# ME588 MECHATRONICS

## INTEGRATED DESIGN OF ELECTRO-MECHANICAL SYSTEMS

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School of Mechanical Engineering
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## INTEGRATED DESIGN *and Fabrication* 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

# ELEMENTS

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?

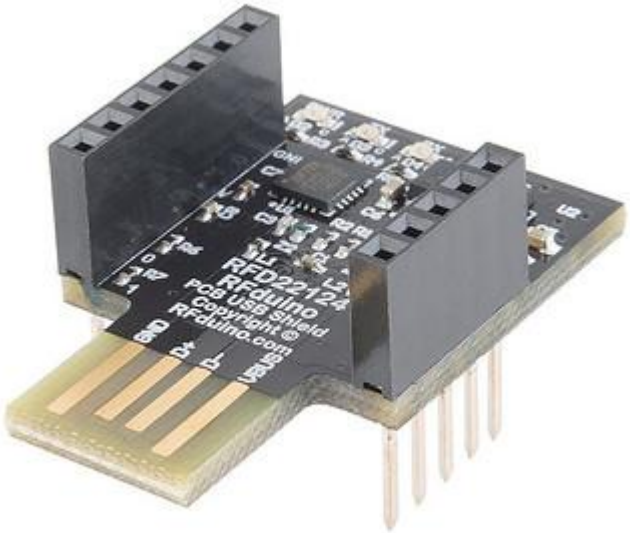
# ELEMENTS


## 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



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# ELEMENTS

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.

# BOTTOM LINE

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

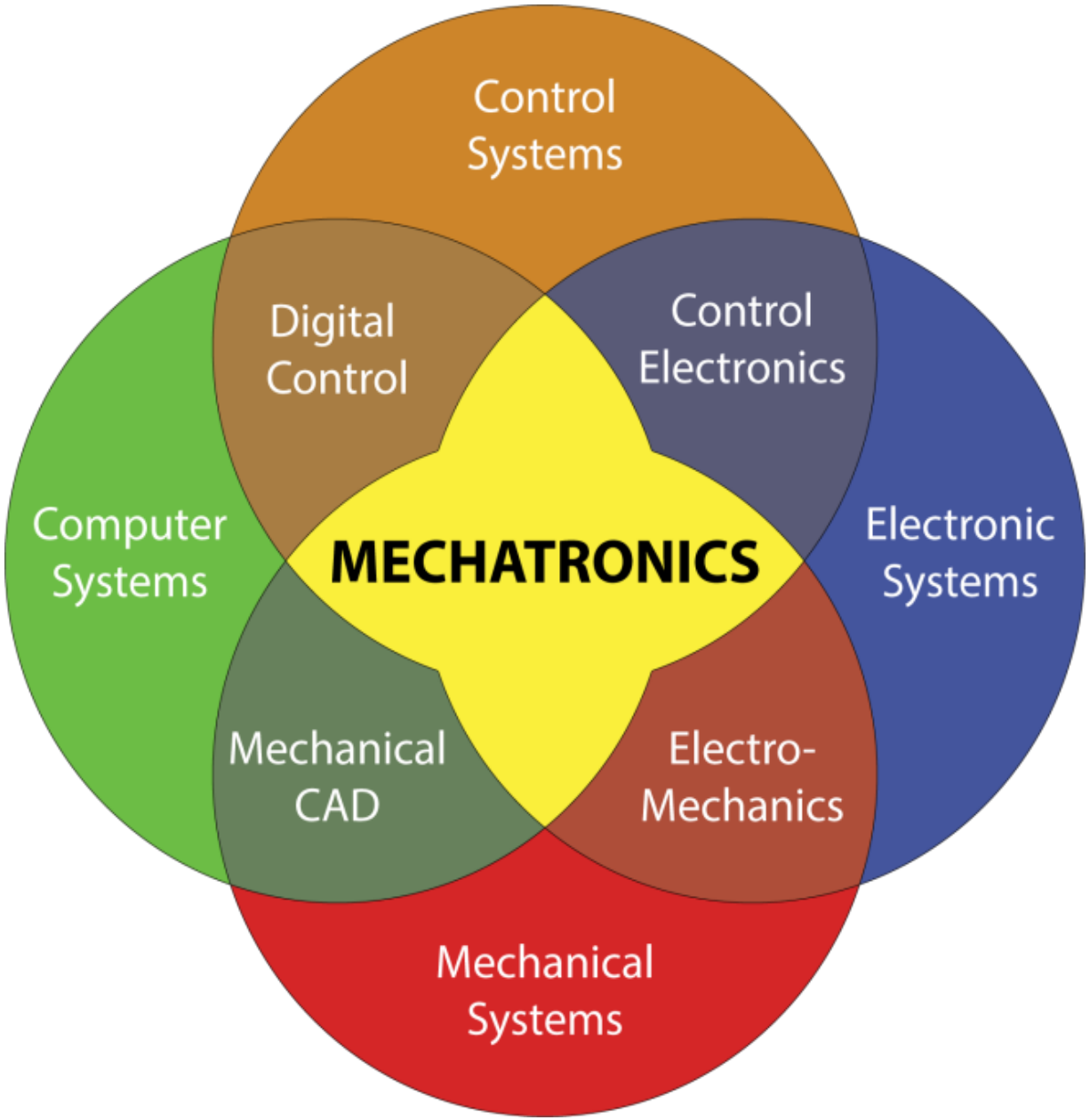
At the end of this section, you should be able to:

