ROCO222: Intro to sensors and actuators

Lecture 7

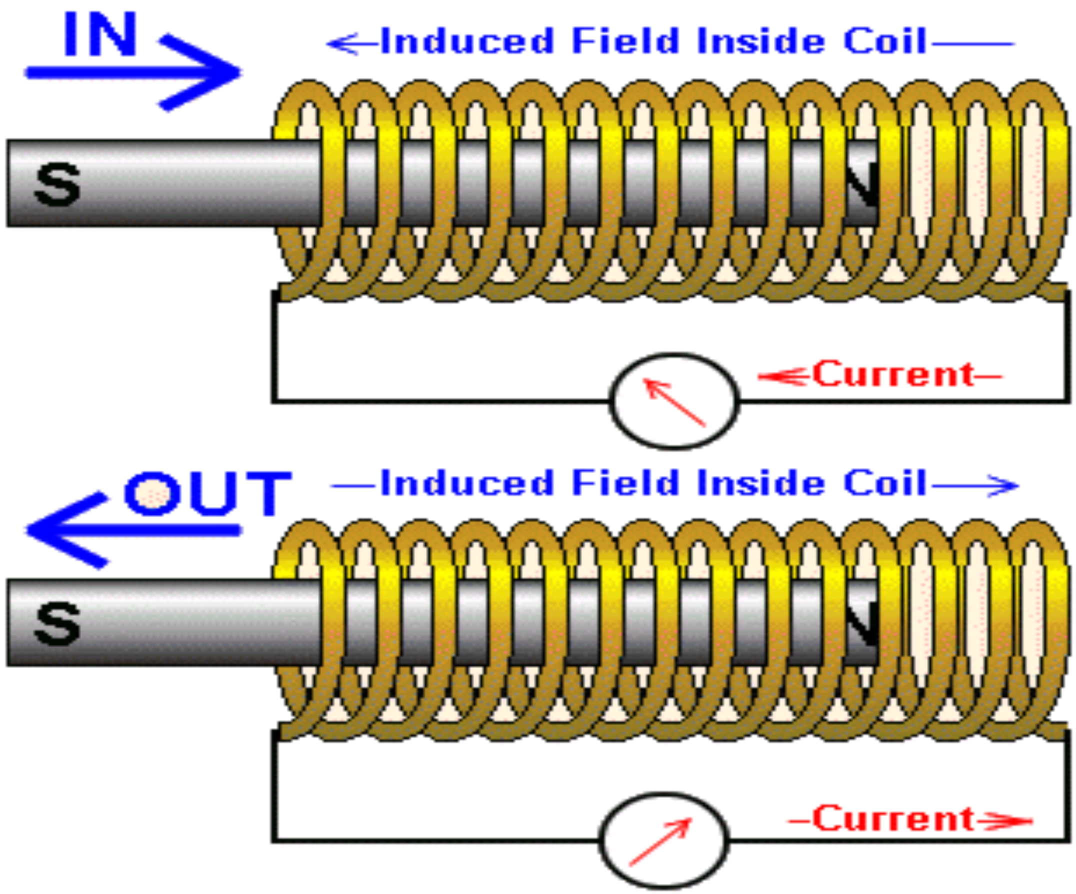
Further types of actuation

Types of Actuators

- Electrical actuators
  - Electric motors
  - DC servomotors
  - AC motors
  - Stepper motors
- Solenoids
- Artificial muscles
  - Shape memory alloys
  - Polymers
- Hydraulic actuators
  - Use hydraulic fluid to amplify the Controller command signal
- Pneumatic actuators
  - Use compressed air as the driving force

