ME 4200: VIBRATIONS AND CONTROLS

COURSE OUTLINE - Winter 2018

TUTH 3:30 pm – 5:17 pm, SFH 365

INSTRUCTOR:

Prof. Zissimos P. Mourelatos

Office: 402D Engineering Center

e-mail: mourelat@oakland.edu

OFFICE HOURS:

2:00 PM - 3:00 PM, TUTH.

TEXT & REFERENCES:

1. ***System Dynamics, 4th Edition***, by Katsuhiko Ogata, Pearson Prentice Hall, 2004. ISBN 0-13-142462-9. This will be the course textbook.
2. ***Course Notes.*** Course notes will be also provided supplementing the textbook.
3. ***Mechanical Vibrations,*** 4th edn., by S. S. Rao, Pearson Prentice Hall, 2004. ISBN 0-13-048987-5
4. ***Mechanical Vibration,*** by W. J. Palm III, John Wiley & Sons, 2007. ISBN 978-0-471-34555-8.
5. ***System Dynamics & Control,*** by E. Umez-Eronini, Brooks/Cole Publishing Comp., 1999. ISBN 0-534-94451-5

COURSE OBJECTIVES:

The general objective of this course is to cover the fundamental principles of vibration and classical control theories and demonstrate their usefulness in engineering practice. A comprehensive treatment of modeling and analysis of dynamic systems will be presented, as well as an introduction to control systems. Emphasis will be placed on mechanical vibratory systems. The course will provide the necessary background for more advanced topics of vibration and control theories. The primary focus will be on the engineering significance of the physical phenomena. A rigorous mathematical structure will be providing a supporting role. Numerous examples will be used to help the student understand the material avoiding therefore, the pitfall of overgeneralization. To further enhance engineering reality, detailed digital computations will be presented so that the student can solve meaningful numerical problems. The student is assumed to have an elementary knowledge of mechanics, dynamics, linear algebra and differential equations, although the basics of these topics will be covered in class. MATLAB will be used for solution and plotting purposes.

Specifically, the course objectives are as follows:

- Free and forced vibration response of one and multiple degree of freedom systems (a,e).
- Derivation of equations of motion of discrete systems using the free-body diagram method (a,e,i).
- Vibration isolation, rotating imbalance and vibration absorbers (a,b,c,e,i)
- Laplace transform and its use in solving linear, time-invariant differential equations (a,e,i,k).
- Transfer function approach to modeling dynamic systems (a,e,k).
- State-space approach to modeling dynamic systems (a,c,e,i,k).
- Time domain analysis of dynamic systems including transient response analysis of first-order and second-order systems (a,b,c,e,k).
- General solution of the linear, time-invariant state equations (a,e,k).
- Frequency domain analysis of dynamic systems. Use of sinusoidal transfer function (a,b,c,e,k).
- Time-domain analysis and design of control systems including block diagrams, PID controllers, transient response analysis and specifications, stability analysis and root-locus plots using MATLAB (a,b,c,e,i,k).
- Introduction to frequency-domain analysis and design of control systems including Bode diagram representation (a,c,e,i,k).
- Extensive use of MATLAB in solving vibration and control problems (b,d,e,k).

HOMEWORK:

Five or six homework assignments will be given during the semester. The due date will be on each homework assignment. Homework will be collected and checked. Late homework can only be accepted at the discretion of the instructor.

EXAMS:

There will be **three** examinations as follows:

First Exam	February 15, 2018
Second Exam	March 22, 2018
Final Exam	April 19, 2018, Noon – 3 pm, 365 SFH

The exams are 105-minute. Four sheets (single-sided) of hand-written notes may be brought to the exams. Solutions of homework assignments or of any other problems are not allowed. No electronic devices (including cell phones) are allowed, except for an approved calculator. Should you have any conflict, please contact the instructor.

GRADING:

The final course grade will be the weighted average of:

First Exam	30%
Second Exam	30%
Final Exam	30%
Homework (5 or 6 sets)	10%

Grades are determined based on a normal distribution curve of the class.

CONDUCT CODE:

Persons suspicious of cheating or plagiarism will be brought to the attention of the Academic Conduct Committee (ACC) for investigation. If found guilty, they will be given a 0.0 final course grade in addition to the possible sanction imposed by ACC.

COURSE CONTENT:

The tentative course content includes the following topics:

1. Introduction to System Dynamics (**Ch. 1**)
   - Terminology
   - Mathematical modeling; differential equations
   - Analysis and design of dynamic systems
2. Laplace Transform (**Ch. 2**)
   - Complex numbers, complex variables, complex functions
   - Laplace transformation and inverse laplace transformation
   - Solution of linear, time-invariant differential equations
3. Mechanical Systems and Basic Vibration Theory (**Ch. 3** and **Notes**)
   - Units
   - Mechanical elements; Elements of a vibratory system
   - Periodic motion, and harmonic motion
   - Phasor representation
   - Fourier analysis of a periodic function
   - Vibration modeling using free-body diagram method
   - Free vibration of a single degree of freedom system
   - Forced vibration of a single degree of freedom system
   - Free and forced vibration of multiple degree of freedom systems
4. Transfer-function approach to modeling (**Ch. 4**)
   - Block-diagram representation
   - Partial fraction expansion
5. State-space approach to modeling dynamic systems (**Ch. 5**)
   - Introduction
   - Transient-response analysis
   - State-space modeling with and without input derivatives
6. Time-domain analysis of dynamic systems (**Ch. 8**)
   - Solution of state equation
7. Frequency-domain analysis of dynamic systems (**Ch. 9** and **Notes**)
   - Sinusoidal transfer function
   - Vibration of rotating mechanical systems
   - Vibration isolation
   - Vibration absorbers
8. Time-domain analysis and design of control systems (**Ch. 10**)
   - Introduction
   - Block diagrams and their simplification
   - Automatic controllers
   - Transient response analysis and specifications
   - Stability analysis

9. Frequency-domain analysis and design of control systems (**Ch. 11**)
    - Introduction
    - Bode diagram representation of frequency response
    - Nyquist plots and Nyquist stability criterion
    - Design of control systems in frequency domain

PROGRAM OUTCOMES:
They are a set of skills that assure the achievement of the program educational objectives. Before graduating, SECS students will demonstrate their skills in the following key areas:

a. an ability to apply knowledge of mathematics, science, and engineering
b. an ability to design and conduct experiments, as well as to analyze and interpret data
c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d. an ability to function on multi-disciplinary teams
e. an ability to identify, formulate, and solve engineering problems
f. an understanding of professional and ethical responsibility
g. an ability to communicate effectively
h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i. a recognition of the need for, and an ability to engage in life-long learning
j. a knowledge of contemporary issues
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.