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

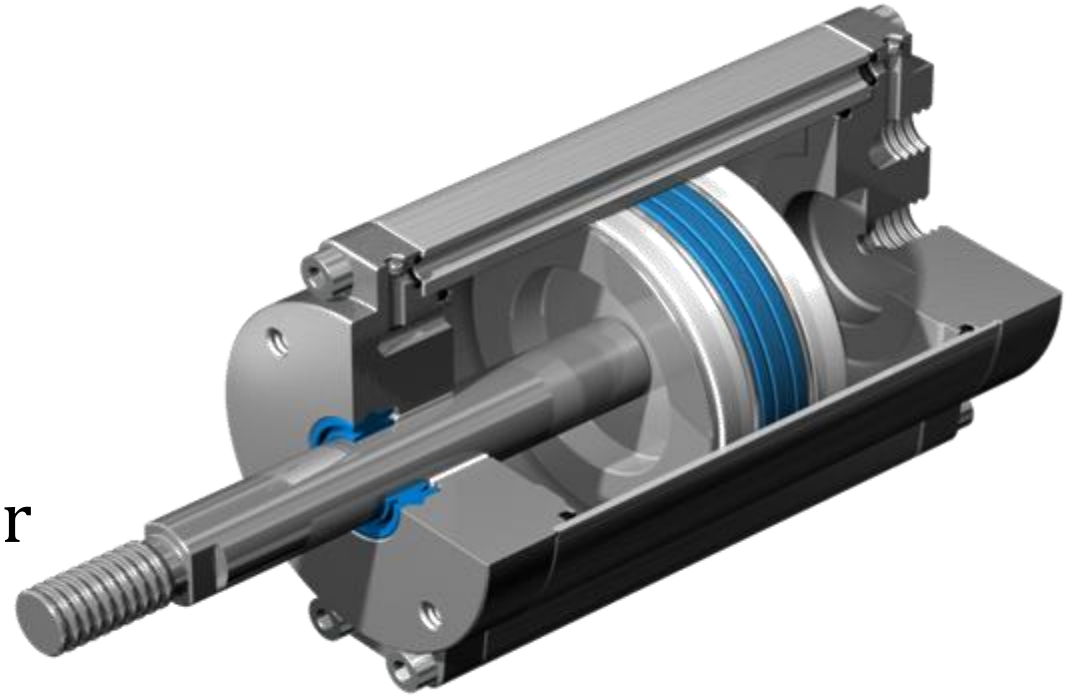
- Pros:
  - Powerful
  - Fast
  - Stiff
- Cons
  - Messy
  - Maintenance
  - External Pump

