

**Manufacturing Cluster**  
**AC Theory, Electric Motors, and Hydraulic Systems**  
**Course Number: 21.46300**

**Course Description:**

This course further expands the student's knowledge and understanding of Mechatronics through introducing students to: alternating current theory and applications of varying sine wave voltages and current, inductance and capacitance, motor theory and operating principles, control devices, symbols and schematic diagrams, preventative maintenance and troubleshooting, and hydraulic system principles and components. Theory and practical application concepts are discussed and illustrated through labs.

**Course Standard 1****MANF-ACTEMHS-1**

The following standard is included in all CTAE courses adopted for the Career Cluster/Pathways. Teachers should incorporate the elements of this standard into lesson plans during the course. The topics listed for each element of the standard may be addressed in differentiated instruction matching the content of each course. These elements may also be addressed with specific lessons from a variety of resources. This content is not to be treated as a unit or separate body of knowledge but rather integrated into class activities as applications of the concept.

**Standard: Demonstrate employability skills required by business and industry.**

The following elements should be integrated throughout the content of this course.

**1.1 Communicate effectively through writing, speaking, listening, reading, and interpersonal abilities.**

| Person-to-Person Etiquette    | Telephone and Email Etiquette   | Cell Phone and Internet Etiquette | Communicating At Work           | Listening                       |
|-------------------------------|---------------------------------|-----------------------------------|---------------------------------|---------------------------------|
| Interacting with Your Boss    | Telephone Conversations         | Using Blogs                       | Improving Communication Skills  | Reasons, Benefits, and Barriers |
| Interacting with Subordinates | Barriers to Phone conversations | Using Social Media                | Effective Oral Communication    | Listening Strategies            |
| Interacting with Co-workers   | Making and Returning Calls      |                                   | Effective Written Communication | Ways We Filter What We Hear     |
| Interacting with Suppliers    | Making Cold Calls               |                                   | Effective Nonverbal Skills      | Developing a Listening Attitude |
|                               | Handling Conference Calls       |                                   | Effective Word Use              | Show You Are Listening          |
|                               | Handling Unsolicited Calls      |                                   | Giving and Receiving Feedback   | Asking Questions                |
|                               |                                 |                                   |                                 | Obtaining Feedback              |
|                               |                                 |                                   |                                 | Getting Others to Listen        |

| Nonverbal Communication                     | Written Communication             | Speaking                  | Applications and Effective Résumés |
|---|-----------------------------------|---------------------------|------------------------------------|
| Communicating Nonverbally                   | Writing Documents                 | Using Language Carefully  | Completing a Job Application       |
| Reading Body Language and mixed Messages    | Constructive Criticism in Writing | One-on-One Conversations  | Writing a Cover Letter             |
| Matching Verbal and Nonverbal communication |                                   | Small Group Communication | Things to Include in a Résumé      |

|                                |  |                           |                               |
|--------------------------------|--|---------------------------|-------------------------------|
| Improving Nonverbal Indicators |  | Large Group Communication | Selling Yourself in a Résumé  |
| Nonverbal Feedback             |  | Making Speeches           | Terms to Use in a Résumé      |
| Showing Confidence Nonverbally |  | Involving the Audience    | Describing Your Job Strengths |
| Showing Assertiveness          |  | Answering Questions       | Organizing Your Résumé        |
|                                |  | Visual and Media Aids     | Writing an Electronic Résumé  |
|                                |  | Errors in Presentation    | Dressing Up Your Résumé       |

**1.2 Demonstrate creativity by asking challenging questions and applying innovative procedures and methods.**

| Teamwork and Problem Solving | Meeting Etiquette  |
|------------------------------|--|
| Thinking Creatively          | Preparation and Participation in Meetings  |
| Taking Risks                 | Preparation and Participation in Meetings  |
| Building Team Communication  | Conducting Two-Person or Large Group Meetings<br>Inviting and Introducing Speakers<br>Facilitating Discussions and Closing |
|                              | Preparing Visual Aids<br>Virtual Meetings  |

