Tennessee CTE

Principles of Manufacturing

Safety

1 **Accurately read, interpret, and demonstrate adherence to safety rules, including rules published by the (1) National Science Teachers Association (NSTA), (2) rules pertaining to electrical safety, (3) Occupational Safety and Health Administration (OSHA) guidelines, (4) American Society for Testing Materials, (4) ANSI Z49.1: Safety and Welding, Cutting, and Allied Processes, and (5) state and national code requirements. Be able to distinguish between rules and explain why certain rules apply.** 1

2 **Identify and explain the intended use of safety equipment available in the classroom. For example, demonstrate how to properly inspect, use, store, and maintain safe operating procedures with tools and equipment.** 2

Overview of Manufacturing

3 **Define manufacturing and describe how it is used to solve problems. Research the five general steps of manufacturing (preparation, processing, assembly, finishing, and packaging). Select a product and trace its development through each of the five steps. For example, deliver a presentation explaining how a smart phone goes from raw materials to final packaged product.** 3

4 **Distinguish between primary and secondary processes involved in the manufacture of industrial goods into finished products. Summarize in a graphic illustration or narrative how different processes make use of specific manufacturing applications, such as the use of welding in assembling processes. Relate the specific operations required to implement the following secondary processes:** 4

- a Casting and molding (e.g., sand casting) 4.A
- b Forging (e.g., metal forming) 4.B
- c Separating (e.g., machining) 4.C
- d Assembling (e.g., welding) 4.D
- e Direct digital and additive manufacturing (e.g., 3-D printing) 4.E
- f Finishing (e.g., electroplating) 4.F
- g Stamping (e.g., stamping press) 4.G
- h Injection Molds (e.g., injecting material into a mold) 4.H

5 **Research the history of manufacturing. Summarize its evolution from the Industrial Age to the rise of mechanization and automation in the manufacturing industry. Create a timeline or infographic that identifies milestones in the industry that led to today's advanced manufacturing environments. For example, discuss**

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both the history of the assembly line and the use of robots, describing how they transformed the manufacturing industry. 5

6 **Explain that manufacturing is a technological system that transforms raw materials into products in a central location (e.g., a factory). Technological systems include the following elements: inputs, processes, outputs, feedback, and goals. As a team, select a manufacturing system, such as metal fabrication, and use diagrams and other multimedia to demonstrate its operation. Identify each element and explain its role in the system.** 6

7 **Explore the onset of advanced manufacturing and explain how it applies information, automation, computation, software, sensing, and networking to make traditional processes more efficient. Describe how advanced manufacturing incorporates the use of modern materials and recent discoveries in physical and biological sciences. For example, report on the use of nanotechnology.** 7

Materials

8 **Identify and describe a wide range of materials used in manufacturing: organic, inorganic, engineering (metallic, polymeric, ceramic, composite), and non-engineering (gases and liquids). Distinguish between the materials and provide examples of how they are converted into products.** 8

9 **In teams, research the major material properties: physical, mechanical, chemical, thermal, electrical/magnetic, acoustical, and optical. Considering the use of materials in the various areas of advanced manufacturing (e.g., welding, machining, mechatronics, and electromechanical technology), discuss the following:** 9

- a Characteristics that make up the physical properties of a material 9.A
- b How the mechanical properties affect the way a material will react to forces or loads 9.B
- c How natural elements react with a material and affect its performance 9.C
- d Characteristics that make up thermal properties of a material (e.g., thermal resistance, thermal expansion, thermal emission, thermal shock resistance) 9.D
- e Three major groups of materials that carry an electrical current (e.g., conductors, semiconductors, resistors) 9.E
- f Two major properties that describe how a material reacts to sound waves (e.g., acoustical transmission, acoustical reflection) 7.
- g Three general optical properties (e.g., color, light transmission, light reflection). 7.G

Explain why these properties are important to the selection and application of materials in a production setting.

Career Exploration

10 **In teams, use an online editing tool to develop an informational paper or infographic illustrating various career opportunities and pathways in the advanced manufacturing industry (welding, mechatronics, machining technology, and electromechanical technology). The descriptions should contain**

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definitions, job roles, professional societies, and applicable licenses and/or certifications associated with each career. Use a variety of sources to gather data, cite each source, and briefly describe why the chosen source is reliable. 10

11 **Research the postsecondary institutions (colleges of applied technology, community colleges, and four-year universities) in Tennessee and other states that offer programs leading to careers in advanced manufacturing. Write an informative paper or develop an infographic identifying admissions criteria, the postsecondary programs of study, and the secondary courses that will prepare individuals to be successful in a postsecondary program.** 11

