

Whether Mechatronics or PLC, the Course Should Be Accepted by Both EECS and EET

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Abstract:

A primary goal of a course in Programmable Controller Applications is to help the student find good employment. Another goal of the course should also be to support other subjects taught in the digital sequence as well as networking and programming.

The paper develops a list of topics that would possibly be covered in a comprehensive PLC course. Rational for inclusion of various topics will be discussed as well as the name change to Mechatronics from PLC.

The instructor has been responsible for teaching and developing texts in the area of PLCs and teaching their content to EET majors for a number of years. One class also included EECS students while their instructor was on a sabbatical. The same instructor is now also responsible for teaching the EECS students in their own PLC course.

From the author's perspective in industry, there is a concern for the lack of student awareness of the high expectations of PLC work once the student graduates. It is commonly accepted that 90% of the jobs in the mid-west served by this university require some proficiency in the use of PLCs. One person who had hired over 20 EET majors in the past few years observed that the EET majors all had some PLC experience and knew how to 'hit the ground running'. Most companies today do not want to spend money trying to convince the recent graduate that programming the PLC is something worthwhile. They want the student to already be convinced and willing to accept the challenges of program creation from day one.

A course for EECS as well as EET using the PLC should be taught by someone with experience from industry and the willingness to stay abreast of trends in the market. It would not have the same impact if taught by one without a passion for the course.

Introduction:

Three courses presently teach PLC content. They are:

EECS	4220	Programmable Logic Controllers (also EECS 5220)
EET	2410	Mechatronics I
EET	4550	Mechatronics II

EECS 4220 has been taught only to EECS students at the senior level. EET 2410 has been taught to EET and CSET students at the sophomore level. EET 4550 has been taught primarily to EET students at the senior level but also has been taught as a sometime substitute for EECS students when EECS 4220 was not available.

The course description as well as topics studied are listed below:

EECS 4220 – Programmable Logic Controllers

Catalog descriptions	An introduction to programmable logic controllers (PLCs), process control algorithms, interfacing of sensors and other I/O devices, simulation and networking.
Topics and reading assignments	<p>Introduction to Relay Logic</p> <p>Introduction to PLC programming on the PC</p> <p>The A-B instruction set</p> <p>The Siemens instruction set</p> <p>Hardware considerations</p> <p>Addressing</p> <p>Relay Instructions</p> <p>Timers and Counter Instructions</p> <p>Integer math</p> <p>Comparison Instructions</p> <p>Control Panel Construction</p> <p>Control Elements exterior to the Control Panel</p> <p>Sequential logic programming and State Diagrams</p> <p>Siemens' Function/Function Block concept</p> <p>HMI concepts</p> <p>Motion programming</p> <p>PID algorithms – writing control programs to control processes</p> <p>Safety programming</p> <p>PLC networking concepts</p> <p>Discrete and analog I/O concepts</p>

EET 2410 – Mechatronics I

Catalog descriptions	A study of programmable controllers emphasizing program development, logic development and troubleshooting. Emphasis on relays, timers, counters, integer math and scan-dependent programming. Factory floor control concepts are stressed.
Topics and reading assignments	<p>Introduction to Relay Logic</p> <p>Introduction to PLC programming on the PC</p> <p>The A-B instruction set</p> <p>The Siemens instruction set</p> <p>Hardware considerations</p> <p>Addressing</p> <p>Relay Instructions</p> <p>Timers and Counter Instructions</p> <p>Integer math</p> <p>Comparison Instructions</p> <p>Control Panel Construction</p> <p>Control Elements exterior to the Control Panel</p> <p>Sequential logic programming and State Diagrams</p> <p>User Specific Instructions</p>

EET 4550 – Mechatronics II

Catalog descriptions	Use of programmable controllers and computers in factory automation. Topics include process control, supervisory software, PLC networking, PLC/CNC integration, device configuration, use of programming software and PLC language standards.
Topics and reading assignments	Review of A-B, Siemens PLC programming Addressing Review Introduction to programming - RS-Logic Software, Siemens TIA Software Introduction to HMI concepts Introduction to PLC – Motion Programming PID algorithms Process programming PLC networking concepts Discrete and analog I/O concepts

