CS-417 INTRODUCTION TO ROBOTICS AND INTELLIGENT SYSTEMS

Actuators

Slides by P. Giguere

Ioannis Rekleitis

What is an actuator?

- Device for moving or controlling a system.

- "Robot Muscles"

Hydraulic Actuators

- Pros:
  - Powerful
  - Fast
  - Stiff
- Cons
  - Messy
  - Maintenance
 - External Pump

Hydraulic Actuator Application

- BigDog from Boston Dynamics

Boston Dynamics

Pneumatic Actuators

- Pros:
  - Powerful
 - Cheap
- Cons
  - Soft/Compliant
  - External Compressor
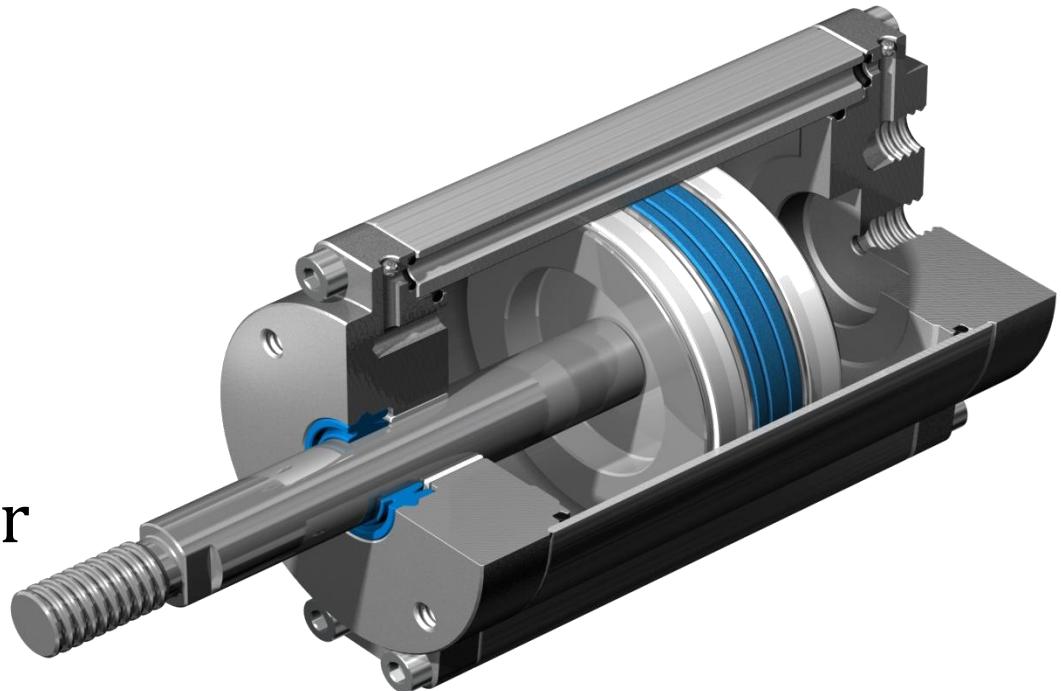
Pneumatic Actuators

- 3D Biped ('89-'95) from MIT Leg Lab

Air Muscle

Soft Silicone Rubber Tube

1/8 inch ID →

¼- inch

4 inch

Polyester Braided-Mesh Sleeve

3/8" Nominal

7 inch

Rubber Tube

Clamp

Wire Loops

Air Fitting

To Air Supply

Mesh Sleeve

10-24 x ¾ Cap head screw plug

Air Muscle Application
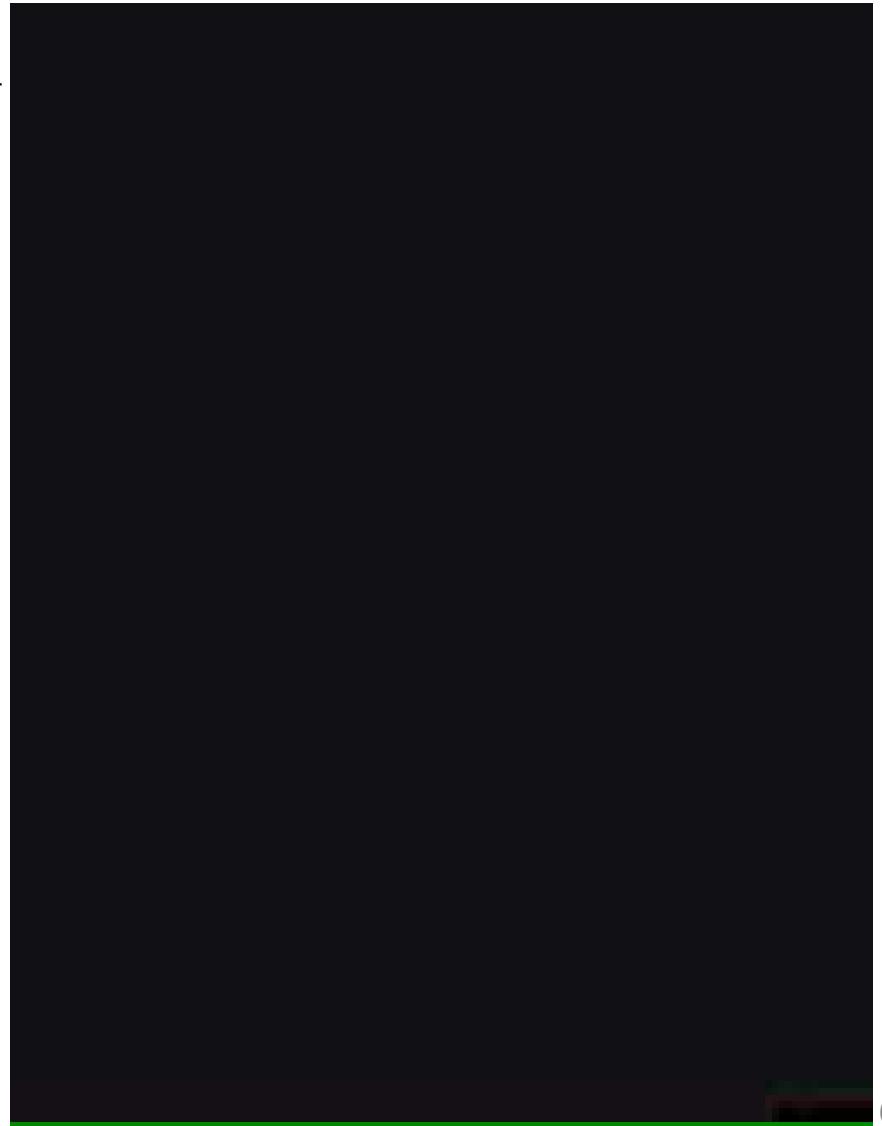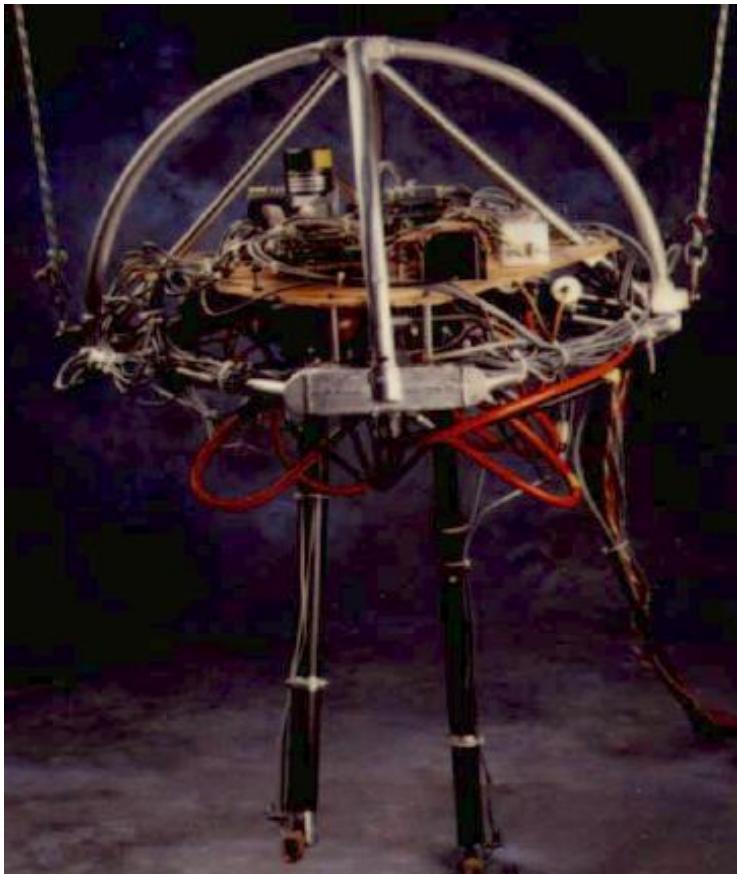