Layout and Measurement

12 **Identify and demonstrate proper use of the following typical measuring tools. Determine when it is appropriate to use linear distance, diameter, and angle measuring tools, and record accurate and repeatable measurements, attending to appropriate units and quantities.** 12

- a Tape rule 12.A
- b Machinist's rule 12.B
- c Bench rule 12.C
- d Caliper 12.D
- e Divider 12.E
- f Depth gage 12.F
- g Micrometer 12.G
- h Square 12.H
- i Protractor 12.I
- j Combination set 12.J

13 **Explain why proper layout is critical to making parts properly. Select a typical part and correctly demonstrate the following steps, or use a similar multistep procedure, to lay out the shape of a part.** 13

- a Measure off the part size on standard stock. 13.A
- b Cut the part blank out of the standard stock. 13.B
- c Draw center lines for holes and arcs. 13.C
- d Locate holes and arcs. 13.D
- e Mark centers of holes. 13.E
- f Draw tangent lines. 13.F
- g Layout straight cuts. 13.G

Blueprint Reading and Interpretation

14 **Define the differences in technique among freehand sketching, manual drafting, and computer-aided drafting (CAD), and describe the skills required for each. Create a two-dimensional orthographic (multi-view) drawing incorporating labels, notes, and dimensions, using sketching/geometric construction**

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techniques. Apply basic dimensioning rules and properly use different types of lines (e.g., object, hidden, center). The orthographic projections should include principle views of a simple object from top, front, and right sides. 14

15 **Compare and contrast the following types of engineering drawings. Describe the characteristics and explain the different applications of each drawing type. Identify and distinguish between symbols that are unique to the different pathways in advanced manufacturing (e.g., machining technology, electromechanical technology, mechatronics, and welding). For example, electromechanical technology often uses schematic symbols for common electrical components and machining technology often uses symbols for surface finishes.** 15

- a Detail drawings 15.A
- b Assembly drawings 15.B
- c Systems drawings 15.C

16 **Inspect and interpret blueprints, schematic diagrams, or written specifications for manufacturing devices and systems. Explain how the pictorial representations relate to an actual project layout, verifying sufficient agreement as prescribed by specified tolerances. For example, use a hydraulic schematic to show how fluid travels through a hydraulic circuit in an actual system.** 16

Sequencing of Manufacturing Operations

17 **In teams, investigate the role of a manufacturing engineer in designing efficient manufacturing systems. Create samples of the following documents which engineers often use to ensure that manufacturing operations are completed in a logical and efficient order. Use the sample documents to manage the completion of short projects and assignments in this course. Documents include the following:** 17

- a Operation sheet 17.A
- b Flow process chart 17.B
- c Operations process chart 17.C

Quality Assurance and Continuous Improvement

18 **In teams, research the three basic types of data that are important to controlling the manufacturing of a product: product output data, quality control data, and labor data. Describe and explain each type, including sample illustrations of the various reports needed by analysts (e.g., production report, material rejection form, inspection report). Provide examples of how a process can be improved depending on the outcome of each data type.** 18

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19 **Examine common statistical processes to analyze data. As a class, develop standard procedures for analysis to apply to manufacturing projects throughout the course and program of study. The procedures should include:** 19

- a Collection of data 19.A
- b Analysis methods 19.B
- c Interpretation of results 19.C

20 **Define the concept of quality control in the manufacturing industry. Summarize the roles of various personnel involved in ensuring quality control over production, including those who make the products, those who design the processes, and those who inspect the finished products. Describe why quality control is important to manufacturing processes, including how it affects customers, retailers, and manufacturers. Provide examples of how quality control could be applied to various manufacturing practices like electromechanical technology, machining technology, mechatronics, and welding.** 20

21 **As a class, research quality improvement tools and strategies such as the Plan-Do-Check-Act cycle, and collaboratively create quality control guidelines and reports to reference as products are fabricated and assembled throughout the semester and program of study. Include plans for corrective action to address common quality problems.** 21

22 **Investigate the functions of process management in a manufacturing workplace: planning, organizing, directing, and controlling. Explain each function and describe the relationship between process management and quality assurance. For example, compare and contrast the costs of preventive maintenance, safety practices, and quality control with the costs of equipment repair, workplace accidents, and inefficient processes.** 22

Machining Technology

23 **Demonstrate proper application of common machine shop hand tools. Identify the following tools and provide examples of how they should be used safely.** 23

- a Clamping devices 23.A
- b Pliers 23.B
- c Wrenches 23.C
- d Screwdrivers 23.D
- e Chisels 23.E
- f Hacksaws 23.F
- g Reamers 23.G
- h Hand taps 23.H
- i Dies 23.I

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Given a specific machining assignment, select two or more of the above hand tools for the task. Explain why the tools were selected to complete the assignment.