A Student/Instructor's Report:

The following was a description of the EECS 4220/5220 course from an instructor taking it as a student. This description was a review after having taken the EECS course as a graduate student (EECS 5220). She had previously taken the EET 2410 and EET 4550 courses as students a number of years earlier. Figures referenced in this report are seen as the referenced figure in Appendix I^[10]

“EECS 5220, Programmable Logic Controllers, is a course that was taken by this author as a graduate course in an effort to learn how to teach the course as well as how to improve upon its current teaching approach. Before proceeding, it must be understood that this singular course is taught by a singular individual at several different levels within the College of Engineering at the University of Toledo. It is taught in the Electrical Engineering Science Department as a senior level elective course for three credit hours, and no lab hour is included. This course is called Programmable Logic Controllers, EECS 4220. It is also taught in the Electrical Engineering Technology Department split into two separate **core** program courses, Mechatronics I (EET 2410) and Mechatronics II (EET 4550) taught at the sophomore and senior level each contributing four credit hours, three weekly lecture hours as well as one weekly hour of lab for a total of eight credit hours. Additionally, the course content is offered as a graduate level electrical engineering elective, Programmable Logic Controllers (EECS 5220). Perspectives on this course were obtained while taking the graduate course including observation of the instruction, participation in several laboratory experiments as well as exam questions.

FINDINGS

The engineering science elective option, EECS 4220, Programmable Logic Controllers, is a newly developed course and as such may still require some modification of its course configuration and student expectations. Upon conclusion of this course, this author spoke with several students and found that as far as the content and presentation of the course material, most students seemed satisfied. Many commented that when this elective become available, the class was perceived as a great opportunity as a PLC's course was invaluable in seeking employment in the controls engineering field. Students were also very pleased with gaining familiarity with programming in both Allen Bradley and Siemens' PLC's. This gave an extreme advantage over others without this experience, and students agreed this offered much confidence in seeking jobs with these experiences in co-ops or upon graduation.

However, as the semester progressed, students commented that the laboratory tasks became quite intense and time-consuming. For a three credit-hour class, students felt the additional lab requirements were a bit of an extreme time obligation. Additional comments included the weight of lab grades versus exam grades. According to the course syllabus shown to the right in Figure 1-1, the only graded items for the course were fourteen labs constituting 40% of the overall grade and two exams weighted at 30% each. Of the students spoken to, most felt that the graded content and associated weights should be revised because the labs that constitute only 40% of the grade required too much time. Additional comments were that although exams were graded in a generous way, the exam questions were quite a bit more in depth even though time was spent in class going over potential test questions in the days preceding an exam. Students felt they often did not know what information the instructor was seeking on the test questions. One student suggested graded homework assignments might help students understand the information being sought during the exam.

A physical limitation observed in association with this course is that while the EECS department seems happy to have this additional elective offering, there is currently no lab space or funds to create a lab space in order to conduct the laboratory experiments for their students. Therefore, EECS students were required to utilize lab space within the Engineering Technology Department that is additionally used for other courses in that department. Students felt the lab space was inadequate to accommodate all the purposes assigned to it. Also, based on the current equipment provided for wiring projects, additional unexpected challenges arose when components would not remain on the board or when circuitry became complex. Several voiced a need for a dedicated training board for use in the labs associated with this course.

Regarding the textbook used, while the text contains a plethora of information and is effectively configured, a compilation of programming instruction, symbols and appropriate uses somewhere in the text would be extremely beneficial to an inexperienced PLC student. This was the opinion of this author as a student and an agreed observation by other students when asked.

This author, who is also a lecturer in the Electrical Engineering Technology Department, has been well-served observing this course and having learned a far greater understanding of the subject matter feels much better prepared to teach this course if ever called upon to do so within the Engineering Technology Department. To understand this material is one thing, but it is another matter entirely to explain this material to students if one has never experienced the real-world applications of PLC's. Although this author was able to complete five of the assigned laboratory experiments, continuous efforts and experience performing the exercises would be needed to successfully teach students this material to a sufficient level. The current instructor and an alternate part-time instructor of this course do an outstanding job preparing students for the workforce using Allen Bradley and Siemens PLC's.

