Lecture 01: Introduction

12 March 2012
General information

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Course description

A course designed to develop analytical and experimental skills in modern engineering measurement methods based on electronic instrumentation and computer-based data acquisition systems. The lectures are concerned with the engineering analysis and design as well as the principles of instrumentation, whereas the laboratory periods afford the student an opportunity to use modern devices in actual experiments. In these Sections of ME-3901, state-of-the-art microelectromechanical (MEMS) sensors and actuators will be introduced.

Lecture topics include:
- Review of engineering fundamentals and, among others, discussions of standards, measurement and sensing devices, experiment planning, data acquisition, analysis of experimental data, and report writing. Laboratory experiments address both mechanical and thermal systems and instrumentation in traditional mechanical engineering: heat transfer, flow measurement/visualization, force/torque/strain measurement, motion/vibration measurement.

General information

**Office hours:** please complete General Information Form (GIF)

**Instructors:** Cosme Furlong / Chris Scarpino
Everyday from 3:00 to 3:50 or by appointment
To be rescheduled after reviewing your completed GIF

**Teaching Assistants:**
To be scheduled after reviewing your completed GIF
Grading

The grade for the course will be based on:

20% FOR HOMEWORK,
20% FOR EXAMS,
50% FOR LABORATORY REPORTS, and
10% FOR LABORATORY AND LECTURE PARTICIPATION AND ATTENDANCE.
Homework

HOMEWORK IS ASSIGNED WEEKLY. Homework will be collected on Mondays the week after it is assigned. Except April 16th, when homework will be collected on Tuesday.

All homework assignments are done by each individual without collaboration.
Exams

THERE WILL BE TWO (2) EXAMS: MIDTERM and FINAL. Exams will be closed books and closed notes, unless otherwise indicated.

All exams are done by each individual without collaboration, unless otherwise indicated.
Laboratories

THERE WILL BE FIVE (5) LABORATORY EXPERIMENTS. Each experiment requires laboratory efforts and the write-up of a report.

All laboratory preparations are done individually and jointly within small laboratory groups (2 students per group.)

Data analysis, reduction, and synthesis are done individually and jointly within small laboratory groups.

Each laboratory group completes the laboratory reports jointly.

Laboratory reports are due Wednesday, the week after they are finished. There is NO credit for later reports.
General information

Review syllabus: see corresponding handout
General information

Review general guidelines for preparation of laboratory reports: see corresponding handout (HER)
General information: laboratory safety

Review note on safety: please complete handout
Required text: Holman, 8th Edition

*Experimental Methods for Engineers*

**Hardcover:** 800 pages  
**Publisher:** McGraw-Hill Science/Engineering/Math; 8 edition  
**Language:** English  
**ISBN-10:** 0073529303  
**ISBN-13:** 978-0073529301  
**Product Dimensions:** 9.2 x 7.4 x 1.3 inches
Recommended text: Bishop

Original version comes with a CD (with software/examples)

**Paperback:** 752 pages

**Publisher:** Prentice Hall; 1 Pap/Dvdr edition (December 28, 2009)

**Language:** English

**ISBN-10:** 0132141299

**ISBN-13:** 978-0132141291

**Product Dimensions:** 9 x 7.3 x 1.2 inches
Engineering experimentation and the CAD/CAE/CAM cycle

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Experimental stress analysis in the field: examples

Bridges: calculated/measured (estimated) stresses

Equivalent stresses

Bridges: calculated/measured (estimated) strains

Equivalent strains

(color not shown)
Experimental stress analysis in the field: examples

Turbine engine: experiments

Calculated (estimated) thermo-mechanical induced stresses on a blade

Model of a rotor

Stress concentration
Engineering experimentation in the field: examples

Tire/dynamics testing

Displacement measurements: large strains induced, dynamic loads

Testing machine
Engineering experimentation in the field: examples
Impact loads/stresses/strains

Display center

PONTOS

WPI
Engineering experimentation in the field: examples

- Turbine blade: Vestas’ 850 kW at Holy Name high school, Worcester MA

  Analyzed as a cantilever beam

  Wind load

  Composite material

  Fixed to rotor

  Computed equivalent stresses
Engineering experimentation in the field: examples

- Turbine blade: Vestas’ 850 kW at Holy Name high school, Worcester MA

Blades dynamics

PONTOS
Modern measurement systems

- Component/System under investigation
- Transducers and signal conditioning
- Analog to digital interface
- Processing system and software
- Analog to digital interface
Modern measurement systems: LabView 2009

Virtual instrument (VI)

Digital oscilloscope
Modern measurement systems: LabView 2009
Virtual instrument (VI)
Behind Digital Oscilloscope VI
Accuracy, precision... and resolution...
Accuracy, precision... and resolution...

**Precision**: ability to reproduce a reading (not necessarily correct);

**Accuracy**: deviation (or error) of reading from a true value;

- **In control, capable**
- **In control, not capable**
- **Capable but out of control**
- **Not capable, and out of control**

**Capable -> precise**
**In control -> accurate**
Accuracy, precision... and resolution...

Instrument Capabilities
DVM - Digital Voltmeter
Assume ~ 8 bit DVM with 0-10 volt scale

\[ \text{Resolution: } \frac{10 \text{ Volts}}{2^8} \approx 0.04 \text{ Volts} \]

0.04 Volts is the "Least Count". This term usually has more significance on an analog meter.
Range... gain...

- **Range**: minimum and maximum voltages
  - Smaller range → more precise representation of signals (for a given digital resolution)

- **Gain**: amplification or attenuation of a signal for best fit in range
Fundamental concepts: basic quantities

• **Length**: describes size of a physical system - UNITS!!
• **Time**: is understood as a succession of events
• **Mass**: property of matter used to compare interaction between bodies
• **Force**: measure of interaction between bodies. Newton’s laws

Examples include:

° **Gravitational**
° **Electrical and magnetic**
° **Thermally induced**

Characterized by their: magnitude, direction, and point of application!! **VECTORIAL QUANTITY**
Fundamental concepts: basic quantities

- **Work**: force $\times$ distance. Scalar quantity
- **Power**: $(\text{force} \times \text{distance}) / \text{time}$. Scalar quantity
- **Etc...**
Reading assignment

- Holman (required): Ch. 1,
  Ch. 2: sections 2.1 to 2.6

- Bishop (recommended): Ch. 1, 2
Homework assignment

• Holman (required): Review questions: 2.1, 2.2, 2.3

• Bishop (recommended): E1.2, E1.3, E1.4, P1.3