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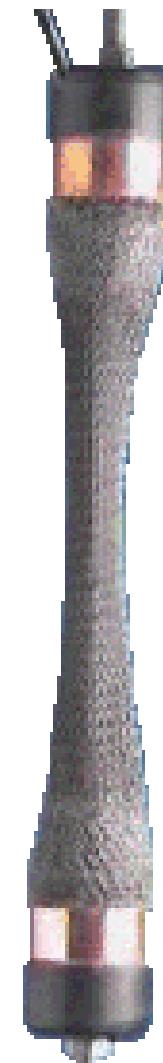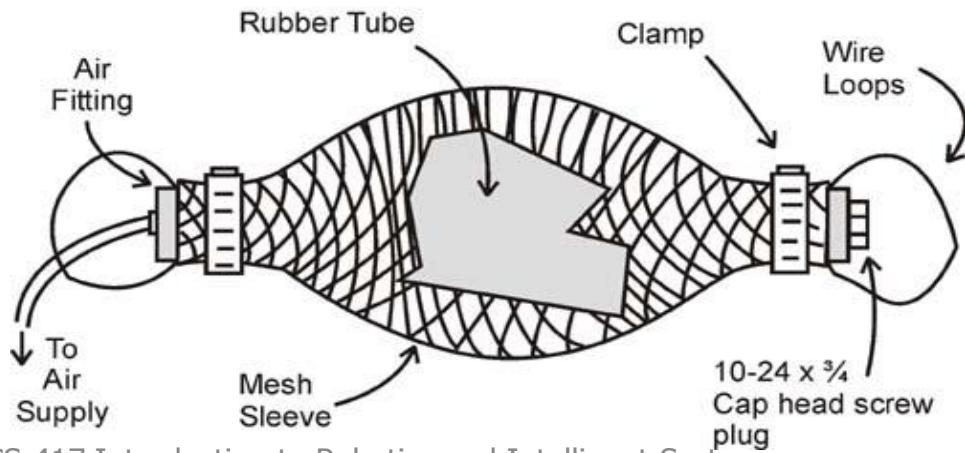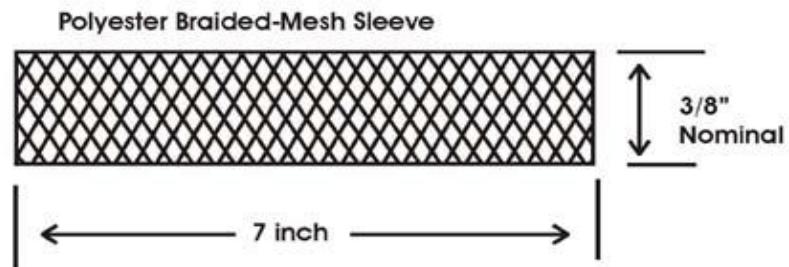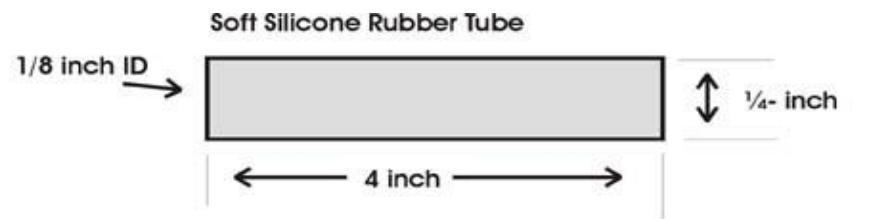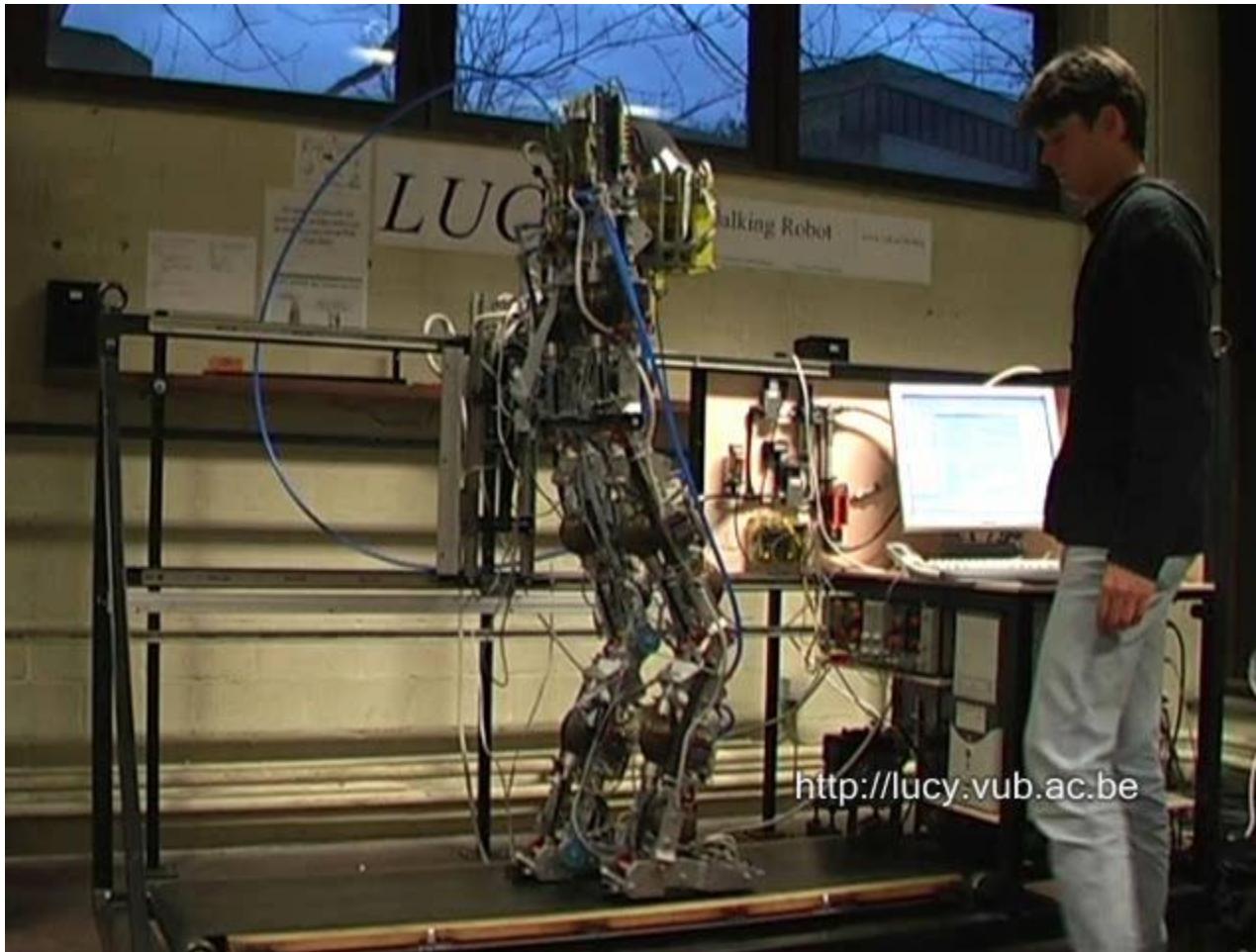
Air Muscle Application

