Massachusetts CTE

Engineering Technology (2014)

Engineering Safety Health and Skills 2.A

1. **Obtain OSHA 10 Hour General Certification.** 2.A.01
    1. Implement safety knowledge obtained on a continuous basis. 2.A.01.01
    2. Identify safety hazards in the shop, remove hazards, and develop continuous improvement solutions. 2.A.01.02
    3. Implement a tag-out and lock-out shop procedure. 2.A.01.03
2. **Read, explain and implement shop safety manual and procedures according to current industry and OSHA standards.** 2.A.02
    1. Demonstrate safety procedure(s)for maintaining machinery and equipment. 2.A.02.01
    2. Demonstrate safety procedure(s)for operating machinery and equipment. 2.A.02.02

Engineering – Introductory Knowledge and Skills 2.B

1. **Demonstrate and apply the design process.** 2.B.01
    1. Identify a problem to be solved based on identifying customer needs. 2.B.01.01
    2. Brainstorm ideas; develop and evaluate solutions; create documentation; build and test prototype; and present design. 2.B.01.02
    3. Create new designs by working in teams using brainstorming techniques. 2.B.01.03
    4. Maintain an engineering journal to document design solutions. 2.B.01.04
    5. Conduct market surveys, research patents, search internet sources, contact companies, and develop justification for at least three solutions of given engineering problems/customer needs.. 2.B.01.05
    6. Develop best solution, sketch and model idea, survey market and customers, produce a timeline, develop industry support, report results periodically, re-evaluate solution, develop criteria and limitations and produce initial drawings. 2.B.01.06
    7. Describe the role of drawings and CAD models as vital documentation components in the engineering process. 2.B.01.07
    8. Fabricate a prototype using hand tools, manual machine tools, CNC devices, joining processes, measuring and cutting techniques. 2.B.01.08
    9. Develop testing protocol, test and evaluate prototype, assess performance and function, and modify design based upon results. 2.B.01.09
    10. Produce final drawing documentation, develop presentation, present results; patent, market, and sell idea. 2.B.01.10

2. **Demonstrate skills in problem solving, diagnostics, and troubleshooting.** 2.B.02
    1. Identify the components and process of the system (equipment). 2.B.02.01
    2. Identify the problem or source of the problem. 2.B.02.02
    3. Develop solutions using a structured problem solving process. 2.B.02.03
    4. Use appropriate testing equipment and tools for diagnosing the problem. 2.B.02.04
    5. Implement the appropriate strategies to remedy the problem. 2.B.02.05

3 **Define and describe types of engineering.** 2.B.03

1 Describe different pathways towards a variety of engineering careers. 2.B.03.01

2 Explain how engineers impact society, the environment, economy, and daily life through their work. 2.B.03.02

3 Identify the unique components and considerations of the different engineering fields (e.g., civil/structural, transportation, electrical, computer, software, manufacturing, mechanical, and biological/environmental/chemical). 2.B.03.03

4 List the attributes of design in a variety of technical fields (e.g., biotechnology, manufacturing, environmental, power and energy, transportation, etc.). 2.B.03.04

5 Describe one major engineering category or sub-discipline and describe core tasks, working conditions, salary, education and training, skills and abilities required. 2.B.03.05

4 **Document and communicate engineering concepts.** 2.B.04

1 Write a technical design report. 2.B.04.01

2 Maintain engineering logs/notebooks/journals and portfolios for projects. 2.B.04.02

3 Utilize a variety of media formats to convey designs and processes (animation, presentation software, web page, etc.). 2.B.04.03

5 **Develop project or product objectives and criteria.** 2.B.05

1 Define requirements for a project or product. 2.B.05.01

2 Create specifications (or follow if given) for a project or product. 2.B.05.02

3 Establish milestones for a project or product. 2.B.05.03

4 Develop a time line for a project or product. 2.B.05.04

5 Identify critical path components. 2.B.05.05

6 Implement a schedule for a project or product. 2.B.05.06

6 **Develop methods and plan of production.** 2.B.06

1 Determine method to be used to create a product (molding, machining, etc.). 2.B.06.01

2 Define efficient order of fabrication operation. 2.B.06.02

3 Identify parts and materials for product. 2.B.06.03

4 Make custom parts (those not readily available that meet specifications). 2.B.06.04

5 Assemble a product. 2.B.06.05

7 **Explain, demonstrate and apply manufacturing process management techniques according to current industry and OSHA standards.** 2.B.07

