ENGI 128

INTRODUCTION TO ENGINEERING SYSTEMS

Fall 2014

"Understand Your Technical World"


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“Understand Your Technical World”

What does that mean, anyway?

1. Understand engineering systems
   - What they are,
   - How they are designed, and
   - How they function
2. Understand these little robots
   - They are a microcosm of engineering systems
3. Understand your interests
   - So you can pick the major that is the best fit for you

Course Overview

Mechanical Engineering

- Motors, gears, and transmissions
- Feedback and control

Electrical Engineering

- Analog and digital signals, digital representation of data
- Sensors
- Communications via infra-red light

Computer Science

- Software design, programming in Python
- Distributed algorithms, robotics

Systems Engineering

- Abstraction and modularity
- Real-world systems: Energy and localization

Wait a minute, this sounds like work…

I thought the course description said “fun”?

Fun and hard work need not be mutually exclusive:

- Cookie Crane Challenge, System Safari, My Simon retro game, Super Sensor Lab, Bug Wars, Robot Croquette, IR Olympics, Tic-Tac-Toe, and more…

Fabulous giveaways and prizes!

- Movie tickets, chocolate deserts, gift certificates…

One super awesome final challenge:

- Robot Quidditch,
- Or Robot Honeybees…

Six Fun Design Challenges

Design Challenge 1:
The Cookie Crane

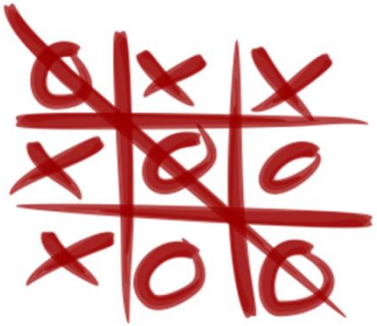
Design Challenge 2:
Bug Wars

Design Challenge 3:
Robot Croquet

Design Challenge 4:
Flocking

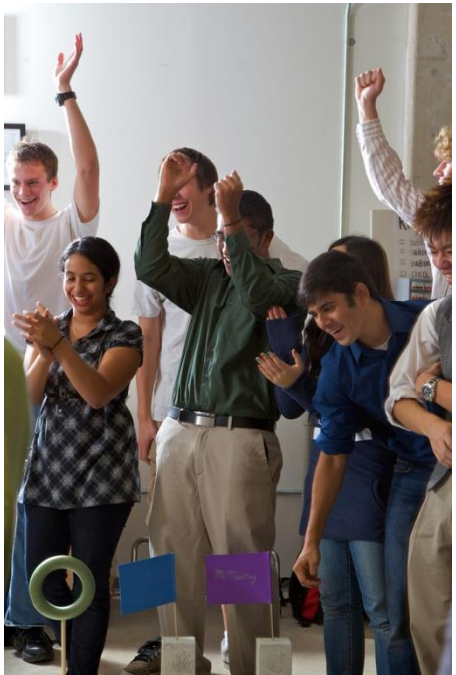
Design Challenge 5:
The IR Olympics

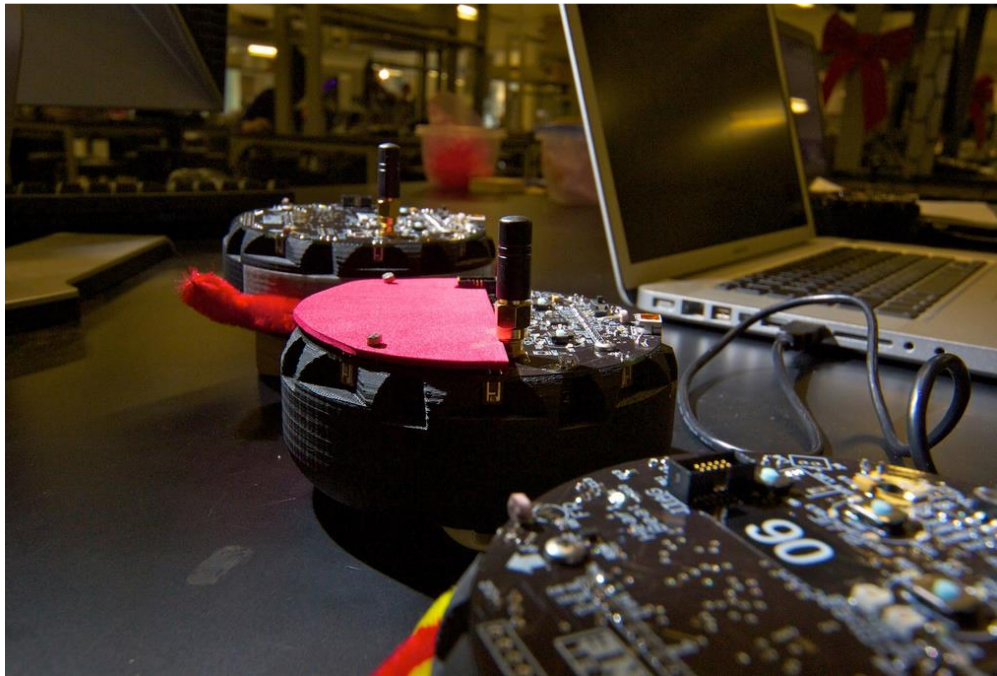
Design Challenge 5:



Design Challenge 6:

