Mechatronics Program
PLCs 2
Suggested Syllabus

Part 1: Course Information

Course Overview

Basic Information

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

Description

PLCs 2 is a study of the concepts, programming, and applications of a programmable logic controller (PLC) in a mechatronics system using the automation system. This course consists of 12 lessons (and two optional lessons), along with corresponding labs and/or class activities. Topics covered include industrial applications of PLCs requiring programming; timers, counters, and subroutines, as well as event-driven and time-driven sequences; and troubleshooting techniques and strategies to identify, localize, and correct malfunctioning PLCs. Practical laboratory experiments reinforce the topics of ladder logic diagrams and programming PLCs.

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

Dunning, G. (2013). *Introduction to the ControlLogix Programmable Automation Controller with Labs* (2nd ed.). Clifton Park, NY: Cengage Learning. ISBN-13: 978-1111539290.

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 Advanced PLCs course, the student will be able to:

Critical Thinking/Problem Solving

- Program a variety of functions and instructions, such as PLC program initialization, subroutines, and jump, label, data manipulation, and math instructions.
- Design and interpret PLC programs that control the sequence of operations of entire machines.
- Design programs that implement various arithmetic instructions.

Equipment

- Correctly and safely install, maintain, and troubleshoot a PLC-controlled system.
- Connect and test a range of components to a PLC.

Foundational Principles

- Identify the components of a PLC, the principles of PLC operation, and the main PLC applications.
- Explain timer and counter instructions, applications, and programming.
- Identify and explain the operation of various program control instructions, such as master control reset, jump, subroutine, immediate I/O, temporary end, move, and math instructions.
- Describe the function and application of data manipulation, transfer, and compare instructions.
- Explain how the PLC sequencer and shift registers operate and apply to control systems.
- Describe a variety of I/O modules, such as discrete, analog, and special modules.
- Identify the kinds of industrial processes that can be PLC-controlled, as well as the integration/communication of non-PLC systems, such as robots, data terminals (HMI) and computers (IPC).

Safety

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

Troubleshooting

- Perform tests on PLC components to learn where failures may occur.
- Undertake a systematic method for troubleshooting the entire PLC system.

- 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 Introduction and Review of PLCs Date

1. Class syllabus, Course Policies and Procedures
2. PLC Overview
    a. Definition
    b. Programming
    c. Main Parts and Functions
3. Timers and Counters
    d. Instructions
    e. Types
    f. Combinations
4. Lab Activities: Safety Review, Timers, Counters
5. Quiz: Timers and Counters

Lesson 2: Program Control Instructions Date

1. Master Control Reset Instruction
    a. Operations
    b. Instructions Set
    c. Zones
    d. Warnings
2. Jump Instruction
    a. Output Instruction
    b. Operations and Program
    c. Ladder Logic
3. Subroutine Function
    a. Definition and Operation

   b. Advantages
   c. Instructions
4. Immediate Input and Output Instructions
   a. Definition, Operation, Usage
5. Forcing External I/O addresses
   a. Definition and Usage
   b. Programming
   c. Safety and Warnings
6. Safety Circuitry
   a. Multiple Levels of Disconnect
   b. Solutions and Operation
   c. Safety PLC
7. Selectable Timed Interrupt
   a. Operation, Usage, Instructions
8. Fault Routine
   a. Operation and Types
   b. Recover Procedures
9. Temporary End and Suspend Instructions
   a. Usage and Operation
10. Lab Activities: Program Initialization, Master Control Reset, Subroutines, Jump and Label Instructions.
11. Quiz: Program Control Instructions

Lesson 3: Data Manipulations Date

1. Data Manipulation
   a. Implementation
   b. Word and Register Levels
   c. Category and Concepts
2. Data Transfer Instructions
   a. File Instructions
   b. Operation
   c. FAL, COP, FLL
3. Data Compare Instructions
   a. Definition and Operation

   b. Instructions
   c. Logic RUNGs
4. Data Manipulation Programs
   a. Operation and Usage
5. Numerical Data I/O Interfaces
   a. Multibits
   b. Analog
   c. Operation
6. Closed-Loop Control
   a. Operation
   b. Schemes
   c. Instructions
7. Lab Activities: Data Manipulation Move Instructions: MOV, Copy
8. Quiz: Data Manipulation Instructions

