Kuwait University
College of Engineering and Petroleum

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ME319 MECHATRONICS

Part I: The Brains – Microcontrollers, Software and Digital Logic

Lecture 0: Introduction

Spring 2021

Ali AlSaibie

Lecture Plan

- Objectives:
  - Understand what mechatronics is about

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Instructor Background

- Education
  - B.S. from University Of Texas at Austin. (Mechanical Eng.) 2006
  - M.S. from Georgia Tech (Mechanical Eng.) 2013
  - Ph.D. from Georgia Tech (Mechanical Eng.) 2018
- Industry Experience
  - Chartered Engineer since 2012 (UK)
  - BP (Oil & Gas) 2006 – 2011
    - Worked in: North Sea, North Africa, UAE and Oman.
- Research
  - Mechatronic Design
  - Service Robotics, Unmanned Vehicles (Air, Land & Sea), Control of Machinery
  - Applied Control and Estimation
- Teaching
  - Lead TA Mechatronics Graduate Course @ Georgia Tech (2015-2018)
  - Faculty Kuwait University (2019-)
- Other Experience
  - Team Lead – Robotics & Mechatronics International Competitions

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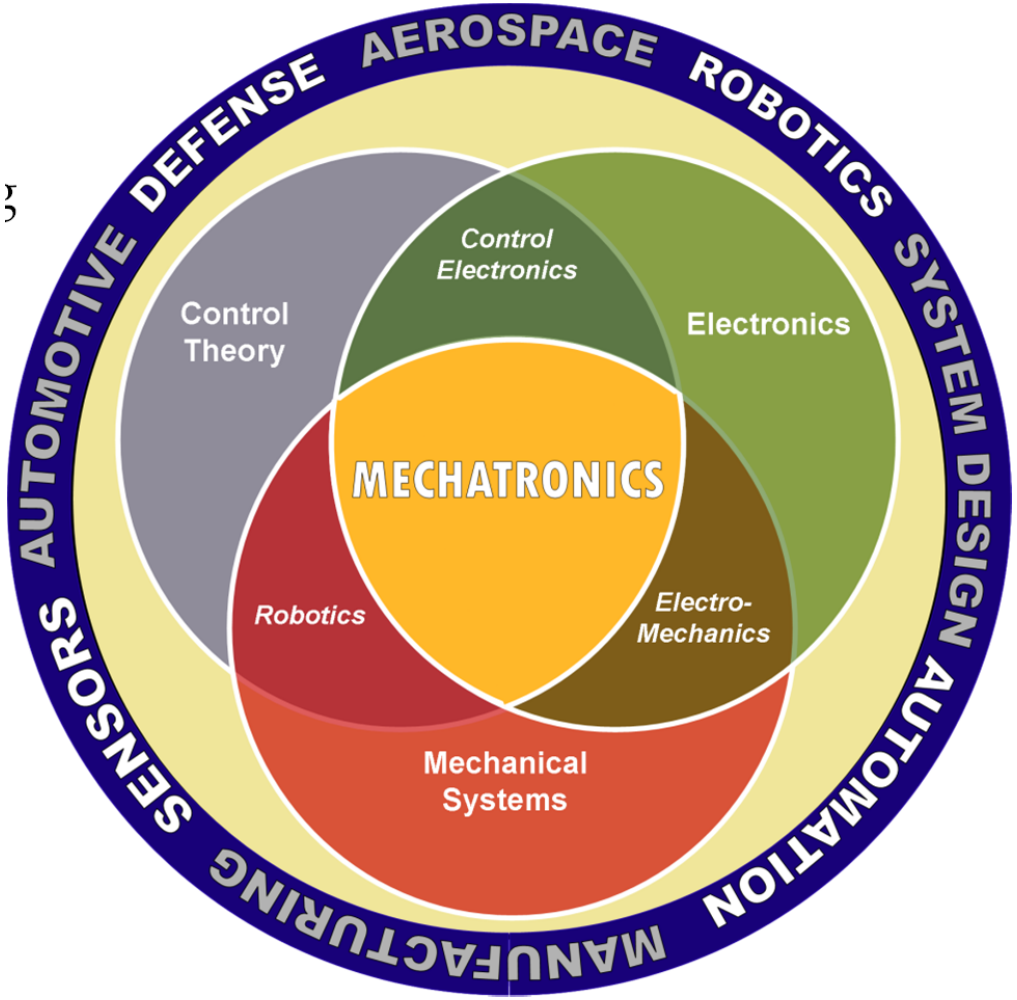
Mechatronics?