Electric linear actuators

Electromagnetic solenoid actuator

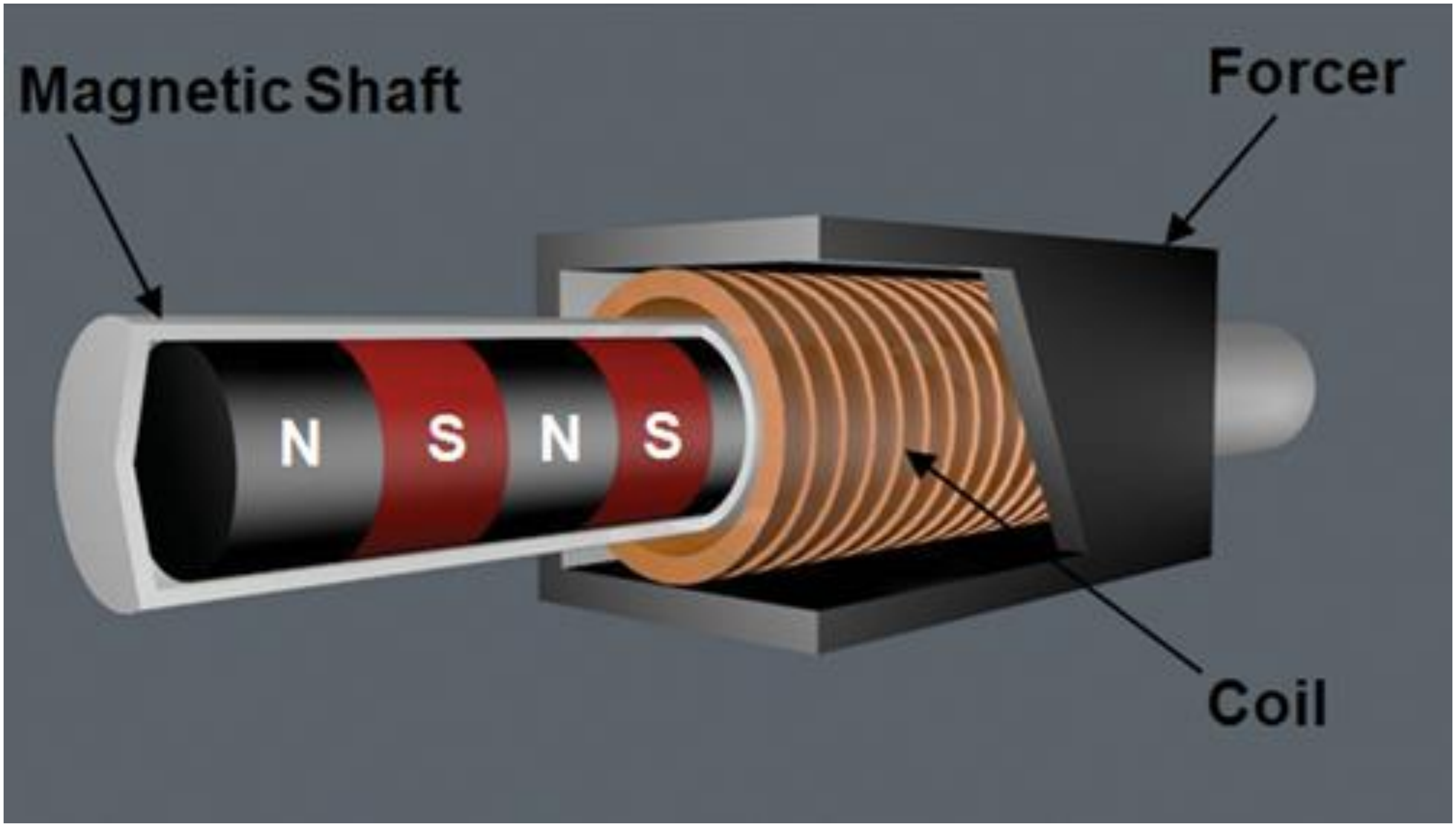


It moves a rod by electromagnetic energy

Electromagnetic solenoid actuator

- Commercially available
- Used a lot to operate valves

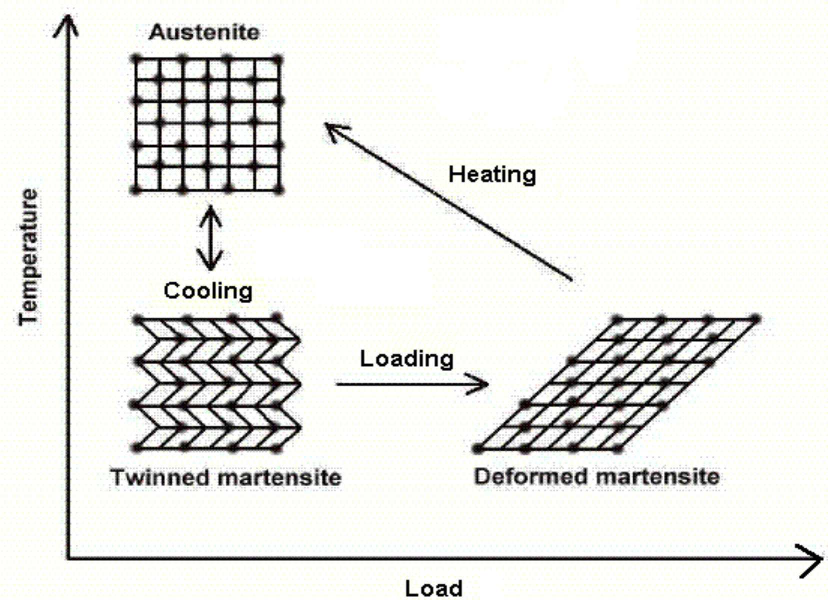