Lesson 4: Math Instructions **Date**

1. Math Instructions
   a. Definition, Functions, Command
2. Addition Instruction (ADD)
   a. Operation
   b. Bit Status
3. Subtraction Instruction (SUB)
   a. Definition and Operation
4. Multiplication Instruction (MUL)
   a. Operation and Usage
5. Division Instruction (DIV)
   a. Operation
6. Other Word-Level Math Instructions
   a. Operations: SQR, NEG, TOD, FRD, CLR
   b. Schemes
   c. Instructions
7. File Arithmetic Operations
   a. Functions
   b. Implementation

   c. Instructions
8. Lab Activities: Math Instructions, ADD, SUB, MUL, DIV
9. Quiz: Math Instructions

Lesson 5: Lab Midterm Date

Lesson 6: Sequencer and Shift Register Instructions Date

1. Mechanical Sequencers
   a. Definition, Functions
2. Sequencer Instructions
   a. Operation
   b. Programming
3. Sequencer Programs
   a. Definition and Types
   b. Operation
4. Bit Shift Registers
   a. Definition, Application
   b. Instructions
   c. Usage
5. Word Shift Operations
   a. Operations
   b. Instructions: FIFO, LIFO
6. Lab Activities: Event Sequencing, Continuous Cycle Logic, Multiple Actuator Event Sequencing
7. Quiz: Shift Registers

Lesson 7: PLC Installation, Editing, and Troubleshooting Date

1. PLC Enclosures
   a. Definition and Functions
2. Electrical Noise
   a. Definition
   b. Causes and Recommendations
3. Leaky Inputs and Outputs

a. Definition and Solutions

4. Grounding
   b. NEC and Definition
5. Voltage Variations and Surges
   c. Operation and Solutions
6. Program Editing and Commissioning
7. Programming and Monitoring
   a. Operations and Modes
8. Preventive Maintenance
9. Troubleshooting
   a. Source
   b. Component and System Troubleshooting
10. PLC Programming Software
    a. Configuration and Communication
11. Lab Activities: PLC Power Supply, Input, and Output Troubleshooting
1. Quiz

Lesson 8: Advanced I/O **Date**

1. Input/Output Modules
   a. Usage
   b. Logical Rack
   c. Addressing Schemes
   d. Advantages
2. Discrete O/O Modules
   a. Flow
   b. Color Codes
   c. Switching Elements
   d. NPN and PNP
3. Analog I/O Modules
   a. Usage
   b. Status
   c. Span
   d. Converters AD, DA

   e. AIO Flow
4. Special I/O Modules
   a. Usage
   b. Intelligent I/O
5. I/O Specifications
6. Lab Activities: Processor Troubleshooting, System Troubleshooting Techniques, Software Troubleshooting
7. Quiz

Lesson 9: Process Control, Network Systems, SCADA Date

1. Types of Control Processes
2. Structure of Control Systems: HMI, IPC, GP HMI+PLC, PLC+SERVO
3. On/Off, PID, and Motion Control
4. Data Communications
5. SCADA
6. Lab Activities: Selecting PLC Discrete Input/Output Modules; Connecting/Testing Components to PLC; Current Leakage on AC Output; PNP/NPN Electronic Sensor Output Interfacing; Configuring Analog Modules
7. Quiz

Lesson 10: Course Review Date

1. Course Review
2. Lab Activities: Controls System, Integration

Lesson 11: Final Class Examination Date

3. Final Class Exam
4. Lab Activity: Course Review

Lesson 12: Final Lab Examination Date

Lesson 13: OPTIONAL Compare/Contrast AB PLC with Siemens S7 PLC I Date

1. Compare the Two Systems for Lessons 2-6
2. Final Lab Project 1: Automatic Car Wash

Lesson 14: OPTIONAL Compare/Contrast AB PLC with Siemens S7 PLC II Date

1. Compare the Two Systems for Lessons 7-9
2. Final Lab Project 2: ADD, MUL, SUB, DIV, JSR, SBR, RET

Part 4: Grading Information

Graded Activities

Midterm Lab Exam

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

Final Class and Lab Exams

There will be a comprehensive final class exam and lab exam, each 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 5% of the final grade.

Class Participation

Class participation is important and will be worth 5% of the final grade.

Grading Breakdown

Midterm Lab Exam = 15%

Final Class Exam = 20%

Final Lab Exam = 20%

Laboratory Exercises = 20%

Quizzes = 15%

Homework = 5%

Class Participation = 5%

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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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.

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