1 Identify internal and external customer needs. 2.B.07.01

2 Identify resources needed (supplies, personnel, equipment). 2.B.07.02

3 Identify/create/provide needed standard operational procedures (SOPs). 2.B.07.03

4 Monitor process using process control data. 2.B.07.04

5 Explain inventory control and the implications to production and performance. 2.B.07.05

6 Test product to verify that it meets customer specifications, regulations, etc. 2.B.07.06

7 Demonstrate process used to document and ensure compliance. 2.B.07.07

8 Insure timely delivery of product to customer. 2.B.07.08

8 **Apply principles of 'world class' operations (i.e., industry quality standard operation).** 2.B.08

1 Explain quality control techniques as applied to manufacturing/engineering and technical processes. 2.B.08.01

2 Identify and apply the concepts of total quality management (TQM) appropriate to the field. 2.B.08.02

3 Assess a plan for continuous improvement. 2.B.08.03

9 **Apply industrial design and packaging.** 2.B.09

1 Explain the different elements of industrial design including branding, usability, ergonomics, sustainability, maintainability, aesthetics, etc. 2.B.09.01

2 Design a packaging solution for a product (such as food, hair care, a tool, etc.). Explain the purposes, goals, and the risks and benefits of your design choices. 2.B.09.02

10 **Explain introductory engineering concepts.** 2.B.10

1 Define and use engineering notations and prefixes: tera, giga, mega, kilo, milli, micro, nano, pico. 2.B.10.01

2 Explain Prior Technologies in several common engineering areas. 2.B.10.02

3 Complete a reverse engineering process for a design or device. 2.B.10.03

4 Use both metric and English systems of measurements. 2.B.10.04

Electrical Engineering Demonstration, Design, and Implementation 2.C

1. **Demonstrate introductory electrical engineering knowledge and skills.** 2.C.01
    1. Identify appropriate test devices for specific tasks (e.g., oscilloscope or multimeter). 2.C.01.01
    2. Calibrate and use test devices accurately (e.g., oscilloscope or multimeter). 2.C.01.02
    3. Read and interpret schematics. 2.C.01.03

2 **Explain and apply electrical engineering principles, and techniques and use design tools and materials according to current industry and OSHA standards..** 2.C.02

1 Label and describe the parts of an atom. 2.C.02.01

2 Explain what classifies a material as an insulator, conductor, or semiconductor. 2.C.02.02

3 Describe resistance and what its function is in circuit design. 2.C.02.03

4 Identify resistors using color code. 2.C.02.04

5 Measure resistance using multimeters. 2.C.02.05

6 Identify basic circuit components (source, load, control, and conductors). 2.C.02.06

7 Describe different types and functions of switches. 2.C.02.07

8 Calculate voltage, current and resistance in circuits using Ohm's law. 2.C.02.08

9 Calculate current and voltage using Kirchhoff's law. 2.C.02.09

10 Measure voltage, current, and resistance in both series and parallel circuits. 2.C.02.10

11 Describe the differences among series, parallel, and series-parallel circuits. 2.C.02.11

12 Measure the value of capacitors using instrumentation. 2.C.02.12

13 Identify different types of capacitors, their values, and their voltage polarity requirements. 2.C.02.13

14 Differentiate between direct and alternating currents. 2.C.02.14

15 Draw and label waveforms (e.g., square, sawtooth, and sine). 2.C.02.15

16 Determine rise time, fall time, frequency, and amplitude using an oscilloscope. 2.C.02.16

17 Demonstrate the operation of diodes and describe their function. 2.C.02.17

18 Demonstrate the operation of transistors and describe their function. 2.C.02.18

19 Describe the differences among display devices: LED (light emitting diodes), seven segment display and LCD (liquid crystal display). 2.C.02.19

20 Locate logic families in a reference catalog. 2.C.02.20

21 Read specification sheets on an individual IC to determine suitability for use in a given circuit. 2.C.02.21

22 Perform conversions between binary and decimal, hexadecimal and binary, and hexadecimal and decimal. 2.C.02.22

23 Use schematics and symbolic algebra to represent digital gates as part of a solution to a design problem (logic symbols: AND, OR, NOT, NAND, NOR, XOR and X-NOR gates). 2.C.02.23

