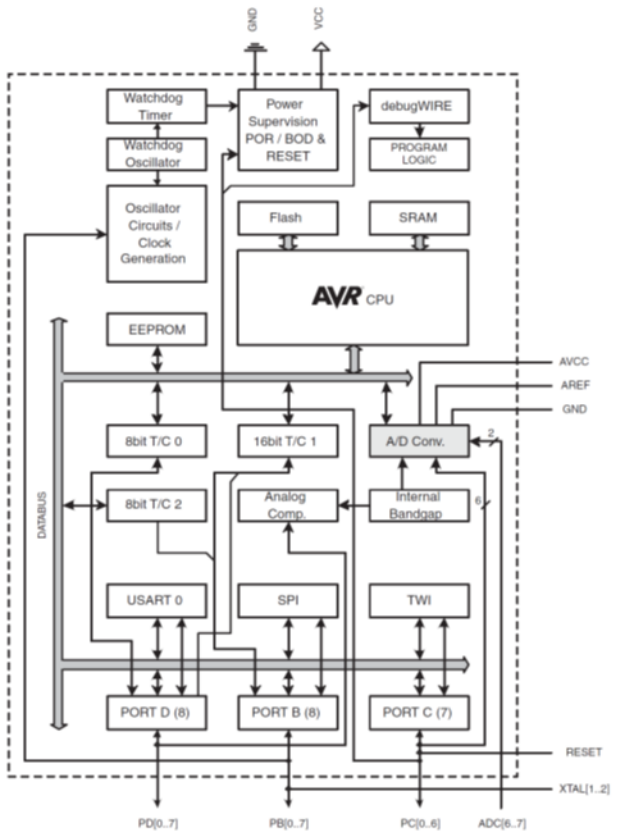
# FOLDABLE ROBOTICS

Class XIV: Actuators, Motors, Motion Control

# Microcontrollers

- Microprocessor
- Serial Ports
- RAM
- ROM
- Clock
- Digital I/O
- Analog I/O?

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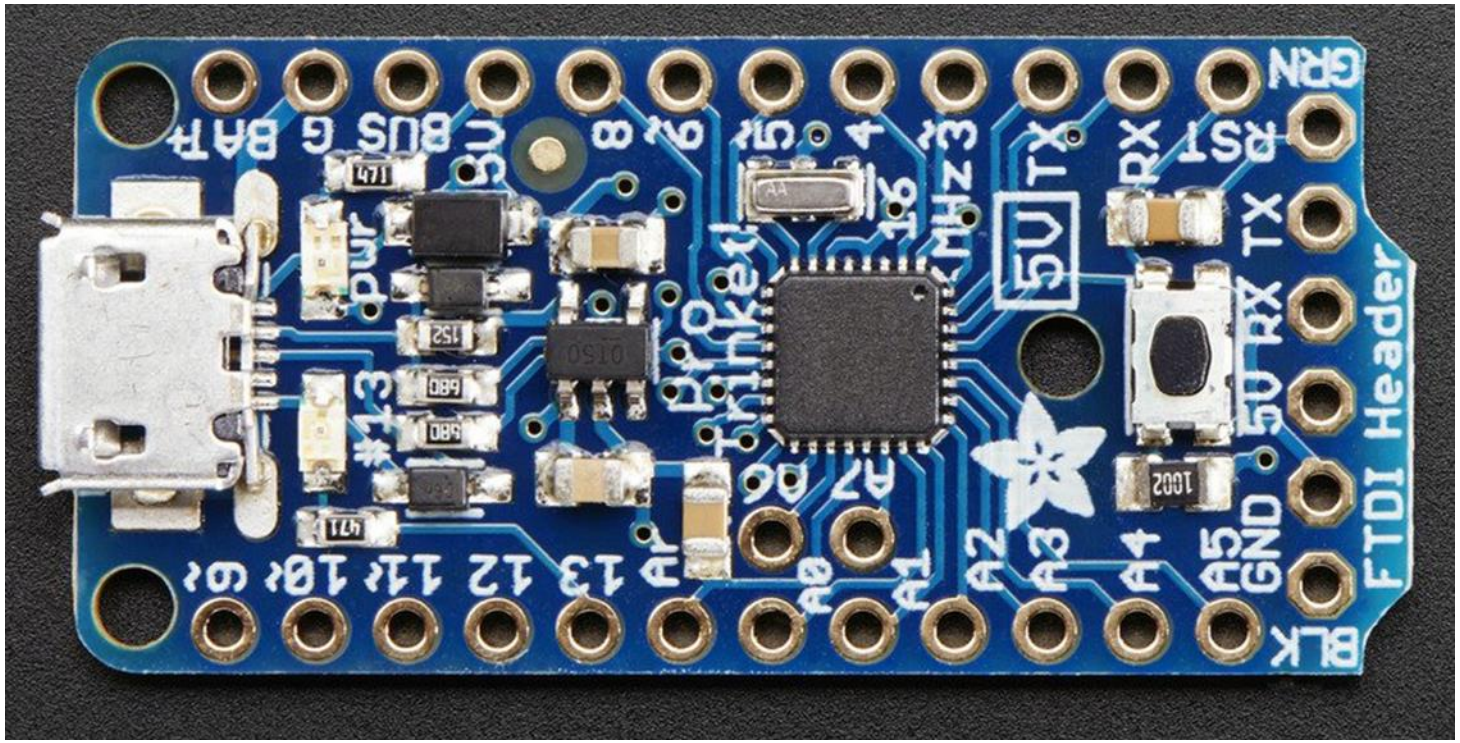
# Adafruit Pro Trinket 5V

