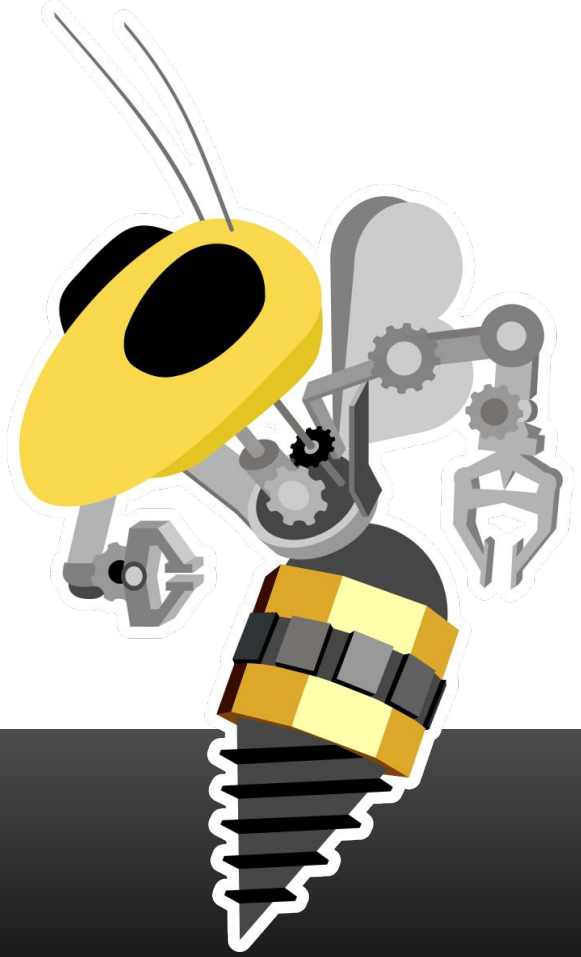
Welcome!

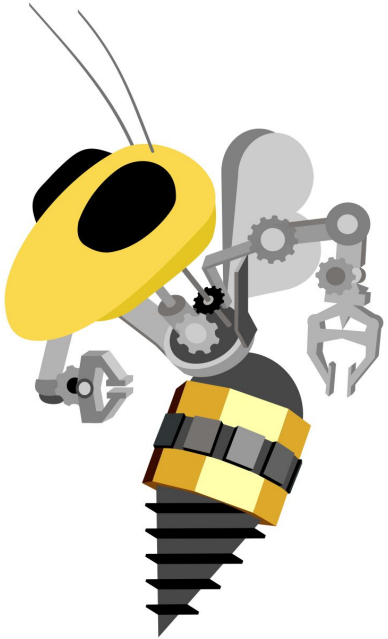
Electrical/Firmware Training Week 0



RoboJackets

Competitive Robotics at Georgia Tech

www.robojackets.org

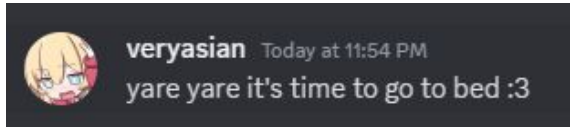


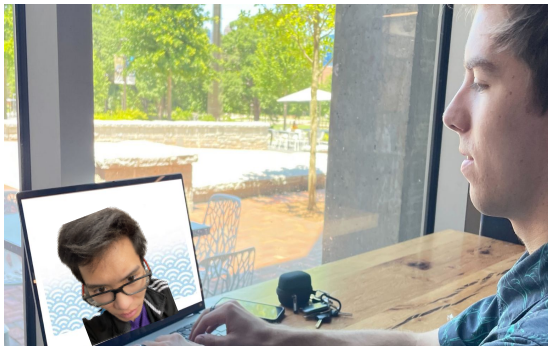
Instructor Introductions

Who are we?

Trainers

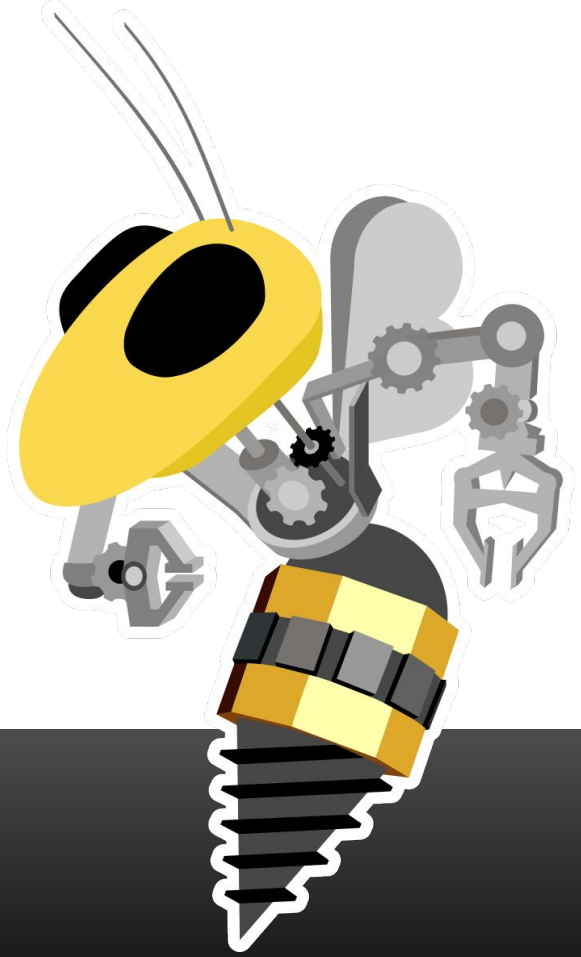
- Kyle Nguyen, Electrical Trainer
  - RoboWrestling, EE
- Xander Riddle, Firmware Trainer
  - RoboWrestling, CS