- Define mechatronics
- Identify mechatronic devices in the wild
- Identify trade-offs in mechatronic design

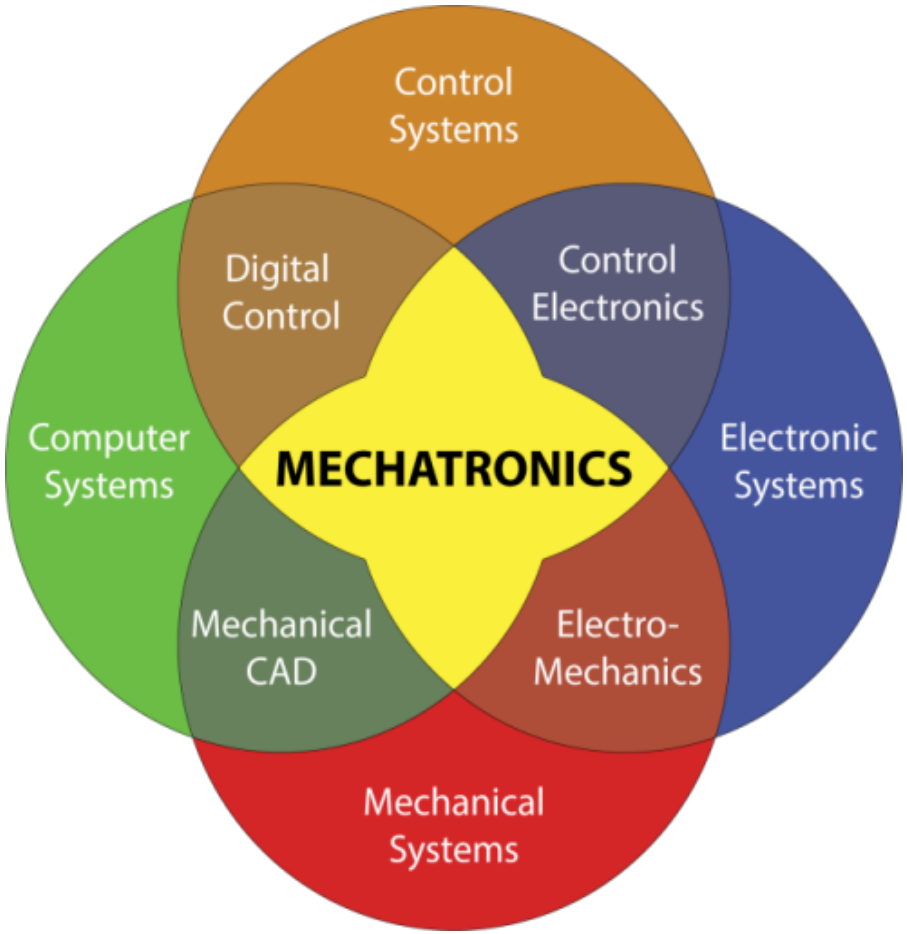
# WHAT IS MECHATRONICS?

Mechatronics describes the synergistic integration of mechanical, electronic, computer, and control systems.