Rob-T Quidditch

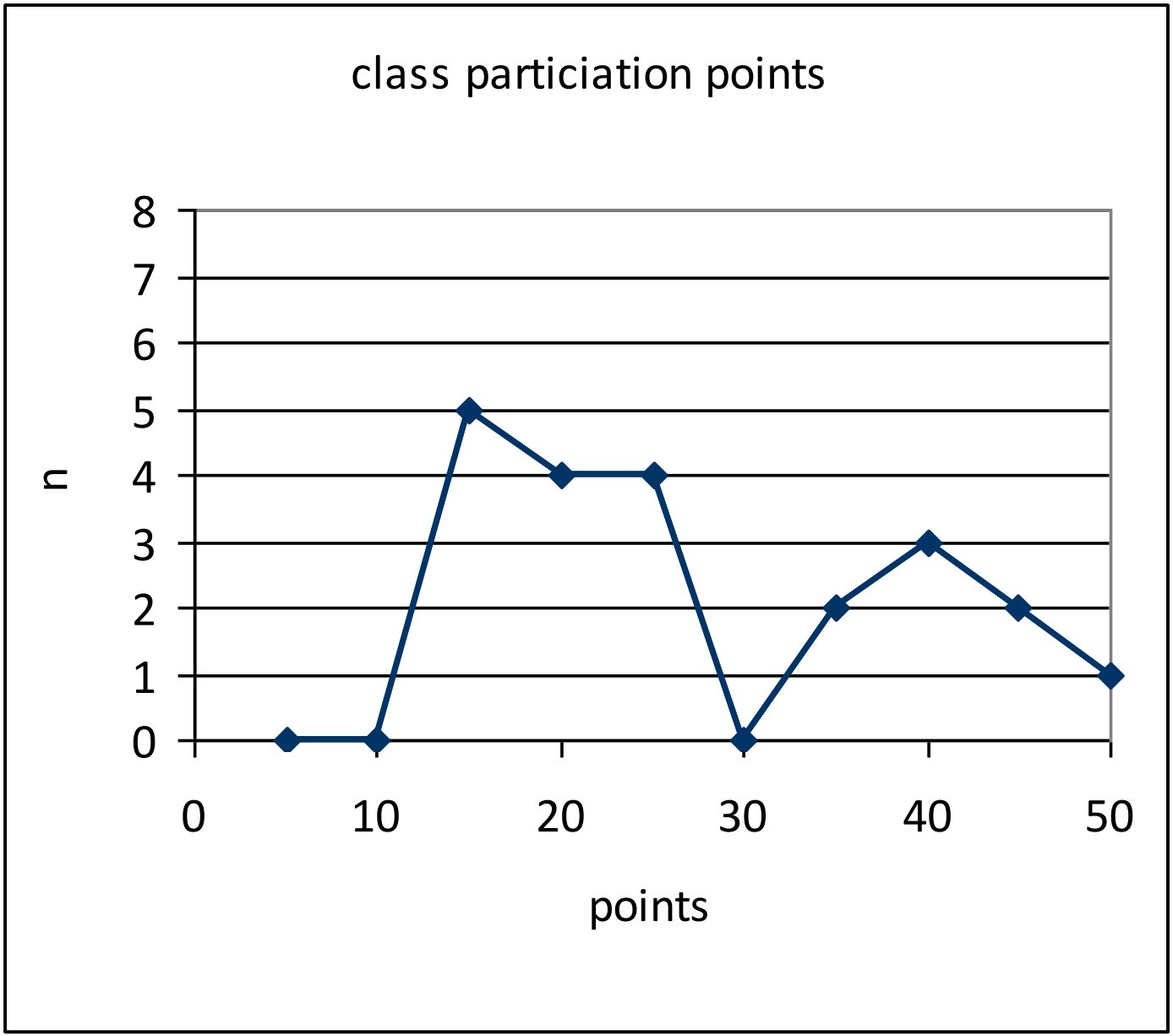




The reading of the syllabus…

blah, blah, blah…

Class Participation Points

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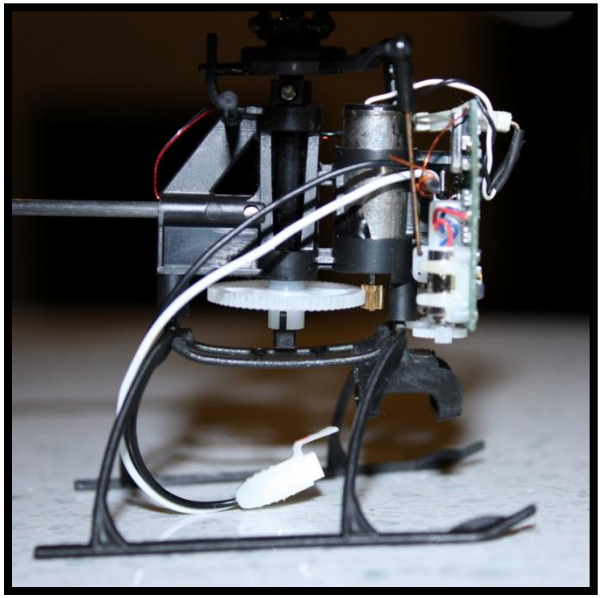
The System Du Jour:

Main parts: Who Engineers What?



Who Engineers What?

There are many engineering majors at Rice:

- Bioengineering
- Chemical and Biomolecular Engineering
- Civil and Environmental Engineering
- Mechanical Engineering and Materials Science
- Electrical Engineering
- Computer Science

We focus on three majors in this course:

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- Bioengineering
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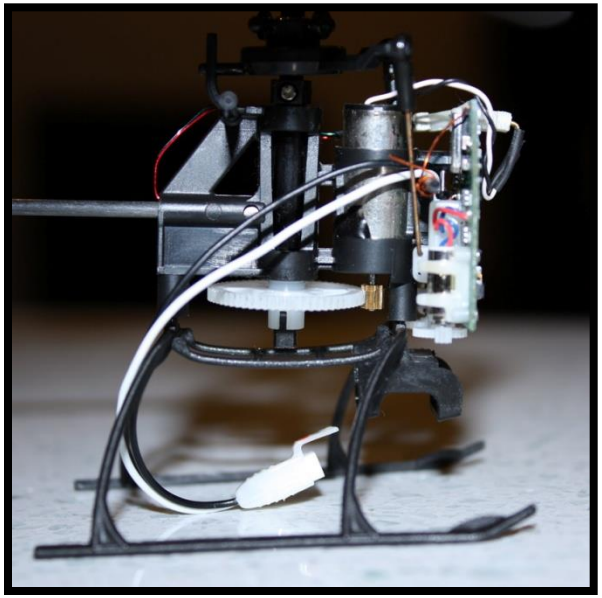
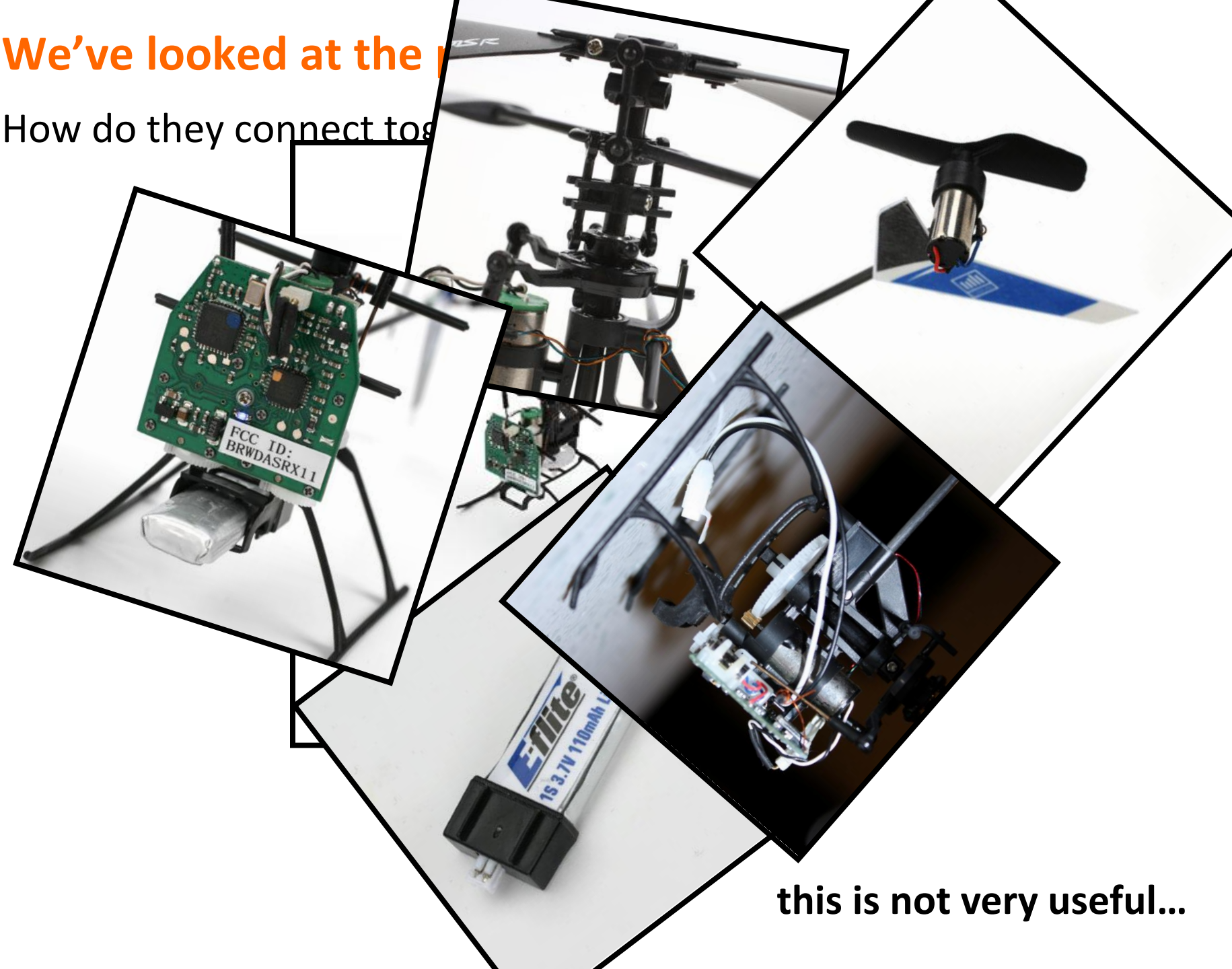
Main parts: System Organization