Shape Memory Alloy Actuators

- Works by warming and cooling Nitinol wires.

- Pros:
  - Light
  - Powerful

- Cons:
  - Slow (cooling)
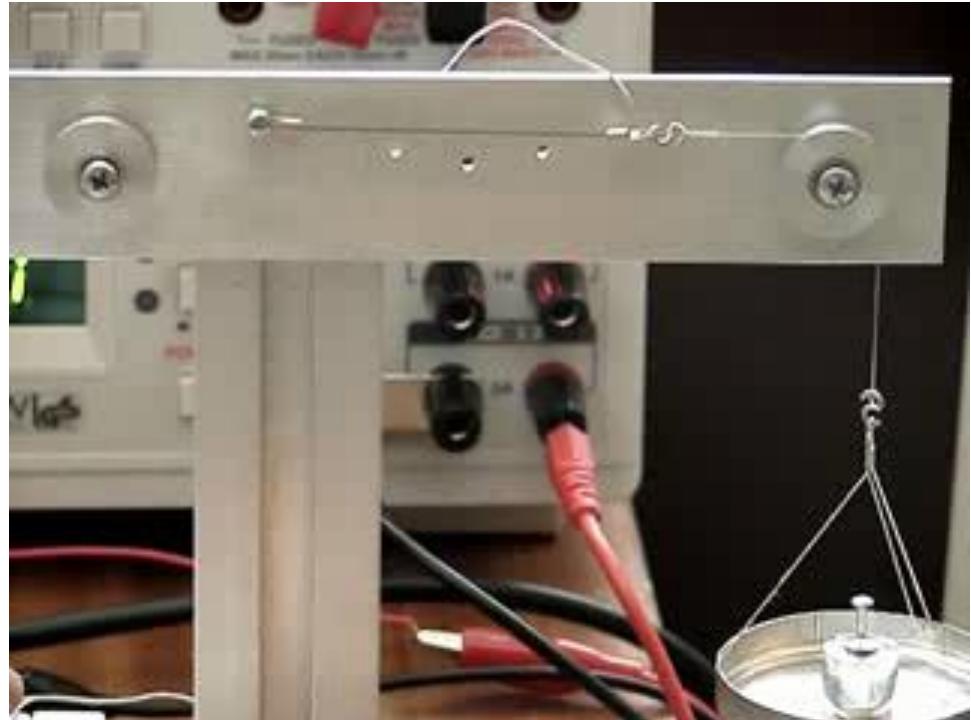
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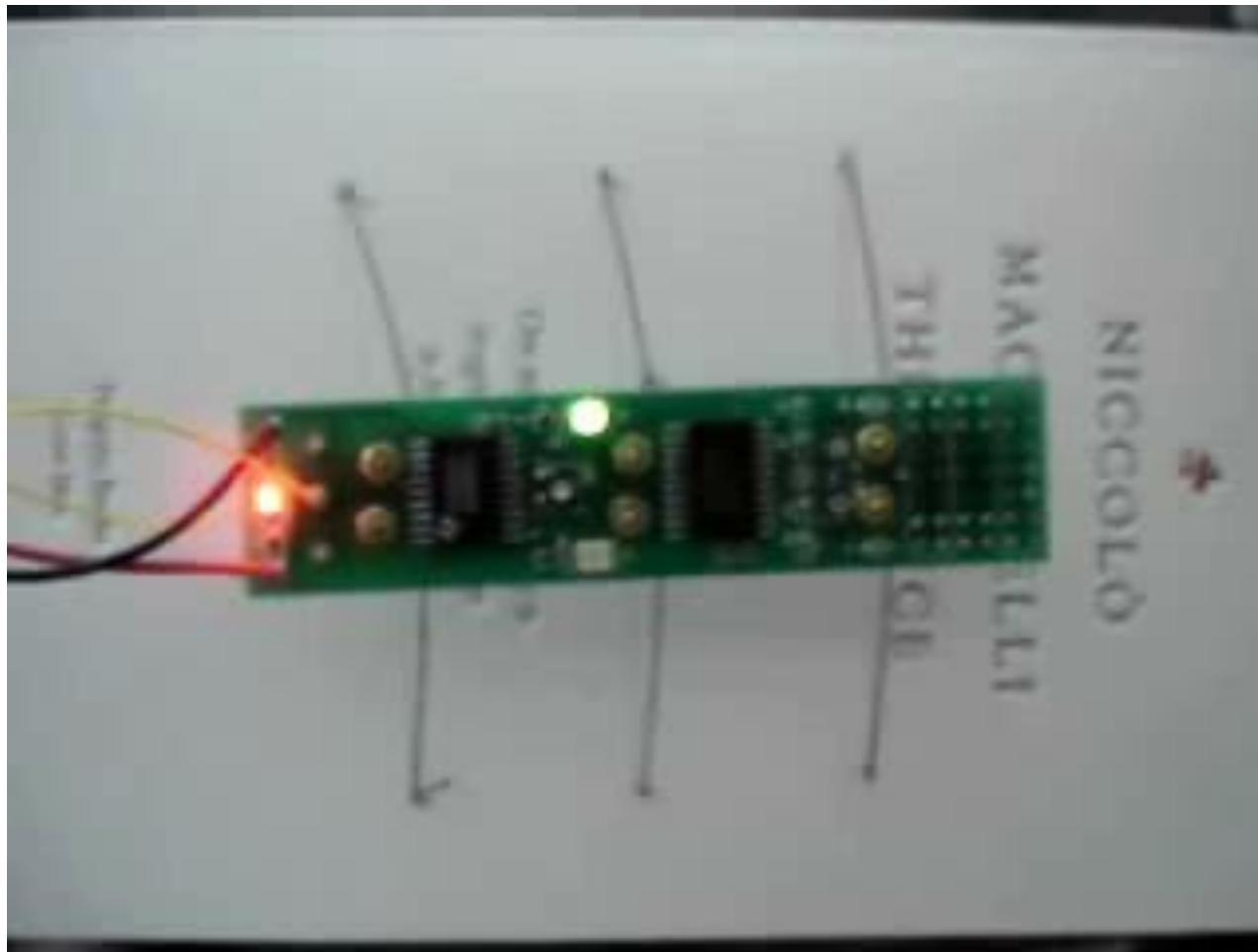
Jonathan Mills, Indiana University