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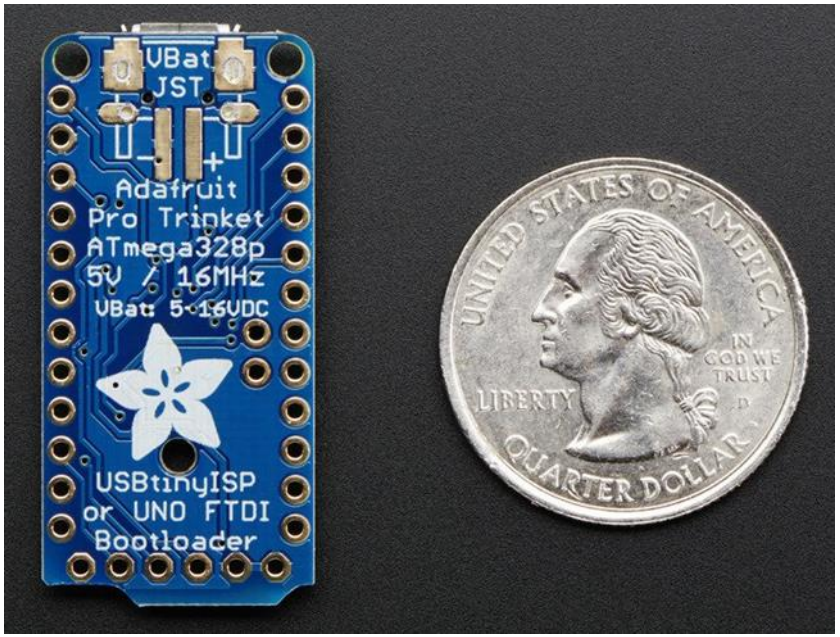
# Specifications

- ATmega328P onboad chip in QFN package
- 16MHz clock rate, 28K FLASH available
- USB bootloader Also has headers for an FTDI port for reprogramming
- Micro-USB jack for power and/or USB uploading, you can put it in a box or tape it up and use any USB cable for when you want to reprogram.
- On-board 5.0V power regulator with 150mA output capability and ultra-low dropout.
- Up to 16V input, reverse-polarity protection, thermal and current-limit protection.
- 28,672 bytes max sketch size

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# Why Arduino?