We've looked at the p

How do they connect tos



this is not very useful…

Block Diagrams

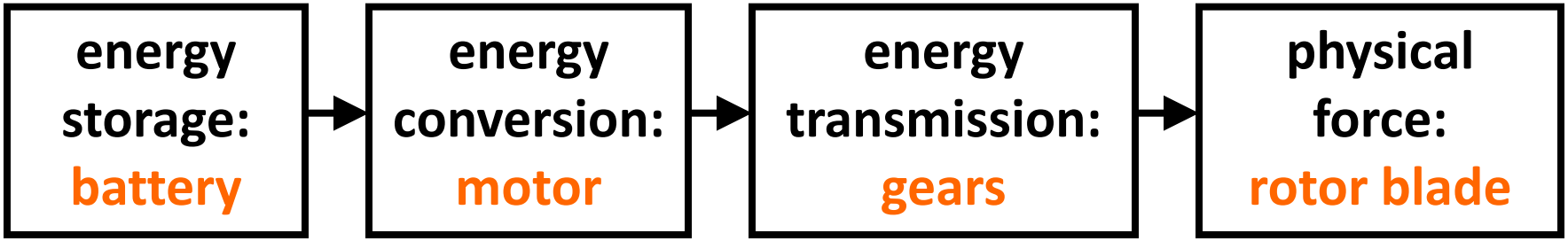
This is a physical arrangement of components

A functional arrangement would be more useful.

- We group things based on what they do

Let's hide some of the detail

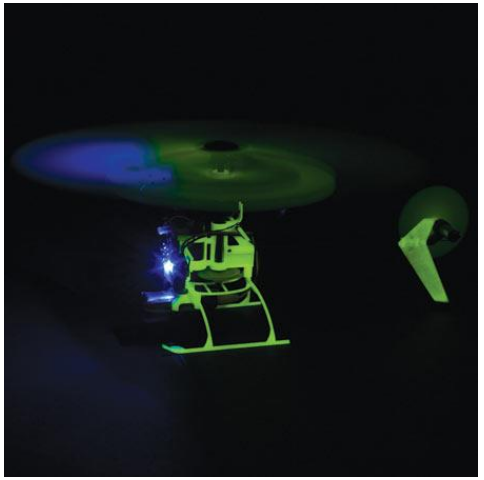
- We'll use boxes instead of pictures:

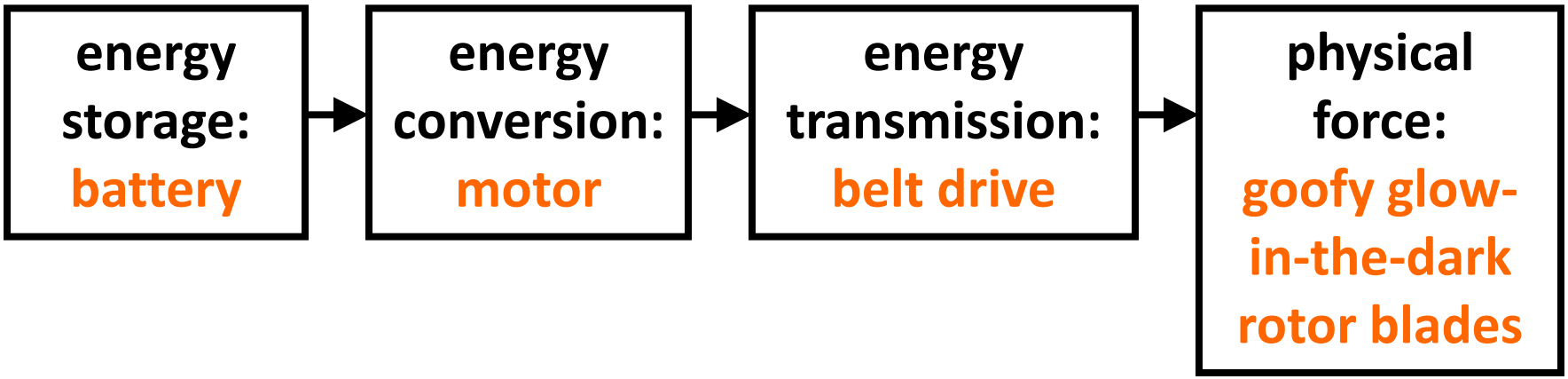


Modularity

With boxes, it's easy to understand how to swap components out

We can swap our gears for a belt drive, or our rotor blades for these goofy glow-in-the-dark versions…