SCC Training

SCC Training Level 0
Join: **sccgt.slack.com**



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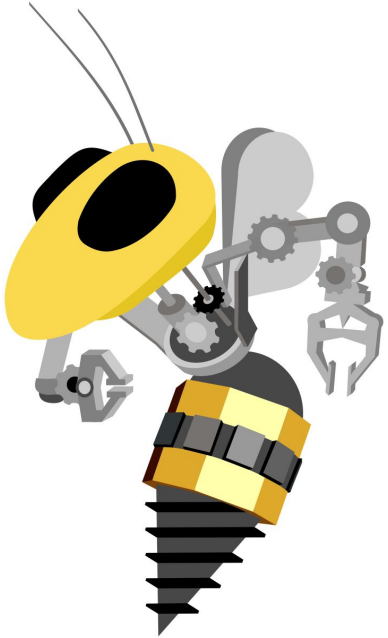
SCC Level 0 Training

- SCC Training Website
- Read the manual and take the level 0 quiz
- You must do this to get BuzzCard access to the SCC
- Make sure you get 100%
    - If you don’t, just retake it

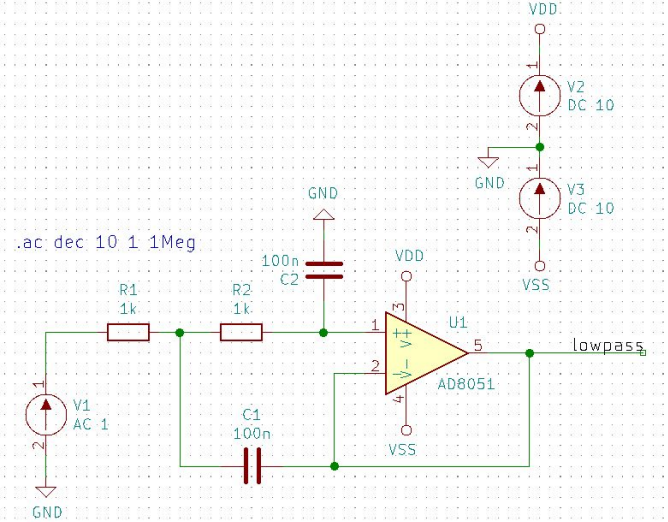


Disciplines

What's the difference?

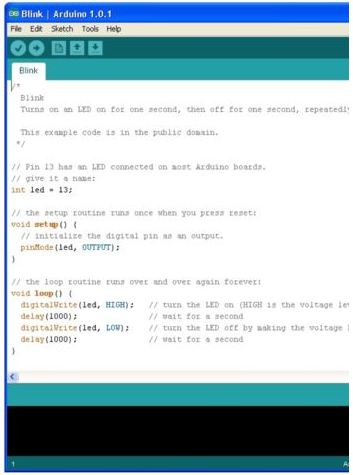
Electrical

- Responsibilities:
  - Develop PCBs
  - Electrical system design
- What you learn:
  - Electrical components
  - Common circuits
  - Prototyping
  - Printed Circuit Board (PCB) design using KiCAD
  - Debugging circuits and soldering



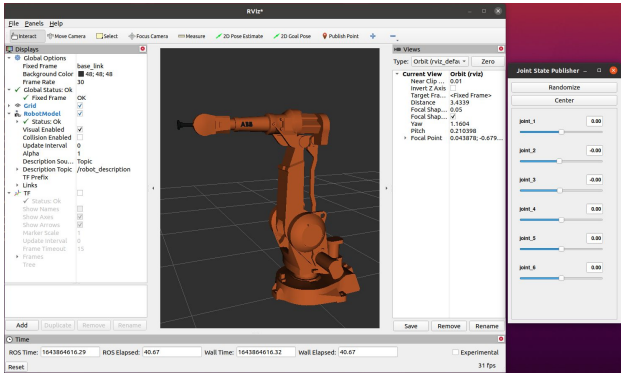
Firmware

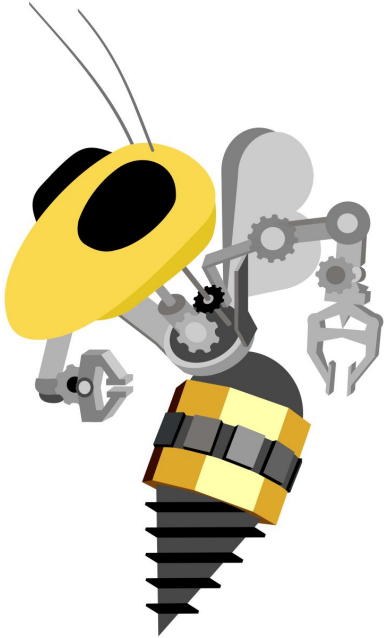
- Responsibilities:
  - Writes the code to run on PCBs that electrical designs
  - Implements the low-level functionality for software
- What you learn:
  - Electrical components
  - Common circuits
  - Prototyping
  - Microcontroller programming
  - Communication Protocols
  - Debugging circuits and soldering



Software

- Responsibilities:
  - Write code that runs (mostly) on “regular” computers
  - “Autonomy”: Vision, motion planning, decision making, etc.
  - A little bit of motion control (split between SW/FW teams)
- What you learn in Software Training:
  - Basics of C++ and ROS
  - Robotics concepts for autonomy





Logistics

How will this work?

Electrical/Firmware Training

- Two sessions a week
  - Monday and Wednesday 6:30pm - 8:00pm
  - Only need to come to one a week

Weekly Plan

Week	Electrical Training	Firmware Training
0	Introductions, Electrical Basics	
1	Introduction to Prototyping and Arduino	
2	KiCAD Parts and Libraries	More C and Interrupts
3	KiCAD Schematics	PWM and Bitwise Operations
4	KiCAD Board Layout	Communication Protocols
5	Debugging and Soldering	

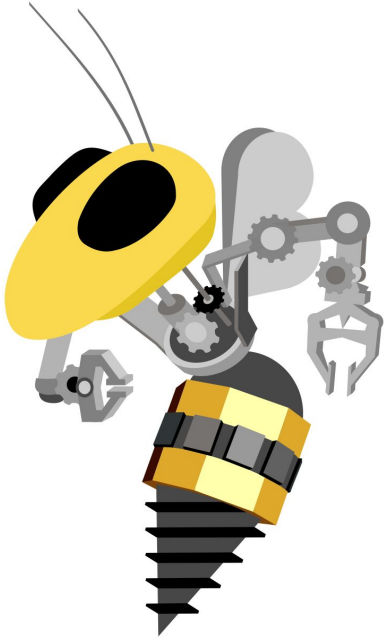
Online Platforms

- GitHub - Slides and Labs
  - **github.com/robojackets/electrical-training**
  - **github.com/robojackets/firmware-training**

- Slack - RoboJackets Team Communication
  - channel: **#electrical-firmware-training-helpdesk**

Important Slack Channels

- Important channels:
  - #<team> (i.e. #robowrestling)
  - #<team>-electrical (i.e. #robowrestling-electrical)
    - #<team>-mechanical and #<team>-software (less important, but good for team collaboration)
  - #electrical-core (electrical/firmware collaboration)
  - #electrical-ama (electrical/firmware questions)
- To-do: Set up your Slack profile!
  - Set profile picture / “What I do” (<team> Electrical)
- Fun channels:
  - #random #rj-girl-gang #swolojackets #trailjackets



Team Introductions

We build robots!