- Mechatronics is the synergistic integration of **mechanical engineering, electronics,** and **control theory** in the design and manufacturing of products and processes

- Mechatronics uses a balance of **theoretical analysis** and **hardware implementation** in system design



Mechatronics vs. Robotics

- What is the difference between Mechatronics and Robotics?
  - Robotics encompasses broad range of theoretical and applied areas of study
    - Path planning, vision systems, mechanical design, controls, dynamic analysis, vibration, etc.
  - Mechatronics intersects with Robotics in terms of dealing with hardware-software integration
  - Mechatronics encompasses other systems not considered robotic systems
    - Washing machines, IoT, Electromotive Systems, vacuum, etc.

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This course is:

- Will learn theory and implementation behind microprocessor control of mechanical systems
- Emphasis on understanding electrical and software fundamentals
  - Toolset learned in this class should be *portable*
- Learn both system modeling and control system design
  - Model real-world systems, design controllers
  - Design and implement mechatronic device

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This course is not

- Course is not about assembling open source hardware and software components
  - But you can explore this through the labs
- Course is not a training camp on How to Use an Arduino
  - But we will use Arduino + Lower Level Device Libraries
  - Focus is on concepts, not tools.
- Class is not about learning to be a “Maker”
  - But it will help you in becoming one if you choose to be.
- *Focus of this class is on understanding underlying fundamentals of electro-mechanical interface, software, in rigorous engineering context*

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Skills You Will Gain

- Understanding of basic electrical components – what they do, how they are used
  - Resistors, capacitors, transistors, semiconductors, op-amps, etc.
- Understanding of basic **active electrical circuits**
  - I will "refresh your memory" as needed
- Understanding of basic **signal processing and conditioning**
- Understanding of **sensor characteristics** and **filtering**
- Understanding of basic **actuator performance** and basic **feedback control**
- Programming in **C/C++** for embedded systems
  - Arduino is NOT a programming language, it's just C/C++
  - A supplementary mini-course is provided
  - Tutorials on embedded application concepts will be scheduled.

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Skills You Will Gain

- Inter-device communications
  - Sensor to processor, processor to actuator, processor to computer, computer to processor
- Simulation of dynamical systems (MATLAB)
- Control system design, filter design (MATLAB)
  - PID control

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Synthesis of Analysis and Hardware Design in Mechatronics

- Balance between **engineering analysis** and **hardware experimentation** is critical to success in Mechatronics
  - Engineering analysis = methods you have learned in classes
- Your ability to perform rigorous engineering analysis is what separates you from hobbyists, makers, etc.
  - Mathematics should be viewed as tool to enhance design efficiency rather than something to be avoided