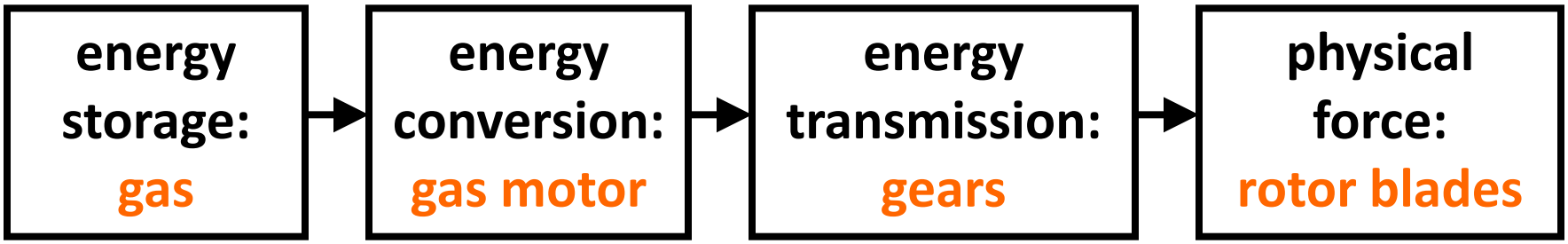


Abstraction

We actually **don't care** about what happens inside these boxes

We care about the *function*, not the *implementation*

We can replace our electric helicopter with a gas helicopter:



Alan Szabo Jr

Las Vegas Fun Fly
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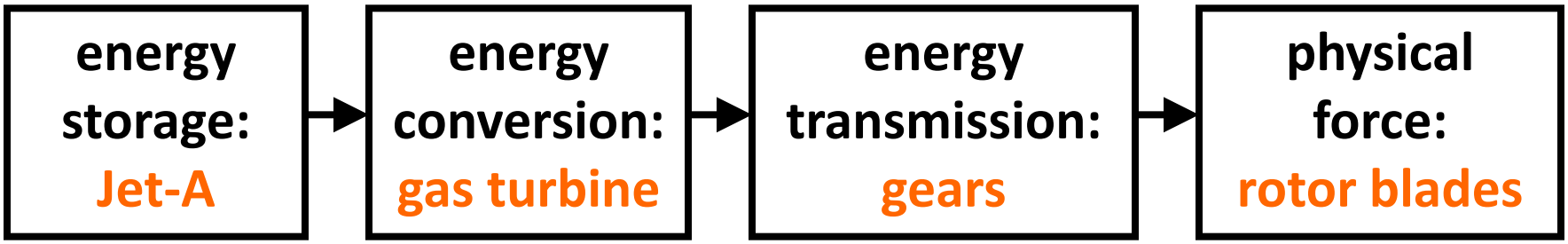
Abstraction

We can even replace our radio-controlled helicopter with a real helicopter. The block diagram remains the same.



This seems kind of dull…

That's because we're only talking about energy transfer from the battery to the rotor blades.

What makes helicopters (and many other systems) cool is control.

But how do you control a helicopter?

[Yes, class participation starts now. Answer the question.]

I am providing control:

1. I sense the position of the helicopter by watching it

2. I compute an appropriate reaction

3. I move the sticks on my remote
   - Which magically moves the motors on the helicopter
     (It won't be magic in about 8 weeks. It will just be homework)