24 Create Boolean expressions and truth tables. 2.C.02.24

25 Select min-term and max-term expressions (sum of product: SOP, product of sum: POS). 2.C.02.25

26 Use DeMorgan's theorem to convert a SOP to a POS in order to save resources in the production of circuits. 2.C.02.26

27 Formulate and use a Karnaugh Map and/or Boolean algebra to reduce logic equation. 2.C.02.27

28 Describe duality of logic functions. 2.C.02.28

29 Simplify, solve, construct, and demonstrate a circuit from a digital word problem. 2.C.02.29

30 Design circuits using reprogrammable logic devices. 2.C.02.30

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3 **Build and implement electrical engineering circuits.** 2.C.03

1 Simulate a circuit. 2.C.03.01

2 Construct a circuit. 2.C.03.02

3 Troubleshoot problems with a circuit. 2.C.03.03

4 Create PLD (Programmable Logic Devices) logic files. 2.C.03.04

5 Construct and test simple latches and flip-flops from discrete gates. 2.C.03.05

6 Interpret, design, draw, and evaluate circuits using logic symbols (triggers, latches, flip-flops). 2.C.03.06

7 Create timing diagrams and truth tables for J-K flip-flop. 2.C.03.07

8 Analyze timing diagrams. 2.C.03.08

9 Explain timing requirements of ICs. 2.C.03.09

Mechanical Engineering Demonstration, Design, and Implementation 2.D

1 **Demonstrate introductory mechanical engineering knowledge and skills.** 2.D.01

1 Identify the various industry-wide prototyping methods in use. 2.D.01.01

2 Describe common engineering plastics, processing, additives, fillers, colorants, modifiers, and their effects on properties. 2.D.01.02

3 Select suitable materials for a given application. 2.D.01.03

4 Use the measurement units of mass, length, angles and time and their extensions (e.g., velocity, density) 2.D.01.04

5 Identify and use devices and gauges (i.e. rulers, scales, timers, calipers, radius gauges, protractors) to accurately measure units of mass, length, angles, and time and their extensions. 2.D.01.05

6 Calibrate mechanical measurement devices and gauges. 2.D.01.06

7 Interpret detail and assembly drawings, technical processes, procedures, and instructions. 2.D.01.07

8 Extract and analyze properties of mass (i.e. volume, density, moment of inertia, etc.). 2.D.01.08

9 Evaluate the function and operation of assembly (motion, interference, etc.) of a mechanical design. 2.D.01.09

10 Demonstrate ethical challenges facing engineers in the design, redesign, repair and implementation of products. 2.D.01.10

11 Demonstrate various classes and subclasses of common engineering materials (e.g., organics, metals, polymers, ceramics, and composites) and their properties (solid, liquid, and plasma gas) from macrostructure to microstructure. 2.D.01.11

12 Demonstrate the use and application of the various classes and subclasses of materials. 2.D.01.12

13 Demonstrate property changing treatments (i.e. heat, chemical, additives, etc) in a variety of materials. 2.D.01.13

14 Describe and define the process of casting and molding as it relates to the engineering process and fabrication. 2.D.01.14

15 Trace the production of engineering materials from raw material to finished product as well as disposal, recycling, and describe the environmental impact of each process. 2.D.01.15

16 Demonstrate how the properties of materials and their use influences the reliability of a mechanical design (i.e. Mean Time Between Failure: MTBF, etc.) 2.D.01.16

17 Describe how design choices will affect the likelihood of safety and liability issues arising within the end use of a designed product. 2.D.01.17

18 Explain and demonstrate where material removal or addition would be the appropriate process to use in production (e.g., turning, milling, grinding, and plating). 2.D.01.18

19 Describe the process of forming (e.g., bending, forging, cutting, etc). 2.D.01.19

20 Explain how design choices will affect the ease and efficiency of manufacturing the designed product. 2.D.01.20

2 **Explain and apply mechanical engineering principles and techniques, and use design tools and materials according to current industry and OSHA standards.** 2.D.02

1 Define geometric shapes, line types, tools, and describe constraints used in sketching. 2.D.02.01

2 Prepare clear and accurate hand sketches using orthographic and perspective views. 2.D.02.02

3 Prepare clear and accurate hand sketches using annotative labels including materials, processes, functions and dimensions. 2.D.02.03

4 Apply scale, dimensioning, and tolerance standards to drawings. 2.D.02.04

5 Define and implement Geometric Dimensioning and Tolerancing (GD&T) for production drawings.Create and edit a solid model using a 3-D modeling program, based upon design sketches. Utilize appropriate materials, measurements, fits, appearances, processes and functions. 2.D.02.05

