Lansing Community College

Course Cover Sheet

M-CAM Training Area:
☐CNC/Machining ☒Multi-Skilled Mechatronics ☐Production Operation ☐Welding/Fabrications

Program(s): Intro to Mechatronics Block 1-3

Course: Controls and Instrumentation

Course Description: This course introduces how to troubleshoot/replace/install circuit boards, sensors, and photoeyes. Participants will learn how loop tuning will assure quality standards and what different modes of control have on maintaining process quality.

Participants will become proficient in troubleshooting motors and variable speed drives, interpreting relay logic, interpreting relay logic and sizing of components for various applications.

Delivery method is hybrid, open entry/open exit.

Date Created: January, 2017

Employer/Industry Partner: Magna/DexSys, Lansing, Michigan and various manufacturing companies in Mid-Michigan.

Faculty Developer(s)/Instructional Designers(s): Sean Hickman/Ann Lapo

College Contact: Jill Doederlein

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Additional Information/Comments: Due to the increased need to offer a flexible delivery format to meet the needs of students'/workers' busy schedules, LCC partnered with AMTEC (Automotive Manufacturing Technical Education Collaborative) led by Kentucky Community Technical College to offer open entry open exit modular courses in a hybrid format (lessons online and hands-on labs with an instructor on campus). LCC instructors added content based on the needs of local industry.

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DESCRIPTION:
This course introduces how to troubleshoot/replace/install circuit boards, sensors, and photoeyes. Participants will learn how loop tuning will assure quality standards and what different modes of control have on maintaining process quality.

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TOTAL TIME REQUIREMENT for the course is approximately 100 hours.

PREREQUISITES: Reading Level 4. Writing Level 4. Math Level 5. All Introduction to Mechatronics Block 1 courses (Safety, Computer Literacy, Print Reading, Machine Tool Operations, Welding) or equivalent. Knowledge of Basic Electricity is helpful.

OBJECTIVES: (for a complete list of objectives, see each module)
After completing this course, the student should be able to:

- Describe the various steps of the SIMPLER troubleshooting method techniques and other faulty troubleshooting methods.
- Define the following terms related to Controls and Instrumentation: Noise, Black Box, Opens, Shorts, Fuse Puller, Intermittent Fault, and Oxidation.
- Perform Troubleshooting procedures using voltmeters, ammeters, ohmmeters, and oscilloscopes.
- Perform fundamental troubleshooting on the following components to determine if they are defective: switches, fuses, inductors, capacitors, transformers.
- Describe how static electricity is formed and how it destroys instruments as a charged body discharges.
- Describe the visual appearance of a good and bad solder connection.
- List the advantages and disadvantages of proximity sensors.
- Describe the difference between visible and infrared LEDs.
- Explain how the different types of timing adjustments affect the operation of optical sensors.
- Describe the operation and application of reed switches.
- Describe what happens to the oscillator of an inductive and capacitive proximity detector when it senses a target.
- Convert psia to psig and psig to psia.
- Explain the Law of Thermodynamics.
- Define BTU and calorie and explain how they relate to temperature.
- Describe the principle of operation for the following temperature measurement instruments: Thermocouple, Resistance Temperature Detector (RTD), Thermistor Radiation Thermometry Devices.
- Describe volumetric flow rate, flow velocity, and mass flow rate, and explain the difference between them.
- Describe the operation of a pH analyzer and a chilled-mirror.

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OBJECTIVES: *(continued)*

- Define the following common industrial control systems terms: Servomechanisms, Motion Control, Batch Process Control, Continuous Process Control, Feedback, Sequential Process.
- List the elements of a closed-loop system on a P&ID and describe the types of operational characteristics the system provides based on a drawing.
- Identify the following elements in a closed-loop system: Primary element, Control valve, Controller, Heat exchanger, Sensor, Feedback loop, Actuator, Transducer, Transmitter.
- Identify how the proportional, integral, and derivative modes are affected by certain conditions in a closed loop system, and how they respond to them.
- Describe the Ziegler-Nichols Continuous Cycling Method used for tuning a controller.
- Identify the mode in which the controller is set (manual or automatic) when performing the process identification procedure and the ¼ decay ratio reaction curve verification method, and whether the controller is open or closed-loop.
- Describe the differences between motion and process control manufacturing equipment.
- Describe the types of linear signals produced by a tachometer to indicate velocity and direction.
- Provide information from the following list regarding absolute encoder.
    - Effects from power loss.
    - Characteristics of the Gray code.
    - Converting Gray to binary on paper and by using logic gates.
    - Converting binary to Gray on paper and by using logic gates.
    - Pattern of the optical tracks on a Gray code wheel.
    - Types of measurements it makes.
    - Resolution.
- Analyze and explain the operation of a closed-loop velocity system.
- Analyze and explain the operation of a closed-loop position system.
- Describe the difference between conventional DC motors, servo motors, and stepper motors.
- Explain how CEMF affect armature current, magnetic field strength, speed, and the torque of a DC motor as load conditions change.
- Describe the operation of a squirrel cage induction motor.
- Given the number of poles and the frequency applied to the stator windings, determine the synchronous speed of an AC motor.
- Given the applied frequency and the rotor speed, determine the slip of an AC induction motor.
- Explain the difference between overload current and short circuit current, and what causes them to develop.
- Describe the operation of fuses in a motor starter circuit and the conditions that cause them to blow.
- Explain how arcing is created when power is removed, and how they are suppressed using arc chutes.
- List the reasons for using motor starters.

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106 Control and Instrumentation consists of four modules:

1061 – Controls and Instrumentation Fundamentals (3 lessons to read on your own, 2 labs to do at the College with an instructor, 10 total hours)
The purpose of this module is to teach the student how to troubleshoot/replace/install circuit boards.

1062 – Sensors and Photoeyes (5 lessons to read on your own, 12 labs to do at the College with an instructor, 16 total hours)
The purpose of this module is to introduce students to photoeyes, limit switches, proximity switches and other common input devices in regards to installation, maintenance and troubleshooting.

1063 – Calibration and Loop Tuning (5 lessons to read on your own, 7 labs to do at the College with an instructor, 12 total hours)
The purpose of this module is to introduce students to the modes of control: on-off, proportional, integral, and derivative; the affect each mode has on maintaining the process quality; how loop tuning will assure that the process will meet quality standards efficiently and maintain the standards.

1064 – Final Control Elements (5 lessons to read on your own, 11 labs to do at the College with an instructor, 12 total hours)
Students will become proficient in troubleshooting motors and variable speed drives, adjusting speed and direction; interpreting relay logic and sizing of components for various applications.

MATERIALS:
Online portion of the class:
Software: Internet access, Web browser, word-processing software, Adobe Reader, up-to-date virus protection for the online portion of this course.

- Go to elearning.autoworkforce.org – modules 1061, 1062, 1063, 1064 to access the lessons, labs specifications and assessments for this course.

Hands-on labs portion of the class:
- Tools and equipment specified in the Resources section—per module — for each hands-on lab.

AMT 1061: Fundamentals of Controls & Instrumentation
Lab 1: Troubleshooting a Power Supply
120 volt AC Power
Customized Power Supply Printed Circuit Boards
Oscilloscope
Voltmeter

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MATERIALS: *(continued)*

1061 (continued)

Lab 2: Soldering
Soldering iron (with holder and sponge)
Solder
10 and 12 gauge wire with vinyl insulation
12 gauge wire with varnish insulation
12 gauge Stranded wires
Wire Terminal
Blank Printed Circuit Board
Resistor ½ watt
Pulley (2 ½ inch diameter)
De-soldering Tool
Knife
Sandpaper

AMT 1062: Sensors & Photoeyes
Lab 1: Inductive Proximity Sensor
Allen-Bradley inductive proximity sensor 871TM-DH5NP18-H2
Variable 0-30 volt DC power supply
DC motor with a gear attached to its shaft
Oscilloscope
Connector cables
5.6KΩ resistor
1/4-inch diameter ferrous metal rod 3 inches long
2" X 2" X 3/8" pieces of the following materials:
Soft Steel
Brass
Glass
Aluminum
Plastic
Magnet
De-soldering Tool
Knife
Sandpaper

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MATERIALS: *(continued)*

1062 (continued)

Lab 2: Capacitive Proximity Sensor
Allen-Bradley capacitive proximity sensor 875CM10NP30D4
+24v DC power supply
2" × 2" × 3/8" sample of the following materials:
soft steel
brass
glass
plastic
Glass jar 8 inches tall, half-filled with water
Plastic container 2" high and 1 1/2" in diameter
Plastic container 2" high and 2 1/2" in diameter
Typing paper and pencil
Small slotted screwdriver
Lab 3: Hall-Effect Sensor
Hall-effect sensor - ZH10 Invensys Sensor Systems
DC power supply +24 volt
10KΩ Resistor
Typing paper
Small bar magnet
Large bar magnet
2 - Soft iron Concentrator, (1/2" in diameter, 3/8" long)
DC Voltmeter (analog recommended)

Lab 4: Retro-Reflective Optical Sensing
+ 24 Volt DC power supply
Allen-Bradley retro reflective sensor 42GRU-9000-QD
Allen-Bradley 3 inch diameter reflector 9239
Protractor
4" × 6" mirror
2' × 1' sheet of white poster board, a pencil and an eraser
3" diameter reflector tape
6" × 6" cardboard with 3/4-inch diameter hole
4" × 6" flat (non-glossy) black cardboard
4" × 6" sheet metal
4" × 6" Plexiglas
Small slotted screwdriver

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MATERIALS: *(continued)*

1062 (continued)

Lab 5: Thru-Beam Optical Sensors
+24v DC power supply
Allen Bradley opposed optical sensor emitter 42 GRL-9000-QD
Allen Bradley opposed optical sensor detector 42 GRR-9000-QD
Connection cables
Several sheets of white typing paper
3 Wooden dowels, 8 inches long, 1/8, 1/4, and 1/2 inches in diameter
Lab 6: Pressure Readings with a Manometer
Regulated variable air pressure supply, 0-30psi
(2) In-line pressure regulators—Control Air Inc., Type 700BD-B, 0-30psi
(2) Air pressure gauges—Omega Engineering Inc. 0-30psi, PGS-25B-30
Manometer, Dwyer 12-W/M
1/4-inch flexible tubing, various lengths
Various 1/4 inch tees and plugs for hose connections
Lab 7: Thermistor
Dual voltage DC power supply
741 IC operational amplifier
Thermistor
47 light bulb with socket
47 Ω resistor
1KΩ resistor
2.7KΩ resistor
(2) 10KΩ resistors
200KΩ resistor
SCR - S4006L
SPST switch
Decade resistance box
Multimeter

Lab 8: Resistance Temperature Detector (RTD)
Thermometer
RTD Probe, 100 Ω platinum, alpha 385, Sensor Tec Inc.
(1) Coffee pot
Ohmmeter

Old metal coffee pot
Dewar flask or pot (1 Qt) with ice and water

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MATERIALS: *(continued)*

1062 (continued)

Lab 9: Thermocouple Sensor
Type J thermocouple probe, Sensor Tec Inc.
(2) Sets of Type J thermocouple couplers and extension wire
Wire nut
Coffee pot
Dewar flask or 1 Quart pot
Ice and water
Thermometer
Voltmeter
Lab 10: Purge Level Measurement Method
Newport panel meter - Model 205E
P/I transmitter Dwyer 604MS - 151
60" graduated beaker
0-20 psi air pressure supply line
Pressure regulator, Control Air Inc., Type 700BA-B, 0-2psi,
Pressure gauge, Dwyer P/N 2-50-60 (0 - 50 inches H 2 O)
DC power supply (+24 Volt)
Milliammeter
1/4 inch plastic flexible tubing and tee connections
Lab 11: pH Measurements
pH meter
(2) Eyedroppers
(2) Watch glasses
Red litmus
Blue litmus
Plastic medicine bottle
Container A - HCl, 8.55ml/L for .IN
Container B - NaOH, 40g F.W., 4.0g/L for .IN
Container C - pH7 buffer with distilled water
Container D - .5G citric acid per liter
Container E - 1.5 g of baking soda per liter
Lab 12: Humidity Measurements
Dew Point Apparatus
Rubbing Alcohol

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MATERIALS: *(continued)*

AMT 1063: Calibration & Loop Tuning
Lab 1: Tachometer Velocity Stabilization
Digiac Model 711 DC Servo Controller (or equivalent)
Multimeter
Lab 2: Time Proportioning DC Control Circuit
DC power supply 15 V
Two Channel oscilloscope
Signal generator (saw tooth 10 V p-p)
DC voltmeter
Op amp IC - LM311
(2) 5.1v zener diodes
2.5v zener diode
(2) 1KΩ resistors
10KΩ potentiometer
Lab 3: Open-Loop Position System
Model 711 DC Servo Controller (or Equivalent)
Multimeter
Lab 4: Closed-Loop Position System
Model 711 DC Servo Controller (or Equivalent)
Multimeter
Lab 5: Instrument Calibration Procedure
DC power supply 0-24 volts
Voltage-to-Current transmitter (0-10 volt, 4-to-20mA), JH Technology, Model JH200
DC Ammeter
Multi-turn potentiometer (5-turn)
Pulley (2 ½ inch diameter)
String (20") with 1/10 pound weight and float
Connection wires
2 gallon fish tank
Ruler (inch scale)
Lab 6: Tuning a Controller
Simulation Software, OR
Actual Closed Process with a Controller
Lab 7: P&ID Drawings
Reference book on P&ID symbols
Paper, pencil straight edge, and template, **OR**
CAD software (optional)

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MATERIALS: *(continued)*

AMT 1064: Final Control Elements
Lab 1: Incremental Encoders
Incremental Encoder, Dynapar Model E1110240200 (Alternative Encoder - Inertial/Friction Load Unit [Lab Volt 9320])
+5 VDC power supply
(8) 68Ω resistors
(8) LEDs
SPDT switch
0.1 mfd capacitor
7400 quad NAND gate IC
7404 inverter IC
(2) 74193 IC Synchronous up/down counters
74121 One-shot IC
Lab 2: Absolute Encoder
Dynapar absolute gray code wheel, A2510240100 (Alternative Encoder - Digiac Model 711 DC Servo Controller)
+5v DC Power Supply
(8) LEDs
(8) 68Ω resistors
7486 logic IC (Exclusive Or gate)
7404 logic IC (Inverter)
(3) 7476 logic ICs (JK-flip-flops)
TTL logic data manual (for IC pin layout reference)
Signal generator (TTL Output)
Lab 3: Feedback Tachometer
Digiac 711 DC Servo Controller
Multimeter
Lab 4: DC Shunt Motor
DC Shunt Motor
DC Generator
DC Power Supply
Dynamometer
(3) Multimeters
Connecting Cables
Tachometer

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MATERIALS: *(continued)*

1064 (continued)

Lab 5: Stepper Motor
1 Power Supply 0 – 24V DC at 1 Ampere and 5V DC at 1 Ampere
1 DMM
1 6-lead Unipolar Stepper Motor (PH265M-33B or equivalent)
X Miscellaneous components
1 5804 Stepper motor translator/driver
1 TIP 120 NPN Darlington Transistor
1 Protoboard and connecting wire
X Power Supply and Multimeter user manuals or pdf files.
Lab 6: DC Series Motor
DC Series Motor
DC Generator
DC Power Supply
Dynamometer
(2) Multimeters
Connecting Cables
Tachometer
Lab 7: DC Compound Motor
DC Compound Motor
DC Generator
DC Power Supply
Dynamometer
(3) Multimeters
Connecting Cables
Tachometer

Lab 8: Single-Phase Capacitor Start AC Motor
Capacitor Start Motor
DC Generator
AC Power Supply
SPST Switch with high current capabilities
Dynamometer
(1) Multimeter
AC Clamp-on Ammeter
Connecting Cables
Tachometer

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MATERIALS: *(continued)*

1064 (continued)

Lab 9: Squirrel Cage Induction Motor
Squirrel Cage Induction Motor
DC Generator
Dynamometer
3-Phase AC Power Supply Module (208V 3 F)
(4) AC Multimeters
Tachometer
Connection Leads
Lab 10: AC Variable Frequency Drives
AC Variable Frequency Drive
Human Interface Module (HMI)
Three-Phase Motor
DC Generator
Dynamometer
VFD Manual
N.O. Start Pushbutton
N.C. Stop Pushbutton
Selector Switch
Lab 11: Motor Starters
Panel box
Magnetic motor starter Module
Polyphase induction motor
AC power supply
N.O. and N.C. Pushbuttons
Line Fuses for Three phase power
Wires (#18 White, #18 Red)
Wire Labels with Number ID tags
Tie wraps

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GRADING POLICY:

- Successful completion of all Labs (at least 80% recommended). Rubrics provided in AMTEC online specify how grading is determined.
- Successful completion of each module's post-assessment (at least 80% recommended).

College Grading Standards	Percent
4.0 Excellent	91-100%
3.5	86-90%
3.0 Good	81-85%
2.5	76-80%
2.0 Satisfactory	71-75%
1.5	66-70%
1.0	60-65%
0.0	0-59%

ACCEPTABLE USE POLICY:

Computer Resources

Use of College-owned computer resources is a privilege extended by the College to students, employees, and other authorized users as a tool to promote the mission of the College. All users agree to be bound by the terms and conditions of the LCC Acceptable Use Policy at the time they complete an account application form. Copies of the LCC Acceptable Use Policy are available at the Library Circulation Desk and may also be accessed on the World Wide Web. The URL is http://www.lcc.edu/policy/policies_1.aspx#ACCEPTABLE_USE_POLICY

Transfer Potential

For transferability information, please consult the Transfer Equivalency Information located at the LCC website at http://www.lcc.edu/transfer. For additional transferability information, contact the LCC Academic Advising Center, (517) 483-1904.

The MACRAO Transfer Agreement simplifies the transfer of students from one Michigan institution to another. The most current MACRAO Transfer Agreement information can be found at http://www.lcc.edu/transfer/macrao_agreement.aspx.

Student Code of Conduct and General Rules and Guidelines

LCC supports a positive educational environment that will benefit student success. In order to ensure this vision, the College has established the LCC Student Code of Conduct and the Student General Rules and Guidelines to ensure the protection of student rights and the health and safety of the College community, as well as to support the efficient operation of College programs. In addition, the College has established guidelines for the redress of grievances by individuals accused in such proceedings. A copy of the most current Code can be found on the College's website at http://www.lcc.edu/catalog/policies_procedures/studentrulesguidelines.aspx#code.

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Subject Matter Expert (SME) Course Review Summary
College: Lansing Community College
M-CAM Training Area: ☐CNC/Machining ☒Multi-Skilled/Mechatronics ☐Production Operation ☐Welding/Fabrication
Degree Program Name:
Title of Course: Mechatronics Controls and Instrumentation
Subject Matter Expert (SME) Reviewer Information **Name: Robert C. Hess** **Title: Senior Instructional Designer/Trainer** **Phone: 566-322-1033** **Email: bob.hess@mhtechnologies.net** **Organization/Affiliation: MH Technologies**
Attach Resume or provide credentials (showing years of experience and work experience that is relevant to course content):
Synopsis of Findings: **1. All labs good for training.**

Reviewers Signature Robert C. Hess Date: 3/8/17

Michigan Coalition for Advanced Manufacturing
Subject Matter Expert Course Review

1. Course Overview and Objectives	Exceptional	Satisfactory	Ineffective
The goals and purpose of the course is clearly stated.		X	
Prerequisites and/or any required competencies are clearly stated.		X	
Learning objectives are specific and well-defined.		X	
Learning objectives describe outcomes that are measurable.		X	
Outcomes align to occupational focus (industry skills and standards).		X	
Comments or recommendations:			

2. Material and Resources	Exceptional	Satisfactory	Ineffective
The instructional materials contribute to the achievement of the course learning objectives.		X	
The materials and resources meet/reflect current industry practices and standards.		X	
The instructional materials provide options for a variety of learning styles.		X	
Resources and materials are cited appropriately. If applicable, license information is provided.		X	
Comments or recommendations:			

3. Learning Activities	Exceptional	Satisfactory	Ineffective
Provide opportunities for interaction and active learning.		X	
Help understand fundamental concepts, and build skills useful outside of the learning object.		X	
Activities are linked to current industry practices and standards.		X	

Michigan Coalition for Advanced Manufacturing
Subject Matter Expert Course Review

Comments or recommendations:			
4. Assessment Tools/Criteria for Evaluation	**Exceptional**	**Satisfactory**	**Ineffective**
The course evaluation criteria/course grading policy is stated clearly on syllabus.		X	
Measure stated learning objectives and link to industry standards.		X	
Align with course activities and resources.		X	
Include specific criteria for evaluation of student work and participation.		X	
Comments and recommendations:			
5. Equipment/Technology	**Exceptional**	**Satisfactory**	**Ineffective**
Meets industry standards and needs.		X	
Supports the course learning objectives.		X	
Provides students with easy access to the technologies required in the course/module.		X	
Comments and recommendations:			

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Robert C. Hess

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Qualifications

Dedicated, articulate, and enthusiastic with strong analytical and organizational abilities. Effective communication and interpersonal skills. Ability to work independently or as an integral part of a team to accomplish goals. Experience prioritizing and completing numerous concurrent responsibilities while meeting time and organizational goals. Sound professional attitude, strong work ethic and pride in personal performance.

Experience

2015 – Present **M H Technologies LLC** **Warren, MI**
Senior Instructional Designer/Trainer

- Perform Needs Analysis and quote training programs
- Develop on-line training programs, system manuals, student workbooks, and job aids
- Deliver on-site training programs

2002 – 2015 **R.C. Technologies** **Shelby Twp. MI**
Business Owner – R.C. Technologies

- Research and quote training programs
- Development of training programs for Ford Motors, DaimlerChrysler, General Motors, Kuka Robotics, Fame Conveyor, Lamb Technicon, Delphi, Magna, and SPX
- Design training programs, system manuals, student workbooks, PowerPoint presentations, and job aids
- Deliver on-site training programs
- Professional Industrial photography

1995 – 2002 **DCT Inc.** **Sterling Heights, MI**
Training Designer

- Research and quote training programs
- Design training programs, system manuals, student workbooks, and job aids
- Deliver on-site training programs

1990 – 1995 **Bond Robotics** **Sterling Heights, MI**
Training Manager / Field Service Engineer

- Managed Training Department
- Research and quote training programs
- Design operation and maintenance manuals plus training guides
- Deliver all training programs
- Perform on-site electrical and mechanical customer support for installation, start-up, and debugging of pressroom automation

1986 – 1990 **Robotic Vision Systems, Inc.** **Sterling Heights**
Field Service Engineer / Trainer

- Research, installation, programming and training of 3D vision guided robotic welding and sealant systems for military, aerospace, and automotive industry

Education **1977 – 1981** **Ferris State University** **Big Rapids, MI**

- BSEE