MEM 380/800 – Mechatronics 2 – Mechanisms and Algorithms

Introduction and Course Philosophy
Paul Oh: Background

- 5+ years industry before Drexel
- MEM Professor since 2000
- Advisor: ASME 10-years
- Advisor: 8+ SD teams
- 3 SD awards (COE, ASME, Baiada)
- $5M+ in research/design funds
- 60+ Journals, Books, Proceedings

- Drexel Autonomous Systems Lab
- NASA, ONR, Boeing Fellow
- NSF Robotics Program Director (2008-2010)

Enjoy creating courses where labs reinforce theory
Motivation for a Mechatronics Course Sequence

More Background:

• **Need 1:** Mechanism design is fundamental but poorly addressed at Drexel
  Evidence: Senior Design projects, lack of courses, competitions

• **Need 2:** Lack of Masters- and senior-level courses at Drexel
  Evidence: few options, fall/winter and spring/summer scheduling conflicts

• **Gap 1:** Mechatronics – taught from point-of-view rather than holistic approach
  ECE: limited coverage of mechanical aspects (e.g. force, torque, gears)
  MEM: heavy focus on electronics and embedded micros

• **Resources:** Mathematical theory versus Experiential discovery
  Mechatronics is essentially a collection of “best practices” that should be experienced
My “Issues” with Mechatronics Courses

Issue 1: Frankenstein Approach
• Ad-hoc: Pieces are slapped together
• One-offs: Hard to reproduce and rarely robust

Issue 2: Lack of Constraints
• If exists, typically only on footprint
• Economics of design are rarely addressed

Issue 3: Software tools rarely used in such courses
• CAD rarely ever discussed or used for prototyping
• Simulation rarely used for testing and evaluation

Issue 4: Books lack
• All very similar: focus on basic circuits or force/torque
• Projects difficult to reproduce
Differences: Western Versus Eastern Approach

Western Philosophy: The “individual” is sacred – perhaps leads to segmentation

Eastern Philosophy: The “group” is sacred – perhaps leads to harmonic integration
Automatons: Form Follows Function

[Images of Japanese Tea Serving Automaton and Japanese Arrow Shooting Automaton]

Japanese Arrow Shooting Automaton
http://www.youtube.com/watch?v=7PiG-FA11UM

Japanese Tea Serving Automaton
http://www.youtube.com/watch?v=MSvb8p7DQkE
Paradigm Shifts in Teaching, Learning and Design

Paradigm Shift
Old: Just-in-Case Teaching
New: Just-in-Time Learning

Paradigm Shift in Skill Development
Old: 3 R’s (Reading, Writing and Arithmetic)
New: 3 S’s (Search, Share and Simulate)

Paradigm Shift in Design
Yesterday
- Rules of Thumb
- Build Prototypes
- Expensive Testing
- Demonstration
- Prototyping
- Prototyping Systems
- Feasibility

Tomorrow
- Analytical Synthesis Methods
- Building Models
- Simulation
- Visualization
- Rapid Prototyping
- Virtual Reality
- Optimal Solutions
Source: Hans Moravec “When Will Computer Hardware Match the Human Brain”, 1997
Biological evolution and human technology both show continual acceleration. The time between events continues to decrease; 2B years from the origin of life to cells and 14 years between the PC and World Wide Web.
2014: Getting Lost
2019: Libraries
2020: Copyright
2030: Keys
2033: Coins
2036: IC cars
2050+: Ugliness, Nation States, Death

Source: “What’s Next” and the “Future Exploration Network”
Erosion of Boundaries in the Information Age

• Between products and services: think cell phones
• Between producers and users: think social media
• Between IT, comm, media, consumer electronics: think Amazon
• Between IT and non-IT industries: think Walmart
• Between academia, industry, disciplines, theory, applied research

1895: “Heavier than air flying machines are impossible”, Lord Kelvin
48 years
1943: “I think there’s a world market for maybe 5 computers”, Thomas Watson
34 years
1977: “There is no reason why anyone should have a PC in their home”, Ken Olsen
4 years
1981: “640K ought to be enough for anyone”, Bill Gates

What can we expect in the next $\frac{111}{2}$ years? i.e. 7 years (decimal)
My “ideal” Mechatronics Courses

“Be the change you want to see in the world” – M. Gandhi

- Hardware design (M.L.CAD)
- Software tutorial
- Sensor integration
- Virtual Reality model

Design

Simulation
- Dynamic model
- Control theory
- MATLAB
- Simulink

Experimention
- Construction
- Programming
- LEGO
- MINDSTORMS NXT
A 10-Week Plan

- Project-Based Course: Automaton (open-loop) and Ball-and-Beam (closed-loop)
- Mechanisms: Cookbook approach – learn fundamental “simple machines” as recipes
- Algorithms: apply fundamental control techniques using sensors and actuators

Anibus Press-ups
http://www.youtube.com/watch?v=YFqkKn9PqNg

Barking Dog
http://www.youtube.com/watch?v=3-Zuj5gO60g

Lego-based Drummer
http://www.youtube.com/watch?v=TFQRzyZFmek

Lego-based Ball-and-Beam
http://www.youtube.com/watch?v=bV9g3AyQ7Vc
Next Steps

• Pick up NXT Kit from Lebow 132 (need Drexel ID card): Mon-Fri 09:00-17:00
• UG Lab card access: ask George Ciarrocchi george@coe.drexel.edu
• Bring NXT Kit to every class