- Dummy proof
  - Polarity protection
  - Thermal Protection
  - USB
  - 5V is compatible with lots of external io
  - Works with arduino

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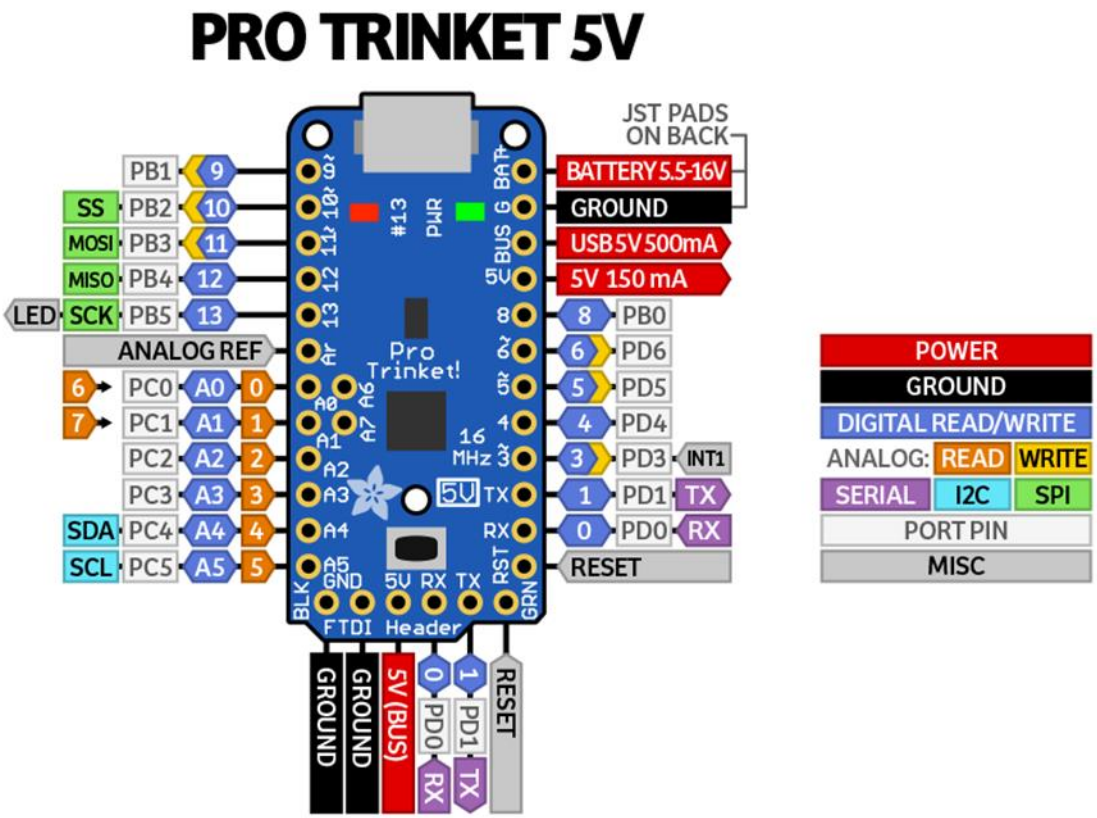
# Pinouts

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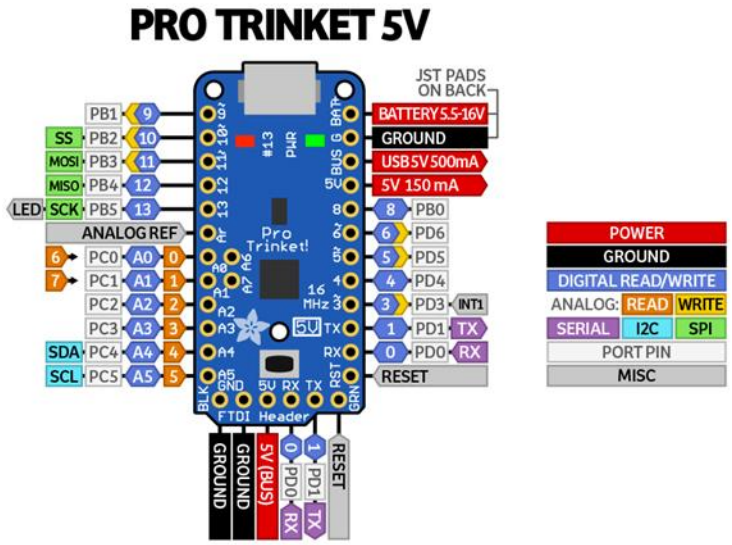
# Pinouts




- Several different power connections
- What is the meaning of each?