Electric Actuators

- Pros
  - Better position precision
  - Well understood
  - No separate power source
  - Cheap
- Cons
  - Heavy
 - Weaker/slower than hydraulics
  - Cooling issue

Electric Actuators

- Stepper motors
- DC motors
  - Servos
    - Continuous
    - Position
- Others (not discussed)
  - Linear actuators
  - AC motors

Stepper Motor Basics

Electromagnet
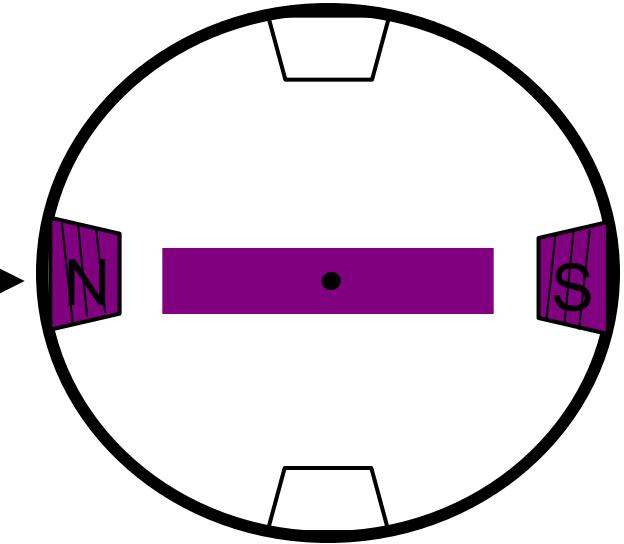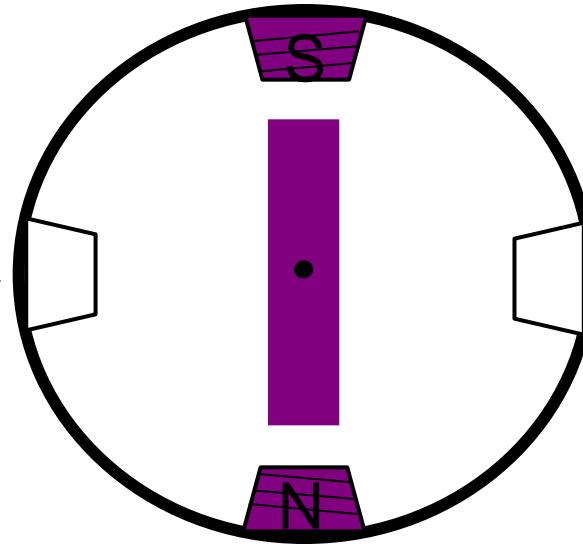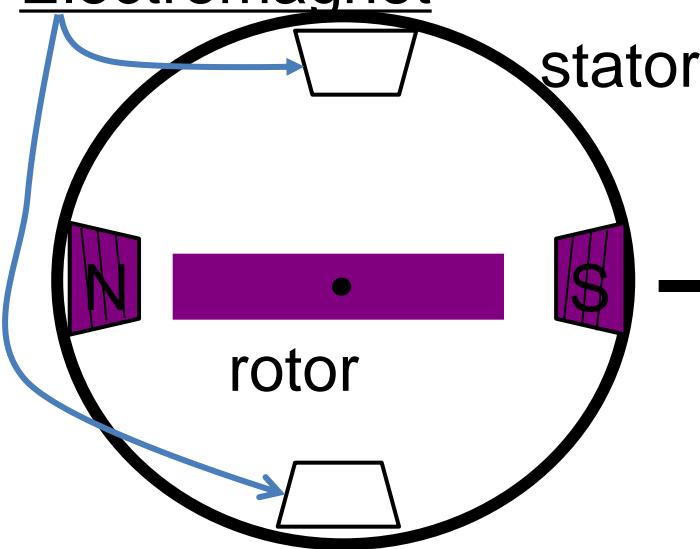
stator

rotor

Stator: made out of coils of wire called "winding"

Rotor: magnet rotates on bearings inside the stator

• Direct control of rotor position (no sensing needed)
• May oscillate around a desired orientation (resonance at low speeds)
• Low resolution

printers
computer drives

Increased Resolution


Half stepping

torque

angle
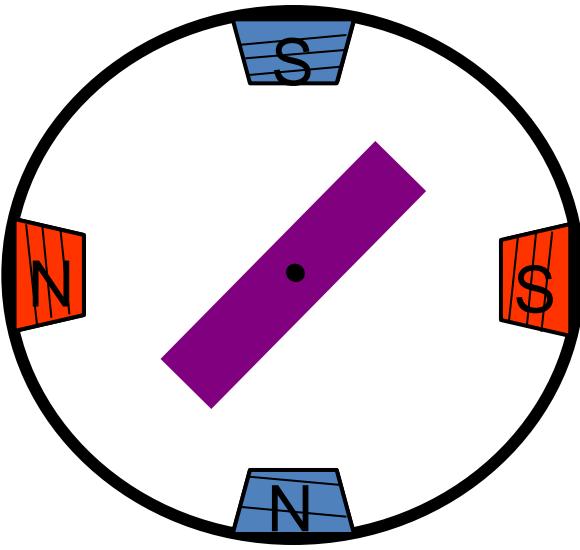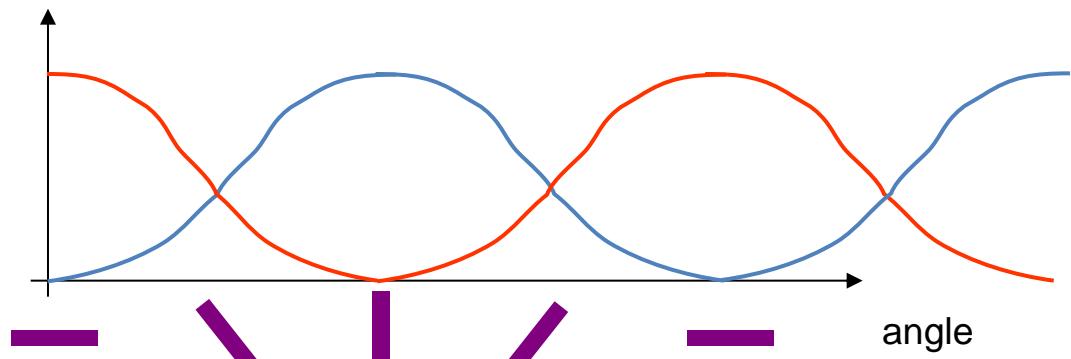
Increased Resolution
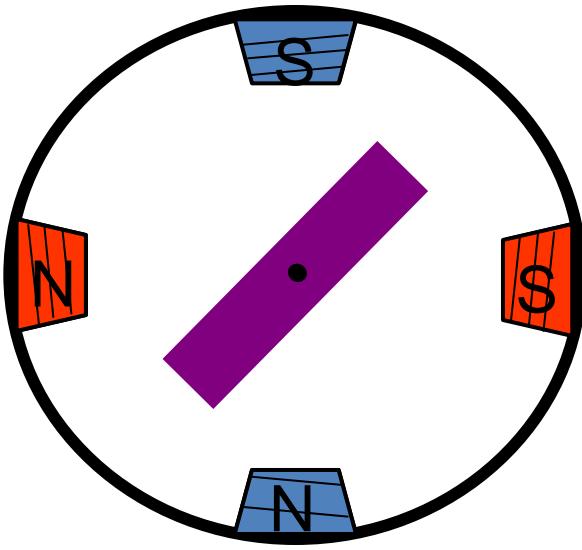
Half stepping

