ME588 MECHATRONICS

INTEGRATED DESIGN OF ELECTRO-MECHANICAL SYSTEMS

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PROJECT
MANAGEMENT
SHELTON'S RULE #1:

All projects of non-trivial complexity will take approximately three times as long to complete as initially expected. A factor of $\pi$ may be used to provide the necessary precision.
SHELTON'S RULE #2:

You will be emotionally attached to your own ideas. Get over it.
SHELTON'S RULE #3:

Respect the reasonableness and goodwill of others with whom you disagree.
GUIDES

Instructor
- Jeff Shelton
- E-mail: shelton@purdue.edu
- Office Hours: By appointment or through e-mail (preferred)

Teaching Assistant
- Manish Anand
- E-mail: manand@purdue.edu
- Office Hours: By appointment
COURSE WEBSITE

https://engineering.purdue.edu/ME588/

- Syllabus
- Course Calendar
- Course Notes
- Lab Instructions
- Project Information
- Tutorials and user manuals: Please don’t print them out!
- FAQs: Frequently asked questions
- Links of Interest
BLACKBOARD

https://blackboard.purdue.edu/
- Only if course website goes down...
ELEMENTS

 Lectures
  ▪ Lecture notes – posted to the course website
  ▪ Ask questions!

 Video lectures:
  ▪ Posted on Wednesday or Friday by 9 pm
  ▪ Enables lectures to finish in mid-March

 No Homework

 One Midterm Exam
  ▪ Design a state machine, 1 hour in-class exam, open books and notes (you probably won’t be using them)

 No Final Exam
ELEME NTS

Seven Structured Labs

- Lab handout – posted on course website before the lab
- Pre-Lab
  - One per lab group, due at beginning each lab
  - Will be spot checked during lab
- Post-Lab (Lab report)
  - One per lab group, due two days after the lab
  - Thursday (for Tuesday lab) and Friday (for Wednesday lab) at 5 PM
- Always ask yourself:
  - Why am I doing this?
  - How and when can I use this?
ELEMENTS

Vehicle Concept Report

- Brief 3-page report that succinctly details your recommendation for an autonomous vehicle.

Printed Circuit Board

- Design and fabricate a printed circuit board that implements an “H-bridge” circuit
- Mechanical template provided
- Video tutorials available
Final Project

- **Interim Progress Reports** – Tuesdays and Thursdays after spring break.
- **Final report, demo, and presentation** – lots of fun after a very trying last few weeks.
- **Start early! Get organized! Stick with the deadlines! DO NOT procrastinate!**
- Requires planning, teamwork, effort, and patience.
- One hour spent in planning can save a day of labor.
- Leave at least 1 week at the end for buffer.
- Class budget plus "bring your own" HW limit.
Grading Policy:

- Final Project (report + demo + presentation) 40%
- Lab Performance (pre + post + participation) 21%
- Midterm Exam 13%
- Instructor and Peer Evaluation 10%
- Vehicle Concept Report 05%
- Working H-bridge PCB 05%
- Interim Reports (participation + content) 05%
- Peer Evaluation Forms 01%

Important dates:

- Friday (1/16) 5 PM – Email questionnaire to Jeff Shelton
- Next Monday (1/19) – Lab groups posted on course website
UNIT 1: INTRODUCTION
MECHATRONIC DESIGN

Topics

- What is mechatronics?
- Traditional vs. integrated design method
- Design trade-offs

At the end of this section, you should be able to:

- Define mechatronics
- Identify mechatronic devices in the wild
- Identify trade-offs in mechatronic design
WHAT IS MECHATRONICS?

Mechatronics describes the synergistic integration of mechanical, electronic, computer, and control systems.
WHAT IS MECHATRONICS?
MECHATRONICS IS AN INTERDISCIPLINARY PROCESS

- Mechanical
  - Thermal or fluid systems
  - Solid mechanics
  - Dynamics and vibrations

- Electronic
  - Sensors and actuators
  - Power systems
  - Communication systems

- Control
  - Classical control theory
  - Modern control theory

- Computer
  - Design computation
  - Microprocessor integration
IS THIS A MECHATRONIC DEVICE?

A. Yes
B. No
IS THIS A MECHATRONIC DEVICE?

A. Yes
B. No
IS THIS A MECHATRONIC DEVICE?

A. Yes
B. No
IS THIS A MECHATRONIC DEVICE?

A. Yes
B. No
OUR DESIGN CAPABILITIES HAVE EVOLVED OVER TIME

- **Industrial Revolution (Mechanical)**
  Energy conversion and transmission

- **Semiconductor Revolution (Electronic)**
  Signal conditioning, power amplification, and high-speed switching

- **Information Revolution (Computing)**
  Ubiquitous computing power and data analysis
DESIGN CAPABILITIES HAVE INFLUENCED THE DESIGN SEQUENCE

Traditional product realization involves sequential discipline-specific design efforts

Mechanical ▶ Electrical ▶ Controls ▶ Manufacturing ▶
MECHATRONICS RETHINKS THE TRADITIONAL DESIGN SEQUENCE

Integrating design and control is a relatively new approach to creating new products and processes.
SEQUENTIAL DESIGN MAY BE INEFFICIENT AND SUBOPTIMAL
The mechatronics engineer must have a **familiarity** with, if not expertise in, **each** of the four mechatronic components.
WHAT IS AIM OF MECHATRONIC DESIGN?

Mechatronics attempts to exploit interdisciplinary synergies, and to make intelligent design decisions when synergies are not available.
EXAMPLE

Achieve intermittent quarter-turn rotations?
INTEGRATED DESIGN

<table>
<thead>
<tr>
<th>Component</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic Systems</td>
<td></td>
<td></td>
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<tr>
<td>Control Systems</td>
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<tr>
<td>Computers/Software</td>
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<td></td>
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</tbody>
</table>

Consider: Application, cost, availability, flexibility, size, storage, reliability, etc.
Q: How to “mark” the location of a landmine?

A “mark” need not be physical

More electronic complexity
Less mechanical complexity

Less electronic complexity
More mechanical complexity
Computing Platform (Not the only one)

Arduino Uno-R3 USB Microcontroller Module

- ATmega328 (32 KB memory)
- 14 Digital I/O (6 PWM output)
- 6 Analog inputs
- Regulated 5V and 3.3V output
- Three power options:
  - USB
  - Wall adapter
  - $V_{\text{in}}/\text{GND}$ pin between 7-12V
- Tx/Rx serial communication
- Removable ATmega328 chip

http://www.arduino.cc/en/Main/arduinoBoardUno
COMING UP...

Electronic Systems
- Why do electronic systems matter?
- Electronic system analysis
- Electronic system building blocks

Computer Systems
- Why do computer systems matter?
- Combinational logic
- Sequential logic
- Finite state machines
ACTION ITEMS

1. Submit student questionnaire (or drop course) by 5 pm on Friday, 16 January
2. Purchase Arduino Uno (R3) and USB cable
3. No lab this week, first lab either 1/20 or 1/21