

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

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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
	Inviting and Introducing Speakers
	Facilitating Discussions and Closing
	Preparing Visual Aids
	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

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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.

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

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.

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 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.