MAE 411 Advanced Mechatronics
SYLLABUS
Fall Semester 2018

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Pre-requisites: MATH-261 (with a grade of C or better), MAE-211, EE-221, and EE-222.

Course structure:
1 hour lectures - MWF 1.00-1.50 pm in ESB-E 801
2.5-hour lab - M or W, 2.00-4.20 pm in ESB-E 953
help/problem sessions - as necessary
Office hours: MW 9.00-9.50 am and R (Thursday) 1.00-1.50 pm. If necessary and possible, I will gladly schedule individual appointments at different times. TA contact information and office hours TBA.

Course topics:
- functionality, modeling, and selection of basic elements of the mechatronic systems (sensors, actuators, signal processing devices, data presentation and acquisition systems);
- computer assisted measurements: data acquisition, processing, and analysis;
- basics of closed loop control.


Course objective:
To provide the MAE students with an advanced perspective on the integrated design and operation of mechanical systems with electronic controls.
Learning outcomes
At the end of this course, the students should be able to:
- describe the basic principles and the functionality of the main types of sensors, actuators, and signal conditioning devices.
- select adequate sensors and actuators for complex applications.
- model mechanical, electrical, fluid, and thermal systems using differential equations and transfer functions.
- analyze first and second order system dynamic response.
- use Matlab and Simulink for modeling, simulation, and control of systems.
- describe the functionality and role of the components of a measuring system.
- build and analyze a measuring system using sensors, signal conditioning devices, and computers.
- measure vibrations, process data through filtering, and perform Fourier analysis.
- describe the use of artificial intelligence techniques (genetic algorithms, fuzzy logic, and neural networks) to solve engineering problems.

ABET Classification
MAE 411 is a key course for ABET outcomes B and K.
Outcome B: Graduates will have an ability to design and conduct experiments, as well as to analyze and interpret data.
Outcome K: Graduates will have an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Web Site Access
Use your MIX account user name and password to access the eCampus system at https://ecampus.wvu.edu. Lecture notes, handouts, lab instructions, homework, additional material, and announcements will be posted there. Grades to all assignments will also be posted on eCampus. Check your eCampus e-mail account often.

Exams:
Midterm (2) and final exams will be closed book. Final is comprehensive.

Homework:
Homework is individual unless it is specifically assigned as a team/group effort. Late submissions are not accepted. Tentative number of homework assignments: 9-10.
Mini-Project:
This is a group assignment. Teams of 4-5 students will formulate the work statement for a complex robotic/mechatronic application and select some of the necessary sensors and actuators. A professionally written technical report is required.

Quizzes:
You will take 4 or 5 short announced quizzes over the material - both lecture and lab - covered since the previous quiz or test.

Lab Reports
There will be 5 labs this semester. You will work in teams of 2. Each person must hand in his/her own lab report. This means that only the data, plots, and computer code may be identical within a group. Answers to questions, descriptions, comments, conclusions, etc. must be individual contribution. All submissions must have your name, the name of your partner, the lab number, and your lab section time in the title block. The format and content of the lab reports must comply with the handout provided and be professional. Reports are due in a week from the day of the lab. Late submissions are not accepted. You must actually perform the lab and submit a report to receive any credit. You must attend and complete ALL labs to qualify for an overall course passing grade.

Grading
Midterm 1 & 2: 12.5% each
Final exam: 15%
Quizzes: 10%
Homework: 10%
Team mini-project: 10%
Lab reports 30%

A= 90% - 100%
B= 80% - 89%
C= 70% - 79%
D= 60% - 69%
F= <60%
Academic integrity/dishonesty policy
Check WVU web page:
http://catalog.wvu.edu/graduate/enrollmentandregistration/#academicdishonestytext
and http://www.libraries.wvu.edu/instruction/plagiarism/

“Academic Dishonesty Defined
West Virginia University expects that every member of its academic community shares the historic and traditional commitment to honesty, integrity, and the search for truth. Academic dishonesty is defined to include but is not limited to any of the following:

1. Plagiarism: Plagiarism is defined in terms of proscribed acts. Students are expected to understand that such practices constitute academic dishonesty 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. Plagiarism includes, but is not limited to: submitting, without appropriate acknowledgement, a report, notebook, speech, outline, theme, thesis, dissertation, or other 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, including (but not limited to) another individual's academic composition, compilation, or other product, or commercially prepared paper.

2. Cheating and dishonest practices in connection with examinations, papers, and projects, including but not limited to:
   a. Obtaining help from another student during examinations.
   b. Knowingly giving help to another student during examinations, taking an examination or doing academic work for another student, or providing one's own work for another student to copy and submit as his/her own.
   c. The unauthorized use of notes, books, or other sources of information during examinations.
   d. Obtaining without authorization an examination or any part thereof.

3. Forgery, misrepresentation, or fraud:
   a. Forging or altering, or causing to be altered, the record of any grade in a grade book or other educational record.
   b. Use of University documents or instruments of identification with intent to defraud.
   c. Presenting false data or intentionally misrepresenting one's records for admission, registration, or withdrawal from the University or from a University course.
   d. Knowingly presenting false data or intentionally misrepresenting one's records for personal gain.
   e. Knowingly furnishing the results of research projects or experiments for the inclusion in another's work without proper citation.
   f. Knowingly furnishing false statements in any University academic proceeding.”
**Academic Integrity Statement**
The integrity of the classes offered by any academic institution solidifies the foundation of its mission and cannot be sacrificed to expediency, ignorance, or blatant fraud. Therefore, I will enforce rigorous standards of academic integrity in all aspects and assignments of this course. For the detailed policy of West Virginia University regarding the definitions of acts considered to fall under academic dishonesty and possible ensuing sanctions, please see the Student Conduct Code at [http://campuslife.wvu.edu/r/download/220286](http://campuslife.wvu.edu/r/download/220286). Should you have any questions about possibly improper research citations or references, or any other activity that may be interpreted as an attempt at academic dishonesty, please see me before the assignment is due to discuss the matter.

**Inclusivity Statement**
The West Virginia University community is committed to creating and fostering a positive learning and working environment based on open communication, mutual respect, and inclusion. If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with the Office of Accessibility Services (293-6700). For more information on West Virginia University's Diversity, Equity, and Inclusion initiatives, please see [http://diversity.wvu.edu](http://diversity.wvu.edu)

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Course outline

Chapter 1. Introduction

Chapter 2. Basic system elements
  2.1. Sensors and transducers
  2.2. Signal conditioning
  2.3. Data presentation and acquisition systems
  2.4. Actuation systems (pneumatic and hydraulic, mechanical, and electrical)

Chapter 3. System modeling
  3.1. System models
  3.2. Dynamic response of systems (time domain and frequency domain)
  3.3. System transfer functions
  3.4. Vibrations
  3.5. Harmonic analysis – Fourier transform

Chapter 4. Filtering - MATLAB tools and digital methods
  4.1. Filter Classification
  4.2. Digital filters in frequency domain
  4.3. Implementation of digital filters
  4.4. MATLAB filtering tools

Chapter 5. Digital and microprocessor systems (time-permitting)
  5.1. Digital logic
  5.2. Microprocessors
  5.3. Input/output systems
  5.4. Programmable logic controller
  5.5. Fault finding

Chapter 6. Closed-loop control
  6.1. Stability criteria
  6.2. Initial and final value theorems
  6.3. Closed-loop control modes (P, D, I)

Chapter 7. Introduction to artificial intelligence techniques
  7.1. Genetic algorithms
  7.2. Fuzzy logic
  7.3. Artificial neural networks

Labs:

1. Data Acquisition Using the Sound Card and the Matlab DAQ Toolbox - Analog Input
2. Temperature Measurement Using the National Instruments DAQ Card and the Matlab DAQ Toolbox - Analog Input
3. Data Acquisition Using Piezoelectric Accelerometers, NI DAQ Card, and the Matlab DAQ Toolbox - Analog Input
4. Modeling and Simulation of a Measurement System Using Simulink
5. Vibration Measurement, Frequency Analysis, and Filtering