# Appendix B

## New Course or Course Change Proposal Form

**Date of Proposal:** March 27, 2012  
**Author:** Doug Laven / David Ewel

### Proposal Type:
- [ ] New Course  
- [X] Modify Course  
- [ ] Delete Course

**Contact for the Course:** David Ewel

**Course Designator, Number and Title:** MECA 1270 Modeling & Simulation

**Number of Credits:** 3

**Prerequisites:** MECA 1131 Computer Applications

**Course Description:** This course will provide students with the understanding of the interaction of the parts of a system, and of the system as a whole. A unified approach to modeling of dynamic systems using computer simulation and model validation is used. Emphasis will be on modeling and simulation of mechanical parts and assemblies, electronic circuits, fluid power systems and PLC controlled automation systems. Technical writing skills and safety procedures will be implemented throughout the course. (Prerequisites: MECA 1131 Computer Applications.)

### Grading Method:
- [X] Grade  
- [ ] Pass/Fail

**Scheduling:**  
- Fall  
- Spring  
- Summer  
- Alternate Years  
- Variable  
- On Demand

**Instructional Type:**  
- Lecture: 2  
- Lab: 1  
- Lecture/Lab:  
- Internship  
- Seminar

**Class Maximum:** (For New Courses Only) / All Unlimited  
faculty members of a program or discipline must sign.

<table>
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<th>Faculty Name</th>
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**Dean’s Name:**  
Dr. Suzanne Nordblom

**Dean’s Signature**

If there is not enough space provided, please use the back of this form for additional signatures or click on a row with the right button of the mouse, select insert and then select insert rows below to add rows to the table.

**Is this Course Proposed as a Liberal Arts Course:**  
- Yes  
- No

If Yes, Which MnTC Area/Areas Will it Fulfill ([http://www.mntransfer.org](http://www.mntransfer.org))?  

**Is This Course a Requirement/Elective for a Specific Program or Programs:**  
- Yes  
- No

If Yes, Which Program(s)? Mechatronics Engineering Technology

Describe What is Changing/Being Added, and the Rationale: This course is being modified to modify some of the curricula to align with the recommendations of our industry partners. In addition, the prerequisite(s) have changed.

**What Impact Will This New Course or Change Have on Other Programs or Areas?**  
- None.

> Attach Common Course Outline to this Form.
Modeling and Simulation
Course Outcome Summary

Course Information
Organization: South Central College
Developers: Doug Laven/David Ewel
Development Date: 9/17/2010
Course Number: MECA 1270
Potential Hours of
Instruction: 64
Total Credits: 3

Description
This course will provide students with the understanding of the interaction of the parts of a system, and of
the system as a whole. A unified approach to modeling of dynamic systems using computer simulation
and model validation is used. Emphasis will be on modeling and simulation of mechanical parts and
assemblies, electronic circuits, fluid power systems and PLC controlled automation systems. Technical
writing skills and safety procedures will be implemented throughout the course. (Prerequisites: MECA
1131 Computer Applications)

Types of Instruction

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Prerequisites
MECA 1131 Computer Applications

Exit Learning Outcomes

Core Abilities
A. Intercultural knowledge and competence
B. Foundations and skills for lifelong learning
C. Teamwork and problem-solving
D. Demonstrate critical thinking and troubleshooting skills
E. Analysis and inquiry
F. Critical and creative thinking
G. Written and oral communication

Competencies
1. Understand the need for Workspace Safety

Learning Objectives
a. Review Lab Safety
b. Demonstrate Lab Safety
    c. Explain Safety Systems

2. **Explain Types of Simulation**
   **Learning Objectives**
   a. Explain Discrete and Continuous
   b. Identify Real-Time and Offline
   c. Explain Stochastic and Deterministic
   d. Demonstrate Modeling Techniques
   e. Explain Dynamics

3. **Discuss the Need of Simulation**
   **Learning Objectives**
   a. Study Complex Systems
   b. Identify Different Designs
   c. Evaluate the Effects of Variables

