

(B) explain an example of a canned cycle;

(C) explain the difference between a modal and non-modal command; and

(D) write a simple program to perform milling operations using a three-axis machine.

(11) The student demonstrates appropriate mathematics for numerical control programming to be used in the computer numerical control lab environment. The student is expected to:

(A) use trigonometry to determine coordinates from technical drawings to cut arcs and angles;

(B) use trigonometry for determining cutter offsets; and

(C) use appropriate mathematical skills to solve problems such as milling and lathe issues.

(12) The student performs cutter radius and diameter compensation for numerical control programming to be used in the computer numerical control lab environment. The student is expected to:

(A) define cutter radius and cutter diameter compensation;

(B) describe ramp-on and ramp-off moves;

(C) identify precautions dealing with the use of cutter compensation; and

(D) write a program that includes the use of cutter compensation.

**§130.327. Flexible Manufacturing (One to Two Credits).**

(a) General requirements. This course is recommended for students in Grades 10-12. Recommended prerequisite: Algebra I or Geometry.

(b) Introduction. Rapid advances in technology have created new career opportunities and demands in many industries. Flexible Manufacturing provides the knowledge, skills, and technologies required for employment in metal technology systems. Students need to develop knowledge of the concepts and skills related to this system in order to apply them to personal and career development. Career and technical education supports integration of academic and technical knowledge and skills. Students must have opportunities to reinforce, apply, and transfer knowledge and skills to a variety of settings and problems. Knowledge about career opportunities, requirements, and expectations and the development of workplace skills prepare students for success.

(c) Knowledge and skills.

(1) The student describes the importance of teamwork, leadership, integrity, honesty, work habits, and organizational skills. The student is expected to:

(A) describe how teams function;

(B) use teamwork to solve problems;

(C) distinguish team roles such as team leaders and team members;

(D) identify characteristics of good leaders;

(E) identify employers' work expectations;

(F) discuss Equal Employment Opportunity law in the workplace;

(G) use time-management techniques to develop work schedules;

(H) describe how teams measure results; and

(I) develop a method to reward team performance.

(2) The student explores the employability characteristics of a successful worker in the global economy. The student is expected to:

(A) determine advanced knowledge and skills required for postsecondary education;

(B) identify employers' expectations to foster positive customer satisfaction;

(C) demonstrate the skills required in the workplace such as interviewing skills, flexibility, willingness to learn new skills and acquire knowledge, self-discipline, self-worth, positive attitude, and integrity in a work situation;

(D) evaluate personal career goals;

(E) communicate effectively with others in the workplace to clarify objectives; and

(F) demonstrate skills related to health and safety in the workplace, as specified by appropriate government regulations.

(3) The student applies academic skills to the requirements of metal materials. The student is expected to:

(A) demonstrate effective oral and written communication skills with individuals from varied cultures, including fellow workers, management, and customers;

(B) appraise blueprints, drawings, charts, diagrams, and welding symbols; and

(C) select algebraic and geometric principles and formulas required for precision measuring operations.

(4) The student differentiates the technical concepts that form the knowledge and skills of metal trades. The student is expected to:

(A) analyze the resources found in The Machinery's Handbook and various American Welding Society specification and code reference books;

(B) examine the theory of shielded metal arc-welding and gas metal arc-welding;

(C) examine the sheet metal industry; and

(D) examine the use of abrasives.

(5) The student differentiates the function and application of the tools, equipment, technologies, and materials used in metal manufacturing. The student is expected to:

(A) safely use hand and power tools and equipment commonly employed in metal manufacturing; and

(B) properly handle and dispose of environmentally hazardous materials used in metal manufacturing.

(6) The student applies the technical concepts and skills of the machining industry to simulated and actual work situations. The student is expected to:

(A) use various work mounting procedures on all appropriate machines;

(B) examine the cutting operations such as drill press, lathe, saw, grinders, and milling machines;

(C) properly execute lathe procedures such as cut threads, turn tapers, drills, reams, polishes, knurls, and bores;

(D) mill flat surfaces, bevels, chamfers, grooves, and key-seats; and

(E) machine precision pieces.

(7) The student applies the technical concepts and skills of the welding industry to simulated and actual work situations. The student is expected to:

(A) examine the cutting processes such as oxy-fuel and plasma;

(B) explore the use of the common types of electrodes;

(C) use various welding machines to weld multiple joints; and

(D) inspect welds.

