

Advanced Industrial Maintenance

Primary Career Cluster:	Advanced Manufacturing
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C13H29
Pre-requisite(s):	<i>Algebra</i> (G02X02, G02H00), <i>Geometry</i> (G02X03, G02H11), <i>Physical Science</i> (G03H00), and <i>Introduction to Industrial Maintenance</i> (C13H28)
Credit:	2
Grade Level:	11
Elective Focus - Graduation Requirement:	This course satisfies two of three credits required for an elective focus when taken in conjunction with other Advanced Manufacturing courses.
POS Concentrator:	This course satisfies one out of two required courses that meet the Perkins V concentrator definition, when taken in sequence in the approved program of study.
Programs of Study and Sequence:	This is the third course in the <i>Industrial Maintenance Technology</i> program of study.
Aligned Student Organization(s):	SkillsUSA: http://www.skillsusatn.org/ Technology Student Association (TSA): http://www.tntsa.org
Coordinating Work-Based Learning:	Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visit https://www.tn.gov/education/educators/career-and-technical-education/work-based-learning.html .
Promoted Tennessee Student Industry Credentials:	Credentials are aligned with postsecondary and employment opportunities and with the competencies and skills that students acquire through their selected program of study. For a listing of promoted student industry credentials, visit https://www.tn.gov/education/educators/career-and-technical-education/student-industry-certification.html .
Teacher Endorsement(s):	477, 523, 531, 537, 551, 552, 553, 554, 555, 556, 557, 575, 580, 582, 584, 585, 596, 598, 700, 701, 705, 707, 760
Required Teacher Certifications/Training:	None
Teacher Resources:	https://www.tn.gov/education/educators/career-and-technical-education/career-clusters/cte-cluster-advanced-manufacturing.html Best for All Central: https://bestforall.tnedu.gov/

Course at a Glance

CTE courses provide students with an opportunity to develop specific academic, technical, and 21st century skills necessary to be successful in career and in life. In pursuit of ensuring every student in Tennessee achieves this level of success, we begin with rigorous course standards which feed into intentionally designed programs of study.

Students engage in industry relevant content through general education integration and experiences such as career and technical student organizations (CTSO) and work-based learning (WBL). Through these experiences, students are immersed with industry standard content and technology, solve industry-based problems, meaningfully interact with industry professionals and use/produce industry specific, informational texts.

Using a Career and Technical Student Organization (CTSO) in Your Classroom

CTSOs are a great resource to put classroom learning into real-life experiences for your students through classroom, regional, state, and national competitions, and leadership opportunities. Below are CTSO connections for this course, note this is not an exhaustive list.

- Participate in CTSO Fall Leadership Conference to engage with peers by demonstrating logical thought processes and developing industry specific skills that involve teamwork and project management.
- Participate in contests that highlight job skill demonstration. These include Career Pathways Showcase, Job Interview, Automated Manufacturing Technology, and Electronics Technology.

Using a Work-Based Learning (WBL) in Your Classroom

Sustained and coordinated activities that relate to the course content are the key to successful work-based learning. Possible activities for this course include the following. This is not an exhaustive list.

- **Standards 1.1-1.3** | During a visit to an industry site have the manager talk about safety in the workplace.
- **Standards 2.1-2.4** | Have the students work with a welder on a real project.
- **Standards 3.1-3.5, 9.1-9.3** | Have the students work with an electrician in the field.
- **Standards 4.1-4.2** | Contact an electrical inspector to talk with the class about NEC and what they see in their role as inspectors.
- **Standards 5.1-5.3** | Work on-site with an electrician or maintenance technician.
- **Standards 8.1-8.2** | Have the students do a project that is supervised or evaluated by a manager at a local company.
- **Standards 11.1-16.1** | Visit a local industry with this equipment and have the students see it in operation and being maintained.
- **Standard 17.1** | Discuss troubleshooting with the employee responsible for troubleshooting.