24 **Identify and explain the equipment, equipment setup, and techniques that apply to the following operations:** 24

- a Sawing 24.A
- b Drilling 24.B
- c Grinding 24.C
- d Milling 24.D

Given a specific machining assignment, comply with safe and efficient work practices and perform basic operations using both manual and machine-guided techniques. Properly set controls and speeds of the machines; remove and replace parts; and visually examine machined surfaces for meeting the given specifications.

25 **Research the development of numerical control machines, including how computer numerical control (CNC) technology evolved. Compare and contrast CNC machines with manually controlled machines and identify the chief benefits associated with them. Demonstrate operation of a CNC machine to perform basic tasks.** 25

Mechatronics

26 **In teams, research the history of mechatronics and summarize how it evolved into modern day applications. Using the research findings, create an infographic or presentation that can be used to (a) explain the mechatronics field, (b) why it is critical to the advanced manufacturing industry, (c) the skills needed to be successful in this field, and (d) why there is a demand for mechatronics professionals.** 26

27 **Identify and describe the following components of a typical mechatronic system. Select a common machine, such as a robot or a copy machine, to illustrate an example of a mechatronic system. Using supporting evidence from the machine and/or its accompanying schematic, explain why the machine is considered a mechatronic system.** 27

- a Actuators 27.A
- b Sensors 27.B
- c Digital control devices 27.C
- d Input devices 27.D
- e Output devices 27.E
- f Graphical displays 27.F

28 **Log, store, and export data received from two or more sensors (e.g., vision/light, audio, and touch) in a robotic or automated system. Explain why these**

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	procedures would be useful in a manufacturing process and provide specific examples. 28
Industrial Maintenance Technology	**29** **Explain how belt drives and chain drives are used to transmit power in an electromechanical system. Compare and contrast the two drive types and describe the advantages and disadvantages of using each. Make a claim about the appropriate drive type for a given situation, citing data and evidence to support claim and address counterclaims.** 29
	30 **Identify and define the following common electrical quantities, including the unit of measurement and symbol (abbreviation) for each unit.** 30 a Current 30.A b Voltage 30.B c Resistance 30.C d Conductance 30.D e Power 30.E f Charge 30.F
	31 **Compare and contrast the two types of fluid power systems (pneumatic and hydraulic). Describe and explain the components they have in common; then identify the characteristics that render certain advantages to using one system over the other. For example, heavy construction machinery often uses hydraulic systems because they have the ability to support heavy loads.** 31
Welding	**32** **Interpret welding-specific drawings and welding symbol information. Differentiating between drawings and blueprints, examine parts to determine the application of symbols from drawings, sketches, and blueprints.** 32
	33 **Examine given shop and assembly drawings for a weldment composed of five to ten components. Interpret the dimensions and write a plan describing the materials and tools needed to complete the assignment. Make the required cuts and execute the plan.** 33
	34 **Identify and explain the equipment, equipment setup, and techniques that apply to the following thermal cutting operations:** 34 a Oxyfuel cutting 34.A b Plasma-arc cutting 34.B c Air carbon arc cutting 34.C d Sawing 34.D e Shearing 34.E f Punching 34.F
	erform straight, shaped, and beveled cutting operations using both manual and machineguided techniques. Properly use weld-washing techniques and visually

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examine cut surfaces for meeting the given specifications.

Trends in Advanced Manufacturing

35 Examine the changes to manufacturing due to the Fourth Industrial Revolution (Industry 4.0). Explore a range of new and emerging trends in advanced manufacturing. A trend could be the change in the types of skills needed in manufacturing, the use of computers, or the use of advanced materials in recent years. Examples include the following: 35

- a Sensing, measurement, and process control 35.A
- b Materials design, synthesis, and processing 35.B
- c Digital manufacturing technologies 35.C
- d Sustainable manufacturing 35.D
- e Nano manufacturing 35.E
- f Flexible electronics manufacturing 35.F
- g Bio manufacturing 35.G
- h Additive manufacturing – Focus on how 3D printing is being used. 35.H
- i Industrial robotics 35.I
- j Advanced forming and joining technologies 35.J

Research one or more of these trends in depth, and compile, review, and revise a presentation or a paper explaining both the technical aspects involved (i.e., what skills are needed) and the effects on businesses, workers, and society.