(8) The student applies the technical concepts and skills of the sheet metal industry to simulated and actual work situations. The student is expected to:

(A) use mathematics in precision measuring operations; and

(B) interpret blueprints, drawings, charts, and diagrams as related to the sheet metal industry.

(9) The student differentiates the concepts that form the technical knowledge and skills of sheet metal manufacturing. The student is expected to:

(A) analyze the types, sizes, and properties of sheet metal materials;

(B) analyze the fundamentals of oxy-fuel processes as related to sheet metal; and

(C) analyze the fundamentals of shielded metal arc-welding as related to sheet metal under American Welding Society code.

(10) The student understands the function and application of the tools, equipment, technologies, and materials used in sheet metal manufacturing. The student is expected to:

(A) safely use equipment; and

(B) properly dispose of environmentally hazardous materials used in sheet metal manufacturing.

(11) The student applies the knowledge and skills of sheet metal manufacturing in simulated and actual work situations. The student is expected to:

(A) draw simple sheet metal layouts; and

(B) construct common sheet metal seams.

**§130.328. Advanced Flexible Manufacturing (Two to Three Credits).**

(a) General requirements. This course is recommended for students in Grades 11-12. Recommended prerequisites: Geometry, Algebra II, and Flexible Manufacturing.

(b) Introduction. Advanced Flexible Manufacturing builds on knowledge and skills developed in Flexible Manufacturing. Students will develop advanced concepts and skills as they relate to personal and career development. This course integrates academic and technical knowledge and skills. Students will have opportunities to reinforce, apply, and transfer knowledge and skills to a variety of settings and problems.

(c) Knowledge and skills.

(1) The student describes the importance of teamwork, leadership, integrity, honesty, work habits, and organizational skills. The student is expected to:

(A) describe how teams function;

(B) use teamwork to solve problems;

(C) distinguish team roles such as team leaders and team members;

(D) identify characteristics of good leaders;

(E) identify employers' work expectations;

(F) discuss Equal Employment Opportunity law in the workplace;

(G) use time-management techniques to develop work schedules;

(H) describe how teams measure results; and

(I) develop a method to reward team performance.

(2) The student explores the employability characteristics of a successful worker in the global economy. The student is expected to:

(A) determine advanced knowledge and skills required for postsecondary education;

(B) identify employers' expectations to foster positive customer satisfaction;

(C) demonstrate the skills required in the workplace such as interviewing skills, flexibility, willingness to learn new skills and acquire knowledge, self-discipline, self-worth, positive attitude, and integrity in a work situation;

(D) evaluate personal career goals;

(E) communicate effectively with others in the workplace to clarify objectives; and

(F) demonstrate skills related to health and safety in the workplace, as specified by appropriate government regulations.

(3) The student applies advanced academic skills to the requirements of metal trades. The student is expected to:

(A) demonstrate effective communication skills with individuals from varied cultures such as fellow workers, management, and customers;

(B) successfully complete work orders;

(C) estimate labor costs using various algebraic formulas;

(D) interpret advanced blueprints such as drawings, charts, diagrams, and welding symbols; and

(E) demonstrate calculation of precision measuring operations using algebra, geometry, and trigonometry.

(4) The student knows the advanced concepts that form the technical knowledge and skills of metal trades. The student is expected to:

(A) analyze the resources found in machinery manufacturing reference materials;

(B) demonstrate knowledge of the various welding theories;

(C) examine the sheet metal industry; and

(D) examine the use of advanced abrasives.

(5) The student knows the function and application of the tools, equipment, technologies, and materials used in metal manufacturing. The student is expected to:

(A) safely use equipment commonly employed in metal manufacturing;

(B) properly dispose of environmentally hazardous materials used in metal manufacturing;

(C) demonstrate knowledge of numerical control machining operations;

(D) demonstrate knowledge of the concepts of automated numerical control welding machines; and

(E) demonstrate knowledge of emerging technologies that may affect metal manufacturing.

(6) The student applies the advanced concepts and technical knowledge and skills of the machining industry to simulated and actual work situations. The student is expected to:

(A) use various work mounting procedures on all appropriate machines;

(B) examine the cutting operations such as drill press, lathe, saw, grinders, and milling machines;

(C) properly execute lathe procedures such as cut threads, turn tapers, drills, reams, polishes, knurls, and bores;

(D) mill flat surfaces, bevels, chamfers, grooves, and key-seats; and

(E) machine precision pieces.