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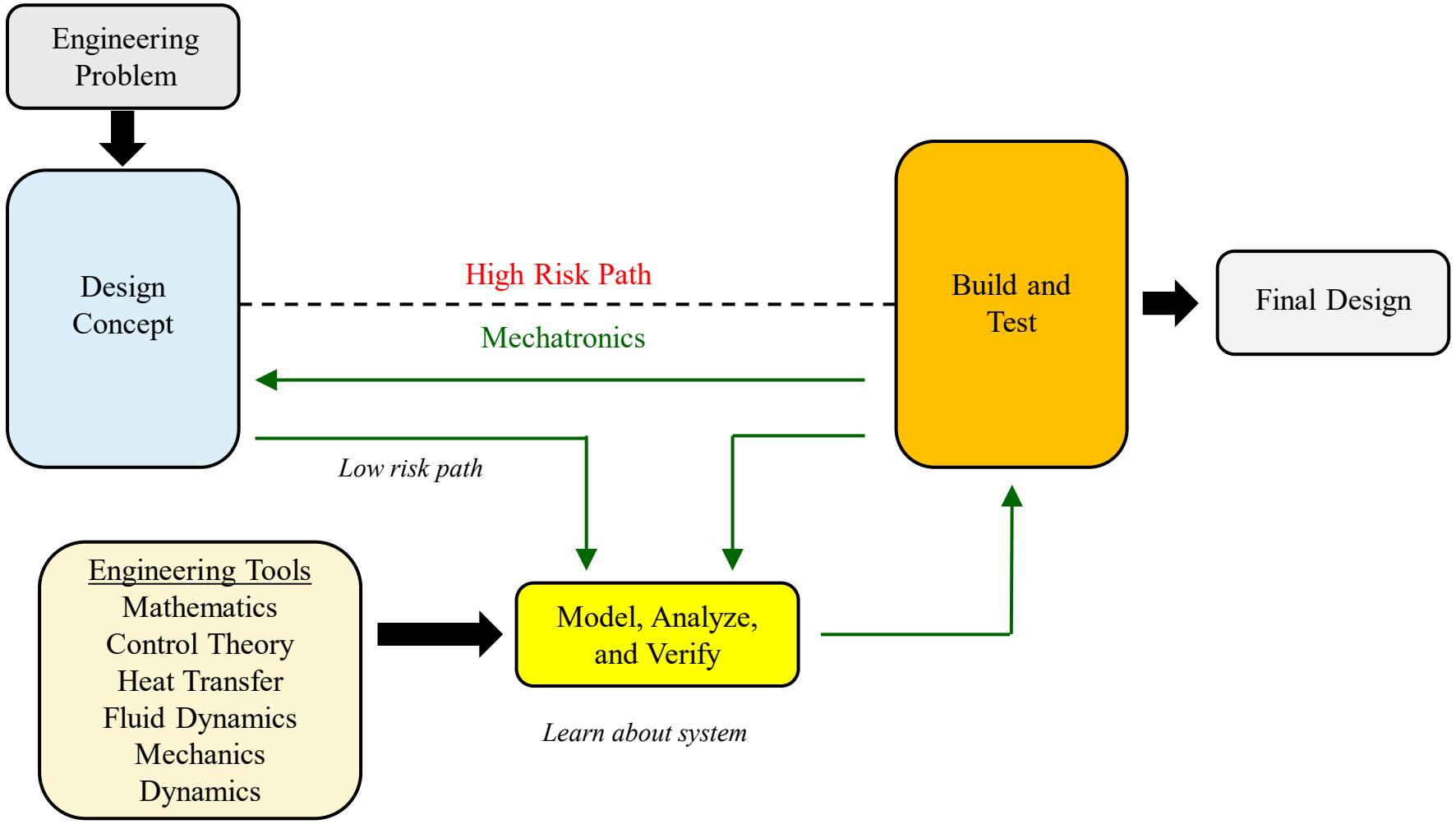
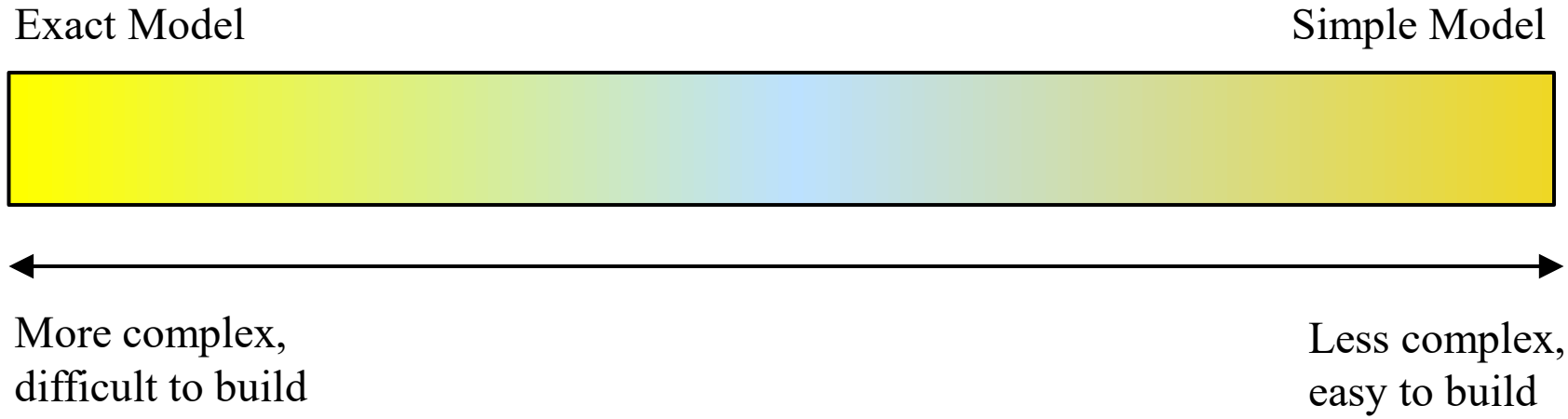
Synthesis of Analysis and Hardware Design in Mechatronics



System Modeling

- System modeling is critical aspect of Mechatronics
- Balancing model complexity and utility is important
  - If extremely complex, can be too time consuming and not work effort
  - If too simple, will not accurately represent system
  - Desire model that captures all relevant dynamics



Course Components

- System Modeling/Analysis
  - Integer and floating point mathematics
  - Circuit Analysis/Design
  - PID Control Theory
  - System Block Diagrams
  - Laplace Transform Analysis
  - Digital Controls
  - Filtering Algorithms
- Hardware Implementation
  - Microcontroller Architectures
  - Interrupts and Clocks
  - C/C++ Programming
  - Memory Structures
  - Inter-Process Communications
  - Analog-to-digital Conversion
  - PWM Actuator Control
  - Sensor Characterization and Signal Conditioning

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