6 Combine model parts into working assembly, manipulate and animate assembly using a 3-D modeling program. 2.D.02.06

7 Analyze parts and assemblies with respect to safety, handling, end user, production, cost, packaging, and environmental impact. 2.D.02.07

8 Create detail and assembly drawings based upon 3-D models. 2.D.02.08

10 Annotate detail drawings with dimensions, materials, processes and appropriate views. 2.D.02.10

11 Create section, detail, broken-out, break, and auxiliary views. 2.D.02.11

12 Create an assembly drawing with: balloons, a parts list containing items, quantities, descriptions and part numbers, appropriate assembly notes; and a titleblock based upon 3-D models. 2.D.02.12

13 Create a numbering system for each drawing set. 2.D.02.13

14 Identify, describe and prescribe ferrous and non-ferrous metals, plastics, ceramics and composites, based upon their micro and macro structures, relationship between micro structure and properties, common property changing procedures and treatments. 2.D.02.14

15 Design items using common engineering plastics based upon their processing, additives, fillers, colorants, modifiers and the effects on properties. 2.D.02.15

16 Analyze, describe, and test the concepts of simple machines: gears, pulleys, lever, wheel and axle, wedge and screw, and determine their mechanical advantages. 2.D.02.16

17 Analyze, describe, and test fluid systems based upon flow, pressure, density, temperature, elevation, and friction. 2.D.02.17

18 Analyze, describe, and test heat flow systems based upon conduction, convection, and radiation, and perform heat loss calculations. 2.D.02.18

19 Analyze, describe and test basic beam deflection relationships; stress, strain, tension, compression, torsion, moments for common cross-sectional shapes and

materials using such techniques as finite element analysis (FEA). 2.D.02.19

20 Construct free body diagrams, resolve forces into vector components, solve static equations and calculate stress, strain, deflection, moment of inertia, linear and angular velocity and acceleration. 2.D.02.20

21 Identify where material joining would be the appropriate process to use in production (gluing, welding, etc.) 2.D.02.21

3 Build and implement mechanical engineering designs. 2.D.03

1 Use industry-wide prototyping methods including rapid-prototyping. 2.D.03.01

2 Build a prototype model from a drawing database. 2.D.03.02

3 Set up and operate a basic manufacturing assembly process, resulting in a finished product. 2.D.03.03

4 Build mechanical parts utilizing techniques such as turning, milling, cutting, bending, etc. 2.D.03.04

Automated Systems Engineering Demonstration, Design, and Implementation 2.E

1 **Demonstrate automated systems engineering introductory knowledge and skills.** 2.E.01

1 Define an automated system and a robot. 2.E.01.01

2 Evaluate the impact robots have on manufacturing and society. 2.E.01.02

3 Classify different types of robots. 2.E.01.03

4 Identify specifications for the work envelope of a robot. 2.E.01.04

5 Identify and sketch the components of a robot. 2.E.01.05

6 Describe servo, stepper and DC motors and possible uses. 2.E.01.06

7 Describe the components of robot controllers. 2.E.01.07

8 Select, size, and implement interface device(s) to control a motor(s). 2.E.01.08

9 Describe ways an end effector is specific to a process. 2.E.01.09

10 Explain the need for end of arm tooling and how it affects the robot's operation. 2.E.01.10

11 Describe various applications of a programmable logic controller (PLC) as related to its use in a computer integrated manufacturing (CIM) system. 2.E.01.11

12 Describe the difference between a PLC and a computer with interface. 2.E.01.12

13 Identify individual components used in CIM systems. 2.E.01.13

14 Explain the significance of teamwork and communication when combining the designs of the individual groups into a complete model of Flexible Manufacturing Systems (FMS). 2.E.01.14

15 Differentiate between open and closed loop control. 2.E.01.15

16 Design and create a program to evaluate data and make decisions using external digital and analog sensors. 2.E.01.16

17 Formulate a flow chart to correctly apply basic programming concepts. 2.E.01.17

18 Describe the function of sensors in electronic circuitry (temp., optical, etc.). 2.E.01.18

19 Explain the principles of control techniques and computer simulations. 2.E.01.19

20 Compare and contrast the benefits and drawbacks of the three categories of CIM manufacturing systems. 2.E.01.20

21 Describe the working relationship between the CNC mill and the robot. 2.E.01.21

22 Analyze and select CIM system components for a specific industrial application. 2.E.01.22

2 **Explain and apply automated systems engineering principles and techniques, and use design tools and materials according to current industry and OSHA standards.** 2.E.02