More teeth on rotor or stator
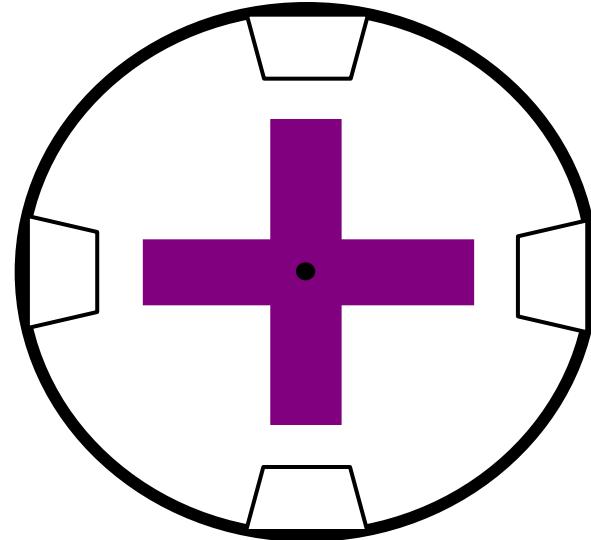
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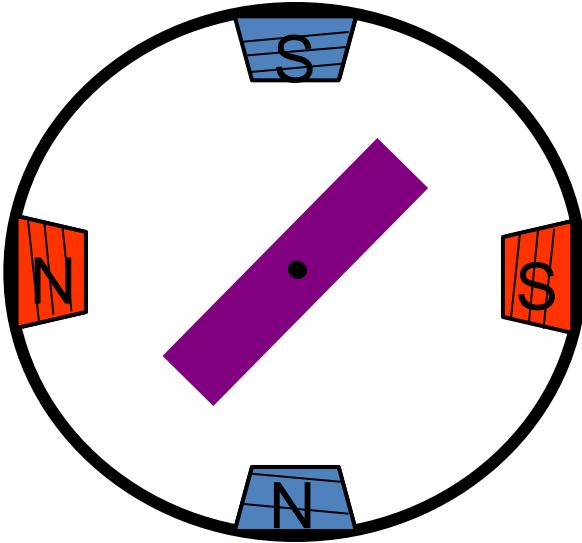
Half stepping

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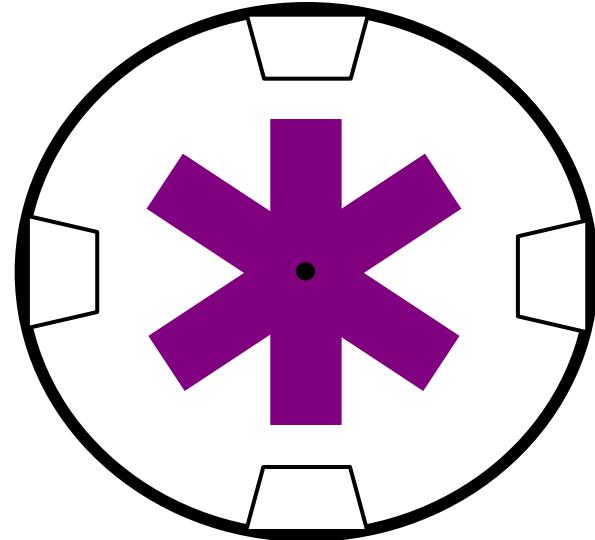
More Teeth on Rotor

Stepper Motors



The
Floppy - Bot
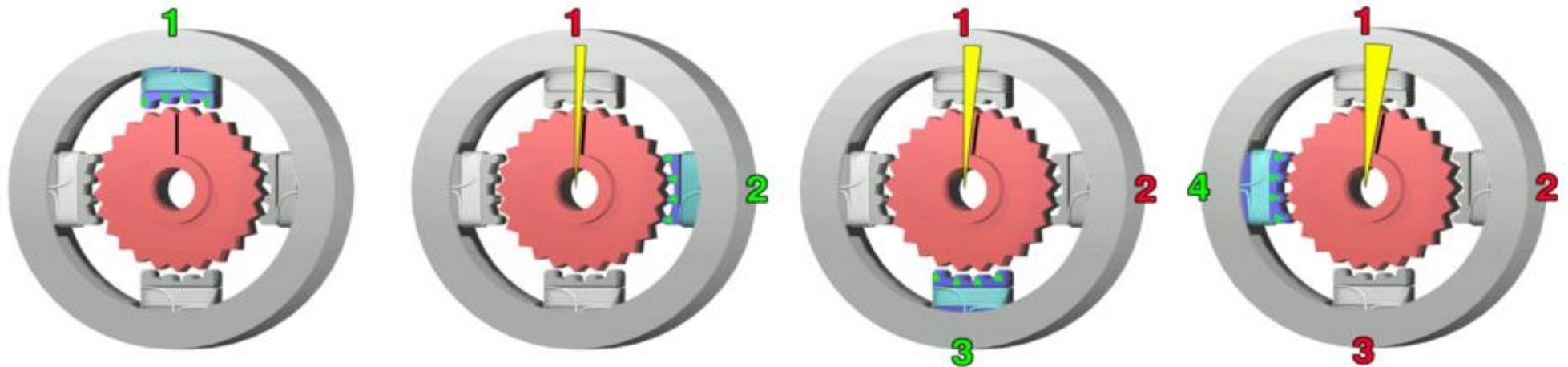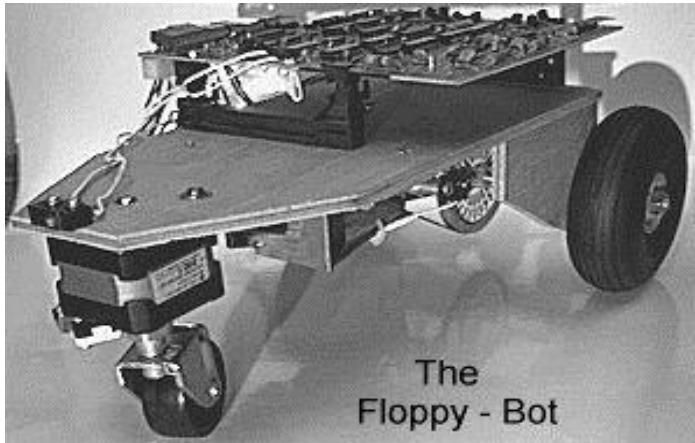
- Pros:
  - Direct position control
  - Precise positioning
  - Easy to control