# WHAT IS MECHATRONICS?

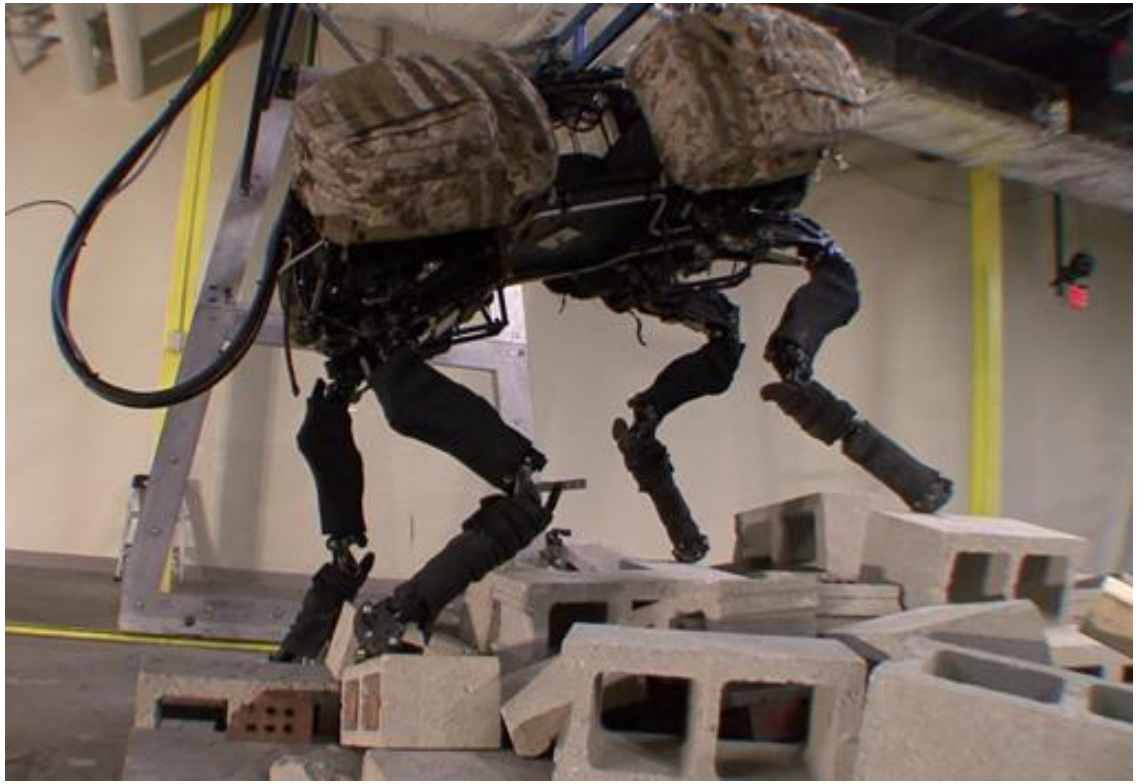


# MECHATRONICS IS AN INTERDISCIPLINARY PROCESS




- 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

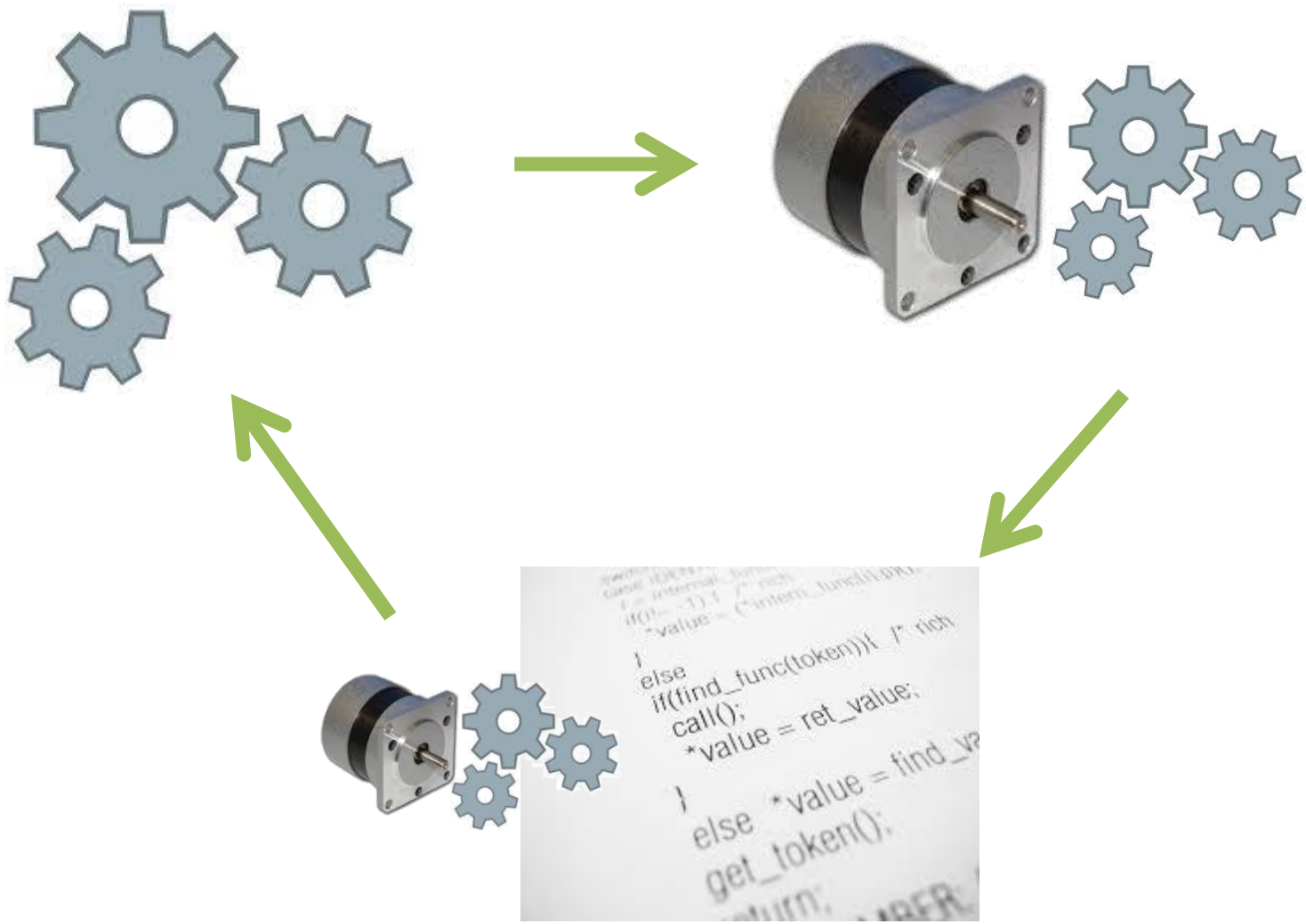
Traditional product realization involves sequential discipline-specific design efforts