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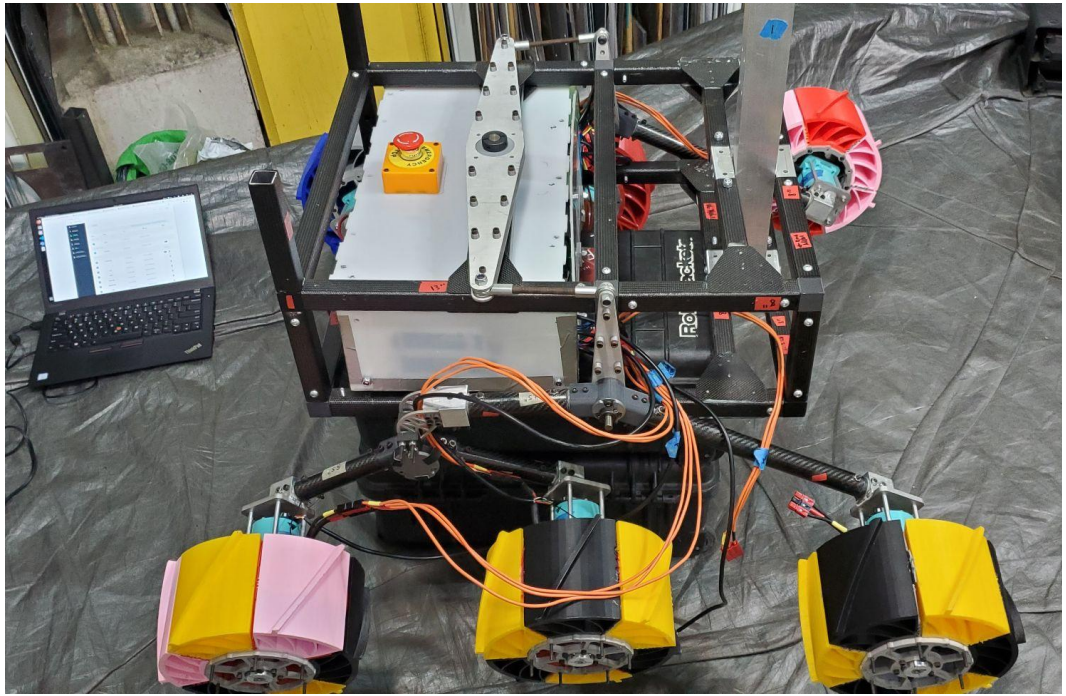
RoboNav

- *Fast Prototyping*
- *Lots of actuators! (Arm, drivetrain, science)*



RoboJackets
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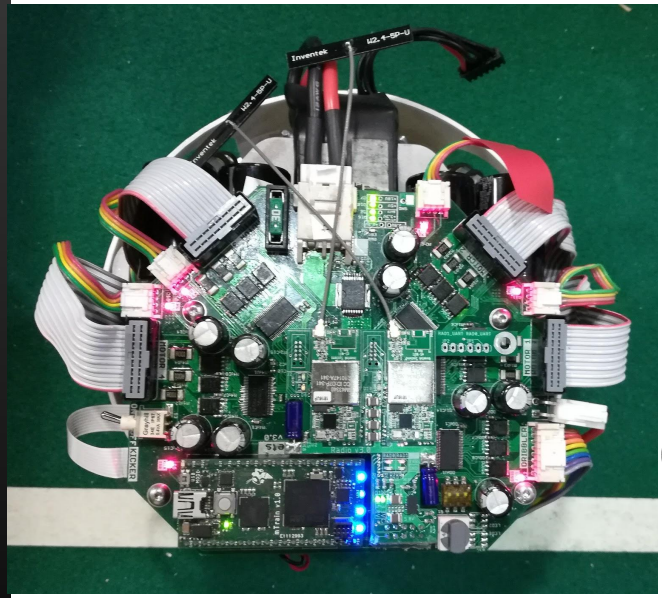
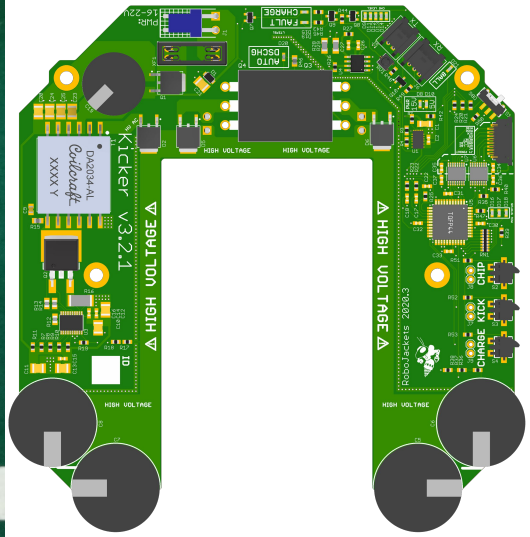
RoboCup