4. **Review the Advantages of Simulation**
   **Learning Objectives**
   a. Define Design-Build-Test-Redesign Cycle
   b. Explain Model Verification
   c. Demonstrate Redundancy Analysis

5. **Explain the Disadvantages of Simulation**
   **Learning Objectives**
   a. Explain Model Variation
   b. Use Simulation Software to Model Variation
   c. Interpret Simulation Results verses Production Build

6. **Obtain Working Knowledge of Data Gathering Techniques for a Design / Model**
   **Learning Objectives**
   a. Discuss Data Gathering
   b. Plot Data
   c. Present Data for Design / Model

7. **Obtain Working Knowledge of Solid Modeling Tools**
   **Learning Objectives**
   a. Identify Solid Modeling Basics
   b. Demonstrate Ability to Produce a Part Using Solid Modeling Software
   c. Demonstrate Ability to Produce an Assembly Using Solid Modeling Software
   d. Demonstrate Ability to Produce a Mechanical Drawing Using Solid Modeling Software
   e. Create 3D Model From Rapid Prototype Printer
   f. Evaluate 3D Model

8. **Obtain Working Knowledge of SPICE Software**
   **Learning Objectives**
   a. Explain What SPICE Stands For and Why It Is Used
   b. Demonstrate Ability to Produce a Model of an Analog Circuit
   c. Demonstrate Ability to Produce a Model of a Digital Circuit
   d. Verify SPICE Model

9. **Obtain Working Knowledge of Automation Simulation Software**
Learning Objectives
a. Demonstrate Ability to Produce Hydraulic Circuits
b. Demonstrate Ability to Produce Pneumatic Circuits
c. Demonstrate Ability to Produce a Simulation of an Automation System That Uses a PLC
d. Verify Results of Automation Simulations

10. Validate Model / Project Requirements
Learning Objectives
a. Identify Model / Project Validation
b. Demonstrate Validation Methods
c. Refine Model / Project
d. Document Model / Project Validation Results

11. Analyze Model / Project Data
Learning Objectives
a. Compare Model / Project to Design Plan
b. Generate Ideas to Improve on Model / Project Proto-type
c. Incorporate Model / Project Improvements
Appendix B

New Course or Course Change Proposal Form

Date of Proposal: April 9, 2012

Author: Jerry Soost

Proposal Type: New Course

Contact for the Course: Jerry Soost

Course Designator, Number and Title (i.e.: ACCT 1800, Business Law): MECA 2110 Sensors and Controls

Number of Credits: 3

Prerequisites: MECA 1120 or MECA 1122

Course Description: This course will provide students with the principles of measurement and control systems. The student will gain an understanding of different sensor technologies used to measure and detect physical properties used in a variety of electro mechanical, electro hydraulic and electro pneumatic systems. The student, through lab work, will also learn how to use and troubleshoot sensors used in open and closed loop control systems. Technical writing skills and safety procedures will be implemented throughout the course. This course assumes the student understands basic electrical, mechanical, and programming concepts. (Prerequisites: MECA 1120 or MECA 1122)

Grading Method: *Grade

Pass/Fail

Scheduling: *Fall Spring Summer Alternate Years Variable On Demand

Instructional Type: Lecture: 2 Lab: 1 Lecture/Lab Internship Seminar

*Class Maximum: (For New Courses Only) / All Unlimited faculty members of a program or discipline must sign.

Faculty Name | Faculty Signature | Class Max | Date
--- | --- | --- | ---
Jerry Soost | | 24 | 4/9/12
David Ewel | | 24 | 4/9/12
Doug Laven | | 24 | 4/9/12
Dean's Name | Dean's Signature | Date
Dr. Suzanne Nordblom | | 24 | 4/9/12

If there is not enough space provided, please use the back of this form for additional signatures or click on a row with the right button of the mouse, select insert and then select insert rows below to add rows to the table.