Mechanical ▸ Electrical ▸ Controls ▸ Manufacturing ▸

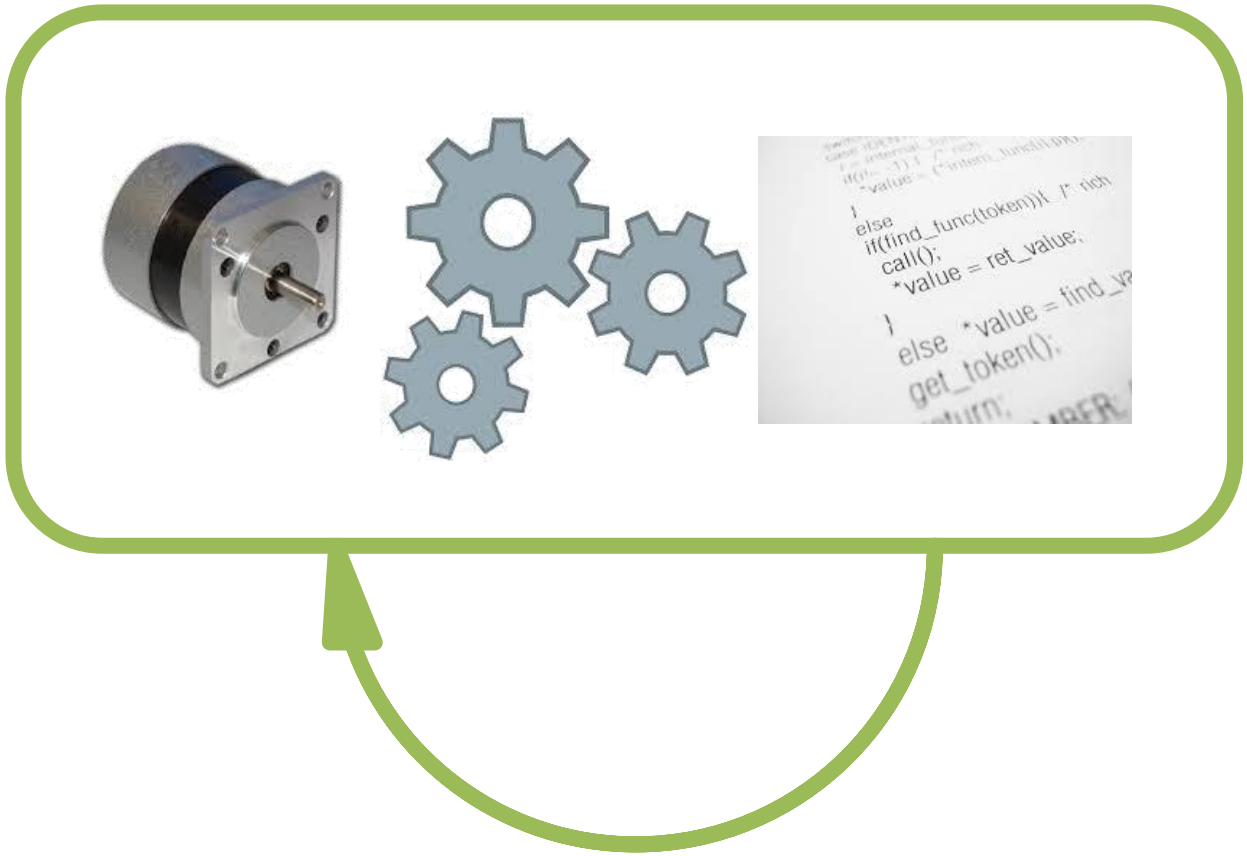
# MECHATRONICS RETHINKS THE TRADITIONAL DESIGN SEQUENCE

Integrating design and control is a relatively