- *Power Electronics*
- *FPGA-based Motor Control*





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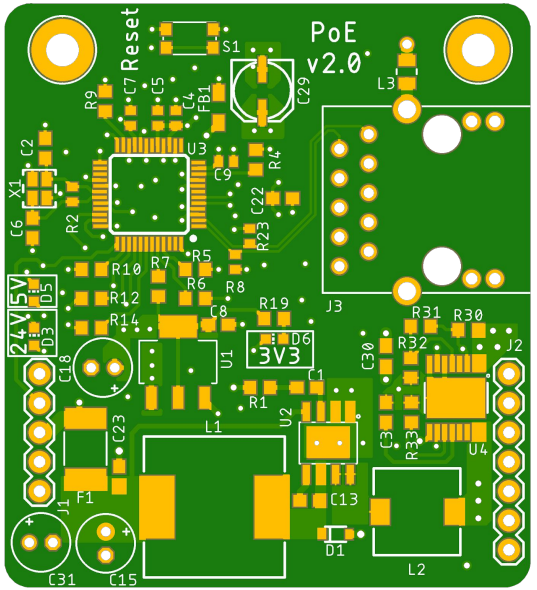
RoboRacing

- *Distributed Network Systems*
- *High Speed and Power*



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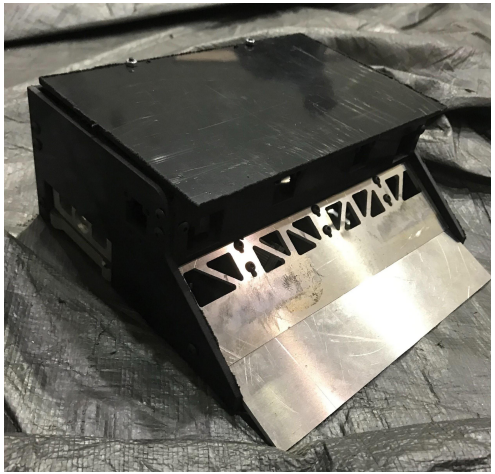
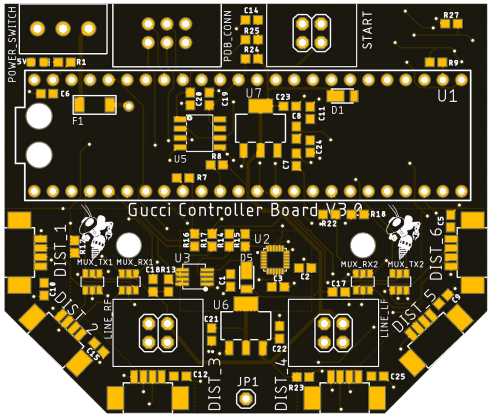
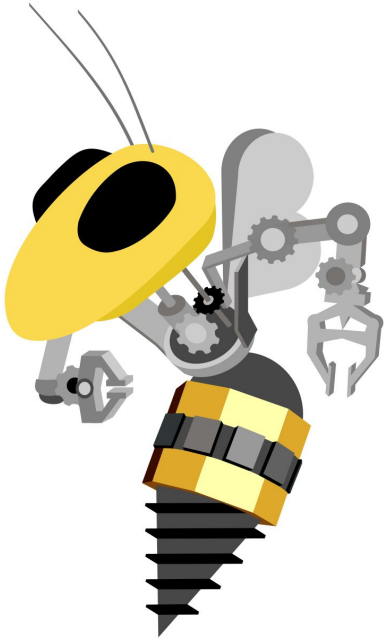
RoboWrestling

- *Real-Time Strategy*
- *Small Packaging*
- *(We're just better)*

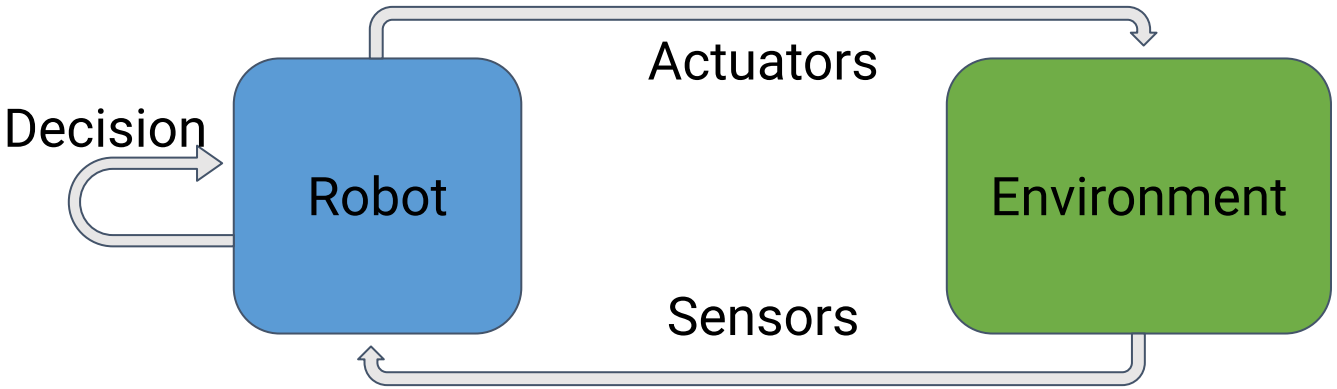






Robotics

What is a Robot?