4. This moves the helicopter in the world, and we repeat

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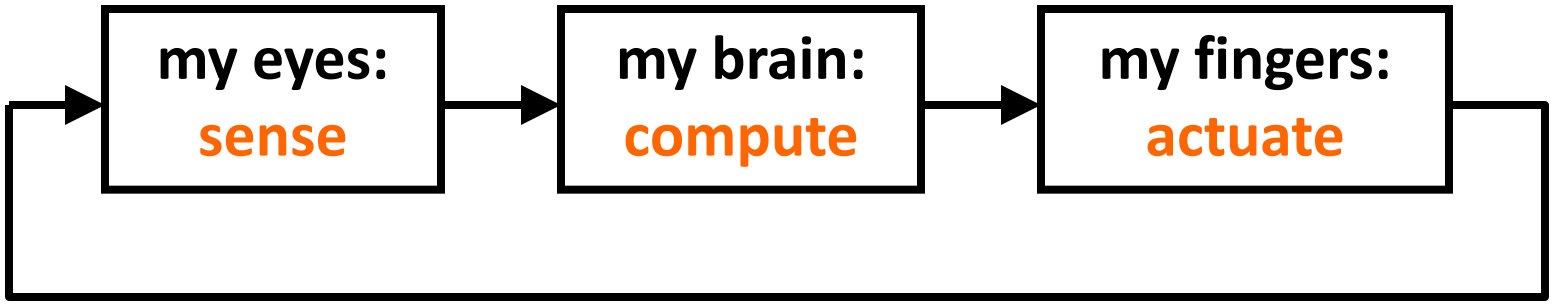


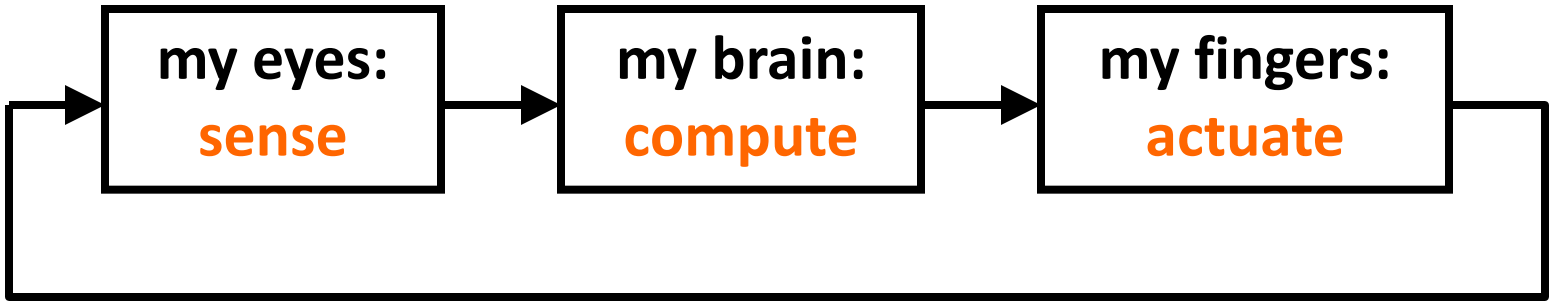
The basic controller block diagram

This is one of the most common system diagrams

We will be using it extensively in this course

This is a **feedback** system. The output "feeds back" to the input.

This is also a **control loop**. (Because it controls and it loops)



Feedback and control loops are everywhere:

	Sensor	Computer	Actuator
Building thermostat			
Automobile cruise control			
R/C helicopter heading lock			

[switch to white board]

Heading lock? What is that?

The Cheetah's Vestibular System

The Fly's "Halteres"