new approach to creating new products and processes.

# SEQUENTIAL DESIGN MAY BE INEFFICIENT AND SUBOPTIMAL



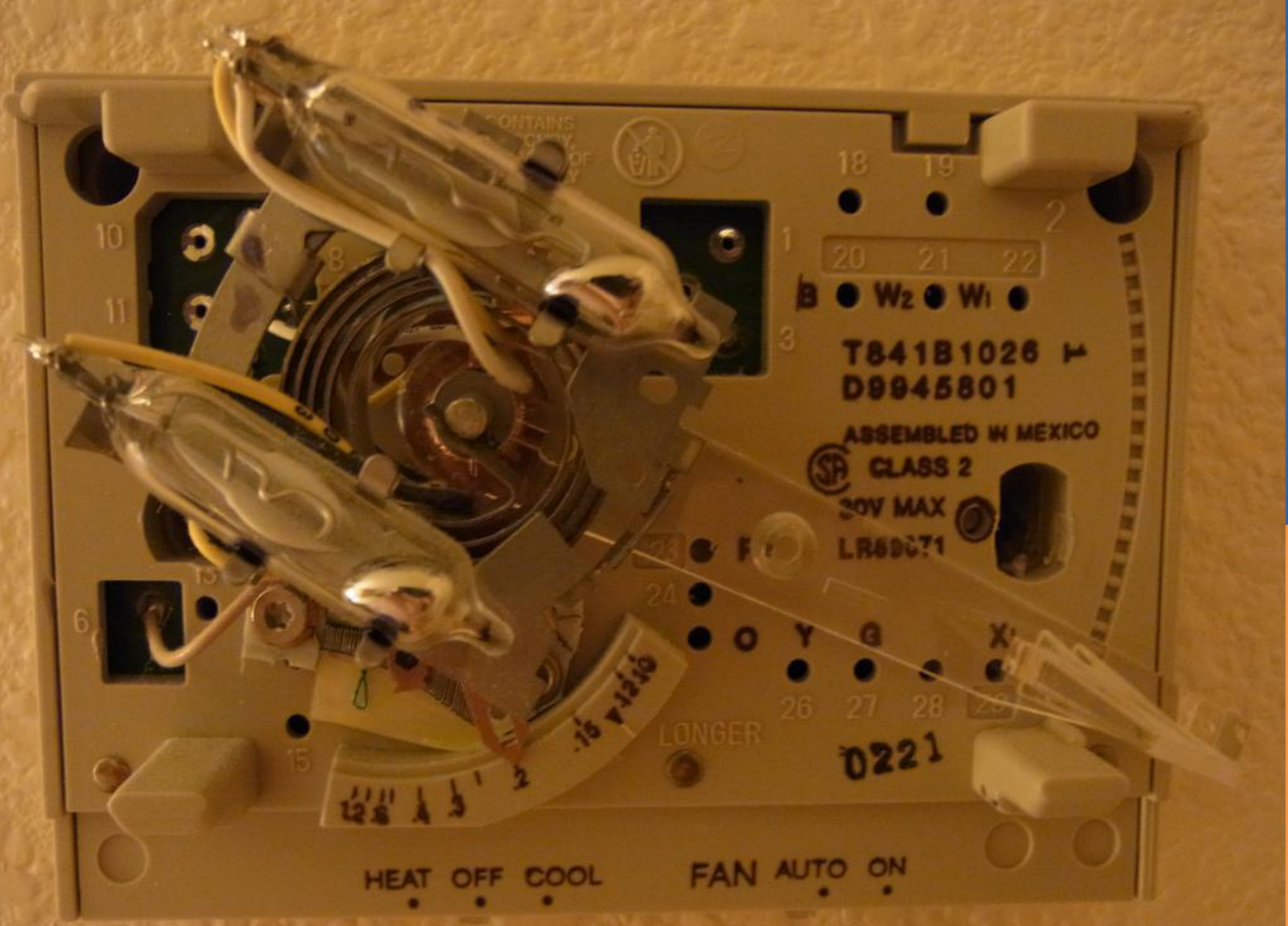
# MECHATRONIC DESIGN SEEKS TO WORK IN PARALLEL