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# What does that mean

- 150mA: maximum you should drive any / all pins
- What about per pin?

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# USB Power

- 0.5 A (USB 2.0)
- 0.9 A (USB 3.0)
- 5 A (BC 1.2)
- 3 A (type-C)
- Up to 5 A (PD)

5V

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# Assembly

- Breadboard basics
- Soldering
- Installing drivers
- Setting up Arduino environment
- Writing basic code
- uploading

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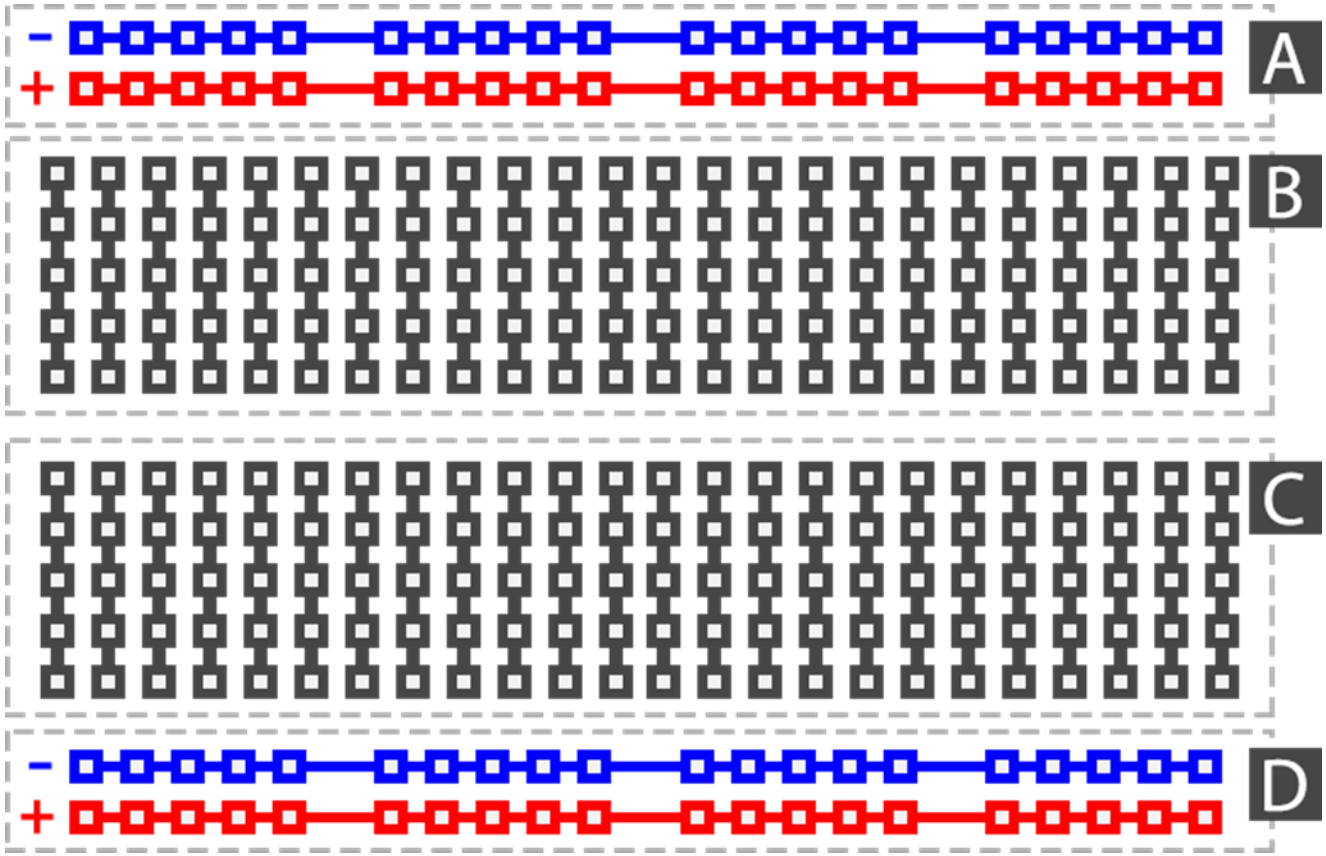
# Breadboard Basics