Cameras, GPS

Monitor

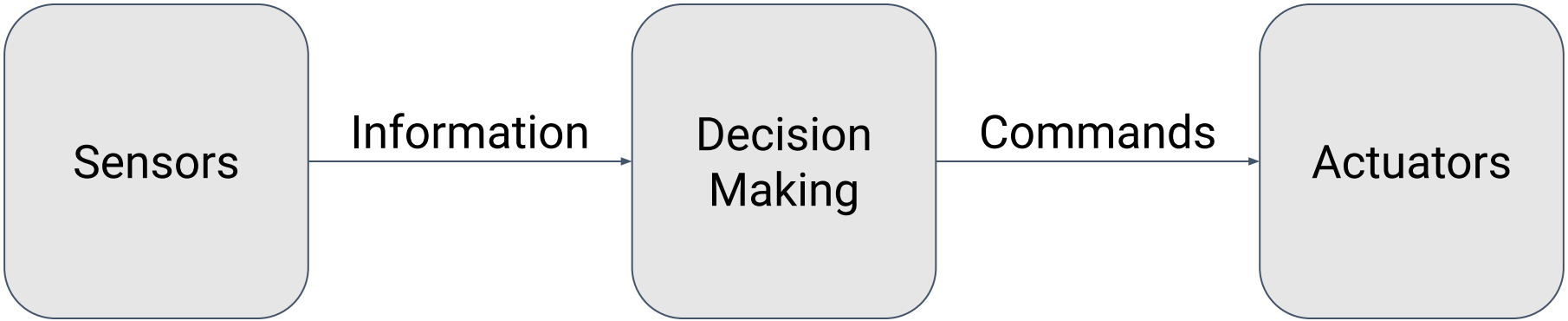
Mast

Computer & Control Electronics

Electronics Tray

Batteries, LiDAR, & Drivetrain

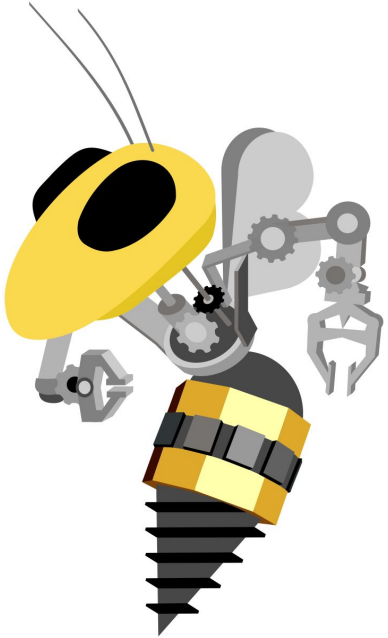
Chassis



- LiDAR
- Inertial Measurement Unit
- Cameras
- Wheel Encoders

- Computer
- Mbed Microcontroller

- 2x Brushed DC Motors

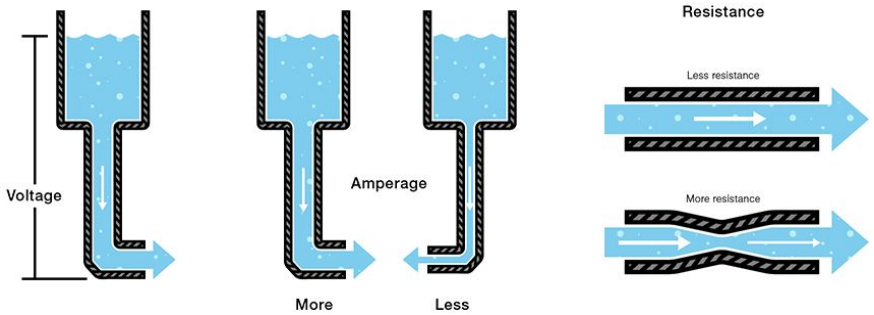


Electricity Basics

Electrons go brrrr

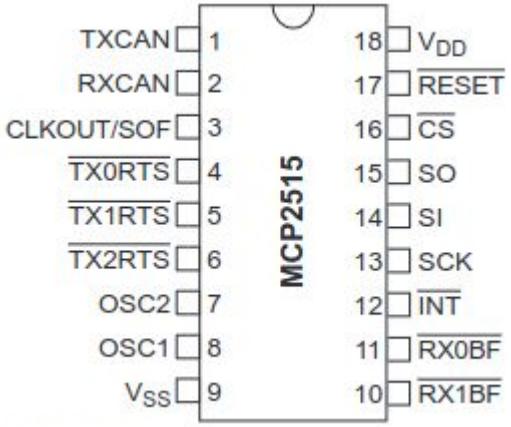
What is electricity?

- Movement of charged particles (electrons)
- Voltage: Amount of potential energy in electrons (J/C)
- Current: Rate at which electrons flow (C/s)
- Current flows from high potential to low potential, releasing energy



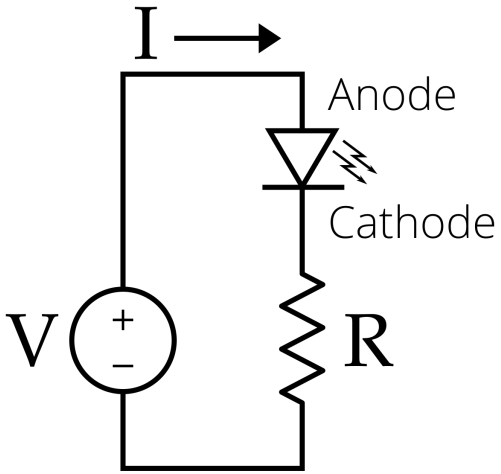
Notation

- Symbols
  - V: voltage, measured in volts (V)
  - I: current, measured in amps (A)
  - R: resistance, measured in ohms (Ω)
- Power and Ground
  - Power: VCC, VDD, +5V
  - Ground: VEE, VSS, GND, 0V



Important Formulas

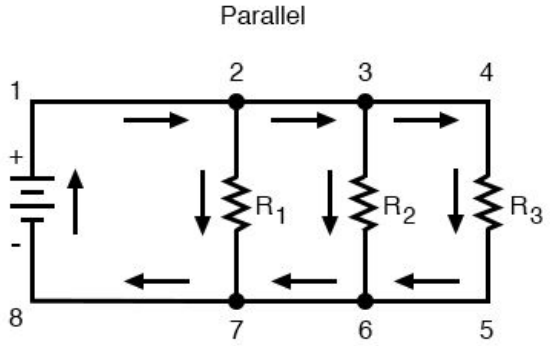
- Ohm's Law: $V = I \cdot R$
- Power: $P = V \cdot I = I^2 \cdot R = V^2/R$



Parallel and Series Circuits

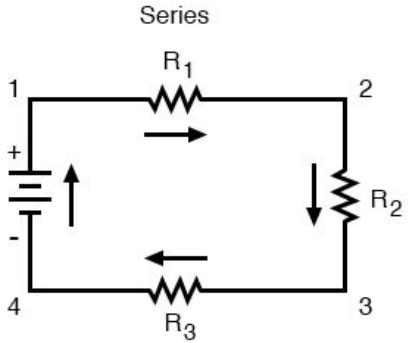
Parallel

- Constant voltage drop for each path



Series

- Current is the same everywhere in the circuit



Takeaway: mind the current!