(7) The student applies the advanced concepts and technical knowledge and skills of the welding industry to simulated and actual work situations. The student is expected to:

(A) examine the cutting processes such as oxy-fuel and plasma;

(B) explore the use of the common types of electrodes;

(C) use various welding machines to weld multiple joints; and

(D) inspect welds.

(8) The student applies the advanced concepts and technical knowledge and skills of the sheet metal industry to simulated and actual work situations. The student is expected to:

(A) estimate labor costs;

(B) use advanced mathematics in precision measuring operations; and

(C) interpret industrial standard blueprints, drawings, charts, and diagrams.

(9) The student knows the advanced concepts and technical knowledge and skills of sheet metal manufacturing. The student is expected to:

(A) analyze properties of sheet metal materials and fasteners;

(B) analyze oxy-fuel processes as related to sheet metal; and

(C) demonstrate knowledge of shielded metal arc-welding as related to sheet metal under American Welding Society code.

(10) The student knows the function and application of the tools, equipment, technologies, and materials used in sheet metal. The student is expected to:

(A) safely use equipment commonly employed in sheet metal;

(B) properly dispose of environmentally hazardous materials used in sheet metal manufacturing; and

(C) demonstrate knowledge of emerging technologies that may affect sheet metal.

(11) The student applies the advanced concepts and technical skills in simulated and actual work situations. The student is expected to:

(A) draw advanced sheet metal layouts;

(B) construct sheet metal seams;

(C) construct transitions and offsets;

(D) use the gas tungsten arc-welding process in sheet metal construction;

(E) apply the principles of sheet metal construction to the fabrication of duct work; and

(F) apply skills in sheet metal to career preparation learning experiences.

**§130.329. Manufacturing Engineering (Two to Three Credits).**

(a) General requirements. This course is recommended for students in Grades 11-12. Recommended prerequisites: Algebra II, Computer Science I, and Physics.

(b) Introduction. In Manufacturing Engineering, students gain knowledge and skills in the application, design, production, and assessment of products, services, and systems and how those knowledge and skills are applied to manufacturing. Knowledge and skills in the proper application of Manufacturing Engineering, the design of technology, efficient manufacturing technology, and the assessment of the effects of production technology prepare students for success in the global economy. The study of Manufacturing Engineering allows students to reinforce, apply, and transfer academic knowledge and skills to a variety of interesting and relevant activities, problems, and settings in a manufacturing setting.

(c) Knowledge and skills:

(1) The student describes the importance of teamwork, leadership, integrity, honesty, work habits, and organizational skills. The student is expected to:

(A) describe how teams function;

(B) use teamwork to solve problems;

(C) distinguish team roles such as team leaders and team members;

(D) identify characteristics of good leaders;

(E) identify employers' work expectations;

(F) discuss Equal Employment Opportunity law in the workplace;

(G) use time-management techniques to develop work schedules;

(H) describe how teams measure results; and

(I) develop a method to reward team performance.

(2) The student explores the employability characteristics of a successful worker in the global economy. The student is expected to:

(A) explore advanced knowledge and skills required for postsecondary education;

(B) identify employers' expectations to foster positive customer satisfaction;

(C) demonstrate the skills required in the workplace such as interviewing skills, flexibility, willingness to learn new skills and acquire knowledge, self-discipline, self-worth, positive attitude, and integrity in a work situation;

(D) evaluate personal career goals;

(E) communicate effectively with others in the workplace to clarify objectives; and

(F) demonstrate knowledge of the concepts and skills related to health and safety in the workplace, as specified by appropriate government regulations.

(3) The student applies software skills in designing for mobility. The student is expected to:

(A) use computer-aided design software to complete a project;

(B) analyze the results of product testing in a simulated modeling environment; and

(C) fabricate a prototype design of a mechanical part.

(4) The student gains advanced skills in writing programmable logic controls so that multiple robots can work together as a team. The student is expected to:

(A) use computer-integrated manufacturing techniques to simulate a manufacturing process; and

(B) troubleshoot programmable logic circuit devices.

(5) The student performs functions and solves problems in the electricity and electronics field. The student is expected to:

(A) develop solutions to use control devices; and

(B) troubleshoot control devices.

(6) The student learns skills in production and programming of computer numerical control operations. The student is expected to:

(A) design on the computer numerical control lathe;

(B) produce on the computer numerical control lathe;

(C) design on the computer numerical control mill;

(D) produce on the computer numerical control mill; and

(E) complete data sheets for plan, do, check, and act forms and projects.

