Mechatronics Program
PLCs 1 Course
Suggested Syllabus

Part 1: Course Information

Course Overview

Basic Information

College:
Department:
Semester:
Instructor:
Office:
Office Hours:
Office Telephone:
Email:

Description

PLCs 1 is a study of the basic digital logic and programmable logic controllers (PLC) in a mechatronics system using the automation system. This course consists of 15 lessons along with corresponding labs and/or class activities. Topics covered include basic PLC functions and testing; industrial applications of PLC requiring motion control; troubleshooting techniques and strategies to identify, localize, and correct malfunctioning PLCs; and writing small programs and problem-solving using computer simulations.

Prerequisites

No Mechatronics courses are required as prerequisites.

To succeed in this course, students should be proficient in English and basic Algebra.

Course Materials

Recommended Textbooks

Dunning, G. (2005). *Introduction to Programmable Logic Controllers* (3rd ed.). Clifton Park, NY: Thomson Delmar Learning. ISBN-13: 978-1401884260

Petruzella, F. (2010). *Programmable Logic Controllers* (4th ed.). New York, NY: McGraw-Hill. ISBN-13: 978-0073510880.

Petruzella, F. (2010). *Activities Manual to Accompany Programmable Logic Controllers* (4th ed.). New York, NY: McGraw-Hill. ISBN-13: 978-0073303420.

Course Structure

This course is designed to provide a hybrid experience, including both face-to-face and online activities. Activities to be completed online and face-to-face will be updated weekly and provided as a supplement to the course syllabus.

Contact time will be divided in the following way:

80% face-to-face
20% online

Face-to-face sessions

Laboratory exercises and in-class work will emphasize skill attainment and content mastery.

Online Sessions

Online sessions will include content and activities from Platform +, Wisc-Online, Tooling U, simulated lab activities, and other resources. To access online activities, students will need access to the Internet and a supported Web browser. Technical assistance can be obtained from local technical support.

Technical Requirements

- Internet connection
- Access to college learning management system and Platform+.
- Access to college email account
- Microsoft PowerPoint
- Microsoft Word

Part 2: Learning Outcomes

Following successful completion of the PLCs 1 course, the student will be able to:

Applied Mathematics

- Convert between the decimal, binary, octal, hexadecimal, and binary coded decimal (BCD) systems, explaining how PLCs use these numbering systems.
- Explain Boolean algebra, stating Boolean equations for various logic functions, constructing circuits from Boolean expressions, and deriving Boolean equations for given logic circuits.

Critical Thinking/Problem Solving

- Convert relay schematics into PLC ladder logic.

Equipment

- Correctly use and explain the operation of PLC hardware and modules.
- Describe a wide variety of field devices commonly used in connection with the I/O modules.

Foundational Principles

- Identify the components of a PLC, the principles of PLC operation, and the main PLC applications.
- Identify and describe different PLC programming methods and languages.
- Describe various programming instructions, such as branch, internal relay, and logic instructions.
- Describe the binary concept and basic logic and gate functions, draw the logic symbol, and construct a truth table.
- Identify basic motor controls, such as switches, relays, and sensors, and explain how the PLC is programmed to control electric motor applications.
- Explain timer and counter instructions, applications, and programming.

Safety

- Understand and apply PLC safety rules and procedures while working on a mechatronic system.
- Operate equipment according to safety protocols.
- Demonstrate proper safety techniques.

Troubleshooting

- Correct malfunctions in PLC programs or correctly identify the expertise required to correct a malfunction.

Part 3: Course Calendar

This course calendar provides a schedule of lessons and an outline of topics covered. Activities, assignments, and assessments will be explained in detail throughout the course. Please contact the instructor with questions.

Lesson 1: Course Overview and History of PLCs Date

1. Class syllabus, Course Policies and Procedures
2. PLC Overview
    a. Definitions
    b. History
    c. Advantages
    d. Purpose: Automation
    e. Operation: Programming Instructions, Ladder Logic
    f. Six Main PLC Components and Their Functions
3. Lab Activity: PLC Safety and Lab Overview

Lesson 2: Operations and Ladder Logic Date

1. Principles of PLC Operation
    a. Monitoring Inputs
    b. Executing Program
    c. Changing Outputs
2. Ladder Logic
    a. RLL
    b. RUNG
    c. IEC 61131-3
3. Methods of Programming a PLC
    a. Hand-held Terminal
    b. PC
    c. Soft PLC Programming
4. Differences Between PLCs and Computers
5. PLC Size and Application
    a. I/O count
    b. Single-ended

c. Multitask
d. Control Management
e. Memory

6. Lab Activities: Relay Ladder Logic and Basic Logic Functions

Lesson 3: Programming Languages and Scan Cycle Date

1. Functions of PLC Memory Map
   a. Memory Map Organization
   b. Memory Sections
   c. Status Data and Codes
2. Input and Output Image Tables
   a. Program files data
   b. Data files Data
3. PLC Program Scan Sequence
   a. PLC Scan
   b. Scan Cycle
   c. Scan Dependencies
   d. Ladder Logic Process
   e. Scan Methods-RUNG
4. PLC Programming Languages
   a. Definitions of Five Standard Languages
   b. Relay-Type Instructions
5. Relay States: XIC, XIO, OTE
   c. Contact State: NO, NC
   d. OTE
6. Lab Activities: Programming Languages, Ladder Diagrams, IO Addresses, Diagrams and Functions