- Cons:
  - Oscillations
  - Low torque at high speeds

DC motors -- exposed !
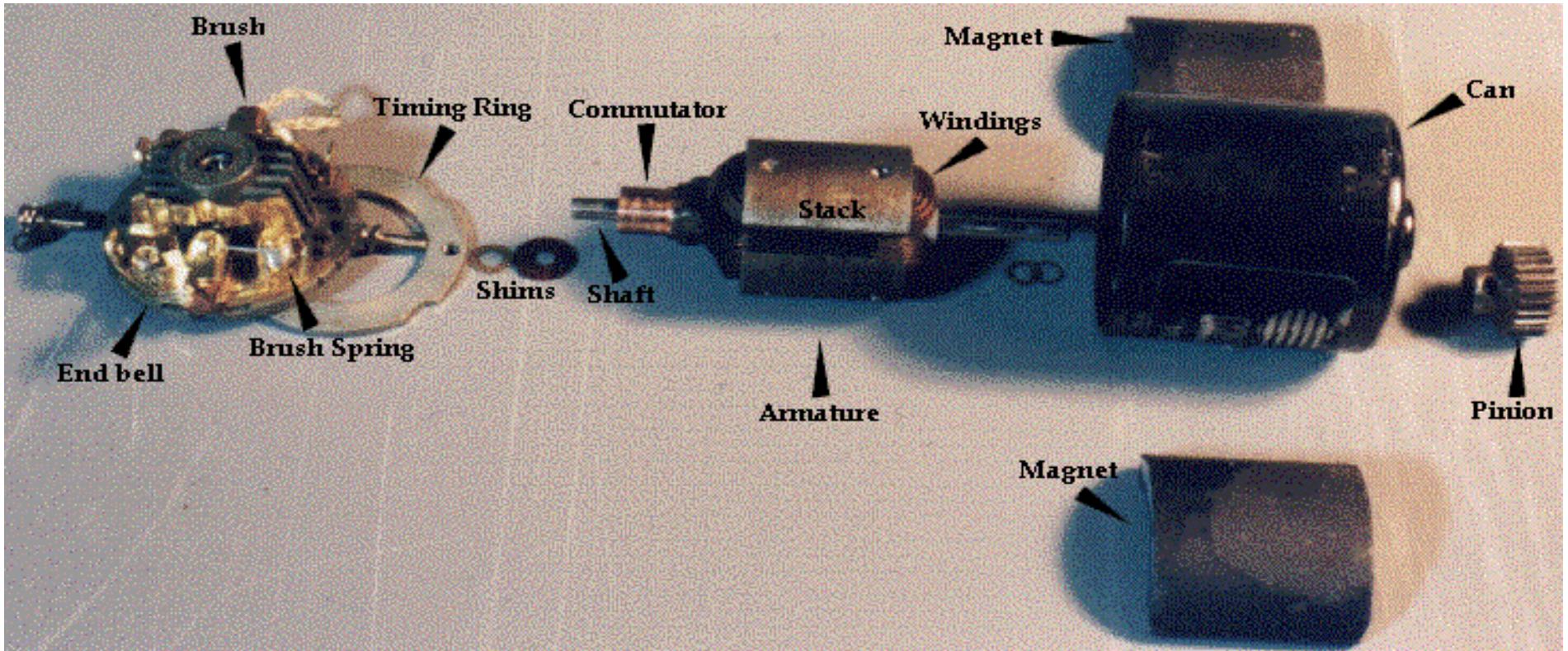
DC motor basics

permanent magnets

N

N   rotor   S

S

stator

brush

+

V

-

commutator
attached to
shaft

DC motor basics

permanent magnets

rotor

stator

N   N   S   S

N   S   N   S

+
V
-

+
V
-

DC motor basics

permanent magnets

rotor

stator