Course Description

Advanced Industrial Maintenance is designed to provide students with the knowledge and skills to effectively perform industrial maintenance procedures in an advanced manufacturing facility. Students in this course develop proficiency in a vast array of electromechanical domains, including: fundamental safety practices in electromechanical technology, shielded metal arc welding (SMAW), basic metal inert gas (MIG) welding, electrical systems, AC and DC motors, calibrating instruments, drive systems, pipe fabrication, hydraulic systems, pumps, digital electronics, programmable logic controllers (PLC), and troubleshooting procedures. Upon completion of this course, proficient students will be prepared to pursue postsecondary electromechanical technology programs and entry-level industrial maintenance technology careers in the advanced manufacturing industry. * *This course is recommended for 2 credits.*

Course Standards

1. Safety

- 1.1 Safe Use of Tools, Equipment, and Materials: Assess a given situation requiring the use of tools, equipment, and materials. Explain the applicability of various safety standards and procedures, and then **safely demonstrate the use of the tools, equipment, and materials**. For example, the hoisting of material requires lifting equipment of sufficient strength and applicability to the task, physical clearance from personnel, necessary alerting to others, and authorization to use the required equipment, as well as conformance to Occupational Safety and Health Administration (OSHA) policies for avoiding and reporting accidents associated with this type of activity.
- 1.2 Safety Rules: **Accurately read, interpret, and demonstrate adherence to safety rules**, including rules published by the (1) National Science Teachers Association (NSTA); (2) National Electrical Code (NEC); (3) Occupational Safety and Health Administration (OSHA) guidelines; (4) American Society for Testing Materials, 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.
- 1.3 Safety in the Classroom: 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. Welding and Machining Operations

- 2.1 Shielded Metal Arc Welding (SMAW): Interpret and use a welding sketch or drawing to demonstrate the proper set up of a shield metal arc welder. **Use the shielded metal arc welding (SMAW) process** and make single-pass and groove welds in the following positions:
 - a. flat,
 - b. horizontal,
 - c. vertical, and
 - d. overhead.

- 2.2 Metal Inert Gas Welding (MIG): Examine a given set of specifications for welding operations and **properly set up a metal inert gas (MIG) welder to demonstrate the following five basic weld joint designs**. Distinguish between the weld joint designs and provide various scenarios of how they are best applied. For example, edge joints are usually welded on one side, whereas a butt joint can be welded on both sides.
- lap joint
 - butt joint
 - corner joint
 - edge joint
 - T-joint
- 2.3 Grinding: **Demonstrate the proper use of various types of grinders**, such as hand-held and pedestal bench. Compare and contrast the process to use each grinder when performing cutting, smoothing, and deburring operations on a piece of metal. For example, use a grinder to cut and bevel pipe and plate prior to welding.
- 2.4 CNC Machines and Lathes: Manage and coordinate the operation of the cutting pieces, feeds, and mounts associated with **both manual and computer-numerical-controlled (CNC) machining tools** to complete projects involving:
- milling machines**, such as indexing operations using a dividing head and rotary tables; and
 - lathes**, such as re-chase and internal threads, taper turning with taper attachments and compound rests, internal tapered surfaces, follower, and steady rests.
For example, select the correct cutting tools and speeds for the CNC processes to create Delrin (plastic) shafts and gears for a class robotics project.

3. Electrical Circuits

- 3.1 Direct and Alternating Currents: Identify the basic characteristics and distinguish between the **operation of direct current (DC) and alternating current (AC) electricity**. Explain how and why the different currents are used. Provide examples of **devices that use AC and DC** respectively.
- 3.2 Ohm's Law: Demonstrate an understanding of **Ohm's law**, and apply it to solving given problems in electrical systems. Defend the solution using supporting evidence that explains the cause-and-effect relationship between Ohm's law and each of the following:
- voltage,**
 - current,**
 - resistance, and**
 - voltage drop.**
- 3.3 Circuits: Examine **electrical circuits and components**. Solve various series-parallel circuit structures, using appropriate instruments to **measure watts, volts, Ohms, and amps**. Explain the multistep procedure used to solve each problem and justify the calculations using Ohm's law.

- 3.4 Wiring: Explain basic control **wiring and wiring processes** used in the electrical industry. Properly apply these processes by **wiring and testing devices**, control circuits, and systems. For example, wire and test electrical switches and devices used in a typical electromechanical system.
- 3.5 Electron Flow: Explain **electron flow as it relates to electricity**. Explain the role of **magnetism and electromagnetic induction** in electrical systems, including a comparison of the following magnetism concepts to their electrical counterparts:
- reluctance to resistance,
 - field distance to voltage, and
 - magnetic force to current.

