ROB 311 – Lecture 1

- Welcome to ROB 311!
- Today:
  - Review policies / syllabus
  - Begin high-level introduction of course
  - Quick quiz (last 5-10 mins)
  - HW 1 assigned
- This will be fun and a bit of an experiment!
- Lets begin with policies:
  - Please raise your hand rather than shouting out
  - Does everyone have a laptop? Mac vs. PC?
  - Laptops can be used in class but please keep it on course content
  - Cold calling – I may call on you to foster discussion
  - Slide format / recordings
- Syllabus overview

ROB 311: What will I learn in this class?

- This class is about modeling, spec'ing, designing, manufacturing, and controlling a ball-bot (with lots of help)
- You will learn the answers to these questions:
  - How do I determine the proper design for my application (motor, transmission ratio, mechanics, etc.)?
  - How can I design something and have it made?
  - How can I predict the performance / characteristics of my system?
  - How do sensors / microcomputers work together to control a robot?
  - What sensors and signal processing are commonly used?
  - How do I write control strategies that live on a microcomputer?
  - How can I control multiple axes with multiple tasks?
- The goal is that you are able to employ these tools in your own future applications on your own

ROB 311: What is a ball-bot?

- A ball-bot is a robot that balances on top of a ball and rolls the ball to move in the environment
- It's a challenging problem – and represents one of many potential challenges you could see in robotics
- It's unstable – meaning it wants to tip over
- It's underactuated – meaning it only has 3 motors but has 6 degrees of freedom
- The goal is to get it to:
    - Design and manufacture
    - Balance on its own
    - Drive / steer using a remote control (PS4)
- The entire course uses the ball-bot as an example to teach many aspects of design and control

What is involved in development of a robot?

- Robots are a collection of subsystems that enable an application
- Including (but not limited to):
  - **Motion:** motors, transmissions, & drives
  - **Structures:** chassis and mechanisms that enable the application
  - **Mechatronics:** sensors, batteries, microcomputers for control
  - **Control:** Control will come later
- Analyses / critical thinking are needed to be sure the robot meets the objective
- These analyses happen before manufacture and control – but they matter crucially to both
- We will teach you how to perform these analyses and be confident in your designs

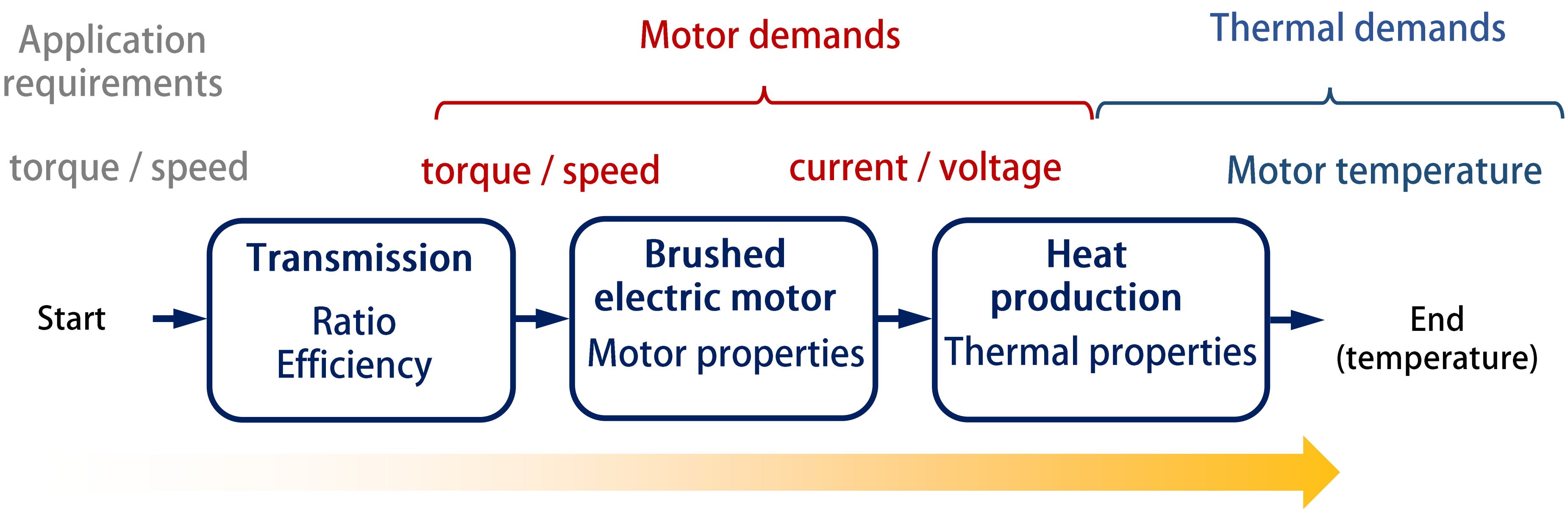
What subsystems do you see?