$$P = I^2 \cdot R$$

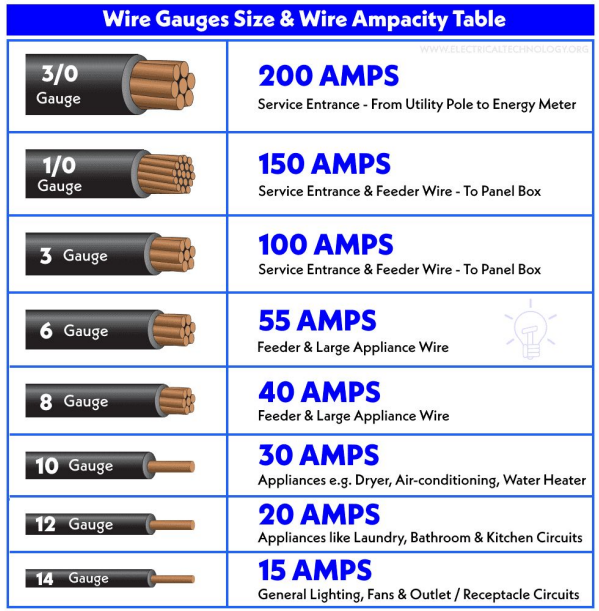
$$Q = I^2 \cdot R \cdot t$$

More current
=
Thicker wire

More current
=
Thicker PCB trace!

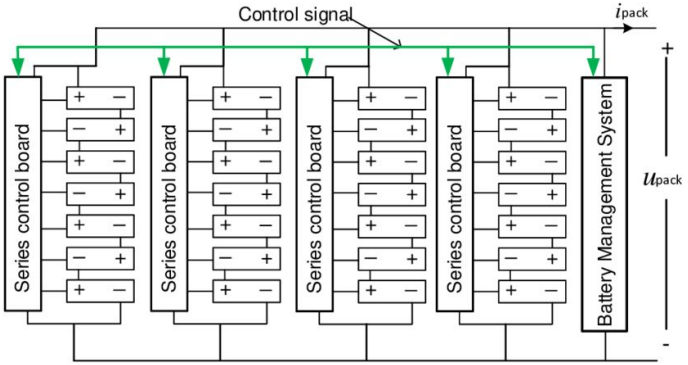
Temp Rise	10°C			20°C			30°C		
Copper	1/2oz.	1oz.	2oz.	1/2oz.	1oz.	2oz.	1/2oz.	1oz.	2oz.
Trace Width (:inch)	Maximum Current Amps								
0.01	0.5	1	1.4	0.6	1.2	1.6	0.7	1.5	2.2
0.015	0.7	1.2	1.6	0.8	1.3	2.4	1	1.6	3
0.02	0.7	1.3	2.1	1	1.7	3	1.2	2.4	3.6
0.025	0.9	1.7	2.5	1.2	2.2	3.3	1.5	2.8	4
0.03	1.1	1.9	3	1.4	2.5	4	1.7	3.2	5
0.05	1.5	2.6	4	2	3.6	6	2.6	4.4	7.3
0.075	2	3.5	5.7	2.8	4.5	7.8	3.5	6	10
0.1	2.6	4.2	6.9	3.5	6	9.9	4.3	7.5	12.5
0.2	4.2	7	11.5	6	10	11	7.5	13	20.5
0.25	5	8.3	12.3	7.2	12.3	20	9	15	24

Table 1 Carrying Capacity per mil std 275

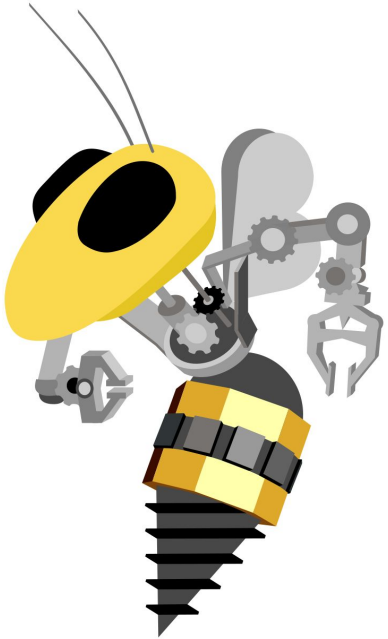


Takeaway: Series & Parallel

Series = voltage adds
Parallel = current adds



Power distribution: in parallel!



Electronic Components & Tools

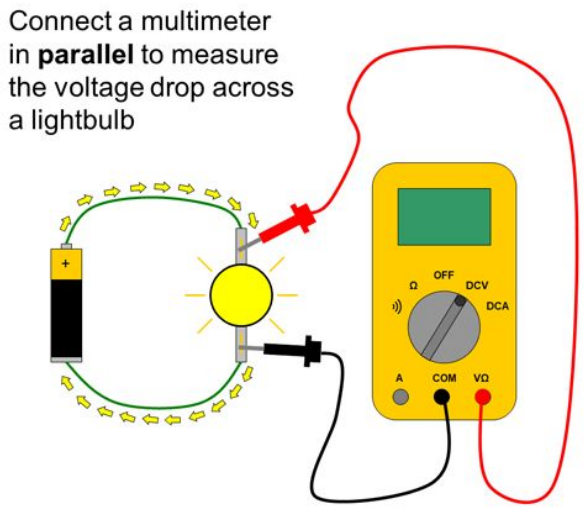
ROBOJACKETS
COMPETITIVE ROBOTICS AT GEORGIA TECH

Multimeter

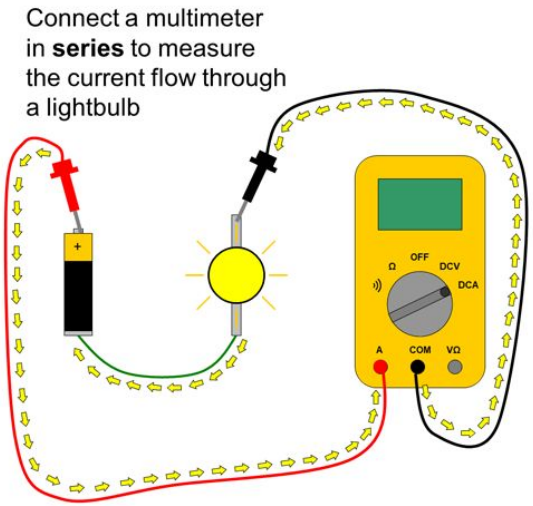
An electrician's best friend!