Is this Course Proposed as a Liberal Arts Course: Yes *No

If Yes, Which MnTC Area/ Areas Will it Fulfill (http://www.mntransfer.org)?

Is This Course a Requirement/Elective for a Specific Program or Programs? *Yes No

If Yes, Which Program(s)? Mechatronics

Describe What is Changing/ Being Added, and the Rationale: Reducing the prerequisites to better align with the requirements of the course.

What Impact Will This New Course or Change Have on Other Programs or Areas? None.

Attach Common Course Outline to this Form.
Sensors and Control
Common Course Outline

Course Information
Organization South Central College
Developers David Ewel and Doug Laven
Development Date 3/18/2010
Course Number MECA 2110
Potential Hours of Instruction 64
Total Credits 3

Description
This course will provide students with the principles of measurement and control systems. The student will gain an understanding of different sensor technologies used to measure and detect physical properties used in a variety of electro mechanical, electro hydraulic and electro pneumatic systems. The student, through lab work, will also learn how to use and troubleshoot sensors used in open and closed loop control systems. Technical writing skills and safety procedures will be implemented throughout the course. This course assumes the student understands basic electrical, mechanical, and programming concepts. Prerequisites: MECA 1120 or MECA 1122.

Types of Instruction

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Prerequisites
MECA 1120 or MECA 1122

Exit Learning Outcomes
Institutional Core Competencies
A. Intercultural knowledge and competence
B. Foundations and skills for lifelong learning
C. Teamwork and problem-solving
D. Analysis and inquiry
E. Critical and creative thinking
F. Written and oral communication

Competencies
1. Explain Measurement Tools
   Learning Objectives
   a. Explain tools used to obtain dimensional measurements
   b. Explain diameter and roundness measurements
   c. Explain tools used to measure physical location
d. Explain tools used to measure hardness
e. Obtain an understanding of the performance specifications used in measurement tools and sensors
f. Attain ability to use tools

2. **Explain Position Sensors and Switches**
   **Learning Objectives**
   a. Explain the physical principles used to measure position
   b. Explain potentiometers
   c. Explain Linear Variable Differential Transformers (LVDT)
   d. Explain magnetostrictive devices
   e. Explain Hall effect devices
   f. Explain the use of rotary position sensors

3. **Construct Open and Closed Loop Position Controls**
   **Learning Objectives**
   a. Attain an understanding of when to apply closed loop control
   b. Attain an ability to tune a PID control loop
   c. Attain an understanding of closed loop control stability
   d. Compare the performance differences between the open loop and closed loop system

4. **Explain Velocity Sensors**
   **Learning Objectives**
   a. Explain the physical properties used in velocity control
   b. Explain the use of Variable Reluctance speed sensors
   c. Explain the use of Hall effect speed sensors

5. **Construct Open and Closed Loop Velocity Controls**
   **Learning Objectives**
   a. Attain an understanding of open and closed loop velocity control
   b. Identify how errors in the velocity control loop are generated
   c. Compare the performance differences between the open loop and closed loop system

6. **Explain Accelerometer Sensors**
   **Learning Objectives**
   a. Explain the physical properties used to measure acceleration
   b. Explain strain gauges

7. **Explain Load Cells**
   **Learning Objectives**
   a. Explain the physical properties used to measure force
   b. Examine how a load cell is manufactured
   c. Attain an ability to install and use a strain gauge

8. **Construct Open and Closed Loop Force Controls**
   **Learning Objectives**
   a. Attain an understanding of how to control force
   b. Explain the limitations associated with this type of control
   c. Create a means to weigh an item using strain gauges
   d. Compare the performance differences between the open loop and closed loop system

9. **Explain Pressure Sensors and Switches**
Learning Objectives
a. Explain the physical properties used in pressure sensors and switches
b. Calibrate a pressure transducer to understand calibration techniques

10. Construct Open and Closed Loop Pressure Controls
Learning Objectives
a. Create a open loop pressure control
b. Create a closed loop pressure control
c. Compare the performance differences between the open loop and closed loop system