Permanent magnet linear motor



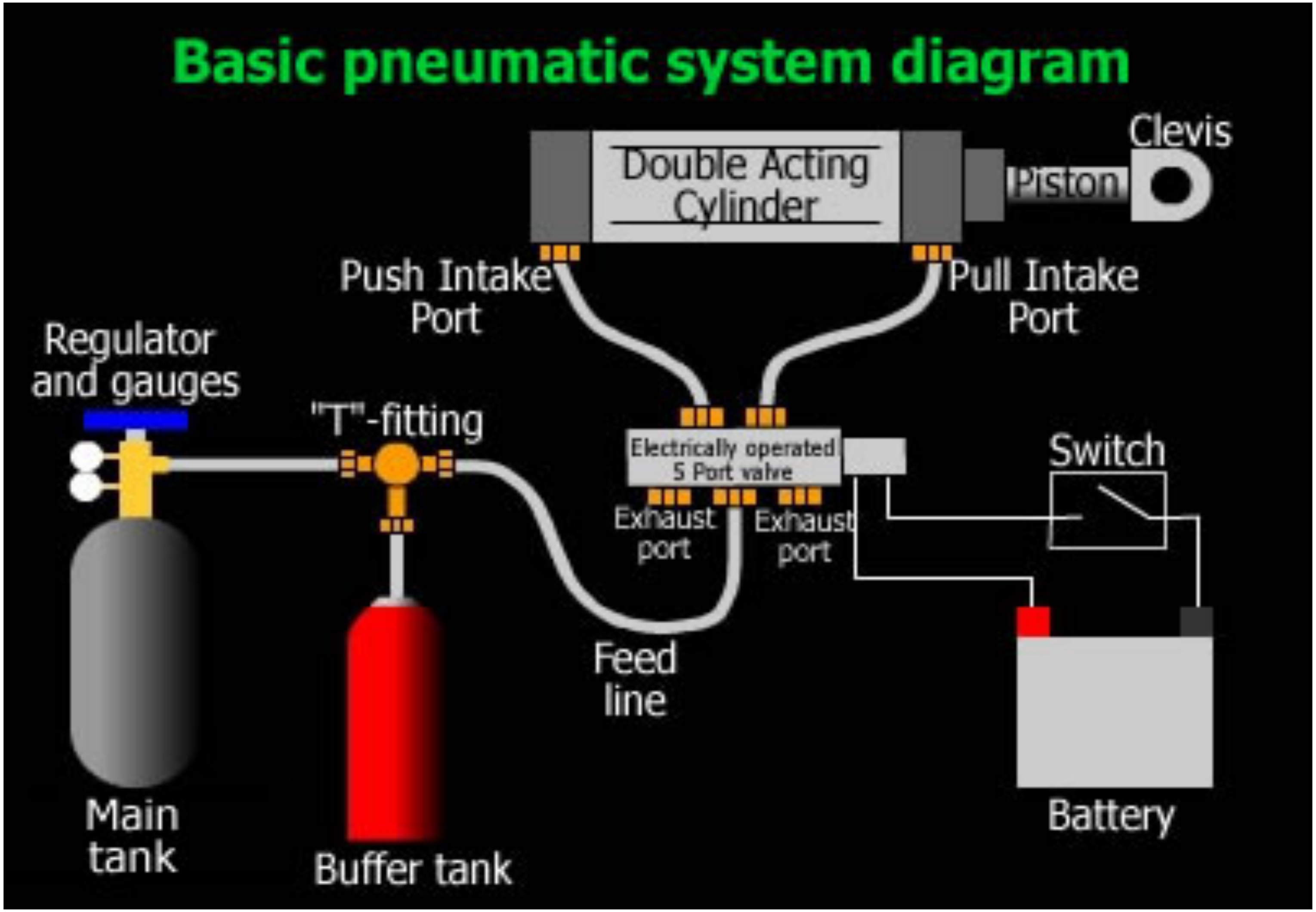
Shape memory alloys

- Used for artificial muscles
- Nickel Titanium – Nitinol
- Crystallographic phase transformation from Martesite to Austenite
- About 1 Hz operation