- 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.

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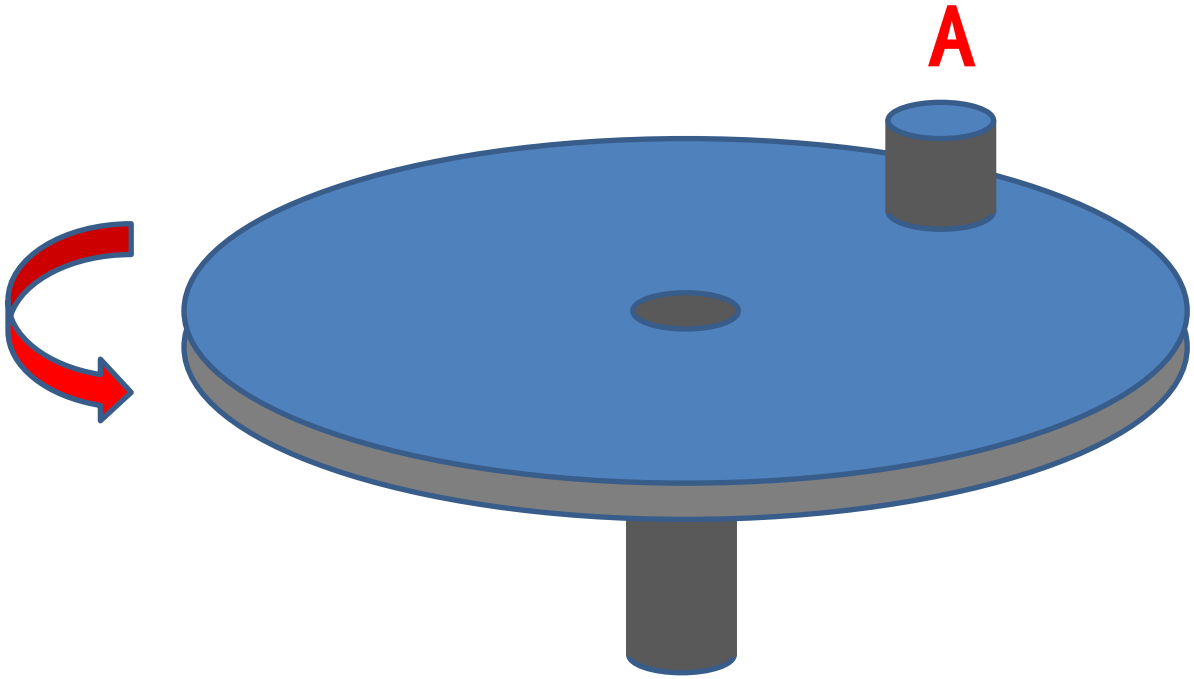
# EXAMPLE

Achieve intermittent quarter-turn rotations?



# INTEGRATED DESIGN

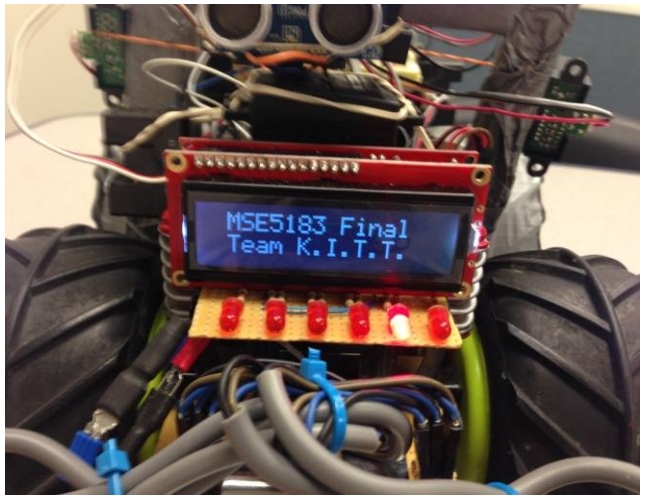
| Component | Pros | Cons |
|---|---|---|
| Mechanical Systems | | |
| Electronic Systems | | |
| Control Systems | | |
| Computers/Software | | |

Consider: Application, cost, availability, flexibility, size, storage, reliability, etc.

