# 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
3. Definitions
4. History
5. Advantages
6. Purpose: Automation
7. Operation: Programming Instructions, Ladder Logic
8. Six Main PLC Components and Their Functions
9. Lab Activity: PLC Safety and Lab Overview

## Lesson 2: Operations and Ladder Logic Date

1. Principles of PLC Operation
2. Monitoring Inputs
3. Executing Program
4. Changing Outputs
5. Ladder Logic
6. RLL
7. RUNG
8. IEC 61131-3
9. Methods of Programming a PLC
10. Hand-held Terminal
11. PC
12. Soft PLC Programming
13. Differences Between PLCs and Computers
14. PLC Size and Application
15. I/O count
16. Single-ended
17. Multitask
18. Control Management
19. Memory
20. Lab Activities: Relay Ladder Logic and Basic Logic Functions

## Lesson 3: Programming Languages and Scan Cycle Date

1. Functions of PLC Memory Map
2. Memory Map Organization
3. Memory Sections
4. Status Data and Codes
5. Input and Output Image Tables
6. Program files data
7. Data files Data
8. PLC Program Scan Sequence
9. PLC Scan
10. Scan Cycle
11. Scan Dependencies
12. Ladder Logic Process
13. Scan Methods-RUNG
14. PLC Programming Languages
15. Definitions of Five Standard Languages
16. Relay-Type Instructions
17. Relay States: XIC, XIO, OTE
18. Contact State: NO, NC
19. OTE
20. Lab Activities: Programming Languages, Ladder Diagrams, IO Addresses, Diagrams and Functions

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

1. Instruction Addressing
2. Dependencies
3. Representations
4. Address Format
5. Branch Instructions
6. Usage and Functions
7. Advantages and Limitations
8. Internal Relay Instructions
9. Operations
10. XIC and XIO Instructions
11. Operations
12. Bit Status
13. OTE
14. Ladder Diagram Programming
15. Software Dependencies
16. Environments
17. Methods of Programming
18. Programming Software
19. Advantages of RLL
20. Modes of Operation: PROG, RUN, TEST
21. Lab Activities: Numbering Systems, Memory Organization, I/O Data Tables Operations and Status
22. Lab Quiz: Programming Relay Instructions

## Lesson 5: PLC Hardware and Modules Date

1. Input/Output (I/O) Modules
2. Usage and Advantages
3. Logical Rack
4. Addressing Schemes
5. Discrete I/O Modules
6. I/O Modules and I/O Flow
7. Color Codes
8. Switching Elements
9. NPN and PNP
10. Analog I/O Modules
11. Usage and Status
12. Span
13. Converters AD, DA
14. AIO Flow
15. Special I/O Modules
16. Usage
17. Intelligent I/O
18. I/O Specifications: Discrete I/O and Analog I/O
19. Central Processing Unit (CPU)
20. Role and Tasks
21. Redundancy
22. Modes: RUN. PROG, REM
23. Advantages and Disadvantages
24. Static Control Procedures
25. Memory Design
26. Role: Writing, Reading
27. Attributes
28. Memory Types: RAM, ROM, EPROM, EEPROM, Flash EEPROM
29. Programming Terminal Devices
30. Types and Advantages
31. Recording and Retrieving Data
32. Scope and Advantages
33. Human Machine Interfaces (HMIs)
34. Usage and Advantages
35. Lab Activities: PLC Program Backup, Discrete Input, Discrete Output
36. Module 1 Exam

## Lesson 6: Numbering Systems and Conversions Date

1. Decimal System
2. System Basics
3. How to Calculate
4. Binary System
5. System Basics
6. Memory Organization
7. LSB, MSB
8. Conversion
9. Negative Numbers
10. Number Polarity
11. Complementing Binary Numbers
12. Octal, Hexadecimal, and Binary Coded Decimal (BCD) Systems
13. System Basics
14. Conversion to Binary
15. Gray Code and ASCII Code
16. Basic Usage
17. Conversion to Binary
18. Parity Bit
19. Binary Arithmetic: Addition, Subtraction, Multiplication, Division
20. Lab Activity: Midterm Exam Review