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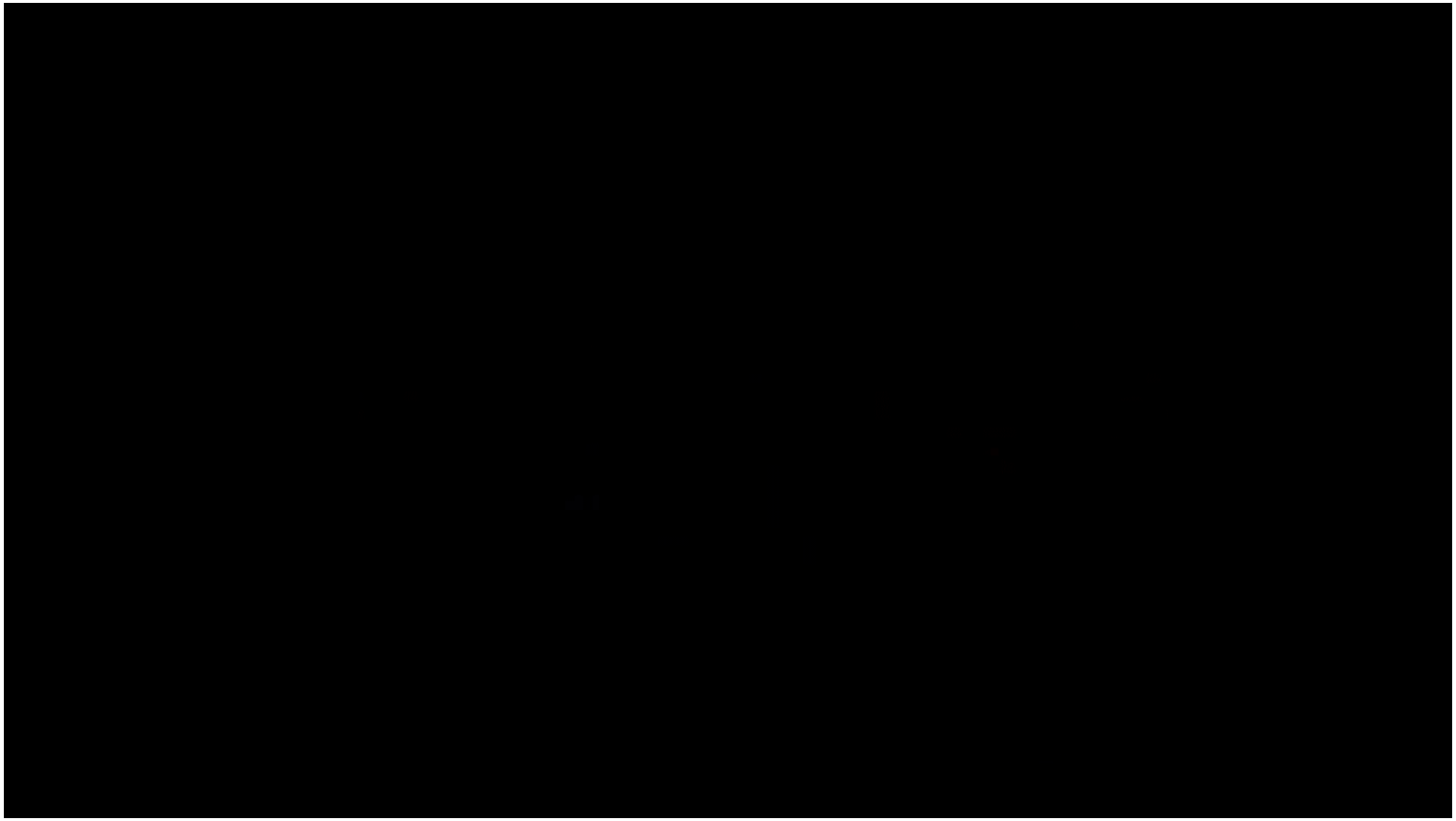
# Soldering



