MEEN 434/634  Dynamics and Modeling of Mechatronic Systems


Instructor:

Won-jong Kim, Ph.D.
Associate Professor
223 Mechanical Engineering Office Building
(979)845-3645, phone
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http://alum.mit.edu/www/wjkim, webpage

TA/Grader:

none

Lectures:

MWF 8:00 AM–8:50 AM at 204 ENPH

Office Hours:

MWF 8:50 AM–10:00 AM at 223 MEOB or 204 ENPH, or by appointment

Textbooks (required):


References:


On-Line Course Materials:

A course web page is being established at ecampus.tamu.edu. You should be able to access the web page if you are registered for the course. All course-related material you will need, e.g. textbooks, homework sets, solutions, and other useful materials will be placed.
**Prerequisite: MEEN 364**

- Dynamic systems and controls (MEEN 364)
- Differential equations, complex variables, and vector calculus (MATH 308 and 251)
- Freshman electromagnetics (PHYS 208)

  MATH 308, MATH 251, and PHYS 208 are prerequisite to MEEN 364. I expect you to be familiar with the following topics.

**Dynamic Systems and Controls:**
- Drawing free body diagrams
- Writing equations of motion
- Finding transfer function
- Simple controller design (PID, etc.)
- System stability

**Differential Equations, Complex Variables, and Vector Calculus:**
- Solving differential equations using Laplace transform
- Exposure to partial differential equations (in heat transfer, fluidics, or waves, etc.)
- Elementary complex variables (poles and zeros, Euler equation, etc.)
- Vector algebra (multiplication of vectors and matrices, matrix inversion, determinant, etc.)
- Vector calculus (gradient, divergence, curl, Laplacian, line integral, surface integral, volume integral, etc.)

**Electromagnetics:**
- Basic knowledge of Maxwell’s equations, Coulomb’s law, Ohm’s law, Faraday’s law, Biot-Savart law, and Ampere’s law
- Calculating electric and magnetic fields and forces for very elementary geometries such as point charges and current-carrying lines

**Course Objectives:**

- Understand dynamics and modeling of lumped-parameter and continuum electromechanical systems.
- Analyze and design linear and nonlinear actuators and transducers as crucial elements in electromechanical systems.

**Course Learning Outcomes:**

Upon successful completion of this course, you will be able to:

- Understand and model mechanical-electrical interactions with dynamics and electromagnetics principles using lumped elements.
- Determine force using force-energy and force-coenergy relations in lumped electromechanical systems.
- Analyze and model magnetic circuits. This will enable you to design linear and nonlinear actuators including voice-coil actuators, electromagnets, etc.
- Analyze and design rotary and linear DC and AC motors.
- Understand dynamics of mechatronic systems.
- Calculate force using Maxwell stress tensor in stationary and moving continuum media.
- Understand dynamics of electromechanical continua, and derive equations of motion of magnetizable elastic strings/membranes under the influence of time-varying field.
Applications:

Conventional linear/rotary motor design/analysis, sensor/actuator modeling and characterization, magnetic bearing/levitation, electromagnetic launcher, specialty (piezoelectric, magnetostrictive, magnetoelastic, electrostatic, electrochemical, ionic etc.) actuators and sensors, and so forth.

Grading:

- Two in-class exams for 25% each
- Final exam for 40%
- Homework for 10% total

There will be nine or ten homework sets. You will be usually given 10 days to work on each homework set. Each homework set is due the beginning of the class on its designated due dates. No late homework will be accepted. Class participation (up to 5%) will not be quantified but might affect the final grades for those on grade borderlines. This class participation includes participation in discussion in class and the instructor’s office hours, volunteering to answer/solve problems, and asking intelligent questions to enhance the class’s understanding of the course material.

Exams:

- First in-class exam: Friday, October 14, 2016.
- Second in-class exam: To be announced.
- Final exam: 10:00 AM–noon, Friday, December 9, 2016.

All exams are closed-book, closed-note. A formula sheet will be provided for each exam.

Policy on Grading Complaints:

If you feel a mistake was made in grading any material, please first contact the person doing the grading within a week after the graded paper is distributed. If you are not satisfied with the resolution of the matter then talk to me. After the one week discussion period, we will not review your exams or change grades. Make your complaint to me in writing and via e-mail. Be specific about your complaints. Please note I do not negotiate my partial-credit policy with students.