As a simultaneous lecturer and student, this author has had many opportunities to speak with ET students regarding this course, which in the ET department is separated into Mechatronics I and II. Most students agree that the course is well presented. In the Electrical Engineering Technology courses, recall that the course has a one credit-hour lab associated and the course is split into two semesters. Students seem to agree that the amount of time spent on lab exercises is commensurate with their expectations. Also, as seen in Figure 1-2, right, graded course content is divided slightly more agreeably, and although it is not shown in the syllabus, according to students, the instructor agrees that if all labs are completed successfully, the final exam is eliminated. Most students seem to appreciate this gesture and feel that more is learned from performing the labs than completing a paper exam.

The effectiveness of these courses conducted within the Engineering Technology Department can be verified by the astounding success of its graduating students obtaining gainful employment in the Controls/PLC's fields, and the satisfaction of industry with what these students know as they enter the work field.

CONCLUSIONS/ RECOMMENDATIONS

This course, as well as the instructor, is an asset to the Electrical Engineering Science Department and its students. Undoubtedly, for this course to continue in this department successfully, the recognition of it as an asset will need to occur by others within this department. The EECS department will need to offer its support both academically as well as financially for this course to be able to continue in its current state. The lab space, equipment and resources maintained by the ET department has many limitations and will not be able to successfully sustain the labs required for this course without resource support from the department whose students it serves. It will quickly become necessary for the instructor seeking the joint appointment between the two departments to get both departments on board in terms of commitment of resources.

As far as the graded exercises of this course, this author recommends another look at the main course objectives and a necessary paring down of the laboratory assignments. In the Mechatronics I course, there are eleven lab assignments completed in a semester and in Mechatronics II, there are only five lab assignments in a semester according to schedules

posted on the instructor's website. As next year, the semester will be fifteen weeks, even shorter in duration, and the number of labs seemed quite excessive at fourteen lab assignments in the EECS 4220 course, it is recommended that some lab assignments be eliminated while maintaining the overall content and integrity of the course.

As far as the text book is concerned ^{[1][2][3][4][5]}, it is a vast work in explanation of the history of PLC's, how to program PLC's, associated codes, safeties and securities, data paths, and much, much more. It is an extensive work, but it is always helpful to have one location for a student to reference all instructions or at least those instructions/syntax used within the course. It would also be helpful since both Allen Bradley and Siemens are used in this course if a compiled instruction list included both variations of instruction. An incomplete start (for Allen Bradley only) to this index or appendix to the text might look like Figure 1-3 on the next page. A simpler option to producing this compiled list would simply be to attach the appropriate links to both Allen Bradley and Siemens Instruction Set Reference Manuals or attach the pdf files of these manuals themselves to the instructors' website or Blackboard site. However, in the beginning of this course, it would be greatly beneficial to go over even a somewhat brief instruction set in both platforms and show examples on how or when to use each one in a simple manner, where each mnemonic can be found within the software and how to tag/label each instruction. As an individual with no PLC's background, understanding the instruction set before beginning the programming process would help immensely.

Overall, the subject material of this course is taught well and quite comprehensively. Only minor adjustments in the format should be considered for continuous success of this course. The videos posted on the instructor's website are extremely helpful in navigating the proper way to connect to the processor and initiate a program. This course provides a path to graduating electrical engineers in the engineering sciences to achieve a much needed skill in industry that prior to now was unachievable at the University of Toledo.”

End of Report

Thoughts on Report and Discussion of EECS 4220/5220:

The report gave great insight concerning the students' perceptions in this course. There was some thought that the subject was being taught at too fast a pace and too much was being expected. The course is not a theoretical course but rather a pragmatic course in dealing with many different concepts and definitely moved at a fast pace. While it was seen as difficult, most students adjusted to its speed and learned a great deal.

The intent of this course was to expose the student to as many different experiences as possible encouraging the student to engage in the programming experiences and become confident in programming a number of very different applications.

These lab experiences are outlined in the table on the next page. They vary from very simple combinational logic programs to advanced motion and PID programming for industry. Descriptions of the various programs can be found by accessing the book and

reviewing the description of the lab. Each lab was to be programmed, wired, and demonstrated to gain credit for the particular lab. The difficulty of the labs increased week to week. The only difference between these labs and labs in other courses was that credit was not given until the lab was completely working. The course adapted the idea that students could learn both Allen-Bradley and Siemens simultaneously by moving back and forth between the two as they progressed through the labs. The EET courses did not make this assumption forcing students to perform labs using both platforms for full credit with each assignment. The list of labs constitutes the entire list for both EET 2410 and EET 4550. The only difference between the EET and EECS courses was that EECS students moved at a faster rate and programmed a different project each week. While it has been noted that there were complaints about the amount of work expected, it is good to consider that for the most part, they were graduating seniors and voiced resistance due to the fact that the end was in sight.

Assignment Sheet for EECS 4220*:

Lab Assn 1 Due 9-7-16	Lab 2.1	Explained in Ch. 2, pg 27-32	Results with report
Lab Assn 2 Due 9-12-15	Lab 4.1	Ch. 4, Hot Dog Counter	Demo with both AB and Siemens Processors with report
Lab Assn 3 Due 9-19-16	Lab 5.1	Ch. 5, Coin Changer (35-cent option)	Demo with either A-B or Siemens Processors with report
Lab Assn 4 Due 9-26-16	Ch. 7	7.1 Traffic Intersection (7.1D)	Demo with either A-B or Siemens Processors with report
Lab Assn 5 Due 10-5-16	Ch. 7	7.2 Cash Register (7.2E)	Demo with either A-B or Siemens Processors with report
Lab Assn 6 Due 10-10-16	Ch. 8	8.1b (subtract)	Demo with either A-B or Siemens Processors with report
Lab Assn 7 Due 10-17-16	Ch. 10	10.1 (MUX)	Demo with either A-B or Siemens Processors with report
Lab Assn 8 Due 10-24-16	Ch. 11	11.1(Three Pumps_ Option 11.1.2	Demo with either A-B or Siemens Processors with report
Lab Assn 9 Due 10-31-16	Ch. 13	13.1.1A Simon or 13.2b Whack-a-mole	Demo with either A-B or Siemens Processors with report
Lab Assn 10 Due 11-7-16	Ch. 14	Lab 14.1 (Ch. 14, pg. 32)	Demo with Siemens Processor with report
Lab Assn 11 Due 11-14-16	Ch. 15	Lab 15.1	Demo with either A-B or Siemens Processors with report
Lab Assn 12 Due 11-21-16	Ch. 15	Lab 15.2**	Demo with either A-B or Siemens Processors with report
Lab Assn 13 Due 11-28-16	Ch. 17	Lab 17.1 or Lab 17.2	Demo with either A-B or Siemens Processors with report
Lab Assn 14 Due 12-5-16	Ch. 19	Lab 19.1 or Lab 19.2	Demo with either A-B or Siemens Processors with report

* Complete description of lab given on website's text
at:www.eng.utoledo.edu/~wevans

** Lab 15.2 was given as an extra credit lab due to compromises with schedule.
(Most students eventually completed this lab)

Coursework other than labs included looking at processes using process flow diagrams. For instance, the PID lab was discussed with various modifications to the PID Block. Among the modifications was the addition of a number of inputs averaged together to form one individual process variable. Another option discussed was the use of auto to manual to auto switching to prohibit integral wind-up as well as other methods to prevent unwanted results of the PID algorithm. The motion lab concentrated on absolute motion statements with the need to include a state diagram to add logic to make pause and resume an acceptable option for the motion blocks.

Overall, lab experiences were designed to allow a large number of lab teams to perform the same experience at the same time. Most labs allow eight or more groups to do the same lab at the same time. While this approach of multiple lab stations for an individual lab was not always the norm, since it was implemented, labs have run much better.

Included in each chapter and lab experience are the specifications or applicable codes pertaining to the subject discussed. For example, the ISA specification for HMI panels was discussed as well as organizational methods useful for a new HMI developer. Books containing specific information on these subjects is discussed as well ^{[6][7][8]}. When discussing the motion application, codes applicable to moving machinery were included.

Both the EECS and EET courses are based on a commitment to modeling of a process. If memory circuits are discussed, their use in filling of a tank or running of a conveyor was given as an example. Coupling a number of memory circuits when running a number of conveyors expands on the basic concept. If timers can be coupled with a memory circuit, their use in a motor starter circuit was given as an example. Each circuit is coupled to an idea used in industry. The idea of the mechatronics name is based on the concept of using the PLC to control a specific machine or part of a machine.

Sensors are discussed as well as panel design. Safety inside the panel and in the process was also included. Specifications pertaining to each are annotated as they pertain to the application. Each portion of the design is discussed along with a time-line discussing the flow of the engineering process.

It is the goal of these courses to bring a student to the point that upon graduation and in a manufacturing environments, the student feels comfortable walking into a project planning meeting and contribute at a junior engineering level being able to conceptually formulate program segments and potential hardware architectures to implement the process being discussed. If they are in a maintenance environment, they could be counted on to discuss potential debugging methods for major problems at hand. In general, they should be able to contribute in a positive manner. They should know the questions to ask and be able to move quickly toward solutions to questions for which they may not have an immediate answer.

While these courses may have found a home at some universities, there are a number that have not adopted them. They may reside in the instrumentation or devices courses but not in a course primarily focused on the PLC. Not considering these courses for EECS students is a mistake.

While the equipment of these labs is useful for the PLC courses, specific experiments may also have potential use in other courses including Automatic Controls. The equipment has use in a number of different courses and can be given over to a multitude of uses as need arises.

While the courses described are difficult and time consuming for student and instructor alike, the enjoyment that the professor may have after teaching these courses should be noted. As the student moves through the course(s), they begin to enjoy the challenge of the next lab and what lies ahead while seeing the potential for creatively programming a process. This joy can be witnessed by the instructor as the student moves through the learning process. This group of courses can be fun even in the midst of the many layers of confusion!

How the course helps in the job search is best described as 'very successful'. Over the last few years, EET students have been very generous with their positive comments related to the job search. One student came to class this past year with a job offer in hand for \$74K starting salary. The natural inclination was to assume the job offered a heavy travel or other unattractive component warranting the relatively high starting wage. But, contrary to this assumption, the job was for a plant electrical engineer in an established manufacturing plant only a few miles from his home, a 40 hour/week job!

Another EET student ready to graduate recently reported a starting salary of \$80K with no prior experience other than co-op's. Again, no heavy travel was in the future for this student either.

The most inspiring story experienced was of a former student recently graduated who showed up at a local ISA conference. He was discouraged in that he couldn't find the 'right job'. The local Siemens representative was standing a short distance away and I encouraged this former student to introduce himself. Quite a long time later, the student re-appeared beaming with a huge smile. He reported the representative had given him four promising leads. Although this student accepted a different offer, the change in his attitude was significant. And he did get the right job soon after.

Anecdotal experiences from EECS students haven't been as plentiful, yet. The course has only been taught once with the present format and students take it in their last semester, a time in which most job offers are already in process. In the present semester, there are some EECS students taking this course in the EET 4550 course. Some are taking the course earlier in their career and they should be better able to use the experience gained in the course together with co-op to find a better job offer.

Conclusion:

At this time, the main concern for these courses is the need for the EECS department to add an hour to their course and encourage it earlier in the student's experience. There may be a discussion about uniting the two-course sequence in EET with a possible parallel path for EECS students. There are no present discussions on this topic.

Course content continues to be enhanced. The next lab experience being planned is a paper-winding machine using toilet paper. It should be an excellent study of motion coupled with PID control. There is a prototype of this machine being built at present. Also, a discussion of safety programming has been planned and may be taught this semester. Hopefully the software will work properly.

These courses continue to mature and produce qualified students looking for good jobs in industrial automation. When tested in the real world, they are believed to be better prepared after having taken these PLC courses.

The EECS course ended well with 11 A's, 10 B's, 3 C's and 3 other. Almost all students finished all the required labs and even the additional extra-credit one. Most finished the exams well showing a great understanding of the subject. They especially enjoyed the motion lab as well as the PID lab. The next group will get to combine the two into the winding machine.

REFERENCES

- [1] Hugh Jack, (2003). *Automating Manufacturing Systems with PLC's*, unpublished
- [2] Jon Stenerson , (2004). *Programming PLCs Using Rockwell Automation Controllers*, Pearson
- [3] Kelvin T. Erickson, (2011). *Programmable Logic Controllers: An emphasis on Design and Application*, 2nd Ed., Dogwood Valley Press
- [4] Wm T Evans, (2006), *Programmable Logic Controllers: Fundamentals and Applications*, Stipes Publishing LLC
- [5] Kamel & Kamel, (2014), *Programmable Logic Controllers – Industrial Control*, McGraw Hill
- [6] Oliver & Habibi, (2008), *The High Performance HMI Handbook*, PAS
- [7] Endsley & Jones, (2012), *Designing for Situation Awareness – An Approach to User-Centered Design*, , 2nd, CRC Press
- [8] Hollifield & Habibi, (2010), *The Alarm Management Handbook*, 2nd, PAS
- [9] National Electric Code- 2014

Appendix 1 (Fig. 1-1)

EECS 4220/5220

Programmable Logic Controller

Fall 2016

When and where	Lecture (R1) PA 2400 8:00-9:15am M,W	Lab NE 2350
Instructor	Prof. Wm Ted Evans, PhD, PE (Ohio)-Office: NE 1607, Phone 419-530-3349, cell 419-343-3681 Email: william.evans@utoledo.edu , web: www.eng.utoledo.edu/~wevans	
Office Hours	9:15-11:00 M, W and 11:00-12:30 T	
Prerequisite	(Undergraduate level EECS 1100 Minimum Grade of D- and Undergraduate level EECS 3210 Minimum Grade of D-)	
Textbook	Provided free on above website	
Useful References		
Grading	Projects 40 %, Midterm exam 30 %, Final Exam 30 % (A >= 90, B >= 80, C >= 70, D >= 60)	
Class rules and regulations	1. No eating, drinking, or smoking in classrooms. 2. There are no make-up exams for this course. If you have a problem or conflict and cannot attend an exam, let me know beforehand and we will try to work something out. No credit will be given for a missed exam that we haven't made arrangements about beforehand unless you have a <i>really excusable</i> emergency. Cell phone use will not be allowed. If you do not have a calculator, buy one and bring it to class. Cheating is not allowed and will be punished by rules of U of Toledo Student Handbook.	
Catalog descriptions	A study of programmable controllers emphasizing program development, logic development and troubleshooting. Emphasis on relays, timers, counters, integer math and scan-dependent programming. Factory floor control concepts are stressed.	
Topics and reading assignments (subject to change, any changes will be notified in the class beforehand)	Introduction to Relay Logic Introduction to PLC programming on the PC The A-B instruction set The Siemens instruction set Hardware considerations Addressing Relay Instructions Timers and Counter Instructions Integer math Comparison Instructions Control Panel Construction Control Elements exterior to the Control Panel Sequential logic programming and State Diagrams Siemens' Function/Function Block concept HMI concepts Motion programming PID algorithms – writing control programs to control processes Safety programming PLC networking concepts Discrete and analog I/O concepts	
Class dates (Exam dates are subject to change.)	8-22, 8-24, 8-29, 8-31, 9-7, 9-12, 9-14, 9-19, 9-21, 9-26, 9-28, 10-5, 10-10, 10-12, 10-17, 10-19, 10-24, 10-26, 10-31, 11-2, 11-7, 11-9, 11-14, 11-16, 11-21, 11-23, 11-28, 11-30, 12-5, 12-7 Final - 8:00-10:00am, Monday 12-12-16	
	Labs are to be printed from the website and brought to lab. Labs to be graded only if submitted at end of assigned class period.	

(Fig. 1-2)

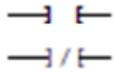
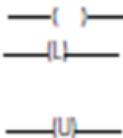
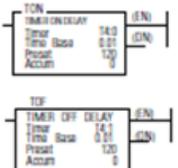
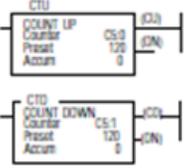
EET 2410

Mechatronics I

Fall 2016

When and where	Lecture (R1) NE 2390 12:30-1:45 pm T,R	Lab (B1) NE 2390 T 1:50-3:30pm Lab (B2) NE 2390 R 1:50-3:30pm
Instructor	Prof. Wm Ted Evans, PhD, PE (Ohio)-Office: NE 1607, Phone 419-530-3349, cell 419-343-3681 Email: william.evans@utoledo.edu , web: www.eng.utoledo.edu/~wevans	
Office Hours	9:15-11:00 M, W and 11:00-12:30 T	
Prerequisite	Prerequisites: Undergraduate level EET 2210 Minimum Grade of D-	
Textbook	Provided free on above website under Hybrid Text (ch. 1-13)	
Useful References		
Grading	Homework 10 %, Projects 40 % Midterm exam 25 %, Final Exam 25 % (A >= 90, B >= 80, C >= 70, D >= 60)	
Class rules and regulations	1. No eating, drinking, or smoking in classrooms. 2. There are no make-up exams for this course. If you have a problem or conflict and cannot attend an exam, let me know beforehand and we will try to work something out. No credit will be given for a missed exam that we haven't made arrangements about beforehand unless you have a <i>really excusable</i> emergency. Cell phone use will not be allowed. If you do not have a calculator, buy one and bring it to class. Cheating is not allowed and will be punished by rules of U of Toledo Student Handbook.	
Catalog descriptions	A study of programmable controllers emphasizing program development, logic development and troubleshooting. Emphasis on relays, timers, counters, integer math and scan-dependent programming. Factory floor control concepts are stressed.	
Topics and reading assignments (subject to change, any changes will be notified in the class beforehand)	Introduction to Relay Logic Introduction to PLC programming on the PC The A-B instruction set The Siemens instruction set Hardware considerations Addressing Relay Instructions Timers and Counter Instructions Integer math Comparison Instructions Control Panel Construction Control Elements exterior to the Control Panel Sequential logic programming and State Diagrams User Specific Instructions	
Class dates (Exam dates are subject to change.)	8-23, 8-25, 8-30, 9-1, 9-6, 9-8, 9-13, 9-15, 9-20, 9-22, 9-27, 9-29, 10-6, 10-11, 10-13 , 10-18, 10-20, 10-25, 10-27, 11-1, 11-3, 11-8, 11-10, 11-15, 11-17, 11-22, 11-29, 12-1, 12-6, 12-8 Final, 12:30-2:30, Tuesday 12-13-15	
	Homework assignments are listed on the website and are accepted only before or on the assigned day. Labs are to be printed from the website and brought to lab. Labs to be graded only if submitted at end of assigned class period.	

(Fig. 1-3)

Allen Bradley			
Instruction Symbol	Instruction Mnemonic	Instruction Name	Appropriate Uses
	XIO / XIC	Contacts: Normally Open/Normally Closed (Examine when OFF/ON)	Inputs / Boolean Bits: Examines a bit for an OFF/ON Condition
	OTE OTL/OUT	Relay/Coil: Output Energize Output Latch/Output Unlatch	Outputs/Control Bit - turns a bit ON/OFF when the rung is executed and retains its state when the rung is not executed or a power cycle occurs
	OSR	One Shot Rising	Triggers a one-time event (on the rising edge)
	TON/TOF	Timer ON/OFF delay	Counts timebase intervals when the instruction is true/false
	CTU/CTD	Count UP/DOWN	Increments/Decrements the accumulated value when the instruction goes false or when the power cycle occurs
	RES	Reset	Resets the accumulated value and status bits of a timer or counter. (Not for use with TOF timers)