- Shape memory alloys (SMAs) have unusual mechanical properties
- Typically, they contract when heated, which is the opposite to what standard metals do when heated (expand)
- Furthermore, they produce thermal movement (contraction) one hundred times greater than that produced by standard metals
- Contract (when heated) 5-7% of length 100 times greater effect than thermal expansion
- two major problems :
- They cannot generate very large forces
- They cool slowly and so recover their original length slowly, thus reducing the frequency response of any artificial muscle in which they are employed



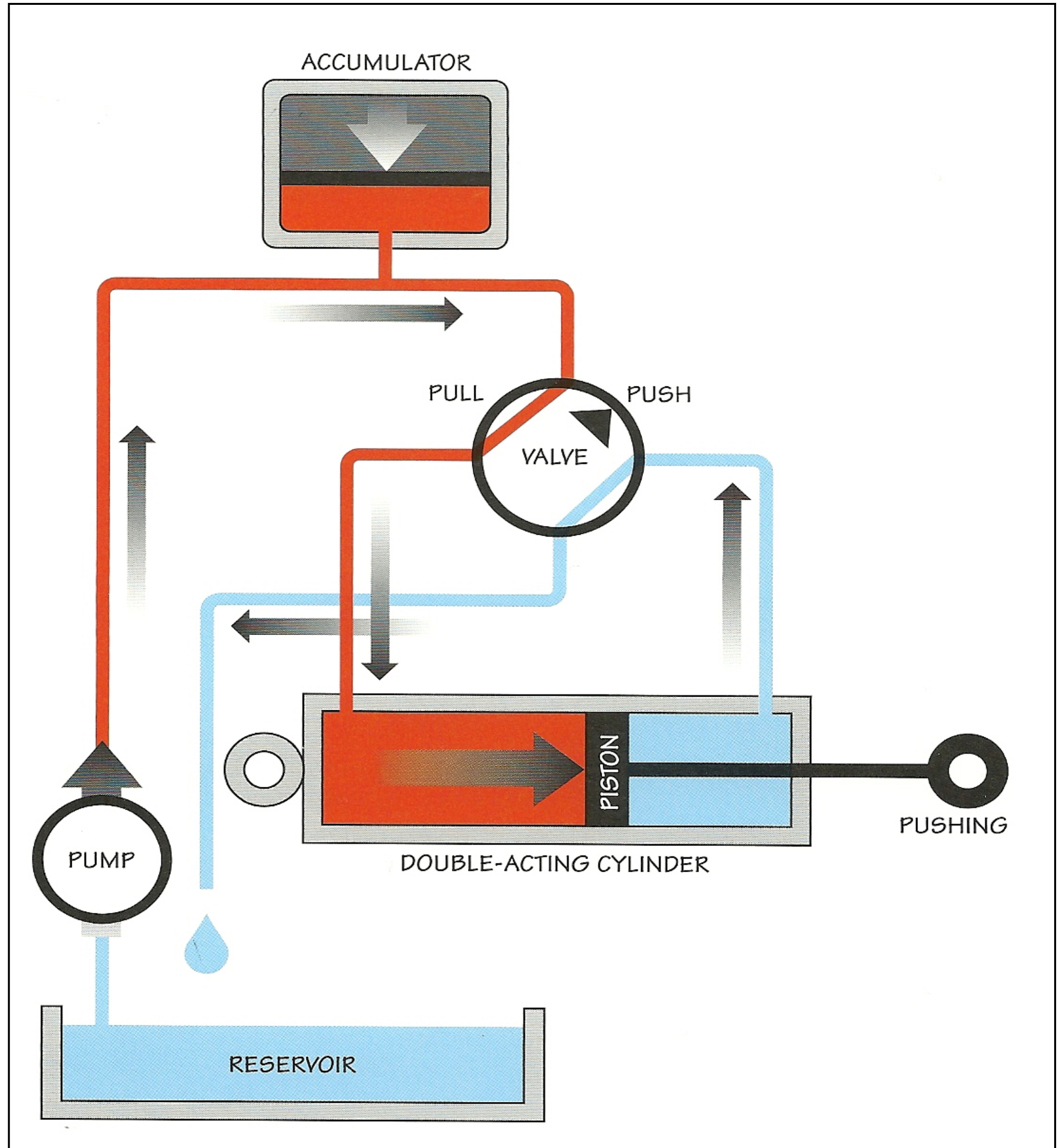
Pneumatic



When we use a gas as the fluid, we call it a pneumatics system

Hydraulic

When we use liquid as the fluid, we call it a hydraulics system



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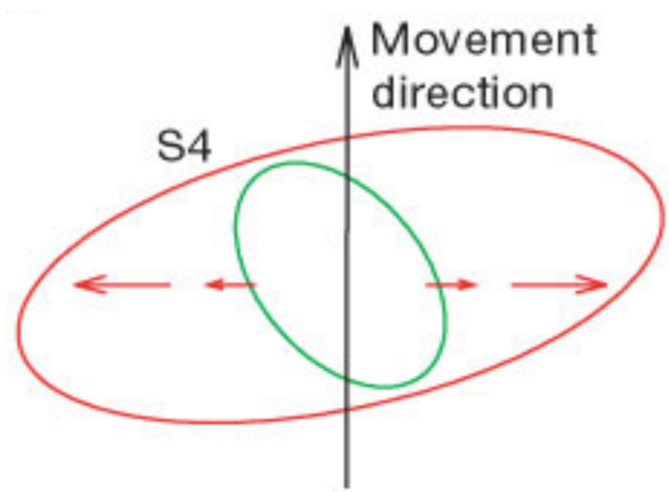
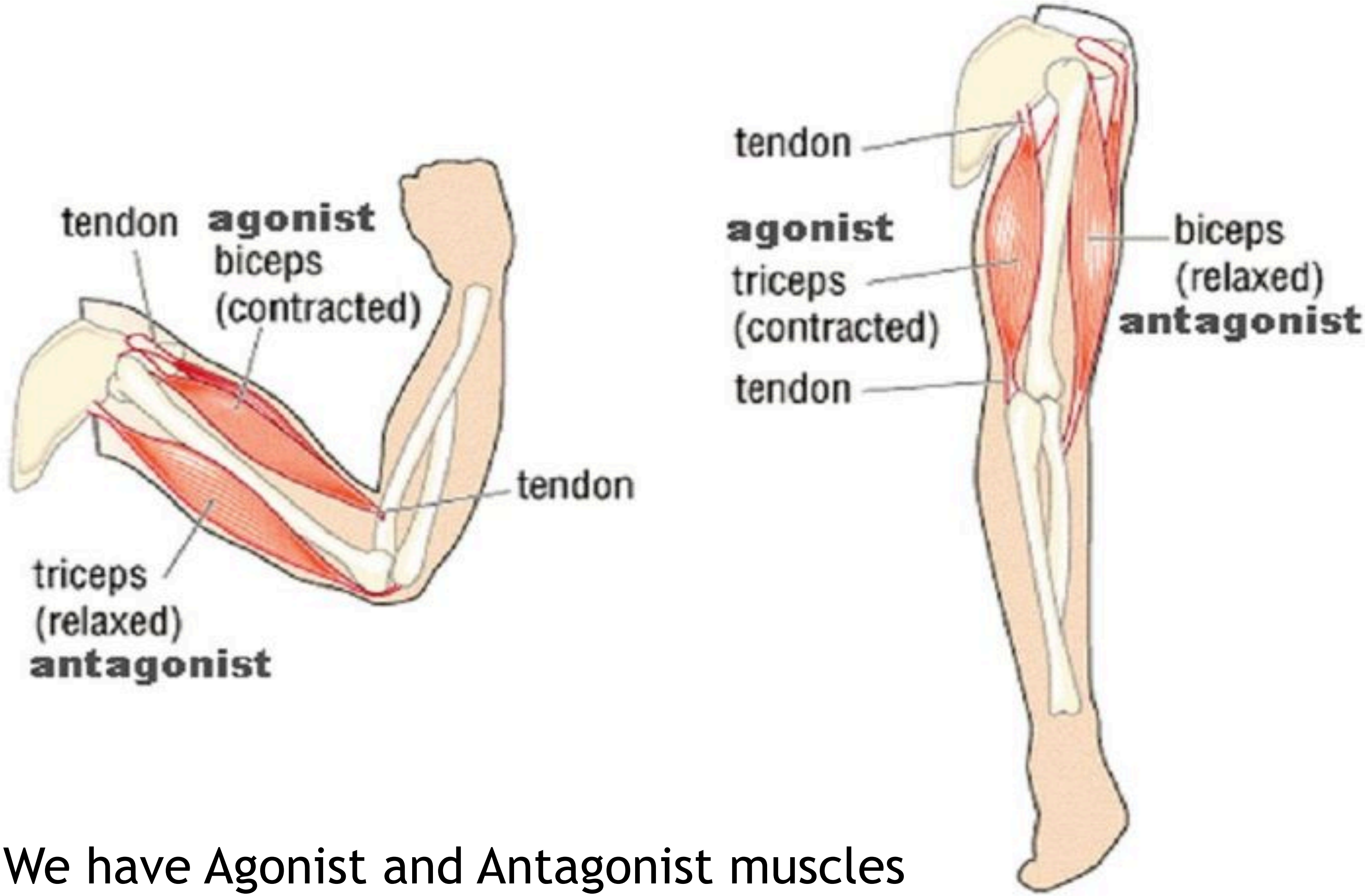
Soft actuation