**1.3 Exhibit critical thinking and problem solving skills to locate, analyze and apply information in career planning and employment situations.**

| Problem Solving             | Customer Service                             | The Application Process                             | Interviewing Skills                     | Finding the Right Job        |
|-----------------------------|--|---|---|------------------------------|
| Transferable Job Skills     | Gaining Trust and Interacting with Customers | Providing Information, Accuracy and Double Checking | Preparing for an Interview              | Locating Jobs and Networking |
| Becoming a Problem Solver   | Learning and Giving Customers What They Want | Online Application Process                          | Questions to Ask in an Interview        | Job Shopping Online          |
| Identifying a Problem       | Keeping Customers Coming Back                | Following Up After Submitting an Application        | Things to Include in a Career Portfolio | Job Search Websites          |
| Becoming a Critical Thinker | Seeing the Customer's Point                  | Effective Résumés:                                  | Traits Employers are Seeking            | Participation in Job Fairs   |
| Managing                    | Selling Yourself and the Company             | Matching Your Talents to a Job                      | Considerations Before Taking a Job      | Searching the Classified Ads |
|                             | Handling Customer Complaints                 | When a Résumé Should be Used                        |   | Using Employment Agencies    |
|                             | Strategies for Customer Service              |   |   | Landing an Internship        |
|                             |  |   |   | Staying Motivated to Search  |

**1.4 Model work readiness traits required for success in the workplace including integrity, honesty, accountability, punctuality, time management, and respect for diversity.**

| Workplace Ethics              | Personal Characteristics      | Employer Expectations      | Business Etiquette               | Communicating at Work            |
|-------------------------------|-------------------------------|----------------------------|----------------------------------|----------------------------------|
| Demonstrating Good Work Ethic | Demonstrating a Good Attitude | Behaviors Employers Expect | Language and Behavior            | Handling Anger                   |
| Behaving Appropriately        | Gaining and Showing Respect   | Objectionable Behaviors    | Keeping Information Confidential | Dealing with Difficult Coworkers |

|                             |                              |                             |                          |                                  |
|-----------------------------|------------------------------|-----------------------------|--------------------------|----------------------------------|
| Maintaining Honesty         | Demonstrating Responsibility | Establishing Credibility    | Avoiding Gossip          | Dealing with a Difficult Boss    |
| Playing Fair                | Showing Dependability        | Demonstrating Your Skills   | Appropriate Work Email   | Dealing with Difficult Customers |
| Using Ethical Language      | Being Courteous              | Building Work Relationships | Cell Phone Etiquette     | Dealing with Conflict            |
| Showing Responsibility      | Gaining Coworkers' Trust     |                             | Appropriate Work Texting |                                  |
| Reducing Harassment         | Persevering                  |                             | Understanding Copyright  |                                  |
| Respecting Diversity        | Handling Criticism           |                             | Social Networking        |                                  |
| Making Truthfulness a Habit | Showing Professionalism      |                             |                          |                                  |
| Leaving a Job Ethically     |                              |                             |                          |                                  |

**1.5 Apply the appropriate skill sets to be productive in a changing, technological, diverse workplace to be able to work independently and apply team work skills.**

| Expected Work Traits              | Teamwork                                    | Time Management                     |
|-----------------------------------|---|-------------------------------------|
| Demonstrating Responsibility      | Teamwork Skills                             | Managing Time                       |
| Dealing with Information Overload | Reasons Companies Use Teams                 | Putting First Things First          |
| Transferable Job Skills           | Decisions Teams Make                        | Juggling Many Priorities            |
| Managing Change                   | Team Responsibilities                       | Overcoming Procrastination          |
| Adopting a New Technology         | Problems That Affect Teams                  | Organizing Workspace and Tasks      |
|                                   | Expressing Yourself on a Team               | Staying Organized                   |
|                                   | Giving and Receiving Constructive Criticism | Finding More Time                   |
|                                   |   | Managing Projects                   |
|                                   |   | Prioritizing Personal and Work Life |

**1.6 Present a professional image through appearance, behavior and language.**

| On-the-Job Etiquette       | Person-to-Person Etiquette        | Communication Etiquette          | Presenting Yourself               |
|----------------------------|-----------------------------------|----------------------------------|-----------------------------------|
| Using Professional Manners | Meeting Business Acquaintances    | Creating a Good Impression       | Looking Professional              |
| Introducing People         | Meeting People for the First Time | Keeping Phone Calls Professional | Dressing for Success              |
| Appropriate Dress          | Showing Politeness                | Proper Use of Work Email         | Showing a Professional Attitude   |
| Business Meal Functions    |                                   | Proper Use of Cell Phone         | Using Good Posture                |
| Behavior at Work Parties   |                                   | Proper Use in Texting            | Presenting Yourself to Associates |
| Behavior at Conventions    |                                   |                                  | Accepting Criticism               |
| International Etiquette    |                                   |                                  | Demonstrating Leadership          |
| Cross-Cultural Etiquette   |                                   |                                  |                                   |
| Working in a Cubicle       |                                   |                                  |                                   |