# DESIGN TRADE-OFFS ARE ALMOST ALWAYS AVAILABLE!

Q: How to "mark" the location of a landmine?

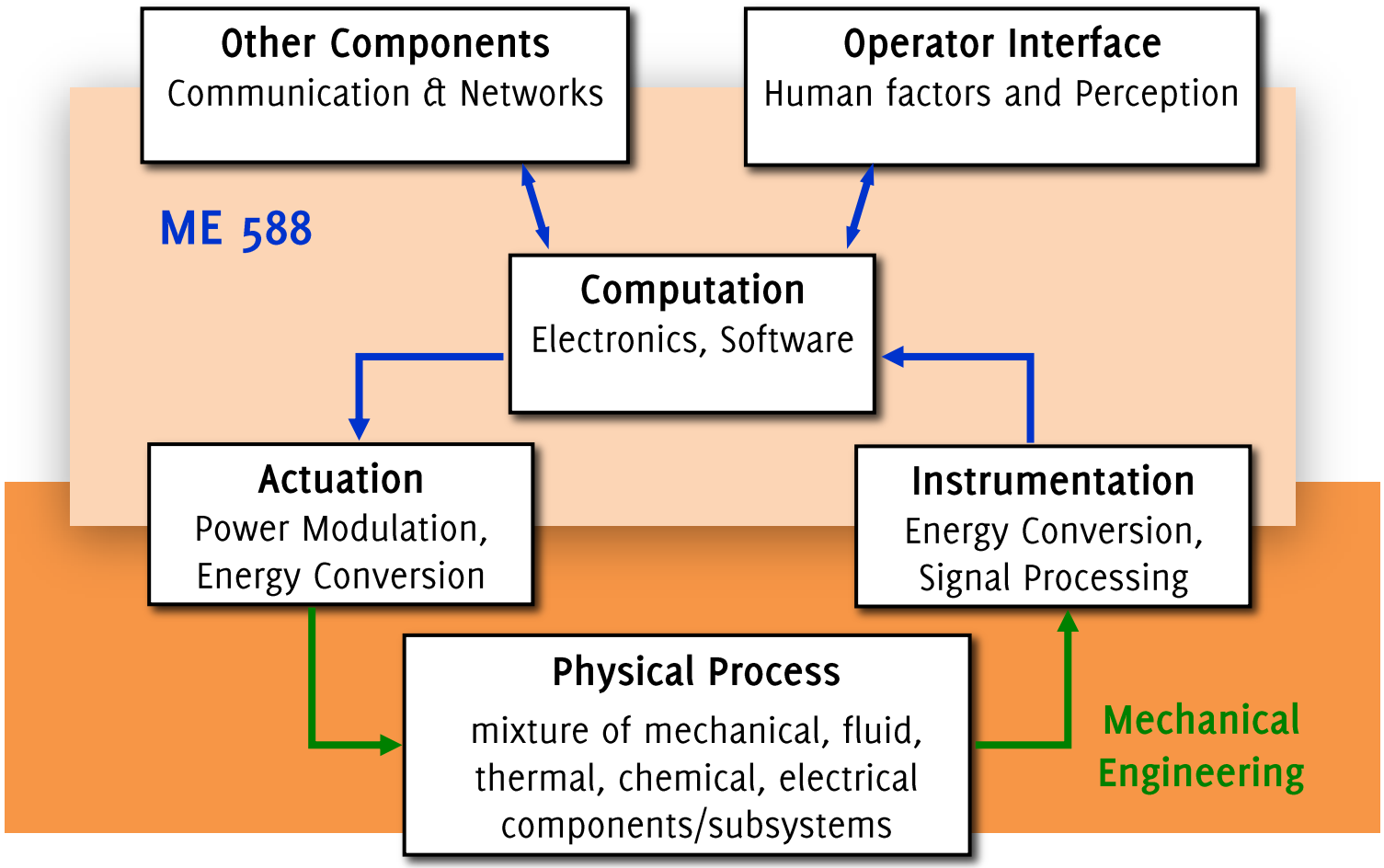
A "mark" need not be physical




More electronic complexity
Less mechanical complexity

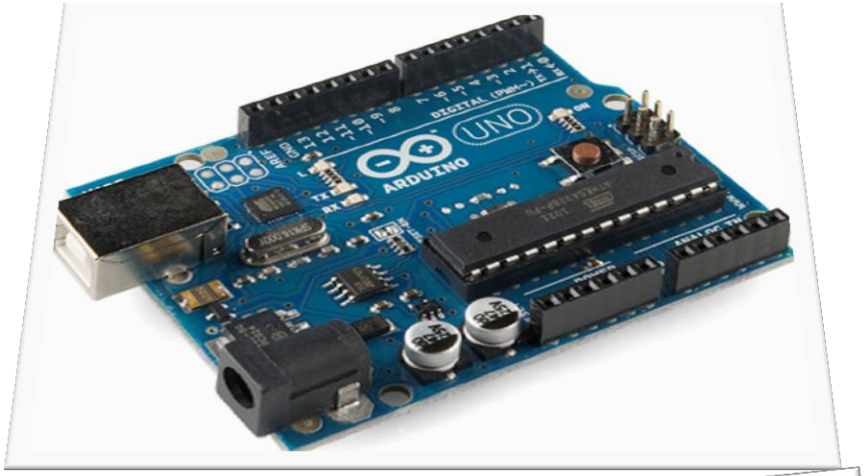
Less electronic complexity