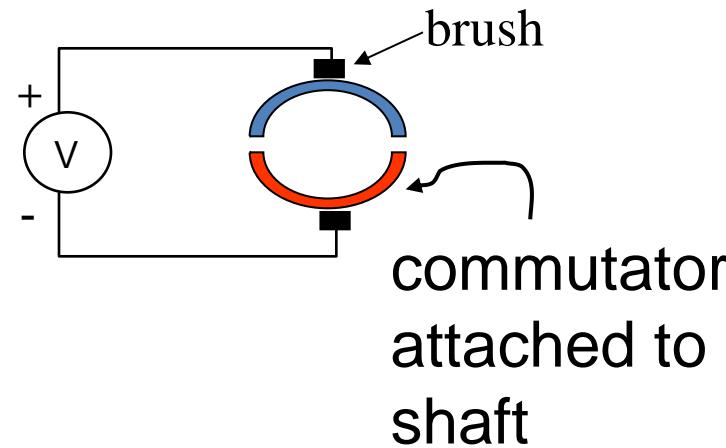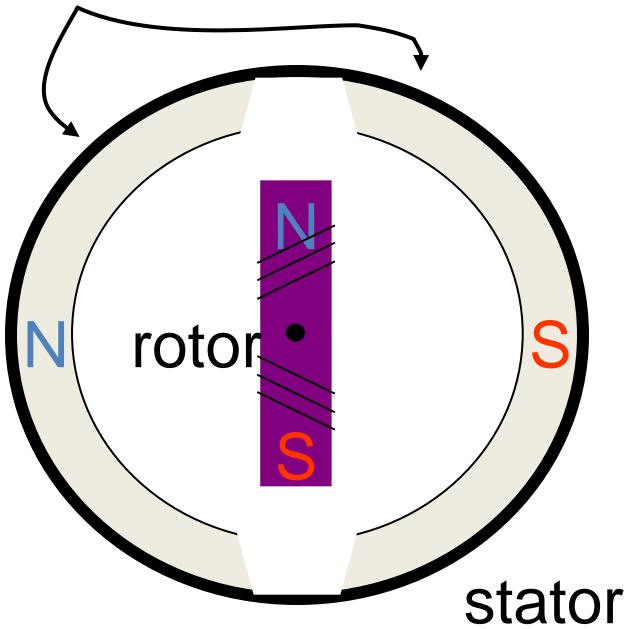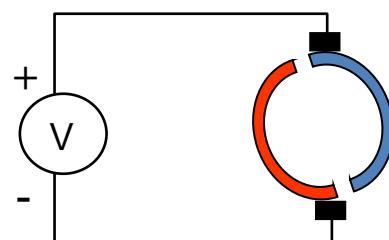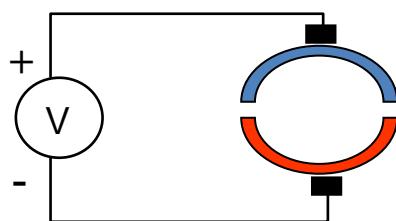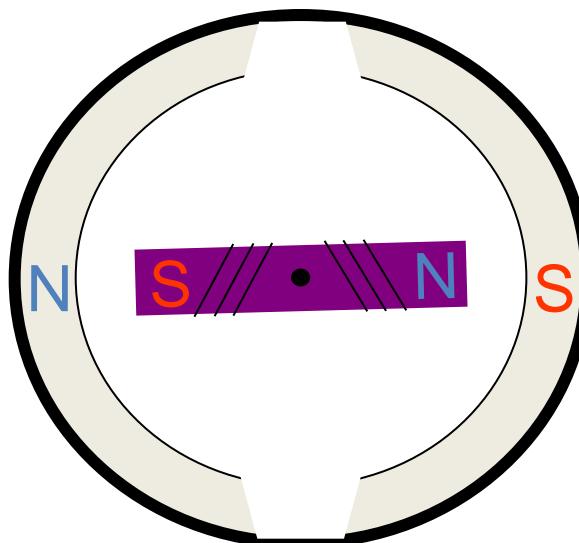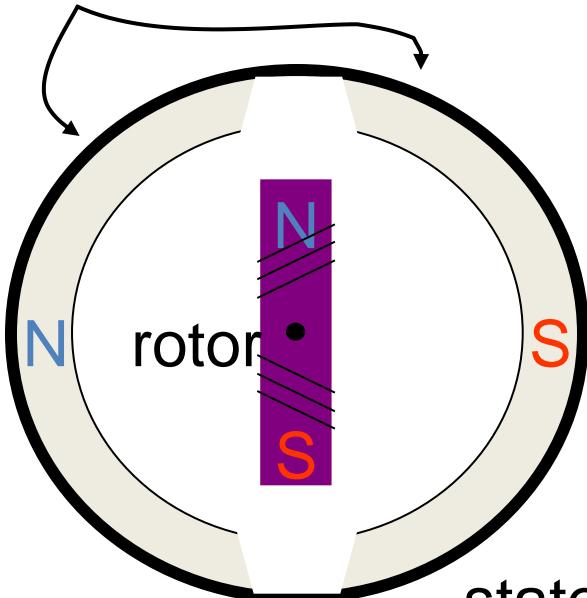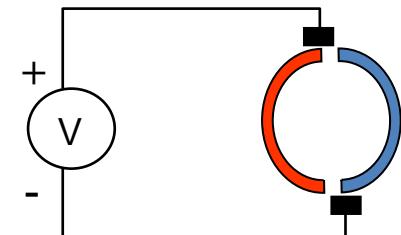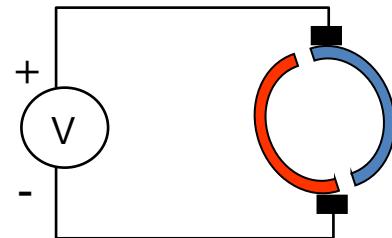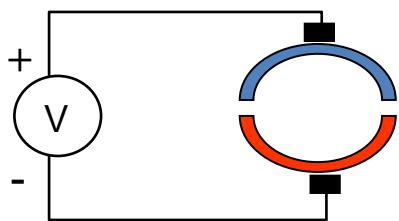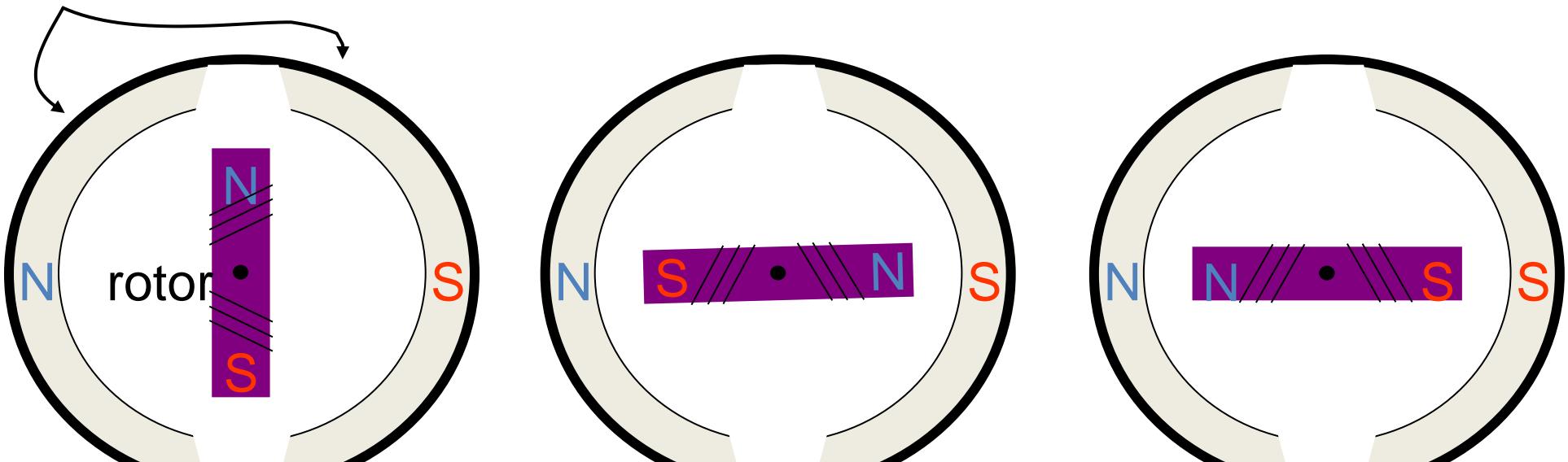
DC motor back-EMF