**Support of CTAE Foundation Course Standards and Common Core GPS and Georgia Performance Standards**

**L9-10RST 1-10 and L9-10WHST 1-10:**

Common Core ELA/Literacy standards have been written specifically for technical subjects and have been adopted as part of the official standards for all CTAE courses. Additional Common Core ELA/Literacy standards for Speaking and Listening are listed in the foundational course standards below.

## Course Standard 2

### **MANF-ACTEMHS-2**

#### **Implement industrial and laboratory safety procedures & practices.**

- 2.1 Wear approved PPE (shoes, eye wear, gloves, hard hats, etc.).
- 2.2 Understand the importance of lockout/tagout procedures to control various energy types (e.g. electrical, thermal (steam), hydraulic, pneumatic, or gravitational). Practice correct lockout/tagout procedures using a padlock and tag as described under OSHA's 29 CFR 1910.147 standard, the Control of Hazardous Energy (Lockout/Tagout).
- 2.3 Understand safety rules to follow when working with electrical systems.
- 2.4 Review general safety standards for working with electrical components in the laboratory.
- 2.5 Identify and discuss the potential safety hazards and precautions of working with specific electric motors and controlling devices.
- 2.6 Identify monitoring agencies from which safety regulations can be requested.
- 2.7 Discuss the Material Safety Data Sheets (MSDS) Right-to-Know Law.
- 2.8 Identify types of fires, types of fire extinguishers, and types of protective clothing.
- 2.9 Identify the appropriate action for reporting fires and appropriate firefighting procedures.
- 2.10 Demonstrate Use of Lab Emergency Power Disconnect ("Kill Switch").
- 2.11 List personal and equipment safety rules for working with electrical and electronic circuits and power supplies.
- 2.12 Demonstrate an understanding of safety precautions and procedures.
- 2.13 Demonstrate the safe use of test equipment.
- 2.14 Identify the major types of hazards associated with the electrical/electronics workplace.
- 2.15 State the location and activation of the main disconnect switch for the electrical/electronics laboratory.

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**ELACC9-10SL1:** Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.

## Course Standard 3

### **MANF-ACTEMHS-3**

#### **Demonstrate an understanding of AC Wave Generation.**

- 3.1 Describe sine waves generated by alternating current.
- 3.2 Define alternating current.
- 3.3 Measure AC voltage and current values.
- 3.4 Describe basic AC generator principles.

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**ELACC9-10SL4:** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

**SPS10:** Students will investigate the properties of electricity and magnetism.

- b. Explain the flow of electrons in terms of
  - alternating and direct current.

## Course Standard 4

### MANF-ACTEMHS-4

**Explain and demonstrate the basic operation of AC Test Equipment.**

- 4.1 Measure and calculate AC sine wave frequency and period.
- 4.2 Use an oscilloscope to analyze sinusoidal wave forms for voltage, current, and frequency measurements.

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**ELACC9-10SL4:** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

**SP5:** Students will evaluate relationships between electrical and magnetic forces.

- b. Determine the relationship among potential difference, current, and resistance in a direct current circuit.

**SPS10:** Students will investigate the properties of electricity and magnetism.

- b. Explain the flow of electrons in terms of
  - alternating and direct current.
  - the relationship among voltage, resistance and current.

## Course Standard 5

### MANF-ACTEMHS-5

**Understand the applications of Inductance and Capacitance.**

- 5.1 Define inductance and identify inductor symbols.
- 5.2 Explain inductor operation.
- 5.3 Demonstrate the effect of connecting inductors in series and parallel.
- 5.4 Draw a vector diagram showing inductor phase relationships of voltage and current.
- 5.5 Determine the inductance value of an inductor.
- 5.6 Define and determine the reactance of an inductor when given the inductance and frequency.
- 5.7 Define capacitance and identify capacitor symbols.
- 5.8 Explain capacitor operation.
- 5.9 Demonstrate the effect of connecting capacitors in series and parallel.
- 5.10 Draw a vector diagram showing capacitor phase relationships of voltage and current.
- 5.11 Determine the capacitance value of a capacitor.
- 5.12 Define and determine the reactance of a capacitor when given the capacitance and frequency.

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## Course Standard 6

### MANF-ACTEMHS-6

**Explain and understand the Basic Transformer Application.**

- 6.1 Apply, define, and explain fundamental electrical terminology and electrical parameters for transformers.
- 6.2 Explain transformer outputs in relation to inputs.

- 6.3 Explain core losses, mutual inductance, and types of transformers.
- 6.4 Use an oscilloscope to evaluate performance of the transformer (i.e. voltage and phase measurements).
- 6.5 Calculate voltage-turn ratios.
- 6.6 Calculate voltage-current ratios.
- 6.7 Determine impedance matching.
- 6.8 Test and identify transformers.

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### **Course Standard 7**

#### **MANF-ACTEMHS-7**

##### **Examine motor theory and operating principles of motors.**

- 7.1 Describe the laws of magnetism and their application to AC and DC motors.
- 7.2 Compare the operating principles of AC motors with those of DC motors.
- 7.3 Compare the characteristics of AC motors with those of DC motors.
- 7.4 Define terms associated with electric motors.
- 7.5 Identify the component parts of an electric motor.
- 7.6 Name different types of AC and DC motors.
- 7.7 Discuss the National Electrical Manufacturers Association (NEMA) standards for electric motors.
- 7.8 Determine voltage, amperage, speed, horsepower, NEMA class, and environmental requirements of electric motors using data from the motor name plate.

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**ELACC9-10SL4:** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

**SP5:** Students will evaluate relationships between electrical and magnetic forces.

- d. Determine the relationship between moving electric charges and magnetic fields.

**SPS10:** Students will investigate the properties of electricity and magnetism.

- c. Investigate applications of magnetism and/or its relationship to the movement of electrical charge as it relates to
  - electromagnets
  - simple motors
  - permanent magnets

### **Course Standard 8**

#### **MANF-ACTEMHS-8**

##### **Investigate the principles of motor controls.**

- 8.1 Name the three classes of DC motors.
- 8.2 Describe the operating characteristics of the three classes of DC motors.
- 8.3 Identify the components of DC motors.

- 8.4 State the function of starter devices in DC motors.
- 8.5 Name the types of manual DC motor starters.
- 8.6 Identify the components used in DC motor control.
- 8.7 Name the types of automatic DC motor starters.
- 8.8 Describe the methods of controlling the speed of DC motors.
- 8.9 Name the three classes of AC motors.
- 8.10 Describe the operating characteristics of the three classes of AC motors.
- 8.11 Identify the components of AC motors.
- 8.12 State the purpose of controllers in AC motor circuits.
- 8.13 Name the types of AC motor controllers.
- 8.14 Identify the components used in AC motor controls.
- 8.15 Describe the methods used to provide circuit protection in AC motor control applications.

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### **Course Standard 9**

#### **MANF-ACTEMHS-9**

**Explain how control devices are used in automation.**

- 9.1 Identify and describe various devices used for sensing temperature, pressure, level, motion, and position.
- 9.2 Identify and describe the devices used in switching circuits.
- 9.3 Identify and describe the devices used for motor overload protection.
- 9.4 Identify and describe the devices used for ground fault and short circuit protection.
- 9.5 Identify and describe various other devices used in motor control circuits.

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### **Course Standard 10**

#### **MANF-ACTEMHS-10**

**Use symbols appropriately when working with schematic diagrams.**

- 10.1 Identify and draw the various symbols for components and conditional state of devices used in motor control circuits.
- 10.2 Describe a typical motor control schematic diagram.
- 10.3 Draw a schematic diagram of a motor control circuit.
- 10.4 Interpret schematic diagrams of various motor control circuits.

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**ELACC9-10SL4:** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

**ELACC9-10SL5:** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

### **Course Standard 11**

#### **MANF-ACTEMHS-11**

##### **Show proper wiring for magnetic starters and braking.**

- 11.1 Wire control transformers for the various 24V, 120V, and 230V secondary control voltages used in the industry.
- 11.2 Wire an across-the-line motor starter using a start-stop switch.
- 11.3 Wire a forward/reverse motor starter using a stop/forward/reverse switch.
- 11.4 Wire a magnetic starter for a motor control using a run/jog/stop switch without a control relay.
- 11.5 Wire a magnetic starter for a motor control using a control relay and a run/jog/stop switch.
- 11.6 Identify and describe the different dynamic, plugging, electronic, electric, and manual types of motor braking devices used in the industry.
- 11.7 Install a braking system on a motor.

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**ELACC9-10SL4:** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

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### **Course Standard 12**

#### **MANF-ACTEMHS-12**

##### **Demonstrate preventative maintenance and troubleshooting for motors.**

- 12.1 Perform a visual inspection using procedures described in a manufacturer's service manual.
- 12.2 Lubricate a motor according to procedures described in a manufacturer's service manual.
- 12.3 Clean a motor according to procedures outlined in a manufacturer's service manual.
- 12.4 Discuss techniques for troubleshooting electric motors.

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## Course Standard 13

### MANF-ACTEMHS-13

#### Explain hydraulic system principles.

- 13.1 Define and discuss the following basic hydraulic terms; hydraulic, force, weight, mass, work, and pressure.
- 13.2 Explain how hydraulic power is transmitted.
- 13.3 Discuss conservation of energy as it applies to a hydraulic system.
- 13.4 State the laws of physics that relate to hydraulic applications.
- 13.5 Explain how force, weight, mass, and pressure are used in the operation of hydraulic devices.
- 13.6 Use formulas to compute solutions for single variable problems relating to hydraulic systems where force, weight, mass, pressure, and work are the unknowns.
- 13.7 Identify the advantages of hydraulic power when compared to other methods of power transmission.
- 13.8 Identify the symbols used to represent components in a hydraulic system.
- 13.9 Identify the purpose of a hydraulic system using circuit diagrams.
- 13.10 Draw a complete hydraulic system schematic using the appropriate symbols.
- 13.11 Read and interpret a hydraulic system schematic.

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**MCC9-12.A.CED.4:** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations

**SPS8:** Students will determine relationships among force, mass, and motion.

- b. Apply Newton's three laws to everyday situations by explaining the following:
  - Inertia
  - Relationship between force, mass and acceleration
  - Equal and opposite forces

d. Explain the difference in mass and weight.

**SPS7:** Students will relate transformations and flow of energy within a system.

- a. Identify energy transformations within a system (e.g. lighting of a match).

**SP3:** Students will evaluate the forms and transformations of energy.

- a. Analyze, evaluate, and apply the principle of conservation of energy and measure the components of work-energy theorem by
  - describing total energy in a closed system.
  - identifying different types of potential energy.
- g. Analyze and measure power.

**SP1:** Students will analyze the relationships between force, mass, gravity, and the motion of objects.

- d. Measure and calculate the magnitude of frictional forces and Newton's three Laws of Motion.

- h. Determine the conditions required to maintain a body in a state of static equilibrium.

## Course Standard 14

### MANF-ACTEMHS-14

#### Demonstrate proper operation of hydraulic system components.

- 14.1 Check for symptoms of binding rods and pistons.
- 14.2 Align a piston in a hydraulic cylinder.
- 14.3 Discuss the purpose and use of servo-proportional valves (SPV).
- 14.4 Discuss troubleshooting procedures for actuators in a hydraulic system.

- 14.5 Inspect a pressure control relief valve.
- 14.6 Measure the pressure in a hydraulic system.
- 14.7 Measure the flow of fluid in a hydraulic system.
- 14.8 Null a hydraulic servo valve.
- 14.9 Replace valves in hydraulic system.
- 14.10 Adjust the hydraulic pressure at a valve.
- 14.11 Test the accumulator charge in a hydraulic system.
- 14.12 Recharge an accumulator.
- 14.13 Replace a defective accumulator.
- 14.14 Explain how hydraulic fluid is manufactured.
- 14.15 Identify types of hydraulic fluids and discuss their characteristics.
- 14.16 Explain viscosity ratings.
- 14.17 Select hydraulic fluids appropriate to the types of seals used in the system.
- 14.18 Check the fluid level in a hydraulic system.
- 14.19 Replace and clean hydraulic filters and strainers.
- 14.20 Drain and refill a hydraulic system with the correct fluid.
- 14.21 Discuss the types and purposes of reservoirs in a hydraulic system.

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**ELACC9-10SL4:** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

### **Recommended Workplace Learning Experience**

1. Conduct interview of individual who works in the Mechatronics field.
2. Compete in local or regional competitions related to Mechatronics.
3. Tour additional local advanced manufacturing operations.