

# MECH 550Q: Advanced Mechatronics

THE UNIVERSITY OF BRITISH COLUMBIA

Department of Mechanical Engineering

September-December, 2009

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## Instructor

Prof. Xiaodong Lu, Kaiser 3103, (604) 827-3541; Office hours, 4-5pm Friday.

## Lectures

Tue & Thu 3:30-5:00pm, CEME 1210.

Course description: Actuator and sensor design principle; time domain, spatial domain and frequency domain analysis and physical tuition.

## Topics Covered

- Review of physical laws: Mechanics, Dynamics, Electromagnetics.
- Quasistatic approximation: generalized loop transmission for decoupled modeling. Examples for electrostatic systems and magnetostatic systems.
- Advanced electromechanics: Maxwell stress tensor and Halbach array.
- Mechatronics design principle I: modulation and demodulation for signal/energy transmission/reception.
- Mechatronics design principle II: reversal for better accuracy.
- Energy and co-energy method.
- Mechatronics design principle III: reciprocity for a unified approach to sensor and actuator analysis.
- Stiffness method
- Mechatronics design principle IV: spatial filtering for better linearity.
- Mechatronics design principle V: guarding for better precision.
- Mechatronics design principle VI: locating right-half plane zero for maximal bandwidth.
- Case study: levitating motors for nanometer precision.

## Assessment

Homeworks(25%) + Project(25%) + Mid-term exam(25%) + Final exam(25%)

Homework is issued on every Thursday and due at the following Thursday.

## Exams

The mid-term exam on Oct. 29. The final exam to be arranged.

## Text

There is no required textbook. Lecture notes will be handed out in class.

## Tentative Schedule

Lecture	Content
1	Course introduction; Superposition; Review of math and physics: physical laws and Maxwell equations.
2	Example applications of Maxwell equations and boundary conditions Quasistatic approximation.
3	Electroquasistatic system (EQS) example
4	Magnetoquasistatic system (MQS), solenoid air-gap example, Demo; DC motor analysis MQS
5	Modulation
6	Fourier analysis of modulation
7	Reversal Two-phase motor and improved commutation Reversal principle, $1 + (-1) = 0$
8	Reversal. Image method. LVDT
9	Permanent magnet. Magnetic charge point of view.
10	Energy and co-energy method. MQS example
11	EQS example. DC motor distributed winding and spatial filtering.
12	Reciprocity Generalized Reciprocity Maxwell reciprocal principle; Structural dynamic systems Symmetry of inductance matrix
13	DC motor analysis Structural dynamics
14	General structural reciprocity Piezoelectric effect, load cell
15	Piezo actuator analysis
16	Voice coil motor
17	Spatial filter
18	Motor evolution, linear motor
19	Levitating motor, Maxwell Stress Tensor
20	Halbach array and levitating planar motor design
21	Case study
22	Non-Minimum Phase system