11. Explain Vision Systems
Learning Objectives
a. Explain vision system uses
b. Attain an understanding of vision system performance
c. Acknowledge vision system limitations
d. Qualify performance through set-up and calibration

12. Explain Temperature Sensors
Learning Objectives
a. Explain the physical principles use to measure temperature
b. Identify temperature sensor uses
c. Identify temperature sensor measurement devices
d. Calibrate temperature sensor

13. Explain Current Sensors and Control
Learning Objectives
a. Explain the physical principles use to measure current
b. Monitor current using sensor

14. Identify calibration techniques for sensors and measuring tools
Learning Objectives
a. Review the Standards used by the National Institute of Standards and Technology (NIST)
b. Review the NIST Calibration Program

15. Discuss Variety of Other Sensors Used to Measure Physical Properties
Learning Objectives
a. Explain the use of Gauss Meters to measure magnetic field
b. Explain Surface Texture measurement tools
c. Explain Flow Meters
d. Explore vibration with the use of sound and strobe light
Appendix B

New Course or Course Change Proposal Form

Date of Proposal: April 9, 2012

Author: Doug Laven / David Ewel

Proposal Type: New Course  *Modify Course  Delete Course

Contact for the Course: David Ewel

Course Designator, Number and Title: MECA 2120 Pneumatics Systems

Number of Credits: 3

Prerequisites: None

Course Description: This course provides the basics of pneumatically operated devices and systems found in modern industrial machinery and automation. Topics include proper safety procedures, basic laws of fluid mechanics, standard symbols, pumps, control valves, control assemblies, actuators, maintenance procedures, and switching and control devices. At the completion of this course, the student will be able to apply basic laws of fluid mechanics to design and specify characteristics of a pneumatic system; select and size actuators and control valves, and match the pneumatic components with its ANSI symbol. Upon completion of this course, the student should be able to identify long-term symptoms associated with a lack of preventive maintenance of pneumatic components while demonstrating good safety practices including lock out procedures. Technical writing skills and safety procedures will be implemented throughout the course. (Prerequisites: none)

Grading Method: *Grade  Pass/Fail

Scheduling: *Fall  Spring  Summer  Alternate Years  Variable  On Demand

Instructional Type: Lecture: 2  Lab: 1  Lecture/Lab:  Internship  Seminar

*Class Maximum: (For New Courses Only) / All Unlimited faculty members of a program or discipline must sign.

Faculty Name  Faculty Signature  Class Max  Date
Doug Laven  24
David Ewel  24

Dean's Name  Dean's Signature  Date
Dr. Suzanne Nordbloom

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Is this Course Proposed as a Liberal Arts Course: Yes  *No

If Yes, Which MnTC Area/Areas Will it Fulfill (http://www.mntransfer.org)?

Is This Course a Requirement/Elective for a Specific Program or Programs? *Yes  No

If Yes, Which Program(s)? Mechatronics Engineering Technology

Describe What is Changing/Being Added, and the Rationale: This course is being modified to change the prerequisite(s).

What Impact Will This New Course or Change Have on Other Programs or Areas? None.

* Attach Common Course Outline to this Form.
Pneumatic Systems
Course Outcome Summary

Course Information
Organization: South Central College
Developers: Doug Laven
Development Date: 3/11/2010
Course Number: MECA 2120
Potential Hours of Instruction: 64
Total Credits: 3

Description
This course provides the basics of pneumatically operated devices and systems found in modern industrial machinery and automation. Topics include proper safety procedures, basic laws of fluid mechanics, standard symbols, pumps, control valves, control assemblies, actuators, maintenance procedures, and switching and control devices. At the completion of this course, the student will be able to apply basic laws of fluid mechanics to design and specify characteristics of a pneumatic system; select and size actuators and control valves, and match the pneumatic components with its ANSI symbol. Upon completion of this course, the student should be able to identify long-term symptoms associated with a lack of preventive maintenance of pneumatic components while demonstrating good safety practices including lock out procedures. Technical writing skills and safety procedures will be implemented throughout the course.