https://www.youtube.com/watch?v=Qps9woUGkvI

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# Arduino Settings

- Install adafruit windows drivers
- Set up Arduino IDE
  - Add repository
  - Add adafruit boards manager
- Select Board:
  - ProTrinket5V/16MHz(USB)
- Select Programmer:
  - USBTinyISP

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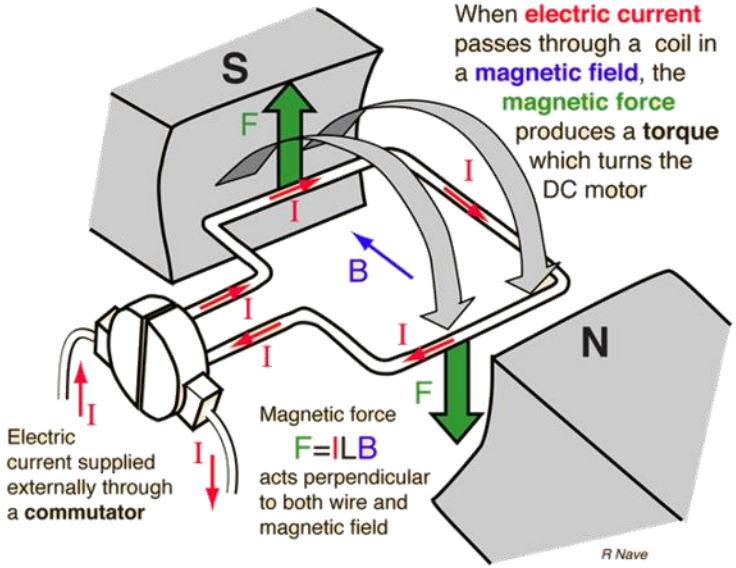
# DC Motors




http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/motdc.html

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# What's the big deal?

Why not just connect a motor to the output?

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# Atmel 328

## 29.1 Absolute Maximum Ratings*

| | |
|---|---|
| Operating Temperature | -55°C to +125°C |
| Storage Temperature | -65°C to +150°C |
| Voltage on any Pin except $\overline{\text{RESET}}$ with respect to Ground | -0.5V to $V_{CC}$+0.5V |
| Voltage on $\overline{\text{RESET}}$ with respect to Ground | -0.5V to +13.0V |
| Maximum Operating Voltage | 6.0V |
| DC Current per I/O Pin | 40.0mA |
| DC Current $V_{CC}$ and GND Pins | 200.0mA |

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# Why Not?

- Microcontroller power limitations
- Drive circuit requirements:
  - Transistors, diodes, resistors
- Directionality
- DC motors: high-speed, low torque
- Sensing and control