Tentative Grading Policy:

- A: greater than 80%
- B: greater than 60% and less than 80%
- C: greater than 40% and less than 60%
- D, F: less than 40%

Absences:

Work missed due to absences will only be excused for University-approved activities in accordance with TEXAS A&M UNIVERSITY STUDENT RULES (see http://student-rules.tamu.edu/rule7.htm). Specific arrangements for make-up work in such instances will be handled on a case-by-case basis. In accordance with recent changes to Rule 7, please be aware that in this class any “injury or illness that is too severe or contagious for the student to attend class” will require “a medical confirmation note from his or her medical provider” even if the absence is for less than 3 days (see 7.1.6.2 injury or illness less than three days).
To Earn Graduate Credit:

MEEN 434/634 is a stacked course. University policy FS.18.033 requires that more rigorous activities be provided for graduate students to ensure work at the graduate level. To earn the MEEN 634 credit, you are expected to perform one of the following (in the descending order of preference):

- Design a new actuator or sensor applying the principles covered in this course.
- Analyze an existing actuator or sensor applying the principles covered in this course.
- Summarize and criticize in the context of this course the contributions of at least three research papers authored by others.

I strongly recommend that you relate this activity to your own graduate research. You should submit a type-written report by 8:00 AM on Monday, December 5, 2016. The report should not exceed 10 single-spaced pages with 12-point fonts. I will be glad to offer my guidance regarding this activity, and you are encouraged to speak with me early in the semester. If you do not feel like doing this assignment or will be too busy this semester to complete it in time, you should change your registration to MEEN 434. An MEEN student in the G7 classification is allowed to include up to two 400-level MEEN courses in his/her degree plan.

ADA Statement:

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact Disability Services, in Cain Hall, Room B118, or call 845-1637. For additional information visit http://disability.tamu.edu.

Academic Integrity:

Aggie Honor Code: “An Aggie does not lie, cheat, or steal, or tolerate those who do.”

Upon accepting admission to Texas A&M University, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning and to follow the philosophy and rules of the Honor System. Students will be required to state their commitment on examinations, research papers, and other academic work. Ignorance of the rules does not exclude any member of the Texas A&M University community from the requirements or the processes of the Honor System. For additional information please visit: aggiehonor.tamu.edu.

On all course work, assignments, and examinations at Texas A&M University, the following Honor Pledge shall be preprinted and signed by the student:

"On my honor, as an Aggie, I have neither given nor received unauthorized aid on this academic work."

Signature of Student
**Schedule:**

Following is a tentative schedule. The pace will be adjusted as the semester progresses.

<table>
<thead>
<tr>
<th>Week</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overview of the course, review of vector calculus, review of electric field theory</td>
</tr>
<tr>
<td>2</td>
<td>Review of magnetic field theory, quasistatic approximations</td>
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<tr>
<td>3</td>
<td>Constitutive laws, energy conservation, force-energy relations</td>
</tr>
<tr>
<td>4</td>
<td>Coenergy, force-coenergy relations, magnetic circuits</td>
</tr>
<tr>
<td>5</td>
<td>Energy conversion cycles, systems with multiple terminals, variable-reluctance actuators</td>
</tr>
<tr>
<td>6</td>
<td>Permanent magnets, coupled mechanical and electromagnetic systems</td>
</tr>
<tr>
<td>7</td>
<td>Static equilibria, linearization about static equilibria</td>
</tr>
<tr>
<td>8</td>
<td>Dynamic equilibria and linearized dynamics, active stabilization, magnetic levitation example</td>
</tr>
<tr>
<td>9</td>
<td>Field transformations, conduction conservative laws, field transformation examples</td>
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<tr>
<td>10</td>
<td>DC Machines, magnetic diffusion</td>
</tr>
<tr>
<td>11</td>
<td>Magnetic diffusion in sinusoidal steady state and in convective media, charge relaxation</td>
</tr>
<tr>
<td>12</td>
<td>Quasistatic stress tensor, stress tensor examples</td>
</tr>
<tr>
<td>13</td>
<td>One-dimensional elastic continua, dynamics of electromechanical continua</td>
</tr>
<tr>
<td>14</td>
<td>Electromechanical dynamics with convection, introduction to continuum electromechanics</td>
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Fall 2016  
Instructor: Prof. Won-jong Kim  

Questionnaire

Name:                      For Credit / Audit
Email address:             
Phone number:              
TAMU ID:                   
TAMU Department:           
Are you a senior, a master’s student, or a doctoral student?  
Advisor (if applicable):  

Have you taken MEEN 364 (or equivalent)?               Yes.  No.
Have you taken MATH 308 and 251 (or equivalent)?       Yes.  No.
Have you taken junior-level Electromagnetic Field Theory?  Yes.  No.
(such as either PHYS 304 or ECEN 322, which is not pre-requisite, though.)

What would you like to learn from this course?  

Will the course material be useful for your research? If so, please tell me about your research briefly.