Hydraulic Actuator Application

- BigDog from Boston Dynamics

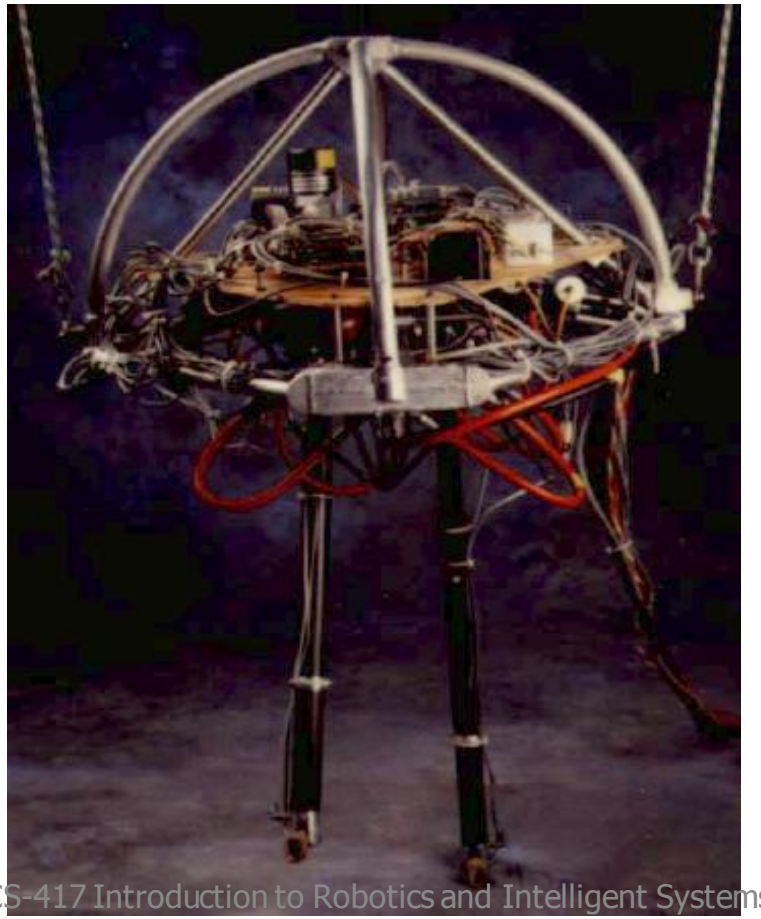
Pneumatic Actuators

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

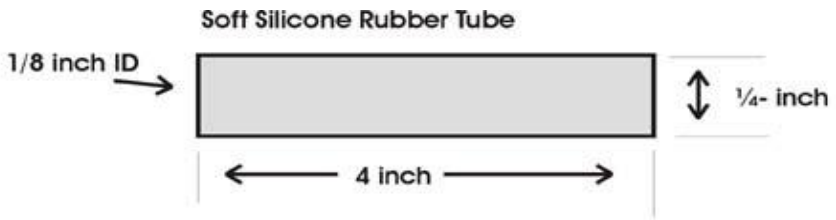


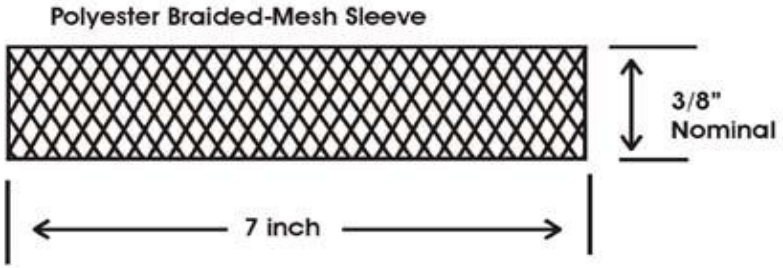
Pneumatic Actuators

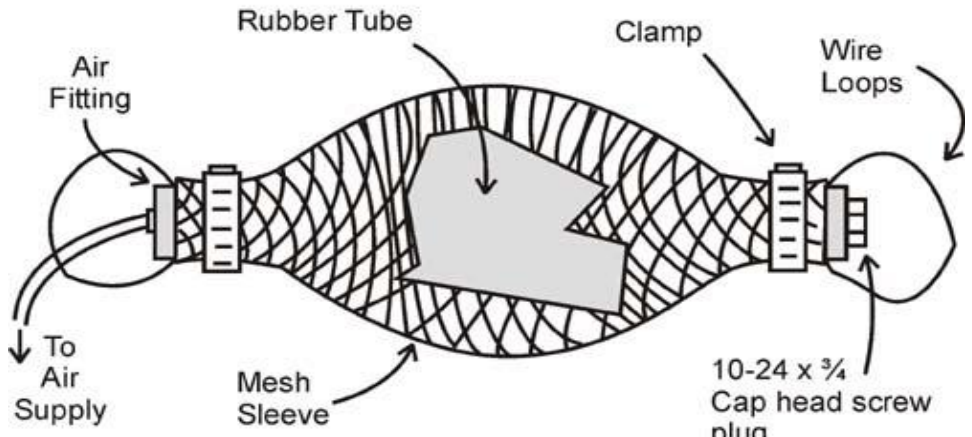
- 3D Biped (‘89-’95) from MIT Leg Lab