## Lesson 7: Midterm Exam Date

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

1. Binary Concept
2. Binary Principle
3. Logic Gate
4. Advantages
5. AND, OR, and NOT Functions
6. Boolean Algebra
7. Definition
8. Boolean Instruction List
9. Logic Symbols and Statements
10. Boolean Equations and Notations
11. Commutative, Associative, and Distributive Laws
12. 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
2. Symbols
3. Gates Required
4. Boolean to Symbol Conversion
5. Producing Boolean Equation for Given Logic Gate Circuit
6. Complex Gates Combinations
7. Multiple Input Combinations
8. Boolean Equation for Logic Circuit
9. Hardwired Logic and Programmed Logic Compared
10. Programming Word-Level Logic Instructions
11. Instruction Set
12. Bit Address Instructions
13. Logic Instructions
14. Word-Level AND, OR, XOR, NOT Instructions
15. Bit-by-Bit Arithmetic
16. Sources Bits
17. Destination Bits
18. Lab Activities: Discrete I/O Interfacing, Application Development
19. Lab Quiz: Basic Logic Functions

## Lesson 10: Motor Control Basics 1 Date

1. Electromagnetic Control Relays
2. Definition and Operation
3. NC and NO
4. Ratings and Notations
5. Contactors
6. Definition and Operation
7. High Power Load Usage
8. PLC Conjunction
9. Motor Starters
10. Overload Relays
11. Wiring Diagram
12. Manually-Operated Switches
13. Operation and Types
14. NEMA Symbols
15. Mechanically-Operated Switches
16. Operation and Types
17. Advantages
18. NEMA and IEC Symbols
19. Sensors
20. Operation and Types
21. Lab Activities: Motor Control Circuits
22. Lab Quiz: Basic Motor Control Using a PLC
23. Module 2 Exam

## Lesson 11: Motor Control Basics 2 Date

1. Output Control Devices
2. Symbols
3. Actuators
4. Stepper Motors
5. Servo Motors
6. Seal-In Circuits
7. Definition and Operation
8. Latching Relays
9. Operation
10. Bit Level Address
11. Latch and Unlatch
12. Converting Relay Schematics into PLC Ladder Programs
13. Conversion Steps
14. Control Processes
15. Writing a Ladder Logic Program Directly from a Narrative Description
16. Program Planning Steps

## Lesson 12: Timer Programming Date

1. Mechanical Timing Relays
2. Solid State, Pneumatic, and Plug-In Timing Relays
3. On-Delay, Off-Delay
4. Timer Instructions
5. Types: TON, TOF, RTO
6. Advantages
7. Instructions
8. Modes of Operation
9. On-Delay Timer Instructions (TON)
10. Principles of Operation
11. Bit Addressing
12. Instructions
13. Off-Delay Timer Instructions (TOF)
14. Principles of Operation
15. Instructions
16. Timed and Instantaneous Contacts
17. Retentive Timer (RTO)
18. Program Planning Steps
19. Cascading Timers
20. Principles of Operation
21. Lab Activities: Retentive and Non-Retentive Timer Instructions, Time-Driven Sequencing, Timer Applications

## Lesson 13: Counter Programming Date

1. Counter Instructions
2. Functions and Operations
3. Instructions Set
4. Representation
5. Applications
6. Up-Counter
7. Instructions
8. Modes of Operation
9. Program
10. Timing Diagram
11. Bit Level Programming
12. Down-Counter
13. Principles of Operation
14. Bit Addressing
15. Instructions
16. Address Sharing
17. Preset with Negative Value
18. Cascading Counters
19. Principles of Operation and Usage
20. Instructions
21. Incremental Encoder-Counter Applications
22. Combining Counter and Timer Functions
23. Lab Activities: Up-Counter and Down-Counter Instructions, BCD Thumbwheel Switches, LED Displays
24. 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

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