(7) The student knows mechanical, fluid, electrical, and thermal systems. The student is expected to:

(A) use pneumatics devices;

(B) use hydraulics devices;

(C) analyze the effects of heat energy and temperature on products; and

(D) develop an understanding of ventilation such as heating, air conditioning, and refrigeration.

(8) The student analyzes quality control systems. The student is expected to:

(A) apply statistical process control;

(B) determine sprocket hardness values in ascending order;

(C) manually calculate resistor capability indices;

(D) demonstrate the use of software to control instruments; and

(E) analyze attribute and Pareto charts.

**§130.330. Practicum in Manufacturing (Two to Three Credits).**

(a) General requirements. This course is recommended for students in Grade 12. The practicum course is a paid or unpaid capstone experience for students participating in a coherent sequence of career and technical education courses in the manufacturing cluster.

(b) Introduction. The practicum is designed to give students supervised practical application of previously studied knowledge and skills. Practicum experiences can occur in a variety of locations appropriate to the nature and level of experience.

(c) Knowledge and skills.

(1) The student demonstrates professional standards as required by business and industry. The student is expected to:

(A) adhere to standard operating procedures;

(B) demonstrate positive work behaviors such as attitudes, punctuality, time management, initiative, and cooperation;

(C) accept constructive criticism;

(D) apply ethical reasoning to a variety of situations in order to make ethical decisions;

(E) complete tasks with the highest standards such as quality products and services;

(F) model professional appearance such as dress, grooming, and personal protective equipment as appropriate; and

(G) comply with practicum setting safety rules such as regulations to maintain safe working conditions and environments.

(2) The student applies concepts of critical thinking and problem solving. The student is expected to:

(A) analyze elements of a problem to develop innovative solutions;

(B) critically analyze information to determine value to the problem-solving task;

(C) analyze a variety of problem-solving and critical-thinking skills; and

(D) conduct technical research to gather information necessary for decision making.

(3) The student demonstrates leadership and teamwork skills in collaborating with others to accomplish goals and objectives. The student is expected to:

(A) analyze leadership characteristics such as trust, positive attitude, integrity, and willingness to accept key responsibilities in a work situation;

(B) demonstrate teamwork skills through working cooperatively with others to achieve tasks;

(C) demonstrate teamwork processes such as promoting team building, consensus, continuous improvement, respect for the opinions of others, cooperation, adaptability, and conflict resolution;

(D) demonstrate responsibility for organization tasks such as shared group and individual work tasks; and

(E) establish and maintain effective working relationships to accomplish objectives such as:

(i) demonstrating effective working relationships using interpersonal skills;

(ii) using positive interpersonal skills to work cooperatively with others;

(iii) negotiating effectively to reach decisions;

(iv) demonstrating respect for individuals from different cultures, genders, and backgrounds; and

(v) demonstrating value for diversity.

(4) The student demonstrates oral and written communication skills in creating, expressing, and interpreting information and ideas, including technical terminology and information. The student is expected to:

(A) demonstrate the use of content such as technical concepts and vocabulary when analyzing information and following directions;

(B) employ verbal skills when obtaining and conveying information;

(C) use informational texts such as Internet websites and technical materials to review and apply information sources for occupational tasks;

(D) evaluate the reliability of information from informational texts such as Internet websites, technical materials, and resources;

(E) interpret verbal and nonverbal cues and behaviors to enhance communication;

(F) apply active listening skills such as obtaining and clarifying the information; and

(G) use academic skills such as effective written and oral communication.

(5) The student demonstrates technical knowledge and skills required to pursue a career in the manufacturing cluster. The student is expected to:

(A) use information literacy skills such as accessing, evaluating, and disseminating information;

(B) describe information management;

(C) maintain records to facilitate ongoing business operations;

(D) develop goals;

(E) prioritize tasks;

(F) develop timelines using time-management skills;

(G) use project-management skills to improve workflow;

(H) evaluate proficiencies in technical skills; and

(I) accept critical feedback provided by the supervisor.

(6) The student documents technical knowledge and skills. The student is expected to:

(A) update a professional portfolio to include:

(i) attainment of technical skill competencies;

(ii) licensures or certifications;

(iii) recognition;

(iv) extended learning experiences such as community service and active participation in career and technical student organizations and professional organizations;

(v) abstract of key points of the practicum;

(vi) resumé;

(vii) samples of work; and

(viii) evaluation from the practicum supervisor; and

(B) present the portfolio to all interested stakeholders such as in a poster presentation.