Cincinnati State

# *EMET 240 - PLC's & Motor Controls*

Spring 2019

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Feel free to visit me during my office hours or by appointment.
*Please contact the CIT office receptionist to schedule a meeting at (513) 569-1743.*

**Course Description**

In this course the student will learn the fundamentals of Programmable Logic Controllers (PLCs), motors, variable speed drives, and mechanisms. Topics include: review of electricity and magnetism, motor and generator characterization, operating and troubleshooting industrial control circuits; evaluating speed, torque, power, and efficiency; and ladder logic programming for the PLC.

**Prerequisites**

*EET 131, EET 132, EMET 140* ***OR*** *EMET 150*

**Required Texts/Supplements**

Electrical Motor Controls for Integrated Systems, 5e Rockis & Mazur, ATP

**Course Outcomes**

*After completing this course the student will be able to*

1. Discuss the operating principle of three-phase and single-phase AC motors and brushed and brushless DC motors.
2. Demonstrate common industrial motor control circuits, including programming a Variable Frequency Drive (VFD).
3. Calculate torque, speed, and power of an electro-mechanical drive system.
4. Practice electrical safety following NEC guidelines with special caution for high voltage circuits, including Lockout/Tagout.
5. Explain the history and major components of the PLC and PLC systems.
6. Demonstrate basic PLC troubleshooting of logic and wiring of motor control circuits.

**Course Grading**

The course grade will be determined by scores on several homework assignments, hands-on labs, and two (2) exams. The distribution of final grade points including class participation will be roughly as follows:

| | |
|---|---|
| Hands-on Labs | 45% |
| Assignments | 15% |
| Examinations | 35% |
| Participation/attendance* | 5% |

*The participation/attendance points are a subjective measure of the student's attendance, participation, and improvement. The points typically improve the grade assigned when on the threshold between letter grades.

The final letter grade for the course is based on the point scale below.

- A = 92% or above "Superior"
- B = 80-91% "Good"
- C = 70-79% "Average"
- D = 60-69% "Poor"
- F = below 60% "Failure"

**Labs, Assignments & Exams**

There will be numerous laboratory assignments throughout the course. The labs will be completed individually or in small groups as announced in class. Many of the labs will use the motor/generator training system with a 208VAC 3-phase supply.
Working with electricity can be dangerous. It is imperative that all safety guidelines be followed as discussed in class.

There will also be some homework assignments in the course. Lecture notes, textbook readings, and classroom activities can be used as a study guide.

There will be two (2) written and/or laboratory exams. The exams will generally cover material from the immediately preceding topics. Exam content will be discussed in class prior to the exam date.

**Attendance & Classroom Decorum**

Attendance is required. The student is expected to attend and participate in every class session and is responsible for completing all assignments on time. It is understood some absences are unavoidable and that missing class hampers the student's ability to learn course material. A penalty will be assessed against your final grade for excessive unexcused absences through a reduction in attendance points. *If you miss more than two (2) weeks class time equivalent, you may fail the class.*

Please refrain from using cell phones and media devices during class periods. E-smoking is not permitted while class is in session. For rooms equipped with workstation

computers, the computers are not to be used during lectures unless authorized by the instructor. *Texting in class will not be tolerated. You may step outside of the classroom if necessary.*

For class periods longer than two (2) hours, breaks for free time will be given as necessary.

**Teaching Philosophy**

My teaching philosophy is simple. I aim to *educate* the individual, and not to merely *train* the individual, using a blend of theory and practice.

Training often focuses on specific tasks necessary to meet specific ends under specific conditions. On the other hand, education focuses on knowing the reasons for the specific tasks such that ends can be met under a variety of conditions.

With education comes the ability to respond to new problems more quickly and effectively. A key element of education is exploring the answers to the underlying questions of what, why, and how. That is, the "theory".

But, knowing the theory is only half the equation. For engineering technologists, the hand skill to implement tasks following theory is uniquely important. Individuals who put into practice solutions to problems using the proper tools and with quality workmanship often have more opportunity.

**Student Learning Focus**

Education is a personalized journey that requires reflection and study. Please allow sufficient time to review concepts before and after class. It is also important to identify how you learn best so that lessons may be presented more effectively if possible.

Critical thinking and troubleshooting are "money-makers" in the engineering world. Armed with an understanding of the root causes of problems in systems, troubleshooting is a skill much easier to master.

Also, language and communication are keys to success. Vocabulary exists so that complete and accurate ideas can be shared efficiently. Say what you *mean*, not what you *meant*.

**Student Responsibility**

Students are responsible for material that may be assigned on this syllabus as well as *additional information announced in class*. The instructor will not rely exclusively on material from the textbook(s).

Good note taking is highly encouraged and helps makes learning successful. Often class sessions are conversational in nature with much of the information presented orally.

Students are advised to capture key ideas and instructions on paper as formal notes will generally not be presented on the board.

Students are expected to complete all assignments on time. Assignments may be submitted online through Blackboard, collected in class on paper, demonstrated using lab equipment, or through other means. *Late work will be penalized 5% per day up to seven (7) days, after which a grade of 0% will be recorded.*

**E-mail Communication**

Electronic-mail (e-mail) is a valuable communication tool and especially useful in distance learning and online education programs. The ease of sending e-mail however has encouraged the loss of writing etiquette and social courtesy. Good message composition has given way to fragments and absent punctuation. I encourage students to read *E-Mail Etiquette: The Do's and Don'ts* in hardcopy or online. *At a minimum, when sending e-mail messages please include in the subject line the class number and section. And, in the body, open with a greeting and close with a salutation including your name.*

*The instructor will only correspond via email using your Cincinnati State account. It is mandatory that this account be checked at least once daily, in addition to Blackboard.*

**Academic Integrity**

Please maintain academic integrity in this and all classes as academic dishonesty of any type will not be tolerated. Refer to the Academic Integrity Policy of the current college catalog for information, available online at http://www.cincinnatistate.edu/real-world-academics/catalogs/. All work submitted in class not original to the student must be cited. This includes text, graphics, images, and the like. ***No excuses.***

**Special Needs**

Students with disabilities may register with the Office of Disabilities Services and present proper paperwork to the instructor in the first week of classes so that special arrangements may be made. The goal is to ensure students have an equal opportunity to pursue their educational objectives.

You may contact the office by phone at (513) 569-1775 or in person in room Main 129.

**Tutoring Services**

The College provides free individual or group tutoring. Students may request a tutor through the Success Center. Walk-in help is available. The approximate hours for the Success Center are Monday through Thursday from 9am to 8pm, Friday from 9am to 4pm, and Saturday from 9am to 3pm in Main 261.

**Course Content**

The content may change. *Check Blackboard often for due dates and announcements.*

| Week | Lecture Topics | Chapter(s) | Assignment(s) |
|---|---|---|---|
| **1** | Review of electricity & magnetism, energy & power, power factor, test instruments | 1, 3 | Assignment 1 – Electrical Review<br>Lab 1 – Series wound DC motor build & troubleshoot |
| **2** | Introduction to motor principles, construction and troubleshooting of series wound DC motor | 13 | Lab 2 – Motor identification practice |
| **3** | Overview of DC brushed motor types, characteristics, and performance curves | 13 | Lab 3 – DC motor characterization (in three parts) |
| **4** | Overview of AC brushless/brushed motor types, characteristics, and performance curves | 14, 18 | Lab 4 – 3ϕ AC synchronous machine "alternator" study |
| **5** | Fundamentals of solenoids, relays, contactors, and motor starters; Electrical safety, Lockout/Tagout | 7, 8<br>4 | Lab 5 – Identification & inspection of industrial relays |
| **6** | Introduction to industrial control circuits, symbols, standard wire colors, and three-wire motor starter | 2, 5, 6 | ***EXAM 1,*** Lab 6 – 3-wire motor starter with 3ϕ induction motor |
| **7** | Reversing motor starter, 3-phase & 1-phase induction motors | 12, 15 | Lab 7 – Reversing motor starter with 3ϕ induction motor |
| **8** | Introduction to the Variable Frequency Drive (VFD) for 3-phase motors, DC motor drives | 26, VFD manual | Lab 8 – VFD introduction |
| **9** | Using the VFD digital and analog inputs & outputs, and "speed" versus "torque" modes | 26, VFD manual | Lab 9 – VFD motor/generator control |
| **10** | Introduction to the Programmable Logic Controller (PLC), wiring diagrams, Allen-Bradley simulator | 27 | Lab 10 – Introduction to PLC Programming |
| **11** | Additional PLC programming and instructions, Allen-Bradley LogixPro-500 simulator | 27 | Labs 11, 12 – PLC garage door & bearing lubrication control |
| **12** | Introduction to the Automation Direct CLICK PLC, addressing, programming environment | PLC manual | Lab 13 – CLICK PLC 3-wire motor starter |
| **13** | Introduction to the Human-Machine Interface (HMI), using it with the PLC for motor control | HMI manual | Lab 14 – CLICK PLC with touchscreen HMI |
| **14** | Additional PLC programming and advanced instructions | 27, manuals | Lab 15 – PLC simple motor/generator interface |
| **15** | Additional PLC programming and preparation for final laboratory exam | 27, manuals | ***EXAM 2,*** Final Lab |