4. Conductor Termination and Splices

- 4.1 Wire Nuts, Lugs, Connectors, and Splices: Understand the National Electrical Code (NEC) and local code requirements for the splicing, terminating, and insulating of conductors. Citing information found in code, explain when it is appropriate to use **wire nuts, crimp-on wire lugs, or mechanical compression connectors** for making connections. Also include special considerations for making **splices** and connections to aluminum, as well as insulation systems applicable to common splices and terminations.
- 4.2 Wiring: Complete a simulation of **wiring for residential service**. Select the appropriate size of wire nuts and complete multiple installations. **Demonstrate wire terminations and splices** by using the proper crimp-on wire lugs and mechanical compression connectors. Explain and justify the selection of parts with supporting evidence (resulting from the previous standard).

5. Fuses and Circuit Breakers

- 5.1 Uses of Fuses and Circuit Breakers: Explain the **characteristics and uses of fuses and circuit breakers**. Apply this information to develop and explain a procedure that could be used to select a specific choice of fuse or circuit-breaker for over-current protection.
- 5.2 Types of Fuses and Circuit Breakers: Identify various examples of **fuses and circuit breakers**. Examine the markings printed on a fuse and identify the characteristics of a fuse needing replacement. Using physical observation and technical manuals, **explain how to classify a circuit breaker** by its voltage, current, and interrupting-capacity ratings.
- 5.3 Install Fuses and Circuit Breakers: Following the correct electrical code practices for residential service, demonstrate the procedures to **install, wire, test, and operate fuses and breakers** in both single-phase and three-phase circuits. Demonstrate effective grounding practices, including the connection of ground wires and installation of bonding straps.

6. Schematic Interpretation

6.1 Schematic Interpretation: Review a basic process instrument diagram (PID) and a basic electrical elementary print. **Interpret the symbols to identify the actual field devices of a process loop (PID) and control loop (electrical elementary print).** Explain and document the basic operation of the devices and equipment for both the process (PID) and control (electrical elementary print) loops.

7. Single-Phase Transformer

7.1 Single-Phase Transformer: Explain the **operation of a basic single-phase transformer.** Given the following scenarios, examine and confirm that the transformer is operating correctly. Write a brief justification supporting the conclusion of each examination. In groups or as a class, discuss results and provide constructive feedback.

- single-phase step-up transformer
- single-phase step-down transformer
- single-phase isolation transformer
- single-phase current transformer

8. Conductors and Cables

8.1 Conduits and Conductors: Given a proposed addition to a commercial electrical system, properly select type and size of both **conduit and conductors** for an installation. Support the selection with evidence drawn from standards in the National Electrical Code (NEC) and local codes.

8.2 Identify Conductors and Cables: Demonstrate an understanding of how to physically read and **identify markings on conductors and cables** according to industry standards such as the National Electrical Code (NEC). Explain how conductors and cables are categorized based upon wire size and gauge, insulation and jacket types, and voltage ratings.

9. Conduit Installation

9.1 EMT and PVC Conduit Installation: Given an assignment to **install a specified run of electrical metal tubing (EMT) and polyvinyl chloride (PVC) conduit**, create and execute a written plan of the procedure to be completed. The plan should include, but is not limited to the following:

- where and why bends (e.g., stub, offset, saddle, parallel) will be used.
- how the material will be cut, reamed, installed, and secured; and
- drawings of how the conduit will be secured with clamps and fittings conforming to standards of the National Electrical Code (NEC) and local codes.

- 9.2 IMC and Rigid Conduit Installation: Given an assignment to **install a specified run of intermediate metal conduit (IMC) and rigid conduit**, create and execute a written plan of the procedure to be completed. The plan should include, but is not limited to, the following:
- where and why bends (e.g., stub, offset, saddle, parallel) will be used;
 - how the material will be cut, reamed, installed, and secured; and
 - drawings of how the conduit will be secured with clamps and fittings conforming to standards of the National Electrical Code (NEC) and local codes.
- 9.3 Cable Pull: Develop a written plan, then **set up and execute a cable pull** through assorted conduit and cable tray configurations. The plan should include a list of the tools used, diagrams of puller systems used, an explanation of how the proper location was selected to start and end the conductor pull, as well as calculations for allowable pulling tension for a specified group of conductors. Justify the written plan with supporting evidence based on observations and prescriptions outlined in the National Electrical Code (NEC).