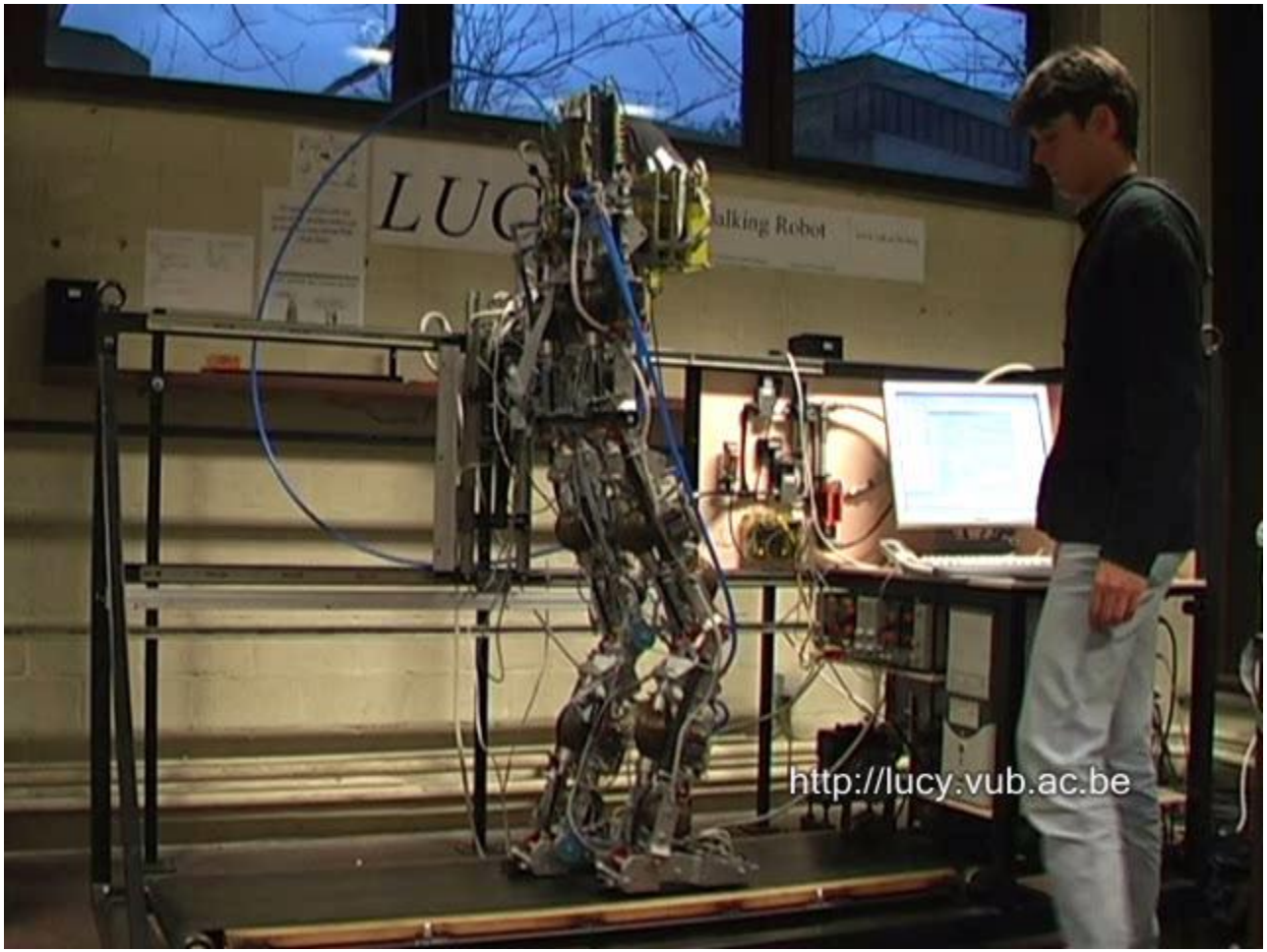
Air Muscle


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

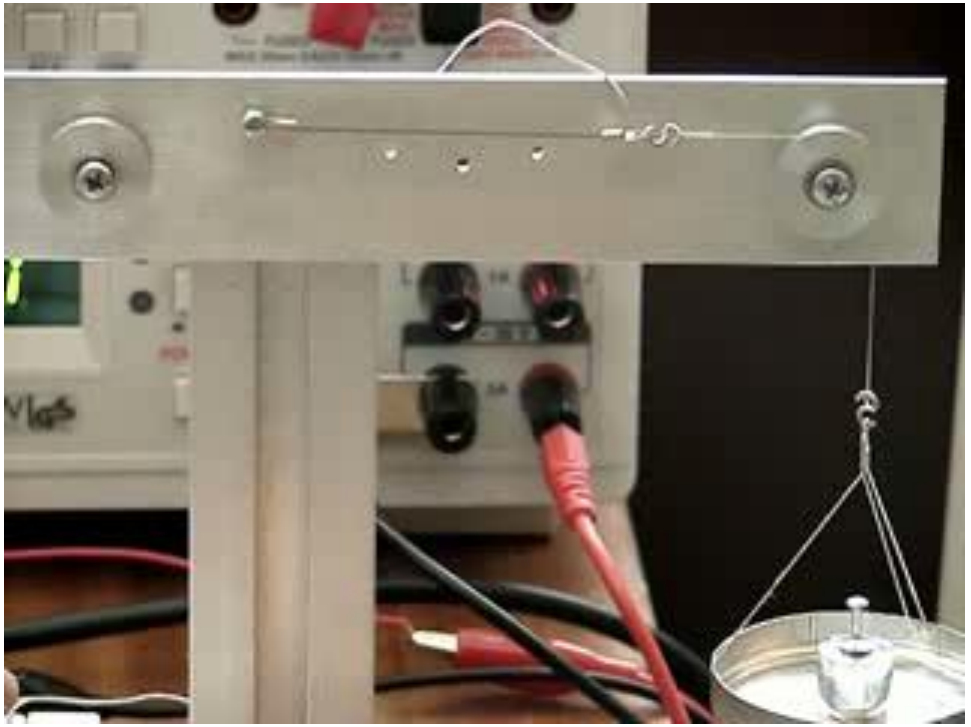


Air Muscle Application

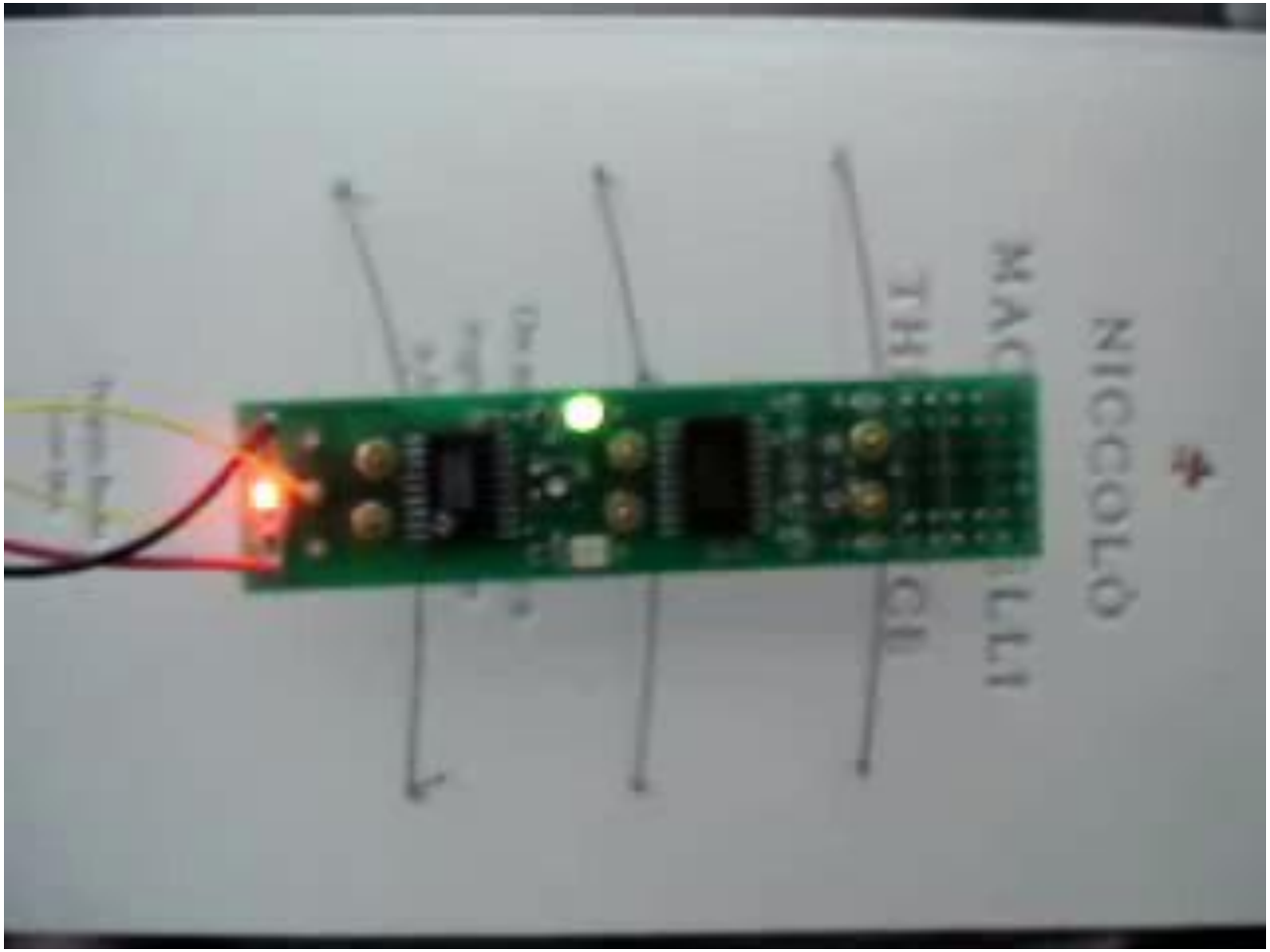
Shape Memory Alloy Actuators

- Works by warming and cooling Nitinol wires.

- Pros:
  - Light
  - Powerful
- Cons:
  - Slow (cooling)



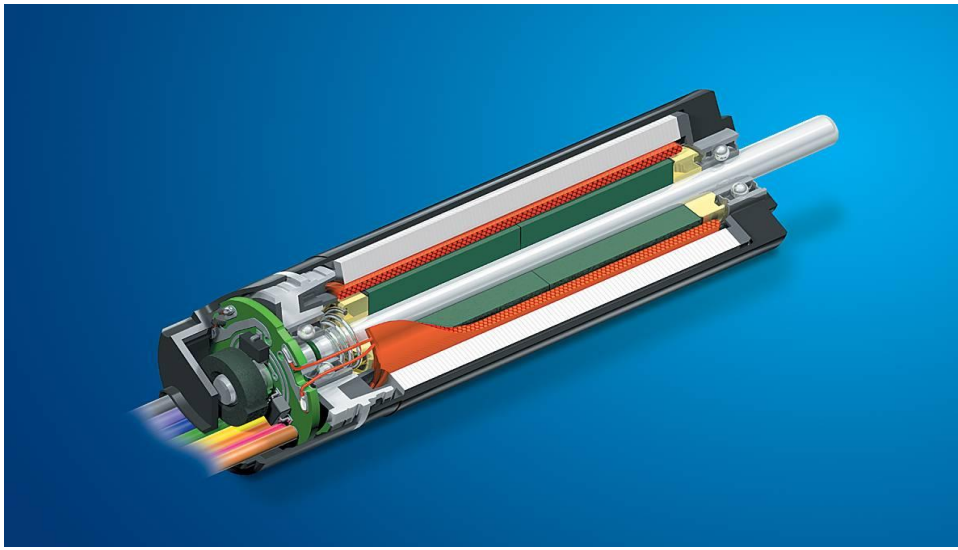
Stiquito



Jonathan Mills, Indiana University

Electric Actuators

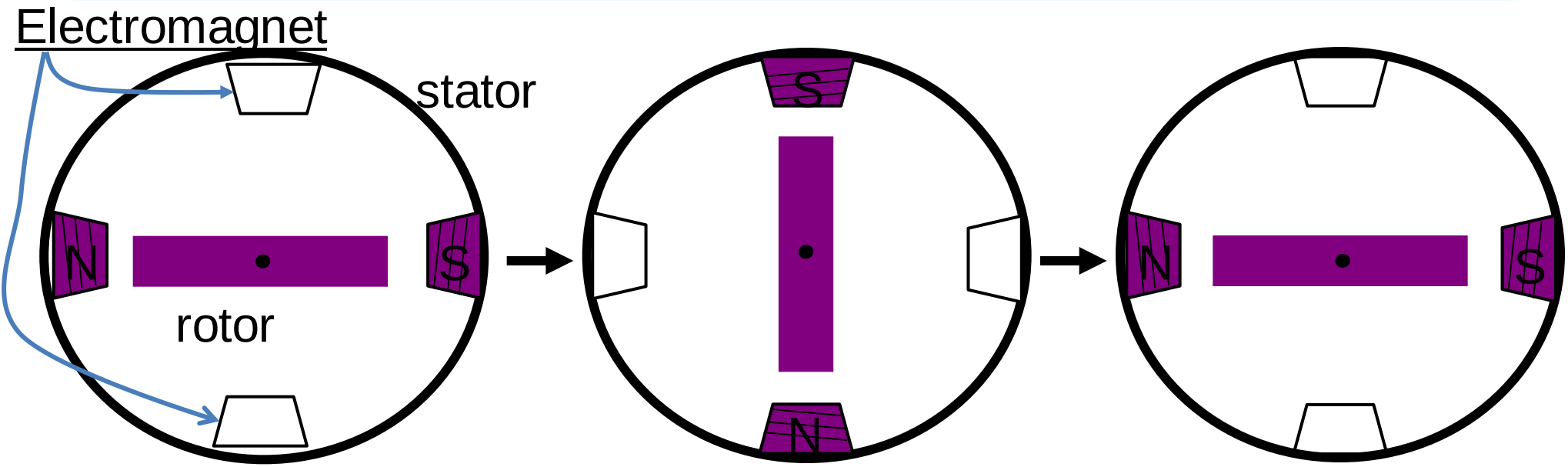
- Pros
  - Better position precision
  - Well understood
  - No separate power source
  - Cheap
- Cons
  - Heavy
  - Weaker/slower than hydraulics
  - Cooling issue



Electric Actuators

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

Stepper Motor Basics



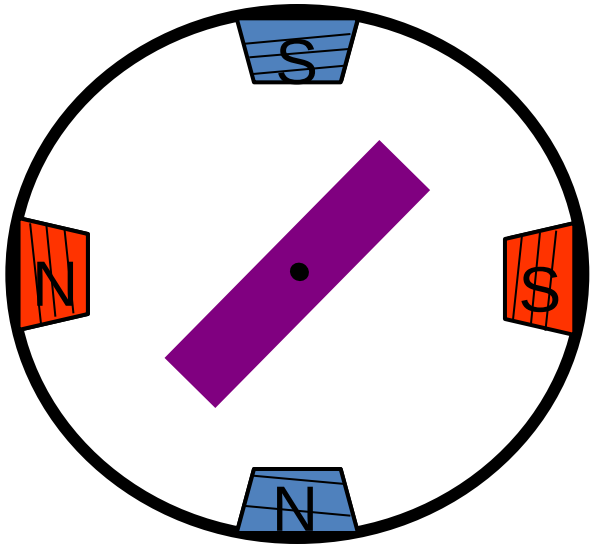
Stator: made out of coils of wire called "winding"

Rotor: magnet rotates on bearings inside the stator

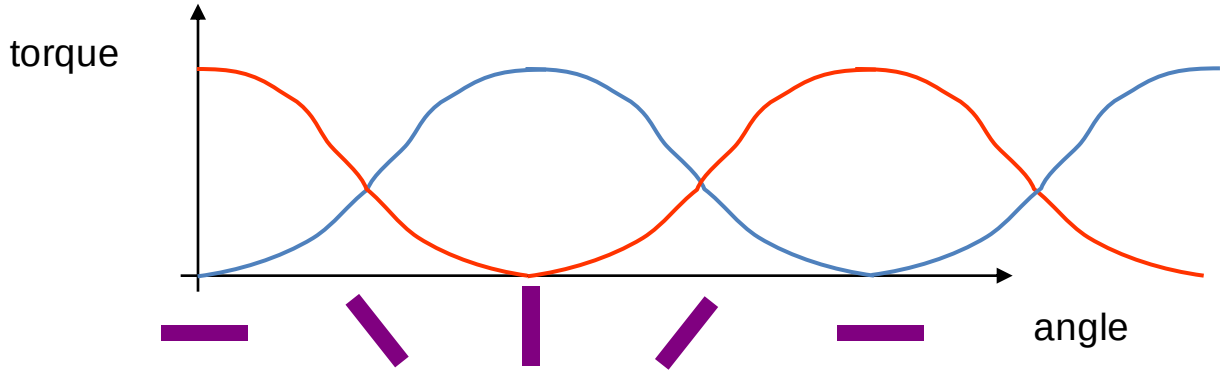
- Direct control of rotor position (no sensing needed)
- May oscillate around a desired orientation (resonance at low speeds)
- Low resolution

printers
computer drives

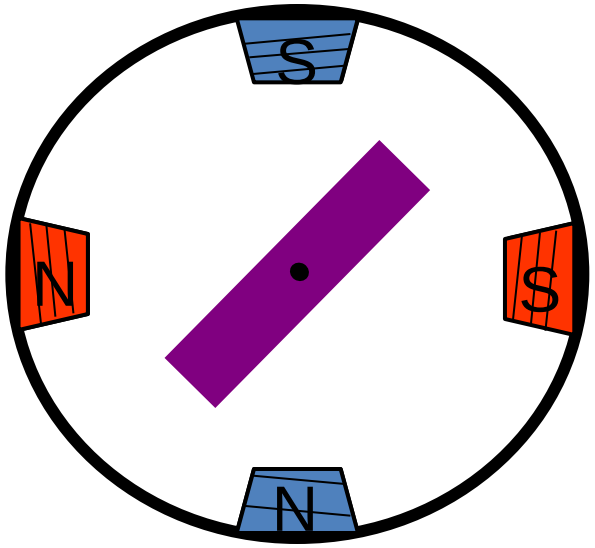
Increased Resolution



Half stepping

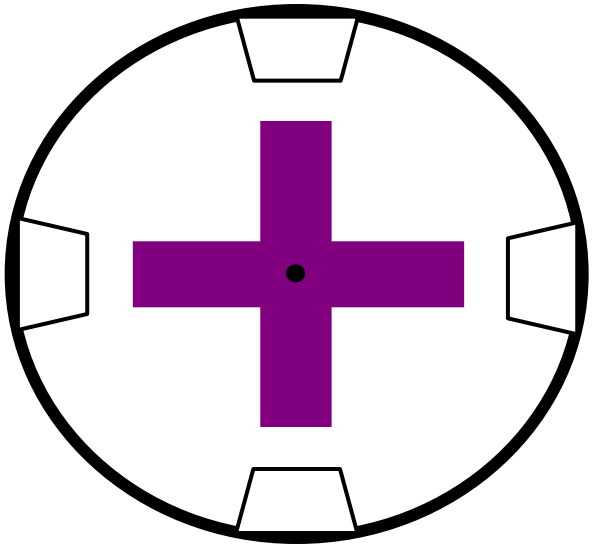


Increased Resolution

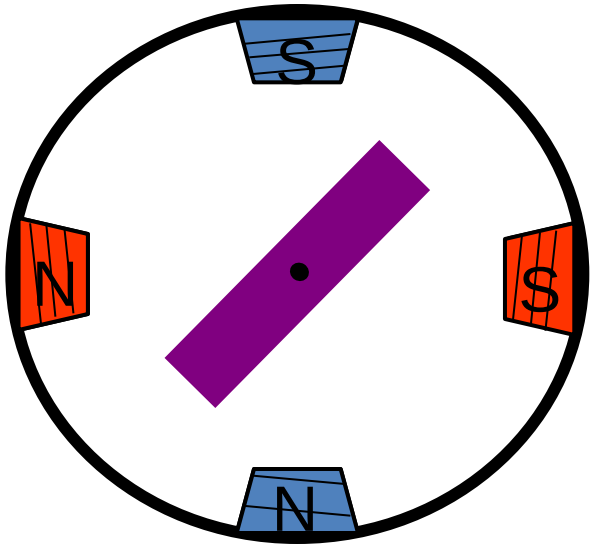


Half stepping

More teeth on rotor or stator

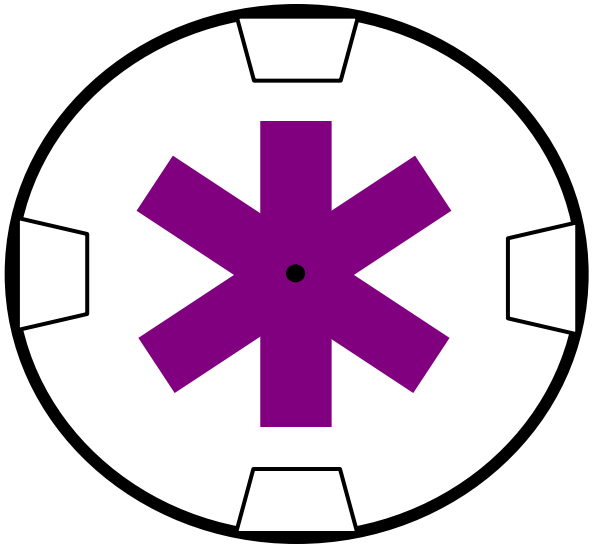


Increased Resolution

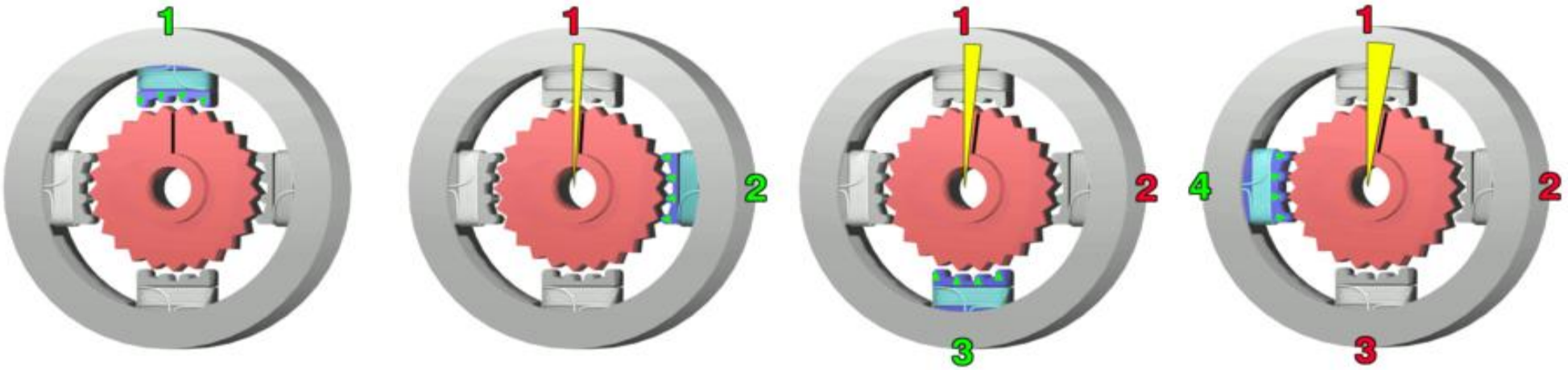


Half stepping

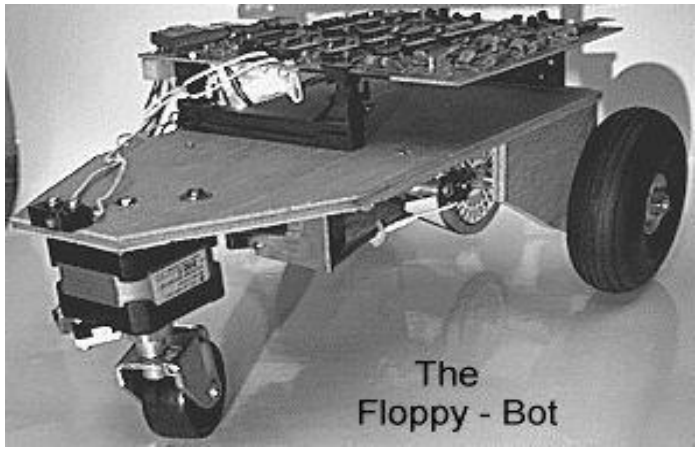
More teeth on rotor or stator



More Teeth on Rotor



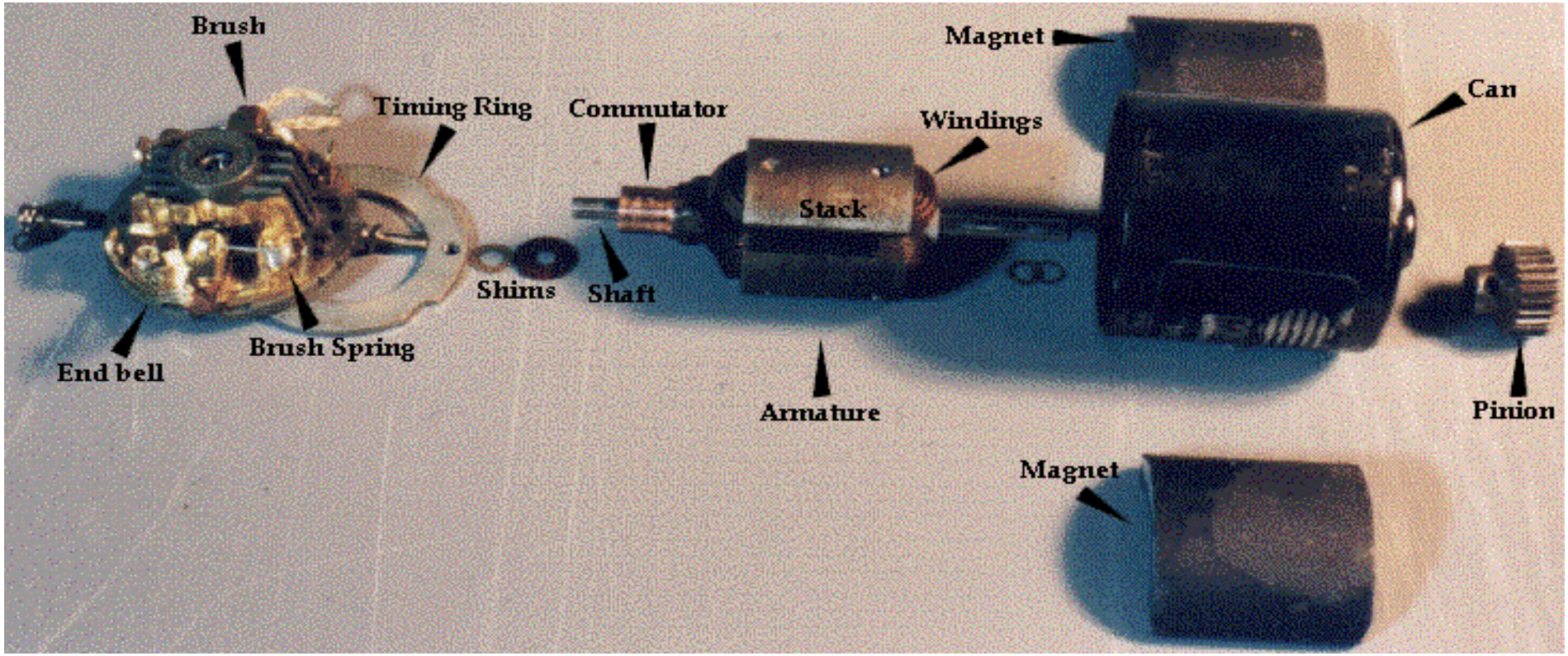
Stepper Motors



- Pros:
  - Direct position control
  - Precise positioning
  - Easy to control

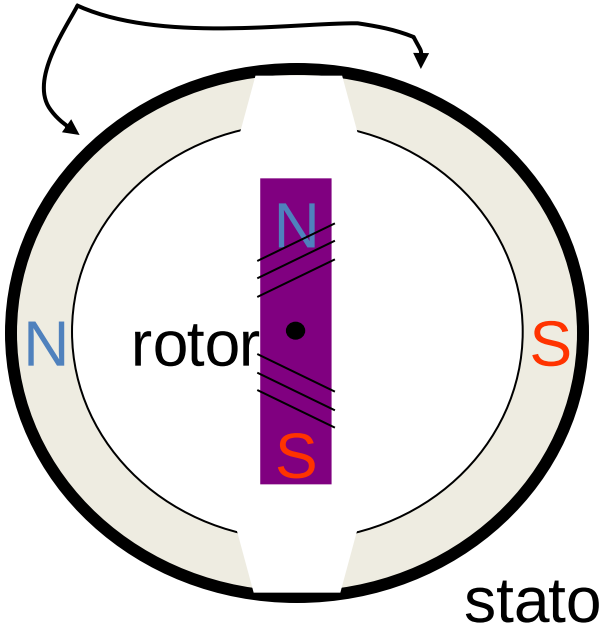
- Cons:
  - Oscillations
  - Low torque at high speeds

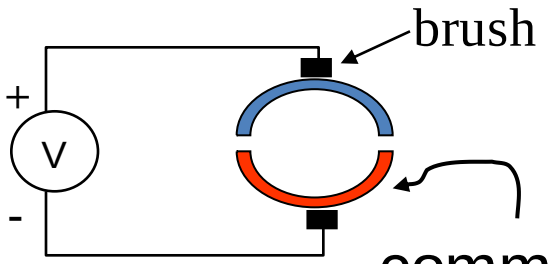
DC motors -- exposed !



DC motor basics

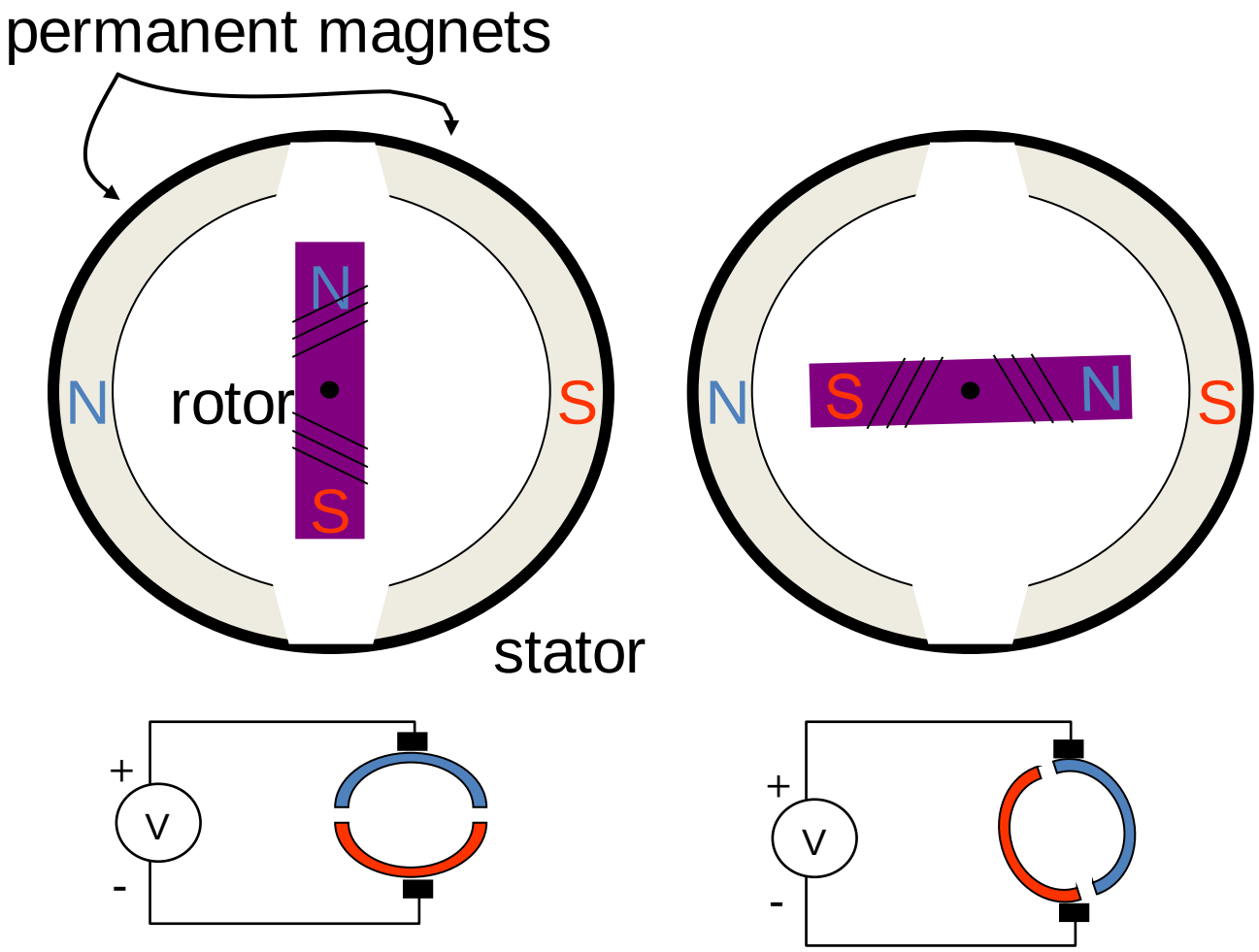
permanent magnets





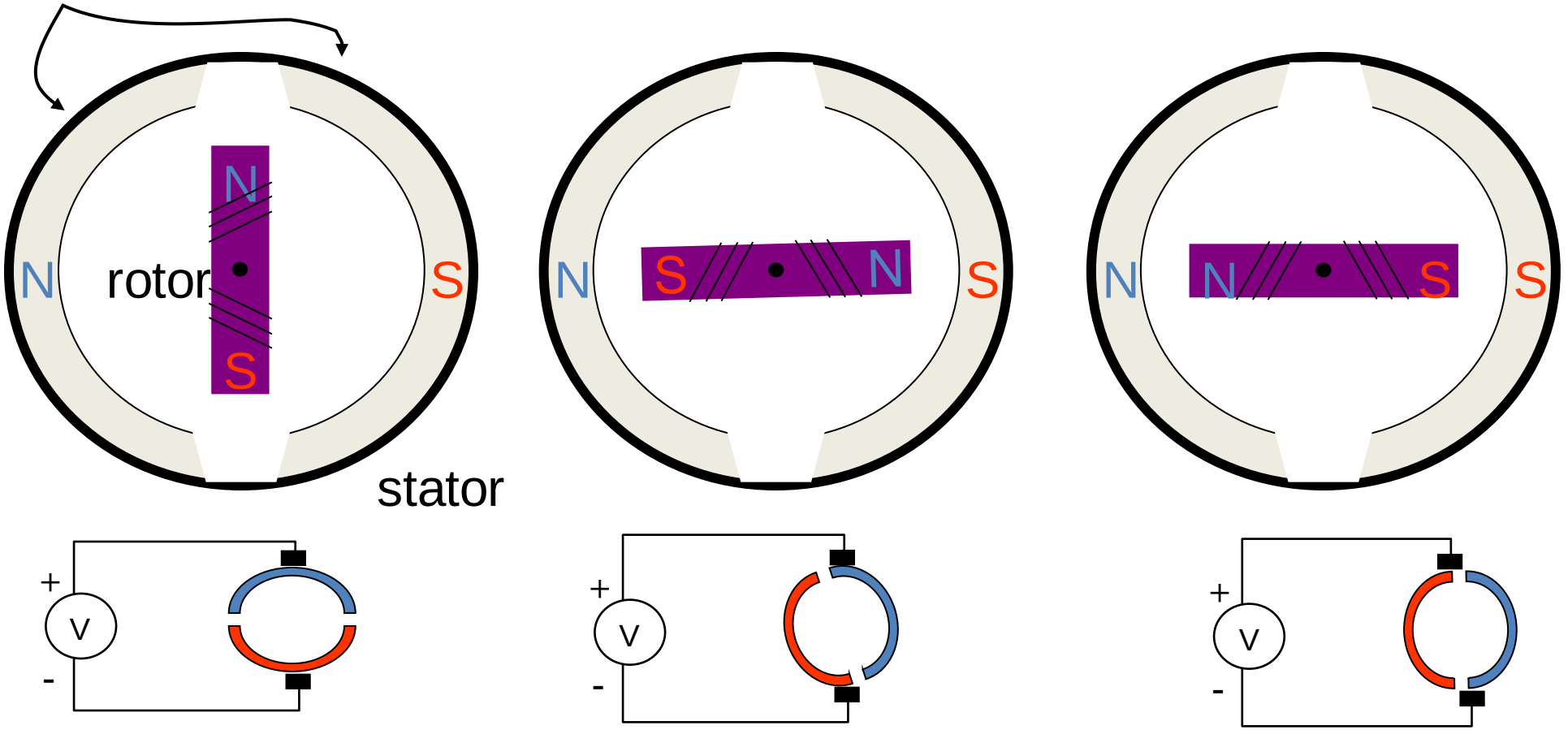
commutator attached to shaft

DC motor basics

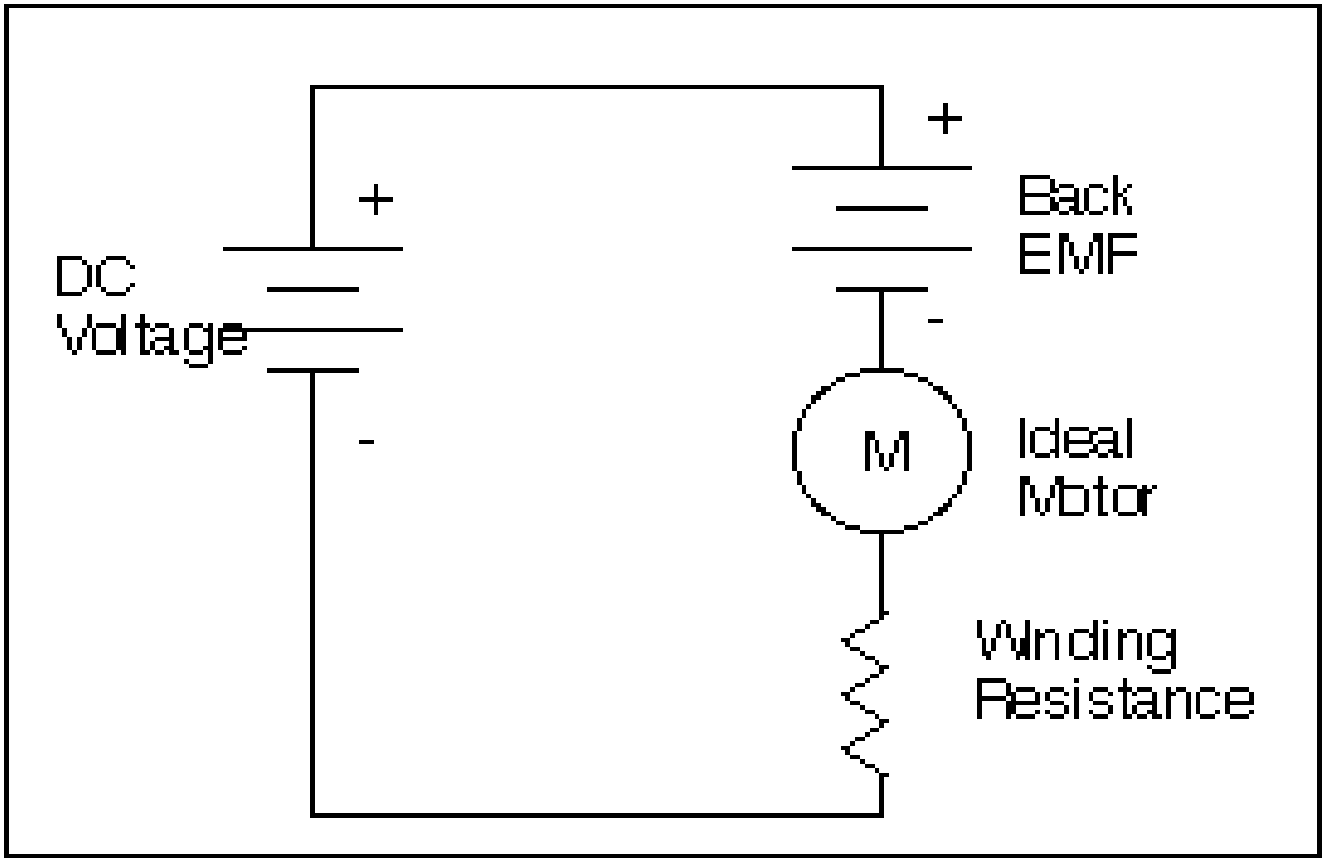


DC motor basics

permanent magnets



DC motor back-EMF

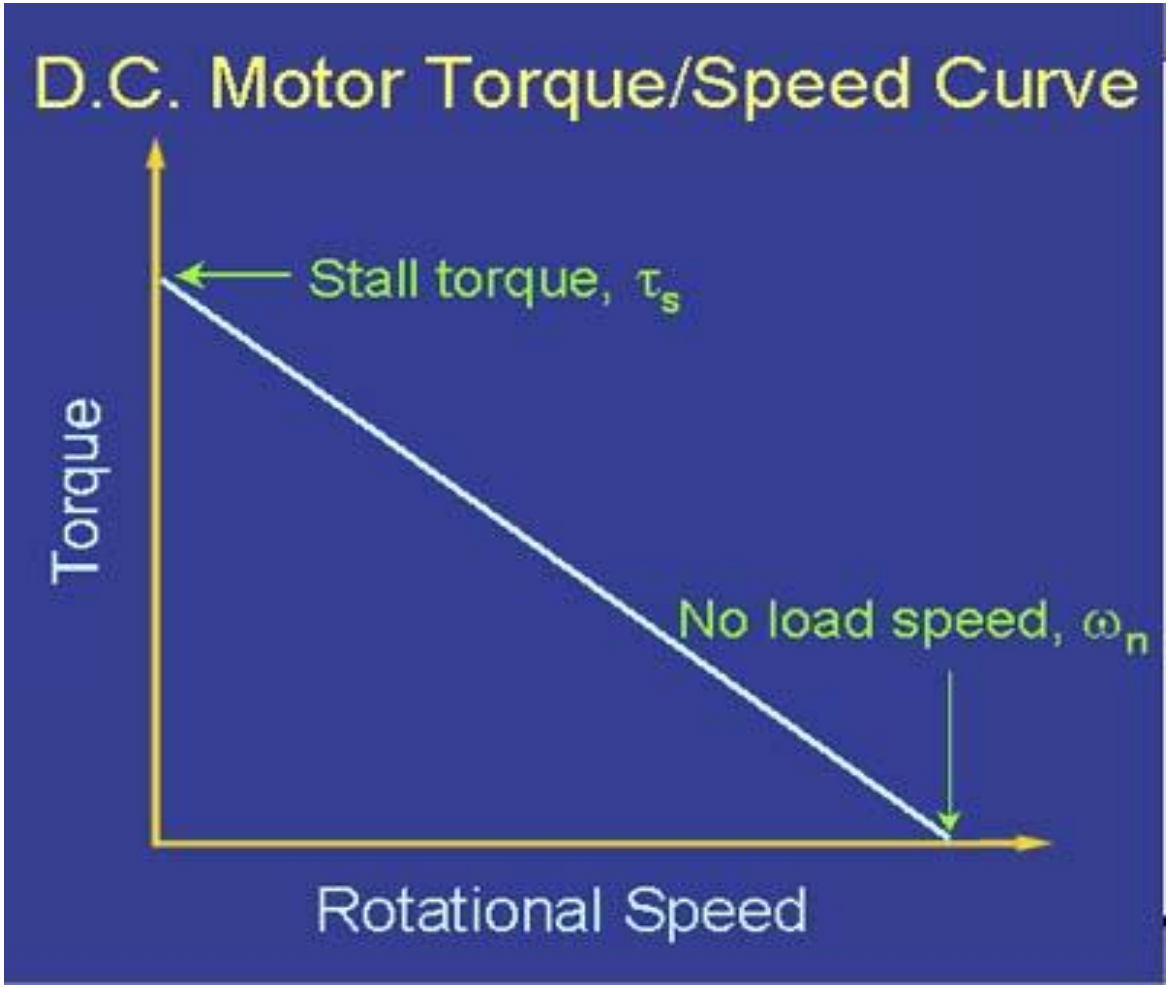


DC motor torque τ

$\tau = \text{torque}$

$I = \text{current}$

$$\tau \propto I$$



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: