Mechatronics Integrated Technologies 1-4
(Activity Codes 6210, 6211, 6212, and 6213)

PROGRAM DESCRIPTION
Mechatronics is a new interdisciplinary field involving mechanical, instrumentation, electronics, robotics/automation, computer components, and control systems. The program prepares students who like to work with their hands as well as their minds. Mechatronics is a dynamic field that changes daily with the rapid improvements in technology and computer systems. Systems are networked to meet the demands of automated manufacturing processes, and technicians are trained to meet necessary entry-level industrial skills and entry into a postsecondary program at a technical college. Dual credit may be available through some SC technical colleges.

CREDIT
1-2 Carnegie units (per activity code)

Sections 1, 2, 3, and 4 are the minimum standards for articulation of Mechatronics to (some) technical colleges in South Carolina.

INDUSTRIAL SAFETY (SECTION 1) 1-4

1. Explain the idea of a safety culture and its importance to mechatronics.
2. Identify causes of accidents and the impact of accident costs.
3. Explain the role of OSHA in job-site safety.*
4. Explain OSHA's General Duty Clause and 1926 CFR Subpart C.
5. Recognize hazard recognition and risk assessment techniques.
6. Explain fall protection and ladder, stair, and scaffold procedures and requirements.
7. Identify struck-by hazards.
8. Demonstrate safe working procedures and requirements related to lock out-tag out procedures.
9. Identify caught-in-between hazards.
10. Demonstrate safe working procedures and requirements related to caught-in-between hazards.
11. Demonstrate safe work procedures to use around electrical hazards.
12. Demonstrate the use and care of appropriate personal protective equipment (PPE).
13. Explain the importance of hazard communications (HazCom) and Material Safety Data Sheets (MSDSs).
14. Identify other construction hazards on your job site, including hazardous material exposures, environmental elements, welding and cutting hazards, confined spaces, and fires.

HAND AND POWER TOOL OPERATIONS (SECTION 2)

1. Illustrate use of basic hand and power tools (see tools and equipment list).
2. Use torque wrenches.
3. Describe the basic procedures for taking care of hand and power tools.
4. Use hand and power tools safely.

5. Demonstrate how to maintain hand and power tools properly.
6. Compare the use of threaded fasteners and non-threaded fasteners.
7. Demonstrate applications for fasteners and anchors.
8. Demonstrate use of precision measurement tools (English/standard and metric).
    a. Use levels.
    b. Use feeler gauges.
    c. Use calipers.
    d. Use micrometers.
    e. Use dial indicators.
    f. Use protractors.
    g. Use parallels and gauge blocks.
    h. Use precision straightedges.
    i. Use a standard ruler and a metric ruler to measure.
9. Evaluate the metric system and how it is important in mechatronics.
10. Use metric units of length, weight, volume, and temperature.
11. Convert English/standard to metric.
12. Demonstrate the ability to perform layout work to include the use of calipers, drills, height and depth gauges, and other measurement tools.

HYDRAULICS AND PNEUMATICS (SECTION 3)

1. Demonstrate hydraulic system safety.
2. Explain the principles of hydraulics and hydraulic fluids.
3. Identify hydraulic components (supply elements, control valves, and actuators).
4. Explain hydraulic systems (forces, speed, friction, flow, and pressure).
5. Identify types of hydraulic pumps.
6. Identify types of hydraulic motors.
7. Demonstrate pneumatic safety.
8. Calculate the physical characteristics and compressibility of gases (Pascal's law and Boyle's law).
9. Describe the pneumatic transmission of energy.
10. Identify types of compressors.
11. Analyze the principles of compressor operation and compressed-air treatment.
12. Construct pneumatic systems from components and symbols.
13. Demonstrate the ability to read, construct, and interpret fluid power symbols as well as fluid power diagrams.
14. Demonstrate correct installation and maintenance as well as preventive maintenance techniques for fluid power systems using service manuals.
15. Troubleshoot and repair fluid power systems using service manuals and gauges.

AC-DC CIRCUITS (SECTION 4)

1. Recognize what atoms are and how they are constructed.
2. Identify ways in which voltage can be produced.
3. Demonstrate the difference between conductors and insulators.
4. Define the units of measurement that are used to measure the properties of electricity.

5. Explain how voltage, current, and resistance are related to each other.
6. Calculate electrical quantities using Ohm's Law.
7. Calculate the amount of power used by a circuit.
8. Demonstrate understanding of capacitance and inductance in a DC circuit.
9. Construct a basic series circuit.
10. Construct a basic parallel circuit.
11. Construct a series-parallel combination circuit.
12. Calculate, using Kirchoff's Voltage Law, the voltage drop and total current in series, parallel, and series-parallel circuits.
13. Measure the total amount of resistance in a series circuit.
14. Measure the total amount of resistance in a parallel circuit.
15. Measure the total amount of resistance in a series-parallel circuit.
16. Compare calculated and measured electrical properties.

ELECTRICAL TEST EQUIPMENT

1. Demonstrate the operation of the following pieces of test equipment: 1-4
    - -Ammeter
    - -Voltmeter
    - -Ohmmeter
    - -Multimeter*
    - -Frequency meter 4
    - -Oscilloscope 4
    - -Continuity tester
    - -Voltage tester
2. Represent results using engineering notation.
3. Understand the importance of proper meter polarity.
4. Demonstrate frequency using a frequency meter.
5. Compare the difference between digital and analog meters.

OPTIONAL ADVANCED STANDARDS

The following section may be required for dual credit at some SC technical colleges.