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Prerequisites
None.

Exit Learning Outcomes
Core Abilities
A. Intercultural knowledge and competence
B. Foundations and skills for lifelong learning
C. Teamwork and problem-solving
D. Demonstrate critical thinking and troubleshooting skills
E. Analysis and inquiry
F. Critical and creative thinking
G. Written and oral communication

Competencies
1. Describe Principles of Pneumatics
Learning Objectives
a. Discuss Fluid Power Systems
b. Recognize Pneumatic Systems
c. Analyze Force, Weight and Mass
d. Identify Pressure and Air Properties
e. Describe Work and Energy

2. Illustrate Pneumatics Logic Schematics
   Learning Objectives
   a. Identify Basic Logic Elements
   b. Create Pneumatic Symbol Library
   c. Draw Air Logic Schematic

3. Define Compressors
   Learning Objectives
   a. Explain Compressor Operation
   b. Describe the Various Compressor Types
   c. Identify Lubrication and Non-Lubrication

4. Explain Primary Air Treatment
   Learning Objectives
   a. Explain Air Treatment
   b. Characterize Preliminary Filtering
   c. Identify the Effect of Moisture and Air Dryers
   d. Install Dry and Wet Filter

5. Explain Air Flow Rate
   Learning Objectives
   a. Discuss Air Flow Rate and Give its Units of Measurement
   b. Incorporate Safety
   c. Describe the Operation of a Flow Meter and give an Application
   d. Demonstrate a Flow Meter Application
   e. Explain the Operation of Exhaust Port Speed Control
   f. Explain the Operation of a Pressure Port Speed Control

6. Implement Piping, Hoses and Tubing
   Learning Objectives
   a. Identify Piping and Tubing Requirements
   b. Identify Hoses and Hose Fittings
   c. Configure a Compressed-Air Piping System

7. Integrate Control Valves
   Learning Objectives
   a. Identify Control Valves
   b. Demonstrate Manually and Automatically Operated Valves
   c. Explain Control Valve Elements
   d. Explain Pressure-Control Valves

8. Identify Cylinders
   Learning Objectives
   a. Identify Pneumatic Cylinders
   b. Demonstrate Single-Acting Cylinders
c. Demonstrate Double-Acting Cylinders
d. Demonstrate Cushioning
e. Explain Cylinder Selection

9. Explain Pneumatic Motors
   Learning Objectives
   a. Explain Pneumatic Motors
   b. Incorporate Safety
   c. Review Pneumatic Motor Construction
   d. Utilize Pneumatic Motors in a Compressed-Air System

10. Display Pneumatic System Maintenance
    Learning Objectives
    a. Identify Maintenance Schedule
    b. Create Parts List
    c. Demonstrate Trouble-shooting Practices

11. Define Vacuum Power Systems
    Learning Objectives
    a. Identify Principles of Vacuum Power
    b. Describe Vacuum Pump Basic Operation
    c. Use Vacuum Regulation and Filtering
    d. Demonstrate Linear and Rotary Motion with Vacuum
    e. Explain Venturi Vacuum Generator Principals
Appendix B

New Course or Course Change Proposal Form

Date of Proposal: March 27, 2012
Author: Doug Laven / David Ewel

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Course Designator, Number and Title: MECA 2235 Robotics & Industrial Automation
Number of Credits: 3

Prerequisites: MECA 2110 Sensors and Controls, MECA 1230 Modeling and Simulation and MECA 2150 Mechatronic System Operation II

Course Description: This course will provide students with the principles of programming and control of automated systems, closed-loop control systems and multi-axis robotic systems used in an industrial environment. The student will gain the ability to program and implement various types of automated machine systems, integrate actuators and sensors commonly found in automated systems, and setup an automated robotic work cell. The student will also perform fundamental automated system troubleshooting procedures. Technical writing skills and safety procedures will be implemented throughout the course. This course builds on the student's understanding of basic electrical, mechanical, pneumatic, and programming concepts.