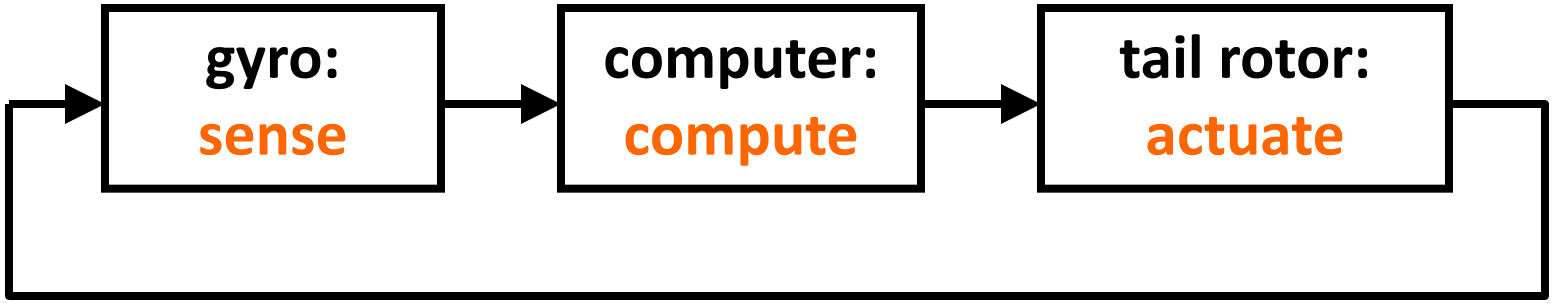
The house fly- *Musca domestica*

A very sleepy fly…

Syrphid Fly blue haltere - *Melanostoma mellinum*

Heading lock gyroscope

Keeps the helicopter pointed in the desired direction

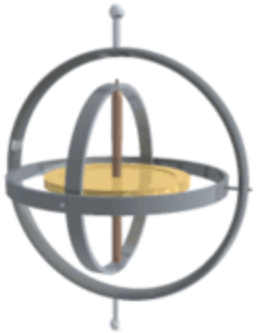


The Gyroscope

A gyroscope is a sensor that measures changes in heading

- This is different from a compass which measures heading directly
- A gyroscope can only measure change in heading:
  i.e. where you are pointed compared to where you were pointed

A Mechanical Gyro:



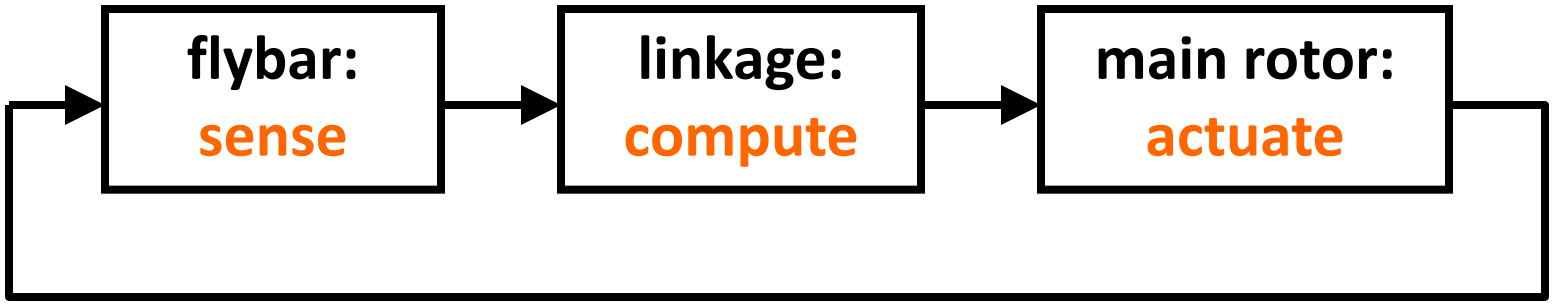
Gyros are everywhere!

- A cheetah's head (the vestibular system)
- Your head (try spinning around then walking)
- Fly's Halteres
- This model helicopter
- Real airplanes
- The r-one robots

Wait, there's another feedback system in this heli?

Yes. The flybar – gyroscopic lateral stabilization (wazzat?)

This is a like a **mechanical governor**, a simple control loop



Ok, that's it, right?

Actually, no:

- Two position control loops for the two small motors that control the main rotor position (they are called servos)
- Velocity control loop for the main rotor
- User input to tail rotor control loop

Not to mention:

- Software on the helicopter to manage all of this
- Digital data communications from transmitter
- Rotary-wing aerodynamics
- Swashplate for cyclic control
- Fancy materials: carbon fiber tubing and super-tough plastic
- Electronic circuits to connect all the pieces together

Summary

1. Electrical/mechanical/computational systems are waaay cool

2. Engineering systems are everywhere

3. Block diagrams are a convenient and powerful way to understand these systems

4. Sense, Compute, Act, Repeat = Control Loop