1 Design an end effector. 2.E.02.01

2 Design a working model of a robot or automated system. 2.E.02.02

3 Program a robot or automated system to perform several tasks. 2.E.02.03

4 Program a robot or automated system to solve a materials handling problem. 2.E.02.04

5 Design an automated feed system with sensors. 2.E.02.05

6 Design an interface that inspects, evaluates, and manages program parameters during the operation of the program. 2.E.02.06

3 **Build and implement automated systems engineering designs.** 2.E.03

1 Develop an end effector. 2.E.03.01

2 Build a working model of a robot or automated system. 2.E.03.02

3 Build drive systems used in robotics or automated system. 2.E.03.03

4 Operate a CIM system utilizing appropriate safety precautions. 2.E.03.04

5 Demonstrate how individual components work together to form a complete CIM system. 2.E.03.05

6 Assemble and test individual component designs by integrating them into a complete model FMS. 2.E.03.06

7 Run, test, evaluate, and redesign system operation. 2.E.03.07

8 Build an automated feed system with sensors. 2.E.03.08

Civil Engineering/Architecture Demonstration, Design, and Implementation 2.F

1 **Demonstrate civil engineering/architecture introductory knowledge.** 2.F.01

1 Describe the importance of architecture and civil engineering and their evolution over time. 2.F.01.01

2 Compare and contrast various architectural styles. 2.F.01.02

3 Describe the components of and coordination required of an entire construction document set including: mechanical, electrical, plumbing, civil, structural and architectural drawings. 2.F.01.03

4 Use an architectural or engineering scale to measure drawings. 2.F.01.04

5 Identify various structural systems (i.e. steel frame, concrete frame, etc.) including foundation types. 2.F.01.05

6 Explain surveying strategies and equipment use. 2.F.01.06

7 Describe the importance of sustainable design. 2.F.01.07

8 Identify and differentiate among the responsibilities of various members of a project team including the design (architect, engineers, etc.) and construction team (general contractor, subcontractors, etc.) members. 2.F.01.08

9 Solve statics problems using computerized packages (e.g., MD Solids). 2.F.01.09

10 Calculate stress and strain in simple parts. 2.F.01.10

11 Plot a stress/strain diagram. 2.F.01.11

12 Describe the parts of a stress/strain diagram. 2.F.01.12

13 Perform moment of inertia calculations. 2.F.01.13

14 Solve for stress, strain, and deflection in common beam shapes. 2.F.01.14

15 Analyze, describe, and test basic beam deflection relationships: stress, strain, tension, compression, torsion, moments for common cross-sectional shapes and materials, using such techniques as finite element analysis (FEA). 2.F.01.15

16 Construct free body diagrams; resolve forces into vector components; solve static equations; and calculate stress, strain, deflection, moment of inertia, linear and angular velocity and acceleration. 2.F.01.16

2 **Explain and apply civil engineering/architectural principles and techniques, and use design tools and materials according to current industry and OSHA standards.** 2.F.02

1 Create a site survey. 2.F.02.01

2 Conduct soil testing and analyze the results. 2.F.02.02

3 Analyze a site and determine the drainage requirements. 2.F.02.03

4 Design site grading including cut and fill volume calculations. 2.F.02.04

5 Create a commercial site design including parking, roads, and landscaping. 2.F.02.05

6 Apply building codes, regulations, and standards to a construction project. 2.F.02.06

7 Calculate dead, live, and environmental (snow, wind) loads on a structure. 2.F.02.07

8 Trace gravity loads through a structure from their point of application to the building's foundation. 2.F.02.08

9 Determine the tributary area of a particular structural element. 2.F.02.09

10 Design a simply supported beam including an analysis of shear, bending moment and deflection requirements. 2.F.02.10

11 Create a cost estimate for a construction project. 2.F.02.11

12 Perform heat loss calculations. 2.F.02.12

13 Apply sustainable design to a project. 2.F.02.13

3 **Build and implement civil engineering/architecture designs.** 2.F.03

1 Create a 3D computer model of both residential and commercial buildings. 2.F.03.01

2 Build a scale model of a building with a particular architectural style. 2.F.03.02

3 Build, test, and redesign a scale model of an engineering structure (e.g., building, bridge, etc.). 2.F.03.03

4 Create an as-built drawing set including plans, sections, and details. 2.F.03.04