Using a Multimeter

Voltage / Resistance / Continuity

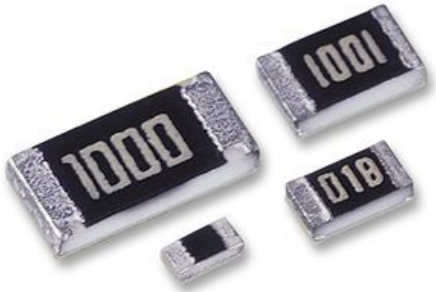


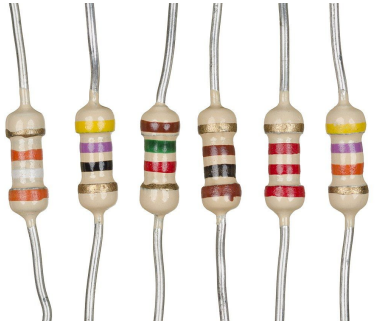
Current



Resistor

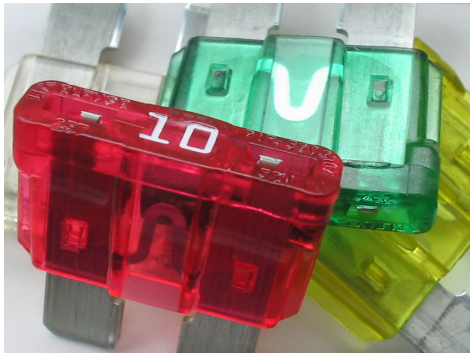
- Purpose: reduces current flow
  - Resistance measured in Ohms (Ω)
  - Makes it harder for current to flow
- Converts electrical energy to heat

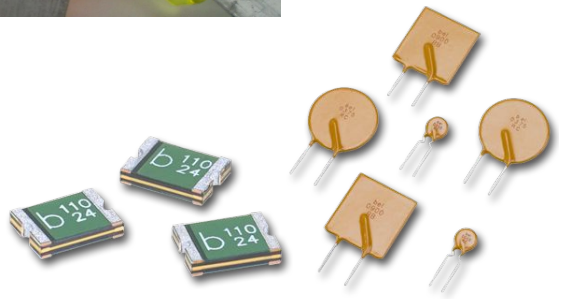




Fuse

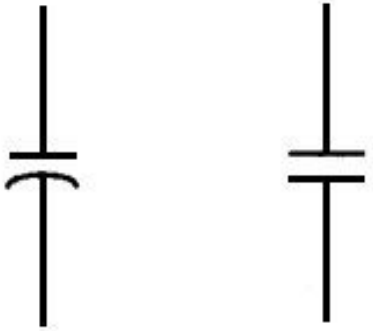
- Safety device which blows when too much current flows through it

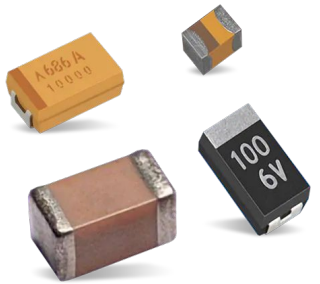




Capacitor

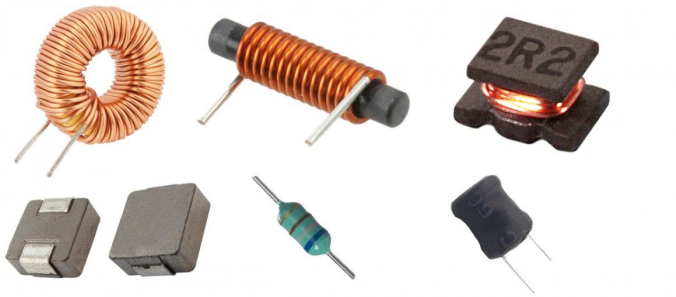
- Purpose: Stores energy as an electric field between two charged plates
  - Measured in Farads (F)
- Uses:
  - Power Source
  - Smoothing voltage signals





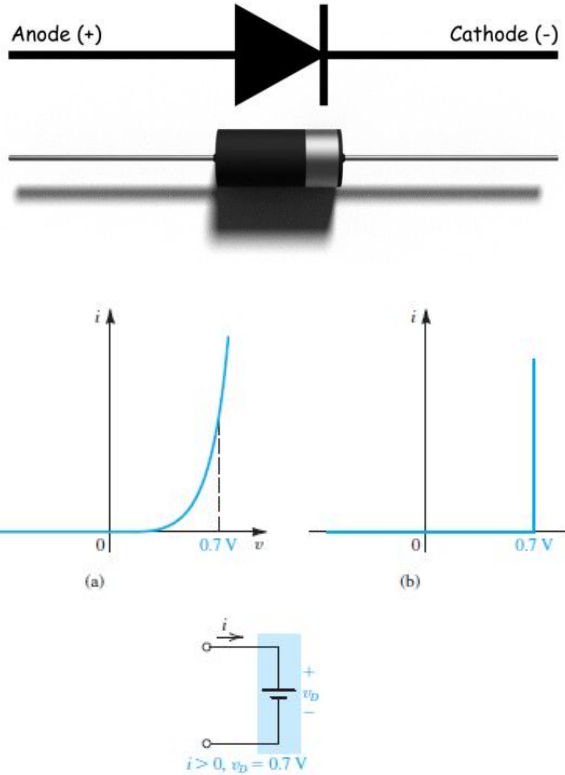
Inductor

- Purpose: Stores energy as a magnetic field in a coil
- Measured in Henry (H)
- Uses:
  - Smoothing current
  - Electromechanical parts (solenoids, relays)



