ENME 482L – Vibrations/Controls Laboratory, Summer 2016

Department of Mechanical Engineering

Lecture Details	Monday/Wednesday, 4:30pm to 5:20pm Information Technology and Engineering (ITE), Room 104
Laboratory Sessions	Monday/Wednesday, 5:30pm to 8:00pm, ITE 242
Instructor	Name: Dr. Neil Rothman Office: ENGR 221 Hours: Monday/Wednesday 2:00 – 4:30pm Phone: 410-455-5507 Email: nrothman@umbc.edu
Teaching Assistants	Jarod Horn (jhorn3@umbc.edu), Kourosh Kalayeh (kourosh2@umbc.edu)

Course Objectives

1. Model and evaluate the behavior of dynamic systems using differential equations and control systems methods.
2. Utilize laboratory test and measurement equipment to evaluate the behavior of dynamic systems and control systems.
3. Design, build, simulate, and test control systems using both MATLAB and LabVIEW.
4. Work in a team to develop a better understanding of microcontrollers.

Course Description

This course is intended to reinforce the concepts learned in ENME 360 (Vibrations) and ENME 403 (Automatic Controls) through hands-on experiments. Students will utilize standard test, measurement, and analysis equipment, as well as computer based data acquisition and control. The following concepts will be considered.

Controls Concepts:

- Systems, input/output relationship, synthesis, modeling (physical system vs. mathematical)
- Analytical tools (e.g., Laplace transforms)
- Time response of a linear dynamic system
- Frequency response (magnitude and phase as a function of frequency), bandwidth, stability margins
- Design of feedback systems to meet steady state and transient performance requirements

Vibrations Concepts:

- Free vibration and forced response
- Under-, critical-, and over-damped vibrations
- Natural frequencies, modal analysis

Additional Course Details

The course will consist of 7 experiments, which will be performed in groups of 2 to 3 people. Each group will be responsible for submitting a laboratory report for each experiment. Each student will be required to submit a pre-lab assignment; this will be done individually (not in groups). The planned

experiments are listed as follows.

Lab #1:	Laboratory equipment familiarization, including *data acquisition* using Labview/ELVIS; effects of sampling rate and filtering; finding time constant of a first order system
Lab #2:	*Second order mechanical system*; damped spring mass system; time and frequency domain analysis; determining time constants, natural frequencies, and effects of varying damping
Lab #3:	*Vibration isolation*; accelerometers; isolator transmissibility
Lab #4:	*Vibration*; two degree of freedom vibration system; eigenvalues and eigenvectors
Lab #5:	*Feedback controller design*; linear actuator control
Lab #6:	*Two controller types;* air tank pressure control
Lab #7:	*Arduino-based PID control;* Ball balance

Each laboratory will require students to create a mathematical model of the system being investigated and/or simulate the behavior of the system using MATLAB. Students will build the data acquisition and/or control systems using Labview and evaluate the performance of each physical system. This will give students the end-to-end experience of modeling, controlling, and evaluating a dynamic system using typical engineering test and measurement tools, as well as the opportunity to observe the differences between ideal system analysis and actual system performance.

Project Details

The course will also include a project. The project will involve programming a controller for a dynamic system to achieve optimal performance or analysis and experimentation with a complex mechanical system undergoing vibrations. Multiple teams will be assigned to a specific system. More details will be provided in class.

Grading Policy

The final course grades will be based on the following grade weights and breakdowns. There are no midterms or final exam.

Pre-Lab Assignments	15%
Laboratory Reports**	50%
Project Presentation/performance	10%
Project Report	20%
Teamwork (Peer Evaluation)	5%

Policies and Procedures

i) The work is due on time. Pre-labs and reports are due before lecture on the day that they are due as per the schedule. No late work will be accepted (must be before 4:30pm as per the schedule). Late work will be assigned a grade of zero. Submission in PDF format is preferred.
ii) Follow the latest report guidelines on Blackboard. Content is most important, however grammar, spelling, and so forth, are also considered.
iii) A teaching assistant (TA) or instructor must be present in the laboratory space while students are working. If no TAs or instructor are present, no students should be working in the laboratory space.

Collaboration Policy

Pre-lab assignments are to be submitted individually. The laboratory reports and project report are to be submitted in groups of 2 to 3 people.

** For each laboratory report, one member of the group will be designated (per your selection) as the lead writer and has final responsibility for completion and submission of the report. The designated person must be indicated on the cover of the report and it will count double toward his/her report grade. This responsibility must rotate among the group members (i.e., no one can be the lead for >4 reports and each person must be the lead for at least 1 report).

Academic Integrity

By enrolling in this course, each student assumes full responsibility as a participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty. Academic misconduct could result in disciplinary action that may include, but is not limited to, a grade of zero on the particular work, a grade of F in the class, suspension, or dismissal. Please refer to the full student academic conduct policy for more information.

ABET Program Criteria

In addition to teaching the subject material, accreditation of the Department of Mechanical Engineering at UMBC by ABET requires the curriculum to meet certain criteria. After completing this course, students should demonstrate:

(a) Apply knowledge: laboratories require students to apply their knowledge of vibrations, control systems, and differential equations to system modeling, simulation, and evaluation

(b) Design and conduct experiments, analyze and interpret data: students conduct experiments to evaluate the behavior of dynamic systems, interpreting their data to better understand test and measurement and the design and evaluation of control systems

(d) Teamwork: students work in teams to perform laboratory experiments and on projects

(e) Solve problems: posing a problem to be solved and then developing experiments to evaluate a solution are required for each experiment.

(g) Communication: students prepare written reports for each experiment and give oral presentations on their team projects

(k) Application to practice: dynamic system design, controller design, and the use of laboratory instrumentation and data acquisition equipment are skills required of professional engineers. Students develop and apply these skills

throughout the course.

Syllabus Note Please note that this course syllabus is subject to change. The most recent version is available on the course website (Blackboard).

Class Schedule

Date	Lab	Topic/Event	Deliverables Due*	
			Pre-Lab	Lab Report
7/11	Lab #1	*Lecture: Course overview; data acquisition* **Lab #1: Data acquisition, first order thermal system**	1	–
7/13	Lab #2	*Lecture: Second order systems; mechanical* **Lab #2: Second order mechanical system**	2	–
7/18	Lab #3	*Lecture: Vibrations; spring-mass system* **Lab #3: Vibration isolation**	3	1
7/20	Lab #4	*Lecture: Multiple DOF systems* **Lab #4: 2 DOF mechanical system**	4	2
7/25	Lab #5	*Lecture: Control systems theory; feedback* **Lab #5: Linear actuator control**	5	3
7/27	Lab #6	*Lecture: Free study day; no lecture* **Lab #6: Air tank pressure control**	6	4
8/1	Lab #6	*Lecture: Free study day; no lecture* **Lab #6: continued**	–	5
8/3	Lab #7	*Lecture: Overview of Arduino systems* **Lab #7: Arduino-based control system**	7	–
8/8	Project	*Lecture: Project introduction* Students will work in groups on their lab project. The lab space will be made available to students during the scheduled lab period. **Final project demonstrations, presentations, and reports are due on 8/17 during the lab session.**	–	6
8/10	Project		–	7
8/15	Project		–	–
8/17	Project	Project demonstrations	Project Demonstration	Project Report

* Note that items must be submitted online (Blackboard) prior to 4:30pm on the due date. No late items will be accepted. A grade of zero will be assigned to late submissions. You must receive a passing grade (70%) in both the lab and project components of the course in order to pass the course.