Lesson 4: Addressing, Internal Relays, and Entering Ladder Logic Date

1. Instruction Addressing
   a. Dependencies
   b. Representations

   c. Address Format
2. Branch Instructions
   a. Usage and Functions
   b. Advantages and Limitations
3. Internal Relay Instructions
   a. Operations
4. XIC and XIO Instructions
   a. Operations
   b. Bit Status
   c. OTE
5. Ladder Diagram Programming
   a. Software Dependencies
   b. Environments
   c. Methods of Programming
   d. Programming Software
   e. Advantages of RLL
6. Modes of Operation: PROG, RUN, TEST
7. Lab Activities: Numbering Systems, Memory Organization, I/O Data Tables Operations and Status
8. Lab Quiz: Programming Relay Instructions

Lesson 5: PLC Hardware and Modules Date

1. Input/Output (I/O) Modules
   a. Usage and Advantages
   b. Logical Rack
   c. Addressing Schemes
2. Discrete I/O Modules
   a. I/O Modules and I/O Flow
   b. Color Codes
   c. Switching Elements
   d. NPN and PNP
3. Analog I/O Modules

   a. Usage and Status
   b. Span
   c. Converters AD, DA
   d. AIO Flow
4. Special I/O Modules
   a. Usage
   b. Intelligent I/O
5. I/O Specifications: Discrete I/O and Analog I/O
6. Central Processing Unit (CPU)
   a. Role and Tasks
   b. Redundancy
   c. Modes: RUN. PROG, REM
   d. Advantages and Disadvantages
   e. Static Control Procedures
7. Memory Design
   a. Role: Writing, Reading
   b. Attributes
8. Memory Types: RAM, ROM, EPROM, EEPROM, Flash EEPROM
9. Programming Terminal Devices
   a. Types and Advantages
10. Recording and Retrieving Data
   a. Scope and Advantages
11. Human Machine Interfaces (HMIs)
   a. Usage and Advantages
12. Lab Activities: PLC Program Backup, Discrete Input, Discrete Output
13. Module 1 Exam

Lesson 6: Numbering Systems and Conversions Date

1. Decimal System
   a. System Basics
   b. How to Calculate
2. Binary System

   a. System Basics
   b. Memory Organization
   c. LSB, MSB
   d. Conversion
3. Negative Numbers
   a. Number Polarity
   b. Complementing Binary Numbers
4. Octal, Hexadecimal, and Binary Coded Decimal (BCD) Systems
   a. System Basics
   b. Conversion to Binary
5. Gray Code and ASCII Code
   a. Basic Usage
   b. Conversion to Binary
6. Parity Bit
7. Binary Arithmetic: Addition, Subtraction, Multiplication, Division
8. Lab Activity: Midterm Exam Review

Lesson 7: Midterm Exam **Date**

Lesson 8: Logic Gates, Truth Tables, and Boolean Equations **Date**

1. Binary Concept
   a. Binary Principle
   b. Logic Gate
   c. Advantages
2. AND, OR, and NOT Functions
3. Boolean Algebra
   a. Definition
   b. Boolean Instruction List
   c. Logic Symbols and Statements
   d. Boolean Equations and Notations
   e. Commutative, Associative, and Distributive Laws
4. Lab Activities: Motor Control Basics, Seal-In Program Logic, Interlock Functions

Lesson 9: Hardwired Logic, Word Programming, and Destination Bits Date

1. Developing Logic Gate Circuits from Boolean Expressions
    a. Symbols
    b. Gates Required
    c. Boolean to Symbol Conversion
2. Producing Boolean Equation for Given Logic Gate Circuit
    a. Complex Gates Combinations
    b. Multiple Input Combinations
    c. Boolean Equation for Logic Circuit
3. Hardwired Logic and Programmed Logic Compared
4. Programming Word-Level Logic Instructions
    a. Instruction Set
    b. Bit Address Instructions
    c. Logic Instructions
    d. Word-Level AND, OR, XOR, NOT Instructions
    e. Bit-by-Bit Arithmetic
    f. Sources Bits
    g. Destination Bits
5. Lab Activities: Discrete I/O Interfacing, Application Development
6. Lab Quiz: Basic Logic Functions

Lesson 10: Motor Control Basics 1 Date

1. Electromagnetic Control Relays
    a. Definition and Operation
    b. NC and NO
    c. Ratings and Notations
2. Contactors
    a. Definition and Operation
    b. High Power Load Usage
    c. PLC Conjunction
3. Motor Starters
    a. Overload Relays
    b. Wiring Diagram

4. Manually-Operated Switches
    a. Operation and Types
    b. NEMA Symbols
5. Mechanically-Operated Switches
    a. Operation and Types
    b. Advantages
    c. NEMA and IEC Symbols
6. Sensors
    a. Operation and Types
7. Lab Activities: Motor Control Circuits
8. Lab Quiz: Basic Motor Control Using a PLC
9. Module 2 Exam

