A. **Academic Division**: Business, Industry, and Technology

B. **Discipline**: Industrial Technology, Industrial Maintenance

C. **Course Number and Title**: EMMT1540 – Ladder Diagrams

D. **Course Coordinator**: Randy Storms  
   **Assistant Dean**: Daniel Wagner

**Instructor Information:**
- **Name**: Click here to enter text.  
- **Office Location**: Click here to enter text.  
- **Office Hours**: Click here to enter text.  
- **Phone Number**: Click here to enter text.  
- **E-Mail Address**: Click here to enter text.

E. **Credit Hours**: 1  
   Laboratory: 3 hours

F. **Prerequisites**: EMMT1010

G. **Syllabus Effective Date**: Fall 2017

H. **Textbook(s) Title**: None

I. **Workbook(s) and/or Lab Manual**: None

J. **Course Description**: A study of the practical knowledge required to maintain and troubleshoot industrial control equipment properly by locating and properly identifying the nature and magnitude of a fault or error. This involves the understanding of electrical components, their symbols, and their relationships. Emphasis is placed on reading and understanding elementary ladder logic circuit diagrams based upon electrical standards, and above all else, promoting safety.

K. **College-Wide Learning Outcomes**

<table>
<thead>
<tr>
<th>College-Wide Learning Outcome</th>
<th>Assessments - - How it is met &amp; When it is met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication – Written</td>
<td></td>
</tr>
<tr>
<td>Communication – Speech</td>
<td></td>
</tr>
<tr>
<td>Intercultural Knowledge and Competence</td>
<td></td>
</tr>
<tr>
<td>Critical Thinking</td>
<td></td>
</tr>
<tr>
<td>Information Literacy</td>
<td></td>
</tr>
<tr>
<td>Quantitative Literacy</td>
<td></td>
</tr>
</tbody>
</table>
L. **Course Outcomes and Assessment Methods:**

Upon successful completion of this course, the student shall:

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessments – How it is met &amp; When it is met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify control components by their schematic symbols.</td>
<td>Weeks 1-11 – Lab exercises, quizzes, midterm and final.</td>
</tr>
<tr>
<td>2. Identify logic circuits as a Boolean function.</td>
<td>Weeks 1-3 Lab exercises, quizzes, midterm and final.</td>
</tr>
<tr>
<td>4. Classify input devices as to their environmental control function, temperature, pressure, motion, flow, or light.</td>
<td>Weeks 2 – 15 Lab exercises, quizzes, midterm and final.</td>
</tr>
<tr>
<td>5. Identify logical control functions, such as latches, interlocks, timing, counting, or sequential using ladder diagrams.</td>
<td>Weeks 2 – 15 Lab exercises, quizzes, midterm and final.</td>
</tr>
<tr>
<td>6. Describe in detail the types of documentation used on a ladder diagram, such as, contact references, dashed and solid lines, component lettering, page references, and tables.</td>
<td>Weeks 2 – 15 Lab exercises, quizzes, midterm and final.</td>
</tr>
</tbody>
</table>

M. **Topical Timeline (Subject to Change):**

1. **TRANSFORMERS**
   a. The symbol for a dual-primary, single secondary control transformer.
   b. Connection diagram for a dual-primary, single secondary control transformer to a higher voltage line and to a 120-volt control circuit.

2. **FUSES, DISCONNECT SWITCHES, AND CIRCUIT BREAKERS**
   a. The basic fuse construction.
   b. The three different types of fuses and some of their uses.
   c. The four different types of circuit breakers and uses for each.
   d. Why time-delay fuses are used with motor starter circuits.
   e. The voltage and current ratings available for fuses and circuit breakers.
   f. The important factors to consider when selecting protective devices.
   g. The symbols for important protective and disconnecting devices.
   h. What is meant by interrupting capacity.

3. **CONTROL UNITS FOR SWITCHING AND COMMUNICATION**
   a. Four types of operators for the push-button switch.
   b. Why different colors are used for push-button switch operators.
   c. The symbols for push-button switch units with:
      1) Flush or extended head.
      2) Mushroom head.
      3) Maintained contact attachment.
   d. Several arrangements available for selector switches.
   e. The symbol for the selector switch.
   f. The symbol for the foot switch.
   g. The advantages of push-to-test pilot lights.
   h. The symbol and detailed circuit for the push-to-test pilot light.
   i. The meaning of the letter in the pilot light.
   j. Simple basic circuits using selector switches.
   k. The use of annunciators to obtain process information.
   l. The use of the LED.

4. **RELAYS**
   a. Two main uses for the control relay.
b. How the control relay is constructed mechanically.
c. The three published ratings for relays.
d. Why silver is used in relay contacts.
e. Several factors involved with relay operation, such as contact bounce, overlap contacts, contact wipe, and split or bifurcated contacts.
f. The interlock circuit and why it is used.
g. The symbol for the relay coil, relay contacts, and on and off time-delay relay contacts.
h. The difference between inrush and holding current in a relay coil.
i. How the latching relay operates.
j. The basic uses for the contactor.

5. SOLENOIDS
   a. Why it is necessary for the plunger in a solenoid to complete its stroke.
   b. The two important problems to consider in the application of a solenoid.
   c. The application of solenoids to operating valves.
   d. The symbol for the solenoid.
   e. Draw a control circuit showing the energizing of a solenoid through the closing of a relay contact, using a control relay, two push-button switches, and a solenoid.
   f. The difference between sealed current and inrush current in a solenoid.

6. MOTION CONTROL
   a. The three basic classes of limit switches.
   b. Where rotating-cam limit switches are used.
   c. Terms relative to limit switches:
      1) Operating force.
      2) Release force.
      3) Pretravel or trip travel.
      4) Overtravel.
      5) Differential travel.
   d. The proximity limit switch and how it is used.
   e. Several methods for achieving proximity switching.
   f. How the vane limit switch operates.
   g. The limit switch symbols for four different conditions.
   h. Draw an electrical operating circuit showing how the operation of a normally closed limit switch contact can be used to deenergize a solenoid, using two push-button switches, a normally closed limit switch contact, a relay, and a solenoid.
   i. The 4 types of photoelectric transducers.

7. PRESSURE CONTROL
   a. Terms used with pressure switches.
   b. Tolerance in a pressure switch.
   c. Four types of pressure switches.
   d. How the piston-type pressure switch operates.
   e. The operation of the diaphragm pressure switch.
   f. How the pressure transducer operates.
   g. The normally open and normally closed pressure switch symbols.
   h. Draw an electrical control circuit showing how a normally closed pressure switch contact can be used to deenergize the circuit.

8. TEMPERATURE CONTROL
   a. How the thermocouple, thermistor, and resistance unit obtain temperature information that can be used in a control circuit.
   b. Name two types of temperature switches or thermostats and how each operates.
   c. How a temperature switch contact can be used in an electrical control circuit to prevent the operation of the circuit unless the temperature of the part being sensed is at or above a preset temperature.

9. TIME and COUNT CONTROL
   a. The differences between a timer and a time-delay relay.
   b. Where the timer has a definite use.
   c. Three major types of timers
d. The difference between the on-delay and off-delay timer operation.

e. The arrangement of the contacts in a reset-type timer under the conditions of reset, timing, and timed out.

f. The function of the timer sequence symbol above each timer contact.

g. The operation of the repeat-cycle timer.
h. Some of the design features of the solid-state timers.

10. CONTROL CIRCUITS

a. How all complete control circuits progress through three basic areas: information or input, decision or logic, and output or work.

b. Draw a Bar chart sequence for an electrical control circuit.

c. How various electrical components are used to gather information from a machine system.

d. How electrical components are used to make a decision as to how the gathered information is to be used.

e. How the decision affects the output or work the machine is to accomplish.

f. Simple electrical circuits from a given set of requirements.

11. MOTOR STARTERS

a. The difference between a contactor and a motor starter.

b. Why overload relays are used on motor starters.

c. How the normally closed contact in the overload relay is connected into the motor starter control circuit.

d. Why both mechanical and electrical interlocks are used on the reversing motor starter.

e. Draw a single phase reversing motor circuit.

12. GENERAL

a. Categorizing a given electro-mechanical control device as:
   1) Input or conditional.
   2) Output or load.
   3) Miscellaneous or support.

b. How to use contact cross references in conjunction with rung numbering to locate both normally open and normally closed contacts associated with the output device of a given ladder diagram rung.

c. How to locate contacts in other rungs that are mechanically linked to a contact located in a given rung of ladder logic.

d. How to use conductor numbers from a given ladder diagram to locate the voltage test points on the terminal strip of a relay control panel.

e. The on/off status of the output or load device in any rung of a ladder diagram when given the on/off status of the input or conditional devices in that rung.

f. The operation of basic rung logic circuits such as "AND" logic, "OR" logic, "NOT" logic, sealing or latching contacts and lockout contacts in a given ladder diagram.

g. The control sequence of a relay control system when given the status of the input or conditional devices and a ladder diagram of that system.

h. Safe use of a voltage tester to verify the on/off status of any device in any rung of a given relay control system when given its corresponding ladder diagram.

i. Safe use of a continuity tester or Ohmmeter to verify that a suspected control device has failed.

j. How to safely troubleshoot and repair any relay control system when given the ladder diagram, the point at which the control sequence failed, a voltage tester, a continuity tester and proper replacement devices(s).

N. Course Assignments:

1. Homework: Selected problems and questions from weekly reading assignments must be completed.

2. Labs: Various self-paced and computer monitored labs administered in the IST lab.

3. Quizzes: Quizzes will be administered online via LMS.

4. Midterm: The midterm exam will be administered during week 8.

5. Final: There will be a comprehensive final at the end of the semester.
O. Recommended Grading Scale:

<table>
<thead>
<tr>
<th>NUMERIC</th>
<th>GRADE</th>
<th>POINTS</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>93–100</td>
<td>A</td>
<td>4.00</td>
<td>Superior</td>
</tr>
<tr>
<td>90–92</td>
<td>A-</td>
<td>3.67</td>
<td>Superior</td>
</tr>
<tr>
<td>87–89</td>
<td>B+</td>
<td>3.33</td>
<td>Above Average</td>
</tr>
<tr>
<td>83–86</td>
<td>B</td>
<td>3.00</td>
<td>Above Average</td>
</tr>
<tr>
<td>80–82</td>
<td>B-</td>
<td>2.67</td>
<td>Above Average</td>
</tr>
<tr>
<td>77–79</td>
<td>C+</td>
<td>2.33</td>
<td>Average</td>
</tr>
<tr>
<td>73–76</td>
<td>C</td>
<td>2.00</td>
<td>Average</td>
</tr>
<tr>
<td>70–72</td>
<td>C-</td>
<td>1.67</td>
<td>Below Average</td>
</tr>
<tr>
<td>67–69</td>
<td>D+</td>
<td>1.33</td>
<td>Below Average</td>
</tr>
<tr>
<td>63–66</td>
<td>D</td>
<td>1.00</td>
<td>Below Average</td>
</tr>
<tr>
<td>60–62</td>
<td>D-</td>
<td>0.67</td>
<td>Poor</td>
</tr>
<tr>
<td>00–59</td>
<td>F</td>
<td>0.00</td>
<td>Failure</td>
</tr>
</tbody>
</table>

P. Grading and Testing Guidelines:

Click here to enter text.

Q. Examination Policy:

Click here to enter text.

R. Class Attendance and Homework Make-Up Policy:

Click here to enter text.

S. Classroom Expectations:

Click here to enter text.

T. College Procedures/Policies:

Attendance Requirements: All students are required to attend all scheduled classes and examinations. Each faculty member has the right to establish regulations regarding attendance that he/she considers necessary for successful study.

Students who do not attend classes may be administratively withdrawn from those classes. However, failure to attend classes does not constitute withdrawal, and students are expected to process a formal withdrawal through the Student Records Office in Kee Hall.

Student engagement requirements: Student engagement is based on the “active pursuit” of learning which can be measured by class attendance, class participation (in class or online), taking required quizzes/examinations, and submission of work assignments or papers. Student engagement consists of a student attending at least 60% of the class sessions (there should be attendance throughout the term) and/or completing 75% of the assignments listed on the syllabus at the midpoint in the term. Exceptions can be made when there is on-going communication between the student and faculty member. The communication must be documented and the faculty member and student must be in agreement regarding the exception. Students not meeting the expectation will be administratively withdrawn from class. If a student believes he/she was administratively withdrawn in error, he/she may file an appeal. Being administratively withdrawn may have program and financial aid implications.
**Academic Misconduct** is any activity that tends to compromise the academic integrity of the college, or subvert the educational process. Examples of academic misconduct include, but are not limited to:

1. **Violation of course or program rules** as contained in the course syllabus or other information provided to the student; violation of program requirements as established by departments and made available to students.

2. **Plagiarism** including, but not limited to, submitting, without appropriate acknowledgment, any written, visual or oral material that has been copied in whole or in part from the work of others (whether such source is published or not) even if the material is completely paraphrased in one’s own words. This includes another individual’s academic composition, compilation, or other product, or a commercially prepared paper. Plagiarism also includes submitting work in which portions were substantially produced by someone acting as a tutor or editor.

   Such practices constitute plagiarism regardless of motive. Those who deny deceitful intent, claim not to have known that the act constituted plagiarism, or maintain that what they did was inadvertent are nevertheless subject to penalties when plagiarism has been confirmed.

3. **Cheating** and dishonest practices in connection with examinations, papers and projects, including but not limited to using unauthorized notes, study aids or information on an examination; obtaining help from another student during an examination; taking an exam or doing work for another student; providing one’s own work for another student to copy and submit as his/her own; or allowing another student to do one’s work and then submitting the work as one’s own. Also included would be altering a graded work after it has been returned, then submitting the work for re-grading; or submitting identical or similar papers for credit in more than one course without prior permission from the course instructors.

4. **Fabrication** including but not limited to falsifying or inventing any information, data or citation; presenting data that were not gathered in accordance with defined appropriate guidelines, and failing to include an accurate account of the method by which data were collected.

5. **Obtaining an Unfair Advantage** including, but not limited to stealing, reproducing, circulating, or otherwise gaining access to examination materials prior to the time authorized by the instructor; unauthorized collaborating on an academic assignment; taking, hiding or altering resource material; or undertaking any activity with the purpose of creating or obtaining an unfair advantage over another student’s academic work.

6. **Aiding and Abetting Academic Dishonesty** including, but not limited to providing material, information or other assistance to another person with the knowledge that such aid could be used in any of the violations stated above, or providing false information in connection with any inquiry regarding academic integrity.

7. **Alteration of Grades or Marks** including but not limited to, action by the student in an effort to change the earned credit or grade.

In addition, cases of academic dishonesty may involve photocopied materials. Materials used may fall under the Copyright Act. Violations of said Act may subject the user and/or the College to sanctions.

**Statement on Disabilities:** Any student who requires reasonable accommodations related to a disability should inform the course instructor and the Coordinator of Specialized Services (Room 138 in Kee Hall; phone 419-755-4727).

Students who encounter difficulty in any of their courses are encouraged to visit the Tutoring Resource Center (Room 119 in Fallerius Technical Education Center) for tutoring assistance, and the Student Success Center (Room 136 in Kee Hall) for academic assistance, advising services, referrals for personal counseling and Learning Disability (LD) Testing.
Statement on Withdrawals: As a student, you are expected to attend class. If you are unable or choose not to attend class, or if for whatever reason you are unable to keep up with the requirements of a course, you need to officially drop the class at the Student Records Office. Refund dates and withdrawal dates will vary slightly from term to term. Contact the Student Records Office for applicable dates. Additionally these dates are posted on the academic calendar available on the college’s website, www.ncstatecollege.edu, under the Academics heading on the home page and are available at the Student Records Office in Kee Hall. Students should go to the Student Records Office (Room 142 in Kee Hall) to process their withdrawal from any class.

If you choose to walk away from your class without officially withdrawing from it, the faculty member teaching the class must grade your classroom performance on the material available to him or her. This normally results in an "F" grade. An "F" grade can lower your grade point average considerably depending on the total credits accumulated.