What is involved in development of a robot?

- The process begins with understanding the requirements
  - In this class, we focus on medium and low-level parts of robotics systems.
  - Meaning, higher level perception / AI-based control would sit above the subsystems described in this course
  - In the medium to low level, what does the robot have to do?
    - **Do a task** – but on a fundamental level (motion or force)
    - Examples: Track a position, force, torque, virtual spring-damper, etc.
    - Not examples: Open a drink, navigate a vehicle... Dexterous or complex tasks
    - How about for our ball bot? Roll the mass of the ball and fight any friction

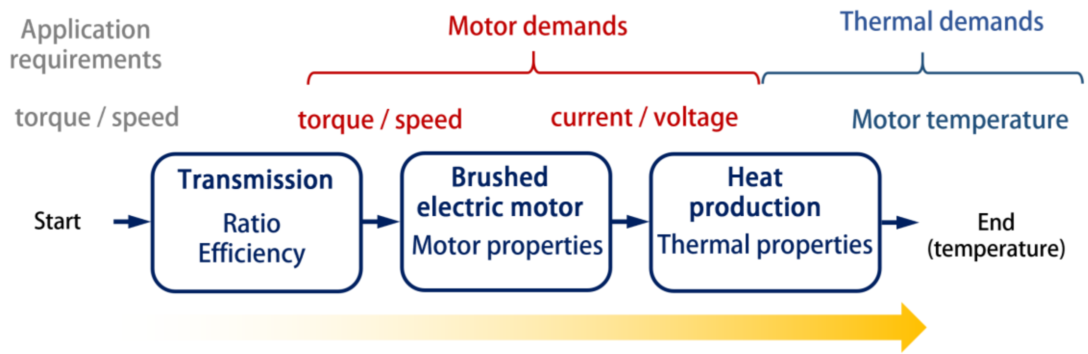
Design Analysis Framework

- For the sake of discussion, lets pretend:
  - We have a description of the required torque to roll the ball / fight friction
  - We have a max velocity goal, say 1 m/s
- We use this torque and velocity to understand the demand on the motion, structural, and mechatronics components



Framework outcome: A motor that has the desired operating voltage, that is able to complete the task without overheating

Design Analysis Framework



What do we need?

- A description of the task
  - Torque-speed, force-displacement, etc.
  - Any electrical requirements (voltage, current limits, etc.)

What do we get?