(Prerequisites: MECA 2110 Sensors and Controls, MECA 1230 Modeling and Simulation and MECA 2150 Mechatronic System Operation II).

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Dean's Name: Dr. Suzanne Nordblom

Date

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Is this Course Proposed as a Liberal Arts Course: Yes *No

If Yes, Which MnTC Area/Areas Will it Fulfill (http://www.mntransfer.org)?

Is This Course a Requirement/Elective for a Specific Program or Programs? *Yes No

If Yes, Which Program(s)? Mechatronics Engineering Technology

Describe What is Changing/Being Added, and the Rationale: This course is being modified to reduce the credit hours from 4 to 3. Some of the curricula will be transferred from the 4 credit hour version of this course to MECA 2110 Sensors and Controls.

What Impact Will This New Course or Change Have on Other Programs or Areas? None.
Robots & Industrial Automation
Course Outcome Summary

Course Information
Organization: South Central College
Developers: Doug Laven/ David Ewel
Development Date: 8/17/2010
Course Number: MECA 2235
Potential Hours of Instruction: 64
Total Credits: 3

Description
This course will provide students with the principles of programming and control of automated systems, closed-loop control systems and multi-axis robotic systems used in an industrial environment. The student will gain the ability to program and implement various types of automated machine systems, integrate actuators and sensors commonly found in automated systems, and setup an automated robotic work cell. The student will also perform fundamental automated system troubleshooting procedures. Technical writing skills and safety procedures will be implemented throughout the course. This course builds on the student’s understanding of basic electrical, mechanical, pneumatic, and programming concepts. (Prerequisites: MECA 2110 Sensors and Controls, MECA 1230 Modeling & Simulation and MECA 2150 Mechatronics System Operation II).

Types of Instruction
Instruction Type | Contact Hours | Credits
--- | --- | ---
Classroom Presentation | 32 | 2
On-Campus Lab | 32 | 1

Prerequisites
MECA 2110 Sensors and Controls
MECA 1230 Modeling and Simulation
MECA 2150 Mechatronic System Operation II

Exit Learning Outcomes
Core Abilities
A. Intercultural knowledge and competence
B. Foundations and skills for lifelong learning
C. Teamwork and problem-solving
D. Demonstrate critical thinking and troubleshooting skills
E. Analysis and inquiry
F. Critical and creative thinking
G. Written and oral communication

Competencies
1. Determine the need for Workspace Safety
Learning Objectives
a. Review Lab Safety
b. Demonstrate Lab Safety
c. Discuss Industrial Safeguards and Guarding Methods
d. Explain Lock-Out Tag-Out
e. Demonstrate Redundant Safety System

2. Discuss Basic Robotic Systems
Learning Objectives
a. Identify and Recognize Robotic Specifications
b. Discuss Difference between Robot and Automated Machinery
c. Explain Robot Classifications
d. Identify Basic Components
e. Define Terms Commonly Used With Robotic Technology
f. Identify 5 Characteristics That Determine Robot Classification
g. Identify Robot Classification by Arm Geometry

3. Acquire an Understanding of Effectors and Manipulation
Learning Objectives
a. Define an effector
b. Determine the two basic purposes of effectors
c. Define an actuator
d. Describe what types of actuation is used in robotics
e. Determine the difference between active and passive actuation
f. Determine what backlash is and its effect on robotic performance
g. Define what a servo motor is and explain why they are used in robots
h. Define degree of freedom (DOF)
i. Evaluate how the controllable DOF compares to the total DOF in a system
j. Define holonomic, nonholonomic and redundant mechanisms
k. Define a robotic manipulator
l. Differentiate between an end-effector and a manipulator
m. Explain teleoperation
n. Determine the meaning of kinematics and reverse kinematics
o. Explain the different type of joints used in robotics
p. Discuss why manipulation is so hard to accomplish
q. Determine the meaning of dynamics