Lesson 11: Motor Control Basics 2 Date

1. Output Control Devices
    a. Symbols
    b. Actuators
    c. Stepper Motors
    d. Servo Motors
2. Seal-In Circuits
    a. Definition and Operation
3. Latching Relays
    a. Operation
    b. Bit Level Address
    c. Latch and Unlatch
4. Converting Relay Schematics into PLC Ladder Programs
    a. Conversion Steps
    b. Control Processes
5. Writing a Ladder Logic Program Directly from a Narrative Description
    a. Program Planning Steps

Lesson 12: Timer Programming Date

1. Mechanical Timing Relays

a. Solid State, Pneumatic, and Plug-In Timing Relays
b. On-Delay, Off-Delay

2. Timer Instructions
   a. Types: TON, TOF, RTO
   b. Advantages
   c. Instructions
   d. Modes of Operation
3. On-Delay Timer Instructions (TON)
   a. Principles of Operation
   b. Bit Addressing
   c. Instructions
4. Off-Delay Timer Instructions (TOF)
   a. Principles of Operation
   b. Instructions
   c. Timed and Instantaneous Contacts
5. Retentive Timer (RTO)
   a. Program Planning Steps
6. Cascading Timers
   a. Principles of Operation
7. Lab Activities: Retentive and Non-Retentive Timer Instructions, Time-Driven Sequencing, Timer Applications

Lesson 13: Counter Programming Date

1. Counter Instructions
   a. Functions and Operations
   b. Instructions Set
   c. Representation
   d. Applications
2. Up-Counter
   a. Instructions
   b. Modes of Operation
   c. Program
   d. Timing Diagram

   e. Bit Level Programming
3. Down-Counter
   a. Principles of Operation
   b. Bit Addressing
   c. Instructions
   d. Address Sharing
   e. Preset with Negative Value
4. Cascading Counters
   a. Principles of Operation and Usage
   b. Instructions
5. Incremental Encoder-Counter Applications
6. Combining Counter and Timer Functions
7. Lab Activities: Up-Counter and Down-Counter Instructions, BCD Thumbwheel Switches, LED Displays
8. Lab Quiz: Timers and Counters

Lesson 14: Final Review Date

1. Final Review
2. Module 3 Exam

Lesson 15: Final Examination Date

Part 4: Grading Information

Graded Activities

Midterm Exam

There will be a midterm exam, worth 15% of the final grade.

Final Exam

There will be a comprehensive final exam worth 20% of the final grade.

Laboratory Exercises

Laboratory exercises measure skills and abilities relating to knowledge learned in class and will be worth 20% of the final grade.

Quizzes

Quizzes on assigned material will be designed for review and evaluation of learning and will be worth 15% of the final grade.

Homework

Doing work outside of class is critical to success. Homework is graded and will be worth 20% of the final grade.

Class Participation

Class participation is important and will be worth 10% of the final grade.

Grading Breakdown

Midterm Exam = 15%
Final Exam = 20%
Laboratory Exercises = 20%

Quizzes = 15%

Homework = 20%
Class Participation = 10%

Grading Scale

A = 90-100
B = 80-89
C = 70-79
D = 60-69
F = 59 and below

Late Work

Late work will not be accepted unless it is pre-approved by the instructor. All graded work will be posted in the college learning management system with 48 hours of due date.

Part 5: College Policies and Resources

Policies

Attendance

Academic Integrity

Campus Civility

Resources

Counseling

Veterans

Students with Disabilities

About These Materials

Copyright

The National STEM (Science, Technology, Engineering, and Mathematics) Consortium (NSC), a collaborative of ten colleges in nine states, was funded by a Trade Adjustment Assistance Community College and Career Training (TAACCCT) grant from the U.S. Department of Labor to develop new workforce training programs in technical fields. For more information about NSC, visit the NSC website: http://www.nationalstem.org.

License

Attribution and Citation

To attribute this work, use: Radu Suciu

To cite this work, use:

Suciu, R.(2015). *Introduction to PLCs.* Mechatronics Technology certificate program of the National STEM Consortium. Retrieved from http://oli.cmu.edu.

Accessibility

The NSC has made every effort to create accessible materials, following best practices and Americans with Disabilities Act (ADA) guidelines. For example, to ensure screen reader systems can work with these materials, we write using plain English, heading styles in outline structure, simple layout, minimal tables and charts, bulleted and numbered lists, high-contrast colors, standard fonts, white space for ease of reading, and so on. For more information about ADA compliance, see the 2010 Design Standards on the ADA website: http://www.ada.gov/2010ADAstandards_index.htm.

Disclaimer

This workforce solution was funded by a grant awarded by the U.S. Department of Labor's Employment and Training Administration. The solution was created by the grantee and does not necessarily reflect the official position of the U.S. Department of Labor. The Department of Labor makes no guarantees, warrantees, or assurances of any kind, express or implied, with respect to such information, including any information on linked sites and including, but not limited to, accuracy of the information or its completeness, timeliness, usefulness, adequacy, continued availability, or ownership.