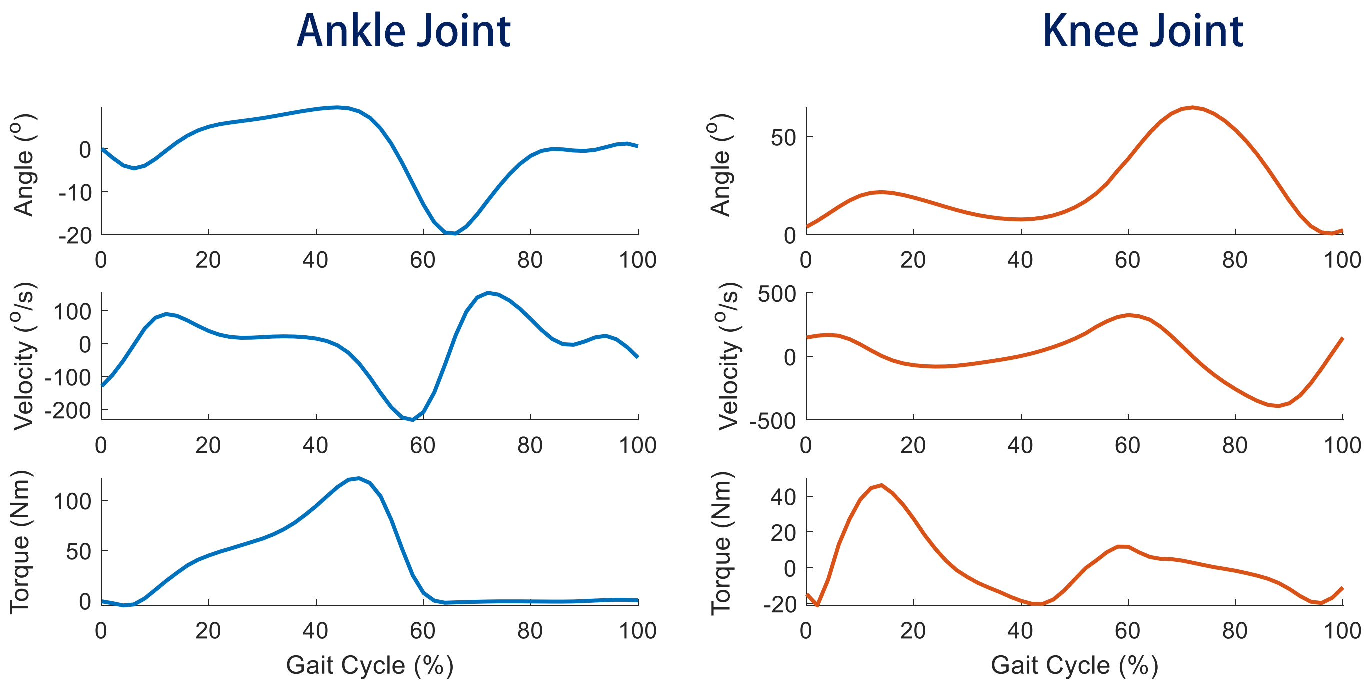
- An analysis framework to investigate transmission ratios, power requirements, motors, and others...
- The framework enables the selection of a motor / ratio with the appropriate:
  - Torque, speed, current, voltage, and temperature

Next lecture we will begin modeling these subsystems

Design Analysis Framework

- Why does this matter?
  - Ensures proper performance
  - Transmission ratio often factors into physical design
  - Enables the system to be lightweight
- We use this analysis framework to investigate designs of wearable robots
- For these and other systems that carry their own power supply, these analyses are critical to specifying the design
- We look to the human body to provide the torque-speed requirements

