TN Department of Education | College, Career and Technical Education

# Advanced Electromechanical Technology

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| **Primary Career Cluster:** | Advanced Manufacturing |
| **Program Manager:** | John Mummert, (615) 532-2835, john.mummert@tn.gov |
| **Course Code:** | 6090 |
| **Pre-requisite(s):** | *Algebra* (0842, 3102), *Geometry* (0843, 3108), *Physical Science* (3202), and *Introduction to Electromechanical* (6091) |
| **Credit:** | 2 |
| **Grade Level:** | 11 |
| **Graduation Requirement:** | This course satisfies two of three credits required for an elective focus when taken in conjunction with other Advanced Manufacturing courses. |
| **Programs of Study and Sequence:** | This is the third course in the *Electromechanical Technology* program of study. |
| **Aligned Student Organization(s):** | Skills USA: http://www.tnskillsusa.com<br>Tracy Whitehead, (615) 532-2804, Tracy.Whitehead@tn.gov |
| **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/career-and-technical-education/work-based-learning.html |
| **Available Student Industry Certifications:** | None |
| **Dual Credit or Dual Enrollment Opportunities:** | There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement. |
| **Teacher Endorsement(s):** | 477, 523, 531, 537, 551, 552, 553, 554, 555, 556, 557, 575, 582, 584, 585, 596, 598, 700, 701, 705, 707, 760 |
| **Required Teacher Certifications/Training:** | None |
| **Teacher Resources:** | https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-advanced-manufacturing.html |

## Course Description

*Advanced Electromechanical Technology* is designed to provide students with the knowledge and skills to effectively perform basic 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.*

## Program of Study Application

This is the third course in the *Electromechanical Technology* program of study. For more information on the benefits and requirements of implementing this program in full, please visit the Advanced Manufacturing website at [https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-advanced-manufacturing.html.](https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-advanced-manufacturing.html)

## Course Standards

**Safety**

1) 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.

2) 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.

3) 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.

**Welding and Machining Operations**

4) Interpret and use a welding sketch or drawing to demonstrate the proper setup 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
    d. Overhead

5) 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.
    a. Lap joint
    b. Butt joint
    c. Corner joint
    d. Edge joint
    e. T-joint

6) 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.

7) 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:
    a. Milling machines, such as indexing operations using a dividing head and rotary tables
    b. 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.

**Electrical Circuits**

8) 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.

9) 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:
    a. Voltage
    b. Current
    c. Resistance
    d. Voltage drop

10) 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.

11) 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.

12) Explain electron flow as it relates to electricity by creating a diagram or model to illustrate electron and induction flow. Use the model to also explain the role of magnetism and electromagnetic induction in electrical systems, including a comparison of the following magnetism concepts to their electrical counterparts:
    a. Reluctance to resistance
    b. Field distance to voltage
    c. Magnetic force to current

**Conductor Termination and Splices**

13) Research the National Electrical Code (NEC) and local code requirements for the splicing, terminating, and insulating of conductors. Citing information found in code, write an explanation describing how and 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.

14) 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 from the research findings (resulting from the previous standard).

**Fuses and Circuit Breakers**

15) Explore 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.

16) 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.

17) Following the correct electrical code practices for residential service, demonstrate the procedures to install, wire, test, and operate fuses and breakers in both single- and three-phase circuits. Demonstrate effective grounding practices, including the connection of ground wires and installation of bonding straps.

**Schematic Interpretation**

18) 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.

**Single-Phase Transformer**

19) 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.
    a. Single-phase step-up transformer
    b. Single-phase step-down transformer
    c. Single-phase isolation transformer
    d. Single-phase current transformer

**Conductors and Cables**

20) 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.

21) 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.

**Conduit Installation**

22) 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:
    a. Where and why bends (e.g., stub, offset, saddle, parallel) will be used
    b. How the material will be cut, reamed, installed, and secured
    c. Drawings of how the conduit will be secured with clamps and fittings conforming to standards of the National Electrical Code (NEC) and local codes.

23) 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:
    a. Where and why bends (e.g., stub, offset, saddle, parallel) will be used
    b. How the material will be cut, reamed, installed, and secured
    c. Drawings of how the conduit will be secured with clamps and fittings conforming to standards of the National Electrical Code (NEC) and local codes.

24) 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).

**Computers and Electronics**

25) Given a set of logic statements and schematic circuits, construct the logic circuits described using the following:
    a. AND, OR, NOR, and XOR gates
    b. 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.

26) Given a working programmable logic controller (PLC), an operator interface, and interfacing computer, safely set up a communication loop in order to view and explain the program's purpose. Identify and explain the functions and interrelationships among the following PLC components:
    a. Power supply
    b. CPU
    c. Input modules
    d. Output modules
    e. Analog input and/or modules

**Motors**

27) Given a specified application in an electromechanical system, properly select a motor based upon its intended use. Using resources such as technical manuals and industry standards, determine the size, speed, operating voltage, and National Electrical Manufacturing Association (NEMA) type for the required motor. Present a justification of the selection to classmates. Be prepared to answer any questions with evidence to support the selection.

28) Consult multiple sources such as National Electrical Code (NEC), Occupational Safety and Health Administration (OSHA) regulations, and given installation drawings. Using this information, determine the required over-current protection, motor control circuits, conductor types and sizes, and conduit types and sizes for a given motor and application. Write a technical report that compares and contrasts the selections with those of other classmates. Provide supporting evidence for any selections that differ from classmates, and work together to come to a consensus on requirements and collaboratively write a final report.

29) 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.
    a. DC motor (other than a permanent magnet motor)
    b. Single-phase capacitor motor
    c. Reversing three-phase motor

**Drive Systems**

30) 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.

**Calibration and Instrumentation**

31) 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.

**Hydraulic Systems**

32) Review drawings and interpret American National Standards Institute (ANSI) symbols to explain the function of a basic industrial hydraulic system. Develop a written text that outlines, describes, and logs recommended regular preventative maintenance on hydraulic equipment and controls. Use the text as a guide to execute the recommended procedures and record the details of the maintenance, explaining how the preventative maintenance will minimize failures in hydraulic equipment.

**Pumps**

33) 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.

**Pipe Fabrication**

34) 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.

**Troubleshooting**

35) 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.