More mechanical complexity

# ELECTRO-MECHANICAL SYSTEM INTEGRATION

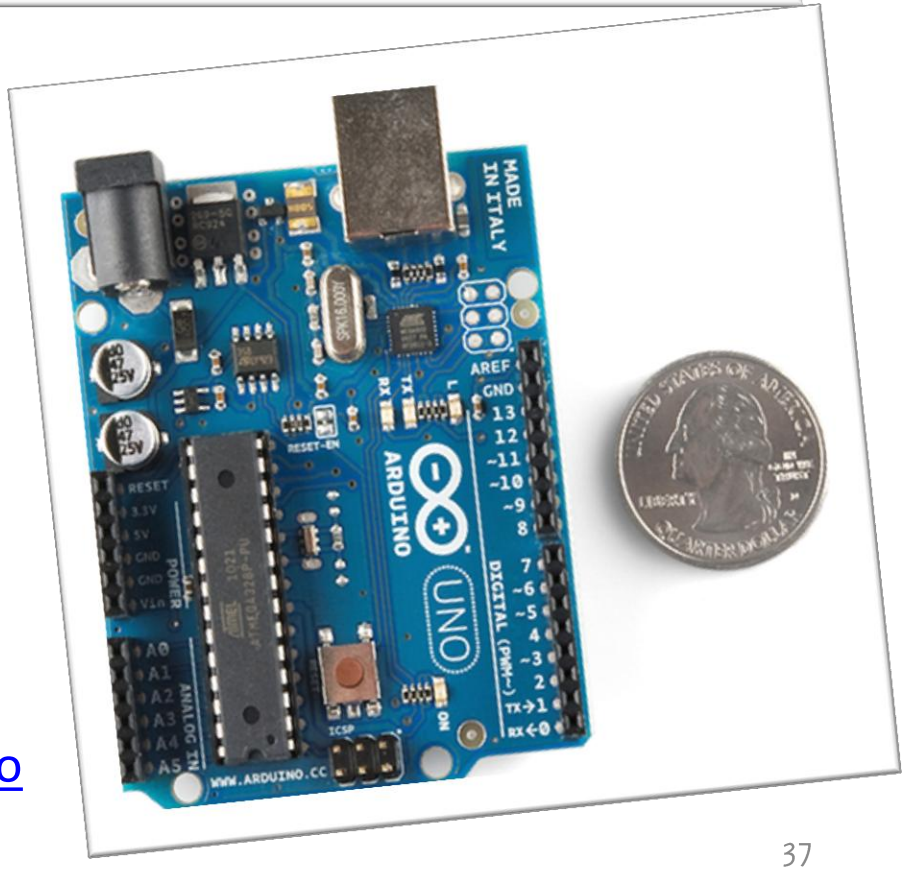


# COMPUTING PLATFORM *(NOT THE ONLY ONE)*

## 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
  - $V_{in}$/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