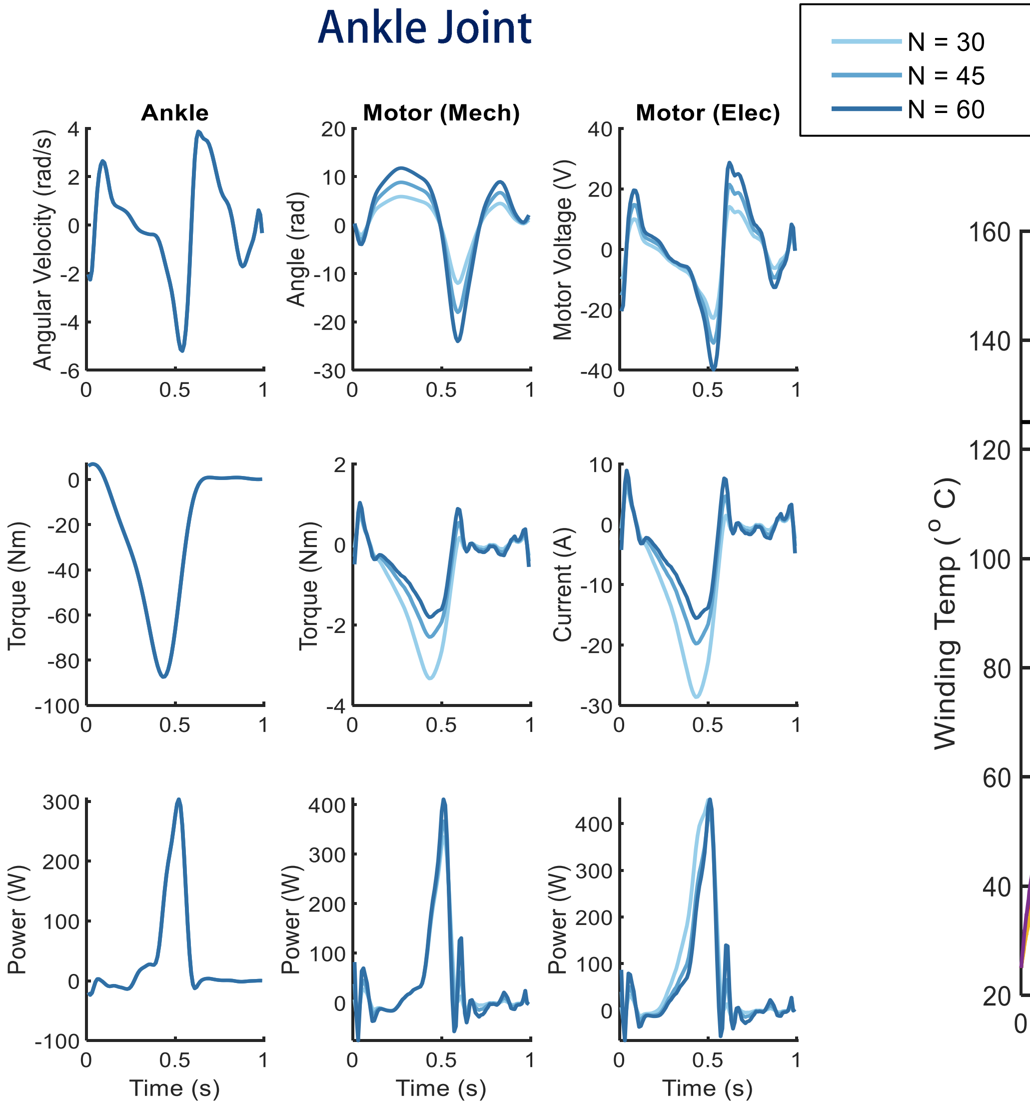
Design Analysis Framework



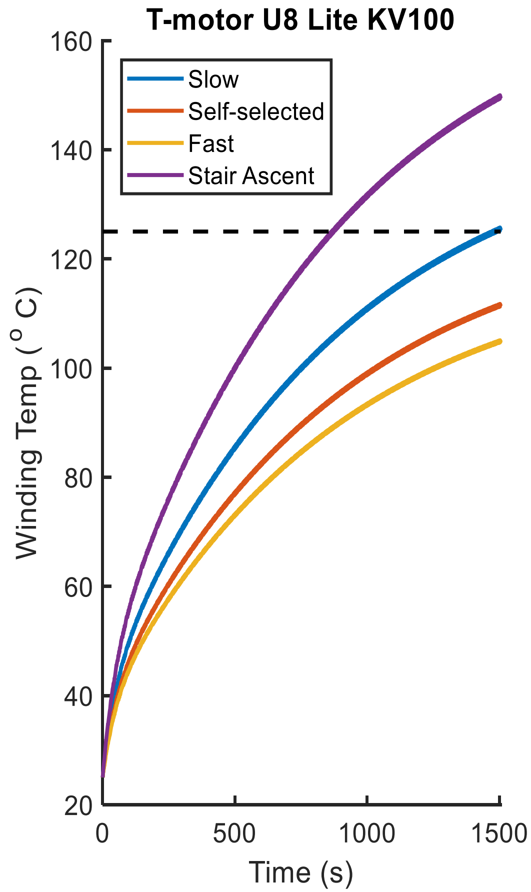
- Torques and speeds for the ankle and knee during walking
- These input data allow us to determine the appropriate transmission ratio and motor for our design
- Lets take a look at our analyses as an example

Design Analysis Framework

Ankle Joint



Motor demands



Thermal demands

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