ADVANCED AC CIRCUITS

1. Calculate the peak and effective voltage or current values for an AC waveform.
2. Calculate the phase relationship between two AC waveforms.
3. Measure the voltage and current phase relationship in a resistive AC circuit.
4. Describe the voltage and current transients that occur in an inductive circuit.
5. Define inductive reactance.
6. Describe the voltage and current transients that occur in a capacitive circuit.
7. Define capacitive reactance.
8. Construct circuits showing the relationship between voltage and current in the following types of AC circuits:
    - -RL circuit
    - -LC circuit
9. Describe the effect that resonant frequency has on impedance and current flow in a series or parallel resonant circuit.
10. Describe how bandwidth is affected by resistance in a series or parallel resonant circuit.
11. Describe the following terms as they relate to AC circuits:
    - -True power
    - -Reactive power
    - -Apparent power
    - -Power factor
12. Describe operation of a transformer.

The following optional standards may be addressed if extra time allows but are not required for dual credit.

PROGRAMMABLE LOGIC CONTROLLERS

1. Describe the function and purpose of a programmable logic controller (PLC).
2. Compare hardwired and PLC systems.
3. Convert between number systems.
4. Analyze a binary logic network.
5. Describe the purpose of the various power supplies used within a PLC.
6. Construct input/output (I/O) circuits.
7. Define the function of the PLC processor module.
8. Describe the interrelations between microprocessor components.
9. State the characteristics of the different types of memory.
10. Demonstrate the features of relay ladder logic instruction categories.
11. Demonstrate the principles used to correlate PLC hardware components to software instructions.
12. Convert a hardware ladder diagram to a PLC ladder diagram.
13. Program PLC using the converted PLC ladder diagram.
14. Troubleshoot problems in PLC circuit using a given diagram.

INTRODUCTION TO ROBOTICS SYSTEMS

1. Explain basic safety of robotics systems.
2. Explain OSHA requirements for robotics systems.
3. Construct a process application for robotics systems.
4. Describe the different types of robots.
5. Identify the different parts of a robot and their functions.
6. Demonstrate the ability to service, maintain, and troubleshoot a simple robot.
7. Demonstrate robotic coordinate systems.

MOTORS: THEORY AND APPLICATION

1. Define the following terms:
   -Ampacity
   -Branch circuit
   -Circuit breaker
   -Controller
   -Duty
   -Equipment
   -Full-load amps
   -Ground fault circuit interrupter
   -Interrupting rating
   -Motor circuit switch
   -Thermal protector
   -NEMA design letter

-Nonautomatic
-Overcurrent
-Overload
-Power factor
-Rated full-load speed
-Rated horsepower
-Service factor
-Thermal cutout
-Remote control circuit

2. Describe the various types of motor enclosures.
3. Describe how the rated voltage of a motor differs from the system voltage.
4. Describe the basic construction and components of a three-phase squirrel cage induction motor.
5. Explain the relationships among speed, frequency, and the number of poles in a three-phase induction motor.
6. Describe how torque is developed in an induction motor.
7. Explain how and why torque varies with rotor reactance and slip.
8. Define percent slip and speed regulation.
9. Explain how the direction of a three-phase motor is reversed.
10. Describe the component parts and operating characteristics of a three-phase wound rotor induction motor.
11. Describe the component parts and operating characteristics of a three-phase synchronous motor.
12. Define torque, starting current, and armature reaction as they apply to DC motors.
13. Explain how the direction of rotation of a DC motor is changed.
14. Describe the design and characteristics of a DC shunt, series, and compound motor.
15. Describe dual-voltage motors and their applications.
16. Describe the methods for determining various motor connections.
17. Describe general motor protection requirements as delineated in the National Electrical Code (NEC).

MECHATRONICS TOOLS AND EQUIPMENT LIST

Multimedia projector and screen
Desktop or laptop computer (one per student)
Variety of personal protective equipment, including:

- Safety glasses, goggles, and face shields
- Safety harness
- Hearing protection

Fire extinguisher
Variety of communication tags and signs
Materials to create hypothetical fire hazards

Variety of safety tags, including:

- Lockout/tagout tag
- Fire extinguisher tag

Variety of ladders, including:

- Straight ladder
- Extension ladder
- Stepladder

Materials and Equipment

Levels
Feeler gauges
Calipers
Micrometers
Dial indicators
Parallels and gauge blocks
Precision straightedges
Calculator (industry does not allow for employment testing)
Standard ruler (with 1⁄16-inch markings)
Metric ruler (with centimeters [cm] and millimeters [mm])
Tape measure
Metric scale
Protractors
Claw hammer
Ball peen hammer
Screwdrivers, including:

- Slotted
- Phillips

Hex key wrenches (English/standard and metric)
Pliers, including:

- Slip-joint
- Long-nose
- Needle-nose
- Lineman
- CHANNELLOCK®

Measuring tools, including:

- Steel rule
- Laser measuring tool

Spirit level
Squares, including:

- Machinist’s square
- Combination square

Plumb bob

Clamps, including:

- C-clamp
- Locking C-clamp
- Spring clamp
- Hand-screw clamp

Files and rasps, including:

- Utility knife
- Square file
- Triangle file
- Flat file
- Rat-tail file

Rasp
File card
Cold chisel
Punches (center and round)
Wrenches, including:

- Nonadjustable wrench (English/standard and metric)
- Adjustable wrench
- Torque wrench

Sockets and ratchets (English/standard and metric)
Power drills, including:

- Electric drill
- Cordless drill
- Hammer drill

Electric screwdriver
Variety of drill bits (letter, number, and fractional)
Saws, including:

- Reciprocating saw (SawZall®)
- Portable handheld band saw

Handheld grinders, including:

- Angle grinder
- End grinder
- Detail grinder

Air compressor
Nuts, bolts, and screws (English/standard and metric)
Hand truck