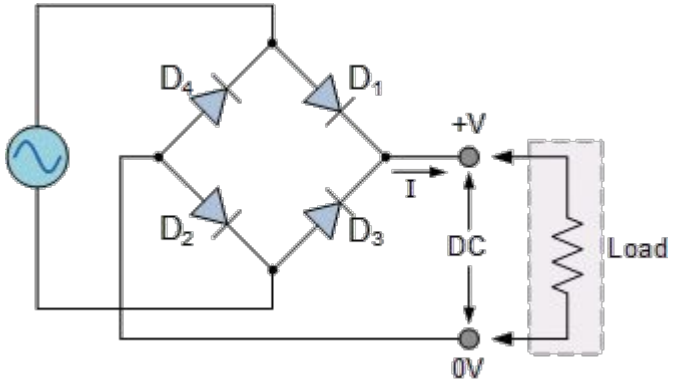
Diode

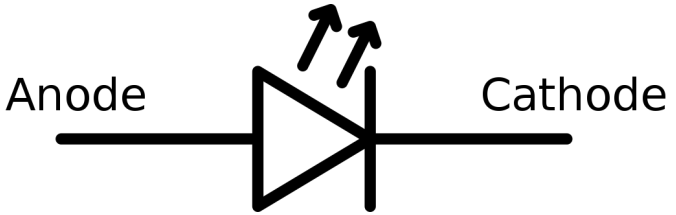
- Conducts current in one direction
- CVD Model: Assume diode conducts infinite current at constant voltage



Diode

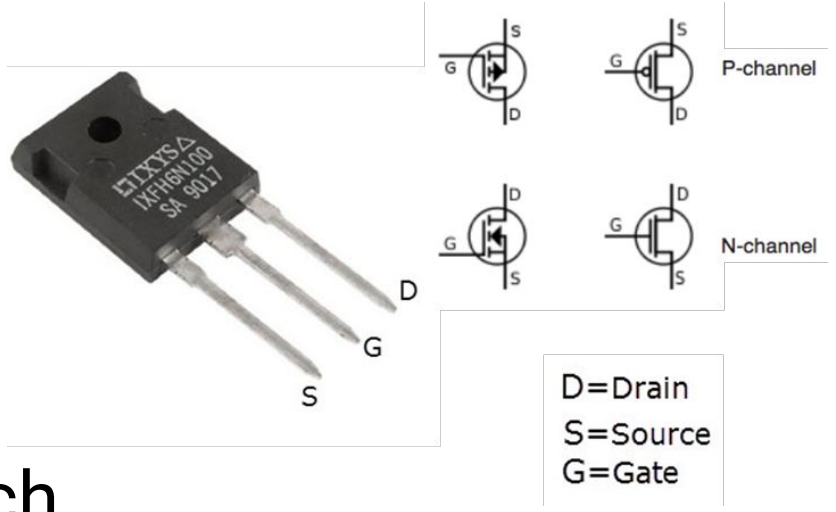
- Uses:
  - Rectification
  - Reverse Polarity Protection
  - Light Emitting Diode





Transistor (MOSFET)

- 3 Terminal Component
  - Gate, Drain, Source
- Voltage signal at gate controls current flow between Source and Drain
- Acts as an electronic switch



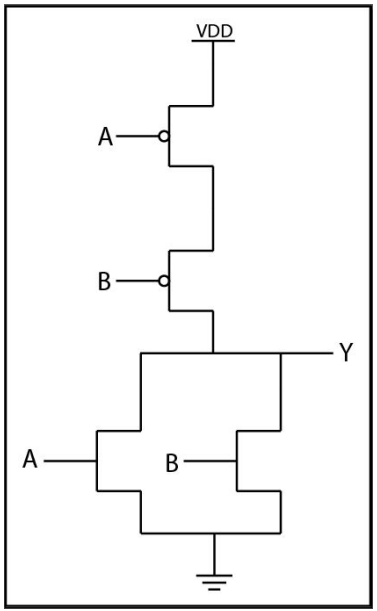
Transistor

- An electrical switch!
  - Transistors “activate” when the gate-source voltage reaches the threshold
- Two types: N- and P-Type
  - N-Type: source kept at GND
  - P-Type: source kept at VCC
- RoboJackets: don’t often use directly
  - Buy integrated circuits (ICs) that contain lots of transistors

Signal on the Gate	PFET	NFET
0 (Logic Low, GND)		
1 (Logic High, VDD)		

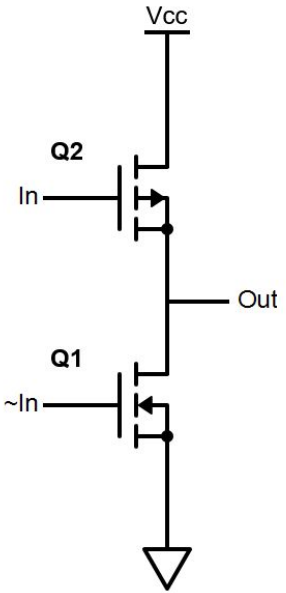
Transistor Uses

Digital Logic



CMOS NOR gate

Power Amplification



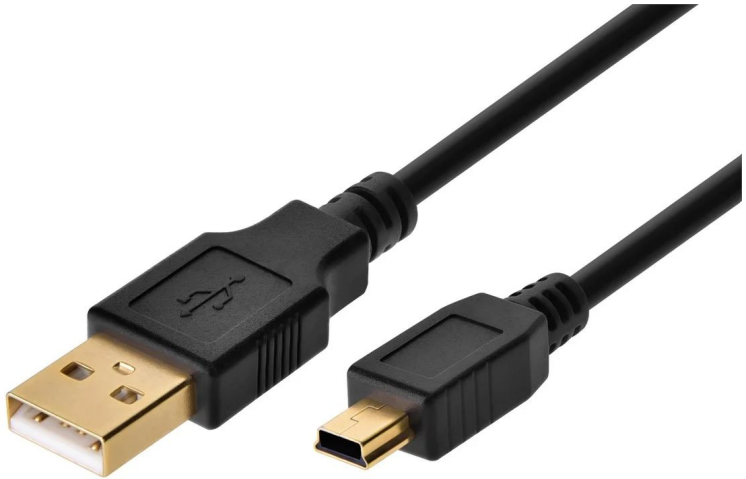
Cascode Amplifier

For next meeting...

Bring the following:

- Laptop with USB
- This cable if you have it

Location: Van Leer C457



Feedback/Attendance