Human impedance control

- Change impedance to deal with unstable tasks
  - Need to stiffen up to prevent tip slipping
    - Use muscle co-contraction

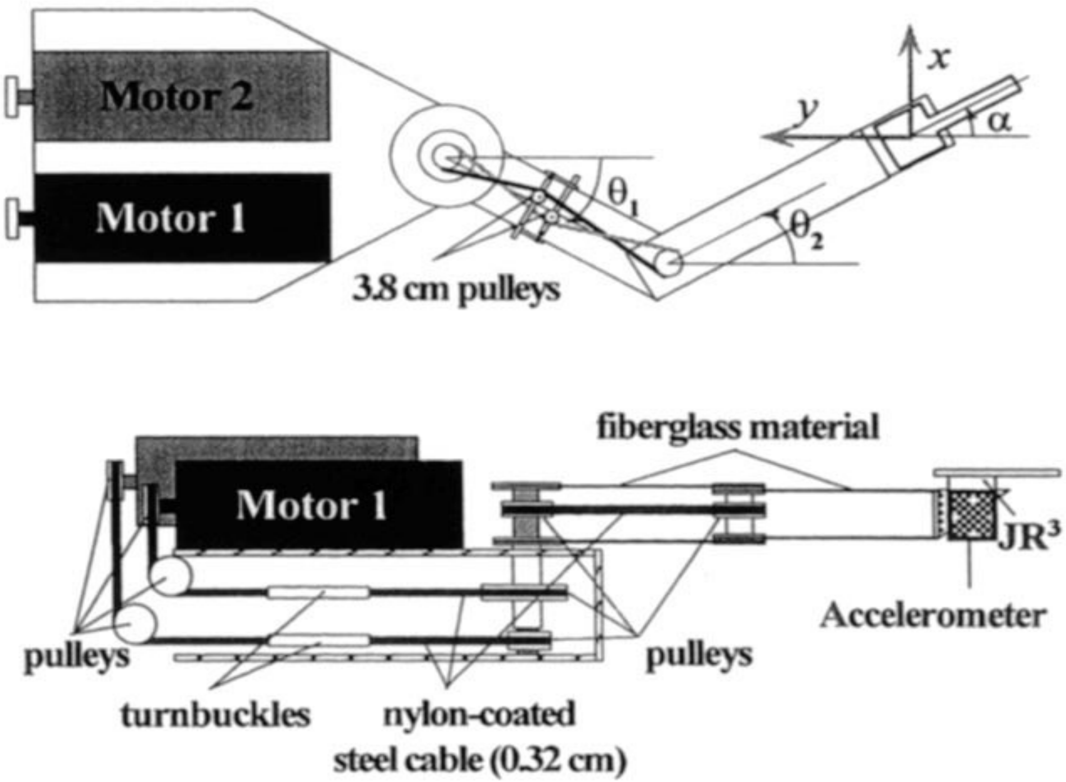