10. Computers and Electronics

- 10.1 Logic Circuits: Given a set of logic statements and schematic circuits, **construct the logic circuits** described using the following:
- AND, OR, NOR, and XOR gates; and
 - flip-flops, counters, and gates.
- Document and define each logic gate including a drawing, a description of its function in a short sentence or paragraph, a specification of each truth table, and the equation for each gate.
- 10.2 Programmable Logic Controllers: Given a working **programmable logic controller (PLC)**, an operator interface, and interfacing computer, safely set up a communication loop to view and **explain the program's purpose**. Identify and explain the functions and interrelationships among the following PLC components:
- power supply,
 - CPU,
 - input modules,
 - output modules, and
 - analog input and/or modules.

11. Motors

- 11.1 Select a Motor: Given a specified application in an electromechanical system, properly **select a motor based upon its intended use**. Determine the size, speed, operating voltage, and National Electrical Manufacturing Association (NEMA) type for the required motor. Justify the selection by providing evidence to support the selection.
- 11.2 Determine motor details: Determine the required **over-current protection, motor control circuits, conductor types and sizes, and conduit types and sizes** for a given motor and application. Compare and contrast the selections by providing supporting evidence for the selections. Work together with classmates to come to a consensus on requirements and report the results.

- 11.3 Install Motors: **Plan and execute the selection, installation, and wiring of the following motors.** Document the plan and explain the detailed multistep process used to complete the procedure by the requirements of the National Electrical Code (NEC) and Occupational Safety and Health Administration (OSHA) regulations.
- DC motor (other than a permanent magnet motor)
 - single-phase capacitor motor
 - reversing three-phase motor

12. Drive Systems

- 12.1 Drive Systems: Identify and demonstrate an understanding of the components in typical mechanical drive systems (e.g., gear and belt drive) within an industrial setting. Compare and contrast gear versus belt drives and explain the differences between them. Simulating a period of production downtime, safely and correctly **disassemble and reassemble both a gear driven mechanical drive and a belt driven mechanical drive** in a specified amount of time.

13. Calibration and Instrumentation

- 13.1 Calibration and Instrumentation: **Examine a smart instrument** (used to measure pressure flow, temperature, or level) and its corresponding communicator. Identify the basic parameters of the instrument such as tag number and calibration range. Plan and execute the setup of a communication loop and demonstrate how to **calibrate the instrument** by changing various parameters.

14. Hydraulic Systems

- 14.1 Hydraulic Systems: Review drawings and interpret American National Standards Institute (ANSI) symbols to explain the function of a **basic industrial hydraulic system**. Explain the recommended regular **preventative maintenance on hydraulic equipment and controls**. Execute the recommended procedures and record the details of the maintenance, explaining how the preventative maintenance will minimize failures in hydraulic equipment.

15. Pumps

- 15.1 Pumps: Identify and explain the operation and basic parts of **gear, centrifugal, and positive displacement pumps** found in an industrial setting. Simulating a period of production downtime, safely and correctly disassemble and reassemble each type of pump (e.g., gear, centrifugal, and positive displacement) within a specified amount of time.

16. Pipe Fabrication

16.1 Pipe Fabrication: Inspect and interpret assembly drawings for **piping in a typical industrial setting**. Given multiple general piping parts, select necessary parts to assemble both a bolted flange and a screw flange. Describe the multistep process used and provide evidence to support the selections that were made.

17. Troubleshooting

17.1 Troubleshooting: Assess blueprints of a typical electromechanical system (e.g., motor driving a pump with a coupling, an instrumentation loop, etc.) and examine a given section of the system. Follow a troubleshooting procedure and **identify the problems in a malfunctioning system** within a specified time. Citing evidence from blueprints and other resources, document the problem(s), explain the nature of the malfunction, and prescribe a recommended solution.

Standards Alignment Notes

*References to other standards include:

- P21: Partnership for 21st Century Skills [Framework for 21st Century Learning](#)
 - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.