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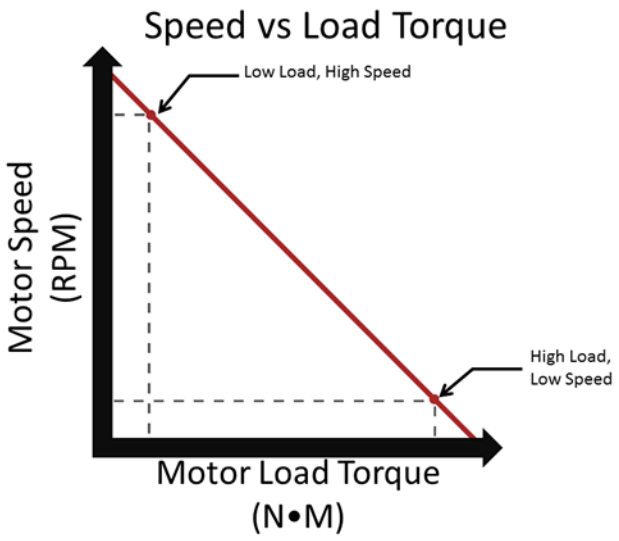
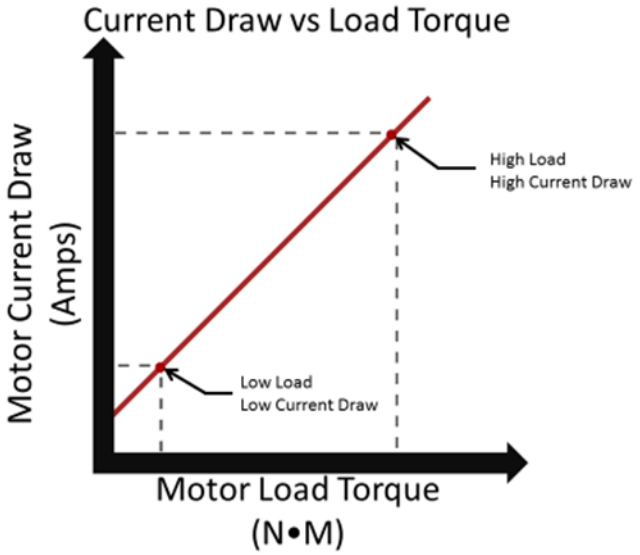
# Speed-torque curve




http://curriculum.vexrobotics.com/curriculum/speed-power-torque-and-dc-motors/dc-motors

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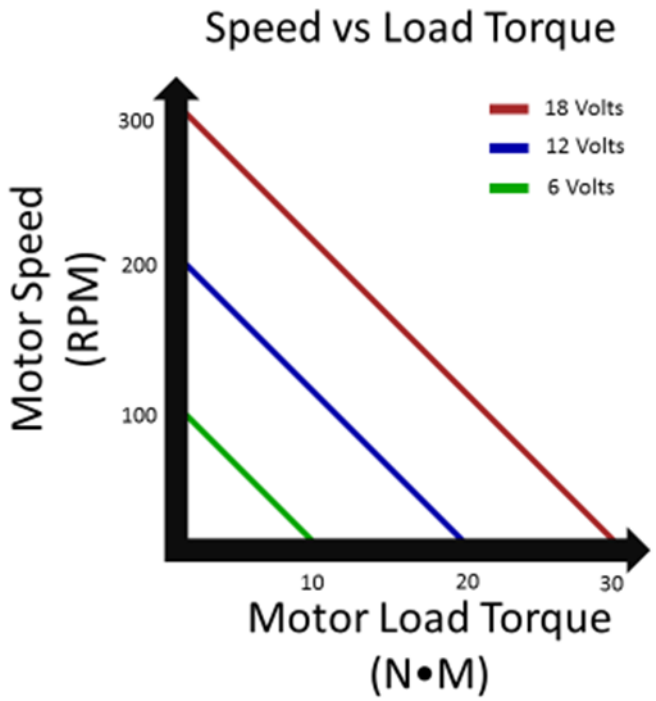
# Voltage Relationship

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# Gear Motors


- 2-oz-in to 125 oz-in
- .015 N-m to .88N-m
- 5:1 to 1000:1
- 800mA stall current
- This means that the motor itself is capable of just one paperclip at ~29 cm

https://www.pololu.com/product/3075

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# Power considerations

Your microcontroller cannot drive motors directly.

NOT EVEN SMALL MOTORS!!

