Manufacturing Cluster
Introduction to Mechatronics -- DC Theory, Pneumatic Systems, and Programmable Logic Controllers
Course Number: 21.46200

Course Description:
By completing this course, students will be introduced to direct current concepts and applications, pneumatic system fundamentals, and programmable logic controllers (PLCs). Topics include, but are not limited to, electrical laws and principles, magnetism, series, parallel, and simple combination DC circuits, pneumatic system principles and components, and PLC installation and programming. Theory and practical application concepts are discussed and illustrated through labs.

Furthermore, this course introduces students to the operational theory, systems terminology, installation, and programming procedures for PLCs. Emphasis is placed on PLC programming, connections, installation, and start-up procedures. Other topics include timers and counters, relay logic instructions, and hardware and software applications.

Course Standard 1
MANF-IMDCTPSPLC-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
	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
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-IMDCTPSPLC-2

Introduction to Safe Laboratory Procedures and OSHA Regulations for the manufacturing lab.

2.1 Identify monitoring agencies from which safety regulations can be requested.
2.2 Discuss the Material Safety Data Sheets (MSDS) Right-to-Know Law.
2.3 Identify types of fires, types of fire extinguishers, and types of protective clothing.
2.4 Identify the appropriate action for reporting fires and appropriate firefighting procedures.
2.5 Demonstrate Use of Lab Emergency Power Disconnect ("Kill Switch").
2.6 List personal and equipment safety rules for working with electrical and electronic circuits and power supplies.
2.7 Demonstrate an understanding of safety precautions and procedures.
2.8 Demonstrate the safe use of test equipment.
2.9 Identify the major types of hazards associated with the electrical/electronics workplace.
2.10 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.

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.

Course Standard 3

MANF-IMDCTPSPLC-3

Understand electrical laws and principles.

3.1 Define voltage, current, power, resistance, and conductance.
3.2 Read and interpret color codes to identify resistors.
3.3 Calculate resistance, conductance, voltage, current, and power (Ohm's Law/Power Law).
3.4 Define and draw simple resistive circuits.
3.5 Build simple resistive circuits and analyze the electrical properties predicted by electrical laws.
3.6 Define basic terms used to describe electronics quantities, components, devices, circuits, and systems.
3.7 Identify the symbols associated with basic electronic components and devices.

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

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.

MCC9-12.A.CED.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
SPS10: Students will investigate the properties of electricity and magnetism.
b. Explain the flow of electrons in terms of
• the relationship among voltage, resistance and current.
• simple series and parallel circuits.
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.

Course Standard 4

MANF-IMDCTPSPLC-4
Demonstrate an understanding of magnetism and applications in manufacturing.
4.1 Explain the principles of magnetism.
4.2 Demonstrate magnetic principle application.

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.
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 5

MANF-IMDCTPSPLC-5
Demonstrate an understanding of batteries and uses in manufacturing.
5.1 Explain the concept of polarity as it applies to batteries.
5.2 Demonstrate a power test of various wet and dry cells and batteries.

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

SPS10: Students will investigate the properties of electricity and magnetism.
b. Explain the flow of electrons in terms of
• the relationship among voltage, resistance and current.

Course Standard 6

MANF-IMDCTPSPLC-6
Compute and apply series, parallel, and simple combination circuits.
6.1 Measure and compute DC series, parallel, and simple combination circuit voltage, current, resistance, and power (Kirchhoff Law of Voltage and Current).

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

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.

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

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.

c. Determine equivalent resistances in series and parallel circuits.

Course Standard 7

MANF-IMDCTPSPLC-7

Explain and demonstrate the basic operation of DC test equipment.

7.1 Explain the basic operating principles of a voltmeter, ohmmeter, ammeter, analog multimeter, and digital multimeter.

7.2 Measure circuit voltage, current, and resistance.

7.3 Explain the conditions that cause "shorts" in an electrical circuit.

7.4 Determine the location of a short in a DC circuit.

7.5 Explain the circuit conditions that cause "opens".

7.6 Determine the location of an open in a DC circuit.

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

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 8

MANF-IMDCTPSPLC-8

Explain pneumatic system principles.

8.1 Define the terms force, weight, mass, pressure, volume, work, PSI, PSIA, PSIG, compressibility pneumatic energy, and kinetic energy as they relate to pneumatic systems.

8.2 Describe the relationship between the following: force and area, work and time, volume and pressure, temperature and pressure, and temperature, volume, and pressure.

8.3 Describe the effects of air viscosity on velocity.

8.4 Explain Bernoulli's Principle.

8.5 Describe the relationship between pneumatic leverage and travel.

8.6 Use formulas to compute pneumatic output force when given input force and cylinder areas.

8.7 Use formulas to compute work when given cylinder bore, stroke, and air pressure.

8.8 Use formulas to compute output cylinder travel when given input cylinder travel and leverage increase ratio.

8.9 Identify the symbols used to represent components of pneumatic systems.
8.10 Describe the operation of pneumatic systems when supplied with a system schematic.
8.11 Verify air logic with a pneumatic system diagram.

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.
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.
MCC9-12.A.CED.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations
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.
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
e. Calculate amounts of work and mechanical advantage using simple machines.

Course Standard 9

MANF-IMDCTPSPLC-9
Demonstrate proper operation of pneumatic system components.

9.1 Describe the various types of compressors.
9.2 Analyze the functions of compressors.
9.3 Service pneumatic system compressors.
9.4 Disassemble and reassemble a pneumatic system compressor.
9.5 Describe the various types of valves used in pneumatic systems.
9.6 Analyze the function of commonly used types of pneumatic valves.
9.7 Verify pneumatic valve operation.
9.8 Identify commonly used types of actuators.
9.9 Describe the operation of commonly used types of actuators.
9.10 Verify the proper operation of an air motor.

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.
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.

Course Standard 10

MANF-IMDCTPSPLC-10
Demonstrate an understanding of Programmable Logic Controller (PLC) safety procedures.

10.1 Discuss techniques for discrete IO signal communications and noise interference.
10.2 Discuss the hazards and proper operation of forcing inputs and outputs.
10.3 Discuss leakage voltage across electronic components.
10.4 Discuss safe methods of installing power and control cables.
10.5 Install power and control cables.

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 11

MANF-IMDCTPSPLC-11
Demonstrate the uses of Programmable Logic Controller (PLC) hardware and software.

11.1 Identify and discuss function of all PLC components.
11.2 Discuss and install PLC software.
11.3 Discuss common terminology used in PLC applications.

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

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.

Course Standard 12

MANF-IMDCTPSPLC-12
Demonstrate correct Programmable Logic Controller (PLC) installation, configuration, and setup.

12.1 Completely install a PLC processor, power supply and IO cards.
12.2 Use PLC software to setup and configure a PLC for operation.

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 13

MANF-IMDCTPSPLC-13
Understand the terms, operations, and values for Programmable Logic Controller (PLC) Programming Basics.

13.1 Discuss the operation of the following logic gates: AND, OR, NAND, NOR, XOR, XNOR, NOT and BUFFERS.
13.2 Discuss and convert values using Decimal, Binary, Octal, Hexadecimal and Binary Coded Decimal.
13.3 Discuss the terms related to data storage including: Data Words, Bytes, Nibbles, Bits, Signed and Unsigned Integers and Double Words.

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 14

MANF-IMDCTPSPLC-14

Understand Relay Logic instructions and uses in automation and controls.

14.1 Discuss and execute relay instructions including Examine if Closed/Normally Open, Examine if Open/Normally Closed, Output/Coil, Latch and Unlatch and One Shot.
14.2 Discuss the addressing for bit level instructions.

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 15

MANF-IMDCTPSPLC-15

Demonstrate the proper uses of timers and counters.

15.1 Discuss the operation of on-delay timers, off-delay timers and retentive timers.
15.2 Program and execute each type of timer in a program.
15.3 Reset operation for timers.
15.4 Discuss the operation of up and down counters.
15.5 Program and execute each type of counter in a program.
15.6 Reset operation for counters.

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.