DC motor torque τ

$\tau = \text{torque}$

$I = \text{current}$

$$\tau \propto I$$

D.C. Motor Torque/Speed Curve

Stall torque, τ_s

No load speed, ω_n

Torque

Rotational Speed
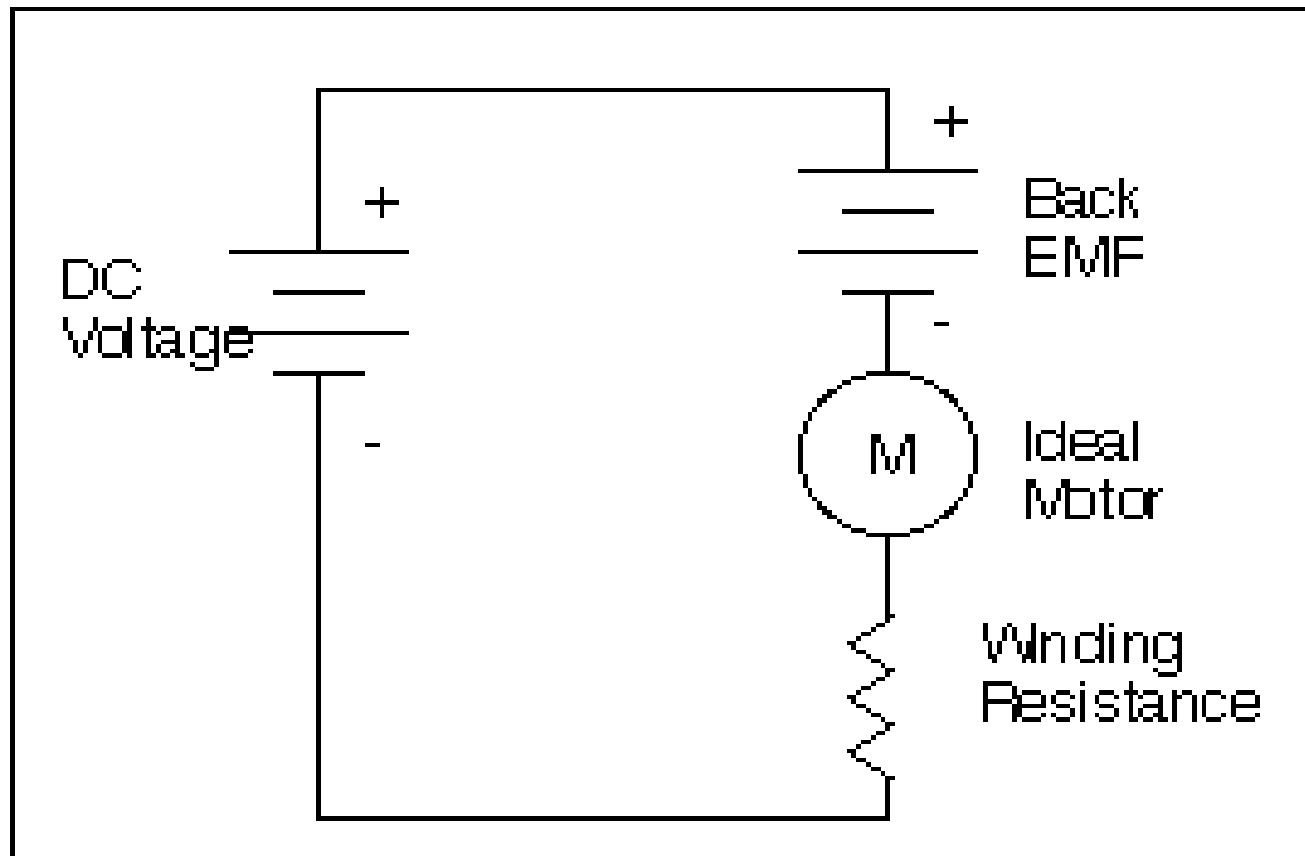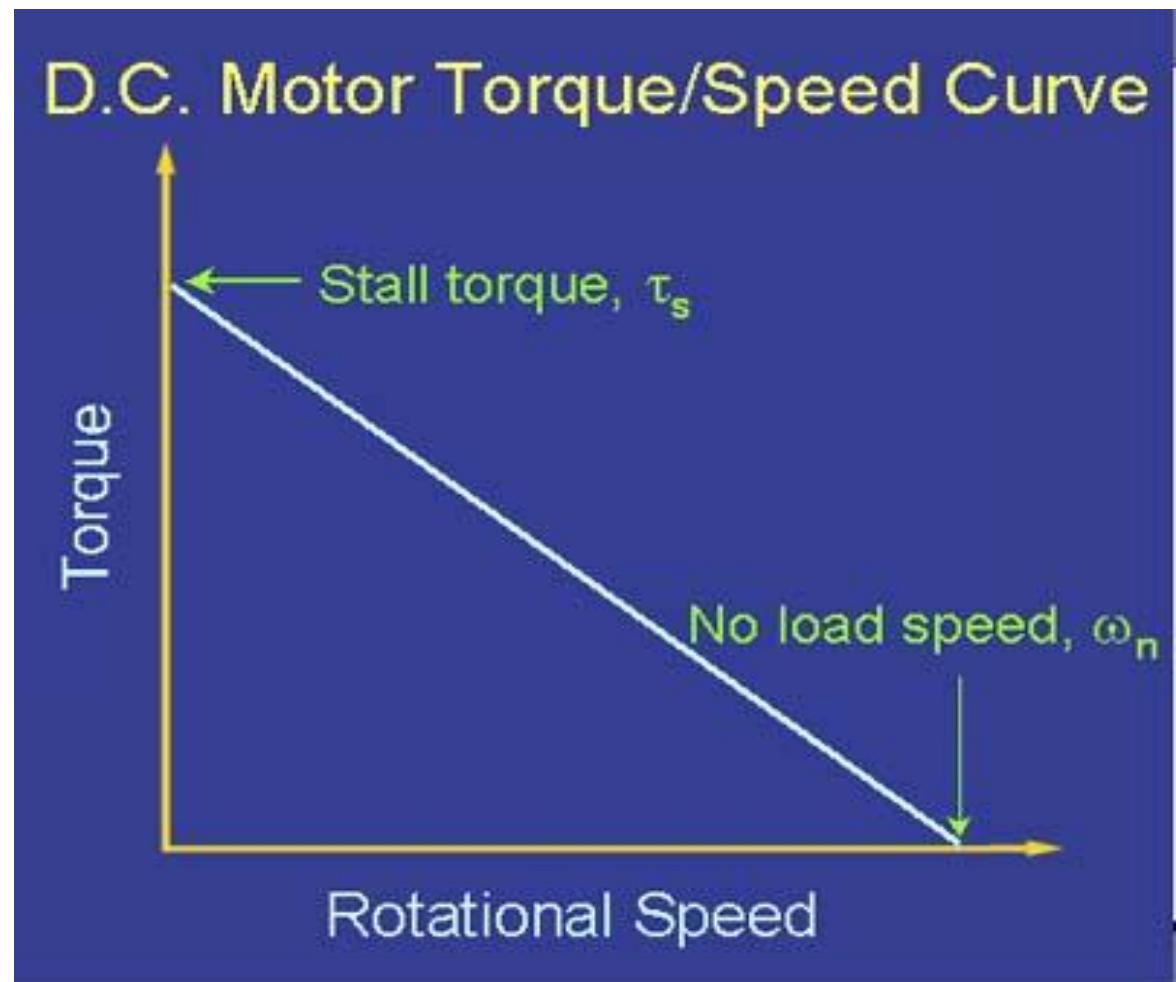
Commercial Electric Hobby "Servos"

- Same as ones found on your robot.
- Dirt cheap (~10$)
- Comes in two flavors:
  - "standard"
    - Position
  - Continuous
    - Rotation rate

Internals of "Hobby" Servo

Commercial Electric Hobby "Servos"

- Use PWM for commands: