ENGR 4421 / 001 – Instruments and Controls – Spring 2014

Instructor: Kevin McFall, PhD

Office Phone: 678-915-3004

Cell Phone: 610-573-6242

Office Address: Q 344

Office Hours: 11:00-12:00 MTWRF, or by appointment

E-mail: kmcfall@spsu.edu

Location: Lecture Q 105 / Laboratory Q 110 and Q 313

Meeting times: Lecture MWF 10:00-10:50 am / Laboratory M 2:00-4:50 or W 2:00-4:50

Start Date: 01/06/2014

Pre-requisites: EE 2110 (Circuits), ENGR 3343 (Fluid Mechanics), and MATH 2306 (Differential Equations)

Textbook: The required textbook is Experimental Methods for Engineers, by J.P. Holman, 8th edition, McGraw Hill, 2012. An earlier edition of the textbook is permissible with the understanding the student is responsible for accounting for discrepancies in end of chapter homework problems between versions; homework problems refer to those in the 8th edition. A supplemental textbook Programmable Logic Controllers, by Frank D. Petruzella, 4th edition, McGraw Hill, will also be used but is not necessary to buy.

Course Catalog Description: Characteristics of instruments used in mechanical systems for determining parameters such as temperature, pressure, and flow are studied. The use of these devices in automated systems is covered. Furthermore, the elements of control theory, selection of control modes, and application to mechanical systems are studied. Laboratory exercises illustrating the use of pertinent instrumentation for determining the performance of mechanical equipment are conducted.

Learning Outcomes:

1) Demonstrate proficiency in engineering data collection, data regression, compilation of results, and technical report writing.
2) Analyze the uncertainty in measurement systems using statistical and other analytical principles.
3) Demonstrate competence in programming for data acquisition using LabVIEW software.
4) Identify, calibrate and use measurement instruments (pressure, temperature, and flow).
5) Evaluate different control methodologies, apply design principles for mechanical systems including pneumatics/hydraulics, and create industrial automation control solutions using programmable logic controllers.

Topics Covered Include:

1) Measurement Systems
   a) Measurement Standards
      NIST, ISO, ANSI
   b) Generalized Measurement Systems
      Sensors, Signal Conditioning, Results, Sensor Performance (Static, Dynamic)
   c) Mechanical Measurements
      Temperature, Pressure, Mass / Force / Torque, Fluid Flow, Motion, Strain
2) Analyzing Measurements
   Statistical Analysis of Experimental Data, Uncertainty Analysis of Measurements
3) Measurements with Computerized Data Acquisition Systems (LabVIEW)
4) Design for Industrial Automation
   a) Instrumentation & Control System Documentation
      Process Flow Diagrams, Piping & Instrumentation Diagrams, Instrument Lists, Specification Forms, Logic Diagrams, Loop Diagrams
   b) Safety Standards of Industrial Automation

c) Programming Programmable Logic Controllers Hardware Configuration, Programming Languages (Ladder Diagrams, Function Block Diagrams)
d) Control applications for industrial automation
   (1) Open loop control
   (2) Feedback control

Grading Policy

Homework (15%): Homework is an essential component of the learning experience in this course. Students who successfully complete and understand all the assigned homework problems will find themselves well prepared for the written tests. Content and numerical results are certainly important in homework problems, but problem presentation is of equal importance. This includes a well-conceived diagram when appropriate, an algebraic solution for the desired quantity in terms of given/known quantities, correct and consistent use of notation, units, and significant figures, as well as overall neatness and clarity. The assigned homework sets will be collected during class periods as detailed in the course schedule, and two or three problems in each will be graded. The lowest homework problem grade for the semester will be dropped. Each submission may include two students' names. A grade of zero will be recorded for any problem whose solution appears copied, even in part, from any source. Be sure to write the solution "in your own words" when collaborating with students from other groups on the solution method. Students who feel they are unfairly assessed a zero for copying homework may request referring the matter to be resolved by the SPSU Honor Council. The instructor may decide to refer directly to the Honor Council in especially egregious cases or when a student is involved in multiple incidences of copying. Problems are graded according to the rubric:

Problem solution is neat and legible (1 point)
Significant progress made towards solving the problem (1 point)
The correct answer is obtained with reasonable accuracy (1 point)
Proper and consistent use of units (1 point)
The answer is expressed in three significant figures (1 point)

Group exercises (10%): Most lecture periods with a reading assignment will begin with a "five-minute" group exercise. The purpose of these exercises is to stimulate learning of new material in groups of two members. Questions on group exercises will be short and generally require only that students have thoroughly read the day's reading assignment. Examples of question topics include definitions, identifying symbols or notation, and drawing/interpreting diagrams. The lowest group exercise grade for the semester will be dropped. Group exercises are graded as follows

Student(s) names appear on submission (1 point)
Some effort was made (1 point)
Some part of the question appropriately addressed (1 point)
Significant progress is made toward answering the question (1 point)
The answer is reasonably close to the correct answer (1 point)

Laboratory exercises (15%): All students are expected to attend the lab sessions and will be assigned zero grades for missed sessions. Three types of lab assignments are used in this course. The simplest involves collecting data during the session, answering some relatively simple questions, and perhaps demonstrating successful operation for the instructor. The assignments will be graded during the lab session. Another type of lab assignment will include design elements with more involved calculations, and will be submitted in electronic form by emailing a digitally produced copy to kmcfall@spsu.edu by the beginning of the lab session immediately following completion of the assignment. No formal lab report is required but the submission must clearly answer the questions posed in the lab description and be submitted as a single Word, or alternatively PDF, document. The results of one lab will be submitted as a professional quality lab report in practice for the final project lab report. Each lab assignment, regardless of the type will count equally.

Tests (3x15%): Three in-class tests will be used to assess progress in the course. Calculators will be allowed on the test, as will one 8½"×11" page equation sheet. The equation sheet may only contain the bare minimum of text to identify the equations or diagrams. The tests, in general, will be curved in an attempt to maintain an overall class average of a mid C.

Final project (15%): A final project will be assigned for which a report must be submitted by email to kmcfall@spsu.edu by the end of the semester. Project performance is assessed by a fully word-processed technical report of professional quality. Information retrieved from any source other than the course textbook must be cited in the report. Reports will be assessed 80% for content and 20% for presentation.

The scale for the final course grade is as follows, but the final grade cannot be more than one letter grade higher than the highest test score.

A	90-100
B	80-89
C	70-79
D	60-69
F	0-59

Attendance Policy

Forcing everyone to come to every class is not practical. Each student bears responsibility for material covered in class. If students choose to miss class, that is their decision. However, completion of group exercises goes hand-in-hand with attendance. Note also that late arrival to class will result in working alone on group exercises. Class time will be spent explaining the day's content and working problems, under the assumption that all students have read and understood the reading assignment. In general, late assignments are not accepted nor can make-up tests be administered. Laboratory attendance is mandatory; students will receive a grade of zero for missed lab sessions. Extenuating circumstances can result in exceptions to these rules, but agreement must be reached with the instructor in advance of the assignment, test, or lab that will be missed.

Academic Misconduct

At SPSU, academic misconduct is defined as "any act that could have resulted in unearned advantage or that interferes with the appropriate academic progress of others". Any act of academic misconduct can be reported to the Honor Council by the instructor. For more information see www.spsu.edu/honorcode. The application of the definition of academic misconduct for each category of assignment in this course is describes as follows:

Discussion of homework problems among peers and even other sources is wholeheartedly encouraged. A single homework submission is allowed for groups of no more than two members. Note, however, that this submission must be a reflection of the group's work alone. Multiple submissions may follow the same solution process, but they may not be copied, not even in part. If more than one group collaborates on the homework, be sure each group sits down individually to write the solution so that each is written in their own words. Be aware that copying of any kind from any source, including clandestine solution manuals, will be considered a violation of academic integrity. If you have a copy of the solution manual, you are strongly recommended to delete it. Using the solution manual as a crutch when solving homework is detrimental to your learning, and the temptation is great to rely heavily on it when rushed to complete a homework set. The majority of reported academic integrity violations in this course result from students copying from the solution manual. Additionally, possession of the solution manual is unnecessary as you will be provided with solutions of all homework problems after they are due, as well as for non-assigned problems upon request.

Collaboration among group members during group exercises, laboratory assignments, and the final project is obviously encouraged, but assistance of any kind from outside the group will be considered a

violation of academic integrity unless properly cited. Information from the course textbooks need not be cited; it can be assumed the reader is familiar with such content.

Tests are to be reflections of the individual's work alone. Assistance other than a calculator and the approved equation sheet, including mobile devices, other class members, etc. will be reported as a violation to the Honor Council.

Disability Statement

If you have a documented disability as described by the Rehabilitation Act of 1973 and the Americans with Disabilities Act (ADA) that may require you to need assistance attaining accessibility to instructional content to meet course requirements, please contact the ATTIC at 678-915-7361 as soon as possible. It is then your responsibility to contact and meet with the instructor. The ATTIC can assist you and the instructor in formulating a reasonable accommodation plan and provide support for your disability. Course requirements will not be waived but accommodations will be made, when appropriate, to assist you to meet the requirements.

Communication

Course material will be disseminated in D2L including lecture notes, homework solutions, old tests, etc. All official course announcements, including instructions when class may be cancelled, will be posted in the D2L course news. Be sure to check D2L regularly. The instructor does not check D2L email; relay all email correspondence to kmcfall@spsu.edu.

Course Schedule

Day	Date	Description	Reading	Homework due	Lab exercise
Mon	01/06	Introduction			
Wed	01/08	Measurement systems	1-2.6		
Fri	01/10	Dynamic measurements	2.7-2.10		
Mon	01/13	Fourier analysis	2.11-2.12		1) Dynamic measurements
Wed	01/15	Uncertainty analysis	3.1-3.5	2.2, 2.4, 2.15, 2.27, 2.38, 2.56	
Fri	01/17	Recitation			
Wed	01/22	Probability	3.6-3.7		
Fri	01/24	Normal distribution	3.8-3.10		
Mon	01/27	Recitation		2.x1[1], 3.3, 3.5, 3.26, 3.x1[2], 3.x2[3]	2) Fourier series
Wed	01/29	Snow closure			
Fri	01/31	Snow closure			
Mon	02/03	Regression	3.11-3.13		
Wed	02/05	Student's *t*	3.14-3.15		
Fri	02/07	A/D conversion	14.1-14.5	3.25, 3.49, 3.60, 3.64[4], 3.74, 3.78	
Mon	02/10	Review			3/4) Pressure/Temp
Wed	02/12	Snow closure			
Fri	02/14	Test 01			
Mon	02/17	Basic measuring devices	4.1-4.6		
Wed	02/19	Amplifiers	4.7-4.9, 14.2		3/4) Pressure/Temp
Fri	02/21	Signal conditioning	4.12		
Mon	02/24	Recitation			Report writing
Wed	02/26	Transducers	4.21-4.31	14.1, 14.14, 4.34, 4.38, 4.44, 4.47[5], 4.60	
Fri	02/28	Pressure measurement	6.1-6.6		
Mon	03/10	Flow measurement	7.1-7.7		6) Accelerometer
Wed	03/12	Temperature measurement	8.1-8.5		
Fri	03/14	Measuring force and torque	10.1-10.8		
Mon	03/17	Strain gages	10.9-10.10, 11.3	4.23, 4.25, 4.58, 6.30, 6.37, 7.3, 7.21	7) PID control
Wed	03/19	Recitation			
Fri	03/21	Review		8.12, 8.33, 10.8, 10.17	
Mon	03/24	Test 02			8) Strain gages
Wed	03/26	PLC basics	1.1-1.6*		
Fri	03/28	Ladder logic	6.1-6.11*		
Mon	03/31	Recitation			9) Intro to PLCs
Wed	04/02	State machines			
Fri	04/04	Recitation			
Mon	04/07	Timers	7.1-7.6*		10) PLC paddle motor
Wed	04/09	Recitation			
Fri	04/11	Counters	8.1-8.6*		
Mon	04/14	Process control	14.1-14.5*	5.1, 5.9, 6.9, 6.10, 7.13, 8.14*	11) HMIs
Wed	04/16	Review			
Fri	04/18	Test 03			
Mon	04/22	Project			Project
Wed	04/23	Project			
Fri	04/25	Project			
Mon	04/28	Project			Project

[1] Download the file HW02.txt from D2L which contains several sinusoids sampled at 1 kHz, and estimate the function generating the data using the fast Fourier transform.

[2] A tire company has determined that its tires have a 1% premature rate of failure on the road. What is the chance that none of the 16 tires shipped to a retailer will have a premature failure?

[3] Circuit boards are manufactured on sheets and tested. On average, there are 3 defects per sheet. What are the chances of 10 defects on a given sheet, no defects on a sheet, and more than 1 defect on a sheet?

[4] Assume the known precision to be "one sigma".

[5] Note the capitalization typo: ΩT should be ωT

* These reading and homework assignments are from Programmable Logic Controllers 4th edition by Frank D. Petruzella. See http://www.scribd.com/doc/72908166/Programmable-Logic-Controllers. Another great resource is the Siemens Easy Book, also posted on D2L.

This course schedule is subject to modification depending on the pace of the course. However, homework assignments and test dates will not be changed unless students anonymously and unanimously vote for a change.