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# Options for a motor:

- Drive Circuit
- H Bridge
- Motor Controller
- Motion Controller
- RC Servo

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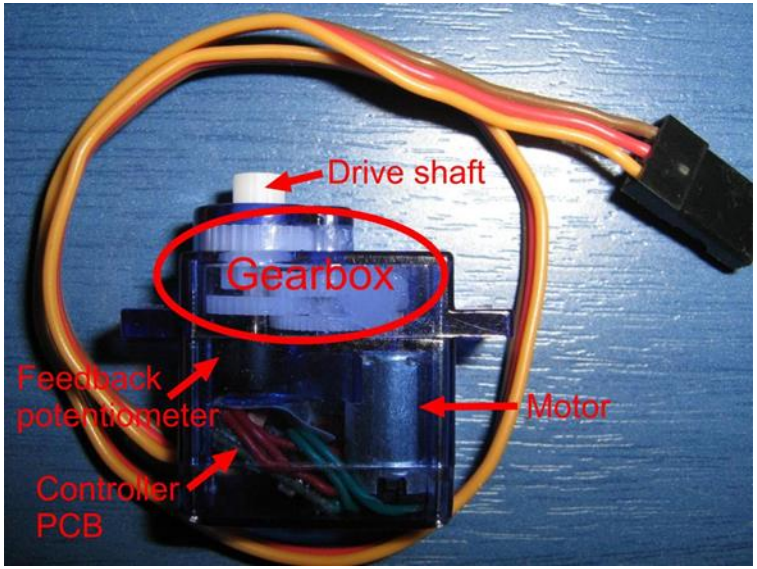
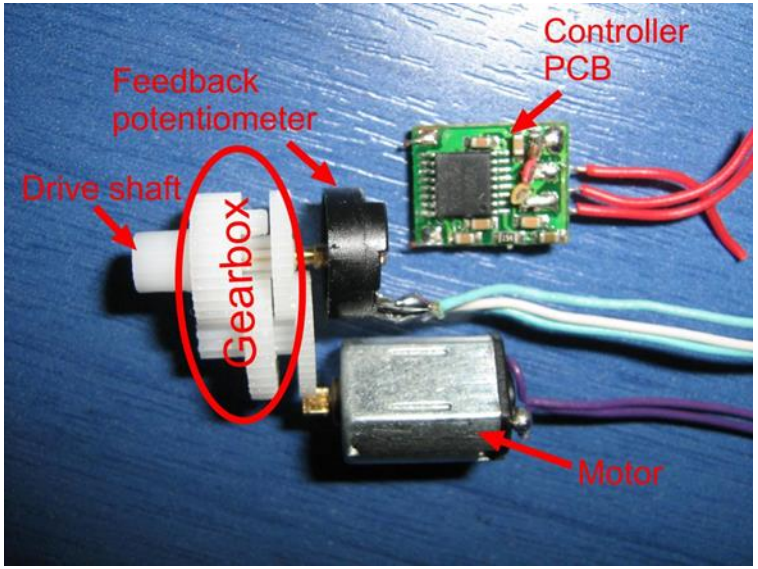
# RC Servo Guts

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# RC Servo

- DC Motor plus other stuff
- Closed-loop position control
- Cheap / Low Power
- Easy to control with microcontroller
- Control signal requires low power
- Loop often does not include microcontroller
- Usually not continuous rotation
- If continuous rotation, usually lose position control

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# Adafruit Servo

- 3V – 6V
- 1.6 kg-cm
- 9g
- Plastic parts
- Do not go over 6V
- Watch the heat!
- Think about usage, average, peak power


https://www.adafruit.com/products/169

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# Dynamixel

- 8Nm stall torque
- $2499 for 6
- Unlimited rotation
- High angular precision: .088 degree
- Load, current, temperature sensing


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# Other Alternatives

- Stepper motors
- Servomotors(not RC servo)
- Hacked RC Servo
- Motor w/ speed control only

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# Budget

- Motor: $17
- Controller: $44
- Encoders:$9
- Total for 4: $148

- Four RC Servos: $6
- Pro Trinket: $10
- Total for 4: 36

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# Get your setup working

- Connect USB, download demo light flashing exercise
- Solder pins onto pro trinket
- Plug in to breadboard
- Add power
- Open servo example
- Change pin numbers to AN0
- Connect Servo

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