4. Review Sensors Used In Industrial Robots
Learning Objectives
a. Define Transducer
b. Determine How a Linear Variable Differential Transformer (LVDT) Works
c. Explain how a Magnetostrictive Transducer Works
d. Discuss Gray Coding of Incremental Encoders
e. Explain Hall Effect and Its Use in Transducers
f. Explain What A Resolver Is and How It Works
g. Discuss Speed Sensors
h. Examine Strain Gauge Technology and Transducers That Use It
i. Discuss The Coriolis Effect and Yaw Rate Sensors
j. Discuss Pressure Transducers and Pressure Switches
k. Discuss Flow Meters and Fluid Level Sensors
l. Explain the difference between Thermocouple, RTD and Thermistor Temperature Sensors
m. Acquire an Understanding of Repeatability
n. Acquire an Understanding of Precision
o. Acquire an Understanding of Accuracy

5. Discuss Control Loop Characteristics
   Learning Objectives
   a. Define Closed Loop Control
   b. Determine the advantages of Closed Loop Control
   c. Define Nomenclature Used in Feedback Control
   d. Examine the Step Response of 1st Order Systems
   e. Examine the Step Response of 2nd Order Systems
   f. Define Damping Ratio of 2nd Order Systems
   g. Explain PID Control Systems
   h. Discuss Feedforward Control

6. Explain Types of Control Strategies Used in Autonomous Robots
   Learning Objectives
   a. Define Representation as Applied to Robotics
   b. Discuss Reactive Control
   c. Discuss Deliberative Control
   d. Discuss Hybrid Control
   e. Discuss Behavior Based Control

7. Obtain a Working Knowledge of Robotic Programming
   Learning Objectives
   a. Explain How A Typical Robot Teach Box Works
   b. Define Relative Commands vs. Absolute Commands
   c. Explain How To Program Places
   d. Explain The Usage of Objects
   e. Describe Timers and Their Use
   f. Explain How To Programming Routes
   g. Discuss Programming Using Cartesian Routes
   h. Discuss "Lead-by-the-nose" Programming Method
   i. Develop Programs for Several Different Types of Robots

8. Discuss the Fundamentals of Control Loops
   Learning Objectives
   a. Obtain an understanding of terms often used in association with control loops.
   b. Identify control loop sensors and their characteristics
   c. Discuss controllers, recorders and signal conditioners commonly used in control loops
   d. Identify common control loop applications
   e. Discuss the modes used in PID control and their characteristics

9. Explain Advanced Control Methods
   Learning Objectives
a. Obtain an understanding of cascade control
b. Obtain an understanding of feedforward control
c. Obtain an understanding of ratio control
d. Obtain an understanding of multivariable control

10. **Discuss Loop Dynamics**

   **Learning Objectives**
   a. Explain Loop Dynamics
   b. Identify the effects of process lag time
   c. Identify ways to compensate for dead time
   d. Discuss higher-order delay lags
   e. Obtain an understanding of controller tuning for increased response and stability
   f. Discuss gain and phase shift of dynamic systems

11. **Explain Loop Protection**

   **Learning Objectives**
   a. Discuss loop protection in hazardous areas
   b. Discuss the three classes of hazardous environments as identified by the National Electrical Code
   c. Identify the requirements of explosion-proof enclosures
   d. Determine what constitutes an intrinsically safe system
   e. Discuss fail-safe mechanisms and their application

12. **Obtain a Working Knowledge of Control System Troubleshooting**

   **Learning Objectives**
   a. Diagnose and Correct Power Problems
   b. Diagnose and Correct Wiring Problems
   c. Diagnose and Correct Sensor Problems
   d. Diagnose and Correct Actuation Problems
   e. Diagnose and Correct Controller Problems
   f. Diagnose and Correct Network Problems
   g. Diagnose and Correct System Adjustment Problems