Course Number & Name: MET 211 Machines and Controls

Credit Hours: 3.0  Contact Hours: 4.5  Lecture: 2.0  Lab: 2.5  Other: N/A

Prerequisites: Grades of “C” or better in PHY 101 and ELC 115

Co-requisites: MET 215  Concurrent Courses: None

Course Outline Revision Date: Fall 2010

Course Description: Students learn about DC and AC motors and generators and the transmission mechanisms used to drive mechanical power. The course covers transducers for position and velocity. Programmable Logic Control (PLC) Systems are introduced. The laboratory work involves the use of computer-integrated manufacturing (CIM) workcell equipment, which includes computer numerical control (CNC) machinery, robotics control systems, and vision control systems.

Course Goals: Upon successful completion of this course, students should be able to do the following:
1. describe elements of process control;
2. describe the design and operation of mechanical parameter sensors;
3. describe elements of the various types of machines, motors, generators, and transmissions;
4. describe and apply the concept of automatic controls and programmable controllers; and
5. explain and design valves, which are needed for the operation of machines.

Measurable Course Performance Objectives (MPOs): Upon successful completion of this course, students should specifically be able to do the following:

1. Describe elements of process control:
   1.1 differentiate between open loop control and closed loop control;
   1.2 explain the action of a transducer in a closed loop control system;
   1.3 define setpoint;
   1.4 explain the function of a comparator in process control;
   1.5 describe the function of an actuator;
   1.6 describe the function of a controller in an automated system;
   1.7 explain the operation of a signal processor;
   1.8 explain negative and positive feedback; and
   1.9 explain the operation of a servomechanism
Measurable Course Performance Objectives (MPOs) (continued):

2. Describe the design and operation of mechanical parameter sensors:
   2.1 differentiate between a transducer and a sensor;
   2.2 identify and describe the various types of potentiometers and their applications;
   2.3 explain the design and operation of the linear variable differential transformer;
   2.4 explain the design and operation of the rotary variable differential transformer;
   2.5 describe the design and operation of the linear motion variable capacitor;
   2.6 explain the design and principle of operation of the optical encoders;
   2.7 describe the operation of the absolute position encoder;
   2.8 describe the operation of the incremental position encoder;
   2.9 explain the design and operation of the absolute and incremental optical shaft encoders;
   2.10 explain the operation of vision system components;
   2.11 explain the design and operation of the piezoresistive force transducers;
   2.12 explain the design and operation of the piezoelectric force transducers;
   2.13 describe the design and operation of various types of pressure sensors;
   2.14 explain the theory behind level sensors; and
   2.15 explain the design and operation of temperature sensors

3. Describe elements of the various types of machines, motors, generators, and transmissions:
   3.1 explain the theory of operation of the AC and DC generators;
   3.2 describe the design and operation of various type of AC/DC motors;
   3.3 connect and operate different configurations of motors and generators, using the electric motor/generator workstation;
   3.4 explain various regimes of motor speed control;
   3.5 calculate the efficiency of motors and generators;
   3.6 explain the operation of the motor starter; and
   3.7 describe full-wave rectification of AC supply

4. Describe and apply the concept of automatic controls and programmable controllers:
   4.1 define operational amplifier;
   4.2 explain the functions of the various configurations of operational amplifiers in control systems;
   4.3 list and describe the function of the hardware components used in PLC systems;
   4.4 describe the basic circuitry and applications for discrete and analog I/O modules and interpret typical I/O and CPU specifications;
   4.5 explain I/O addressing;
   4.6 describe the general classes and types of PLC memory devices;
   4.7 list and describe the different types of PLC peripheral support devices available;
   4.8 write PLC logic programs to control various operations; and
   4.9 operate the PLC

5. Explain and design valves, which are needed for the operation of machines:
   5.1 explain the design and operation of solenoid valves;
   5.2 explain the design and operation of relays;
   5.3 explain the design and operation of various types of check valves;
   5.4 explain the design and operation of needle valves (flow control valves);
Measurable Course Performance Objectives (MPOs) (continued):

5.5 explain the function of pressure-compensated and temperature-compensated flow control valves;
5.6 design pressure-compensated and temperature-compensated flow control valves;
5.7 explain the operation of globe valves;
5.8 explain the operation of gate valves;
5.9 explain the operation of ball valves;
5.10 explain the design and operation of pressure relieve valves;
5.11 explain the design and operation of pressure control valves;
5.12 explain the design and operation of directional control valves; and
5.13 design circuits with the various valves and explain the function of each valve in the control process

Methods of Instruction: Instruction will consist of lectures, problem solving, and laboratory exercises.

Outcomes Assessment: Selected homework, quiz, test, and exam questions are blueprinted to course objectives. A checklist rubric is used to evaluate lab reports and the term project for the presence of course objectives. Data is collected and analyzed to determine the level of student performance on these assessment instruments in regards to meeting course objectives. The results of this data analysis are used to guide necessary pedagogical and/or curricular revisions.

Course Requirements: All students are required to:

1. Maintain regular attendance and participate in classroom discussions.
2. Complete homework assignments and lab reports on time.
3. Sit for all quizzes, tests and exams that are scheduled.
4. Participate in all lab exercises.
5. Read all assigned textbook pages.
Methods of Evaluation: Final course grades will be computed as follows:

<table>
<thead>
<tr>
<th>Grading Components</th>
<th>% of final course grade</th>
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<tbody>
<tr>
<td>• Quizzes and class participation</td>
<td>5 – 10%</td>
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<tr>
<td>A perusal of quizzes and analysis of class discussion will indicate the extent to which students master course objectives.</td>
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<tr>
<td>• Homework</td>
<td>10 – 15%</td>
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<td>A perusal of homework problems will indicate the extent to which students master course objectives.</td>
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<tr>
<td>• 3 or more Tests (dates specified by the instructor)</td>
<td>30 – 40%</td>
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<td>Tests will show evidence of the extent to which students meet course objectives, including but not limited to identifying and applying concepts, analyzing and solving problems, estimating and interpreting results and stating appropriate conclusions using correct terminology.</td>
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<tr>
<td>• 2 or more Lab Reports</td>
<td>15 – 25%</td>
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<td>Lab reports will show evidence of the extent to which students can apply course concepts to physical problems, analyze errors, and compose a technical report. Labs are designed to reinforce student mastery of course objectives.</td>
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<tr>
<td>• Term Project</td>
<td>10 – 20%</td>
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<td>The term project will show evidence of the extent to which students can apply course concepts to real world problems, design a solution, and compose a technical report.</td>
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<td>• Team work</td>
<td>5 – 10%</td>
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<td>Collaboration between colleagues, an essential component of engineering practice in industry, will be practiced as students complete their lab and term projects.</td>
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<td>• Final Exam (comprehensive)</td>
<td>25 – 35%</td>
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<td>The same objectives apply as with tests, but it is anticipated that students will provide increased evidence of synthesizing a combination of concepts.</td>
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**NOTE:** The instructor will provide specific weights, which lie in the above-given ranges, for each of the grading components at the beginning of the semester.
**Academic Integrity:** Dishonesty disrupts the search for truth that is inherent in the learning process and so devalues the purpose and the mission of the College. Academic dishonesty includes, but is not limited to, the following:

- plagiarism – the failure to acknowledge another writer’s words or ideas or to give proper credit to sources of information;
- cheating – knowingly obtaining or giving unauthorized information on any test/exam or any other academic assignment;
- interference – any interruption of the academic process that prevents others from the proper engagement in learning or teaching; and
- fraud – any act or instance of willful deceit or trickery.

Violations of academic integrity will be dealt with by imposing appropriate sanctions. Sanctions for acts of academic dishonesty could include the resubmission of an assignment, failure of the test/exam, failure in the course, probation, suspension from the College, and even expulsion from the College.

**Student Code of Conduct:** All students are expected to conduct themselves as responsible and considerate adults who respect the rights of others. Disruptive behavior will not be tolerated. All students are also expected to attend and be on time for all class meetings. No cell phones or similar electronic devices are permitted in class. Please refer to the Essex County College student handbook, *Lifeline*, for more specific information about the College’s Code of Conduct and attendance requirements.

<table>
<thead>
<tr>
<th>Week (2 meetings @135 minutes)</th>
<th>Topic</th>
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<tbody>
<tr>
<td>1</td>
<td><strong>INTRODUCTION</strong>: Machines and controls fundamentals</td>
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<tr>
<td>2</td>
<td><strong>MECHANICAL PARAMETER SENSORS – TRANSDUCERS</strong>: Introduction, motion and position sensors, force sensors</td>
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<tr>
<td>3</td>
<td><strong>MECHANICAL PARAMETER SENSORS – TRANSDUCERS (continued)</strong>, Test 1</td>
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<td>4 – 5</td>
<td>DC GENERATORS: Introduction, some construction details, field poles, field winding connections, core and coil, voltage regulation, efficiency and performance, shunt and self excitation, characteristics</td>
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<td>6</td>
<td>DC MOTORS: Introduction, construction and theory of operation, counter EMF, classification, starting, speed characteristic, speed, power, torque, speed control using diodes, SCRs, AC rectification, regulation, efficiency, losses</td>
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<tr>
<td>7</td>
<td>LAB 1: DC series motor, Test 2</td>
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<td>8</td>
<td><strong>Lab 1 Report due</strong>, SINGLE PHASE MOTORS (AC): Introduction, types, construction, speed control,</td>
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<td>9</td>
<td><strong>MOTOR STARTERS AND CONTROLLERS</strong>: Different types of relay and automatic controls</td>
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<tr>
<td>10</td>
<td>LAB 2: DC Shunt motor and DC Compound motor, Test 3</td>
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<tr>
<td>11</td>
<td><strong>Lab 2 Report due</strong>, OPERATIONAL AMPLIFIERS (Op Amp): Introduction, op amp characteristics, basic op amp configurations, op amp applications</td>
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<td>12</td>
<td><strong>PROGRAMMABLE CONTROLLERS</strong>: Basic concepts, general idea of programming, safety, controller hardware, analog and digital type of process controllers</td>
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<td>13 – 14</td>
<td><strong>CONTROL VALVES</strong>: Introduction, types of flow control valves, pressure control valves, pressure regulating valves, and directional control valves</td>
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<tr>
<td>15</td>
<td><strong>Term Project due</strong></td>
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</tbody>
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|                                | **Comprehensive Final Exam**