Agonist and Antagonist

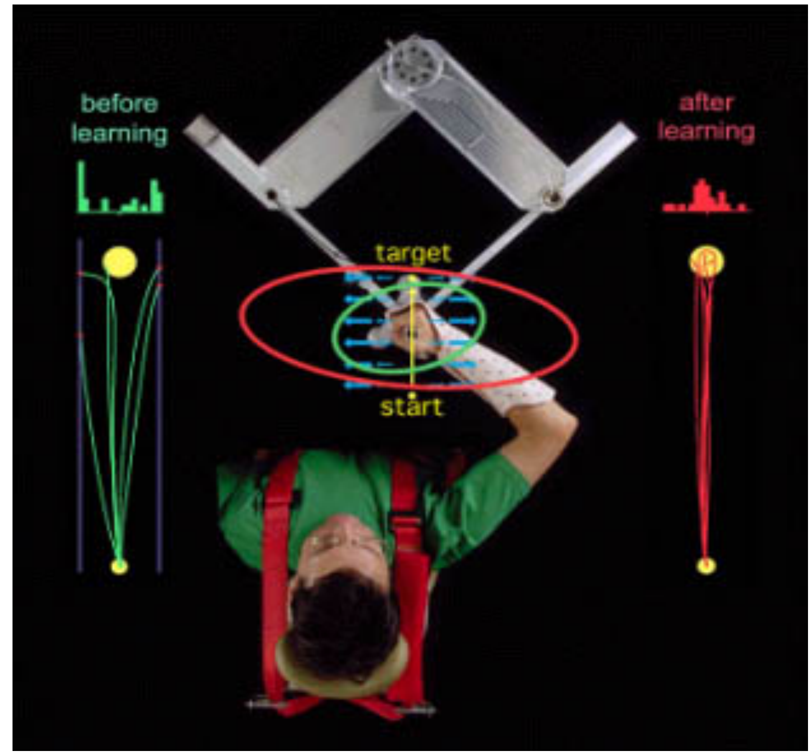


We have Agonist and Antagonist muscles

Robots for stiffness measurement

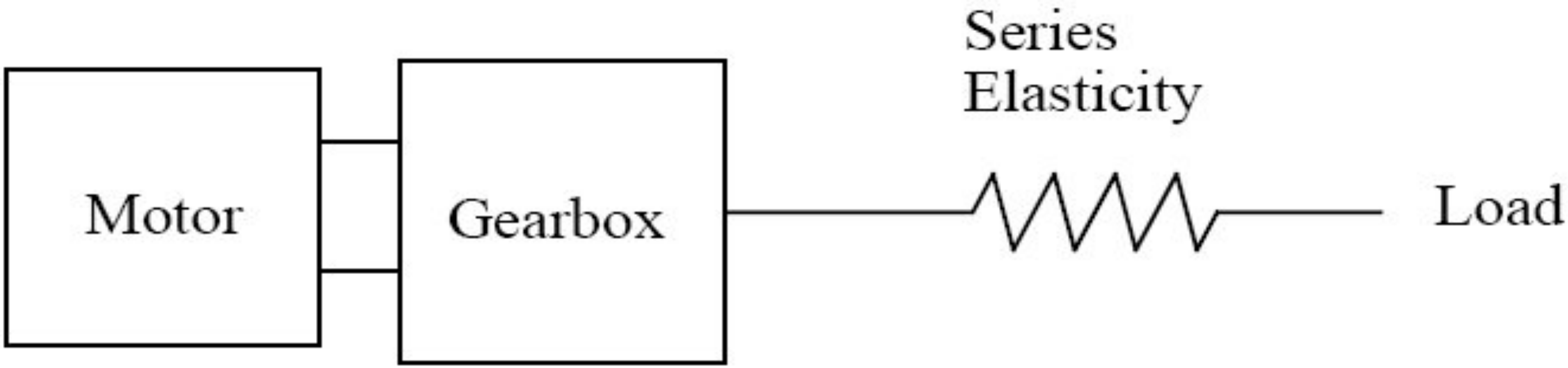


Acosta et al 2000



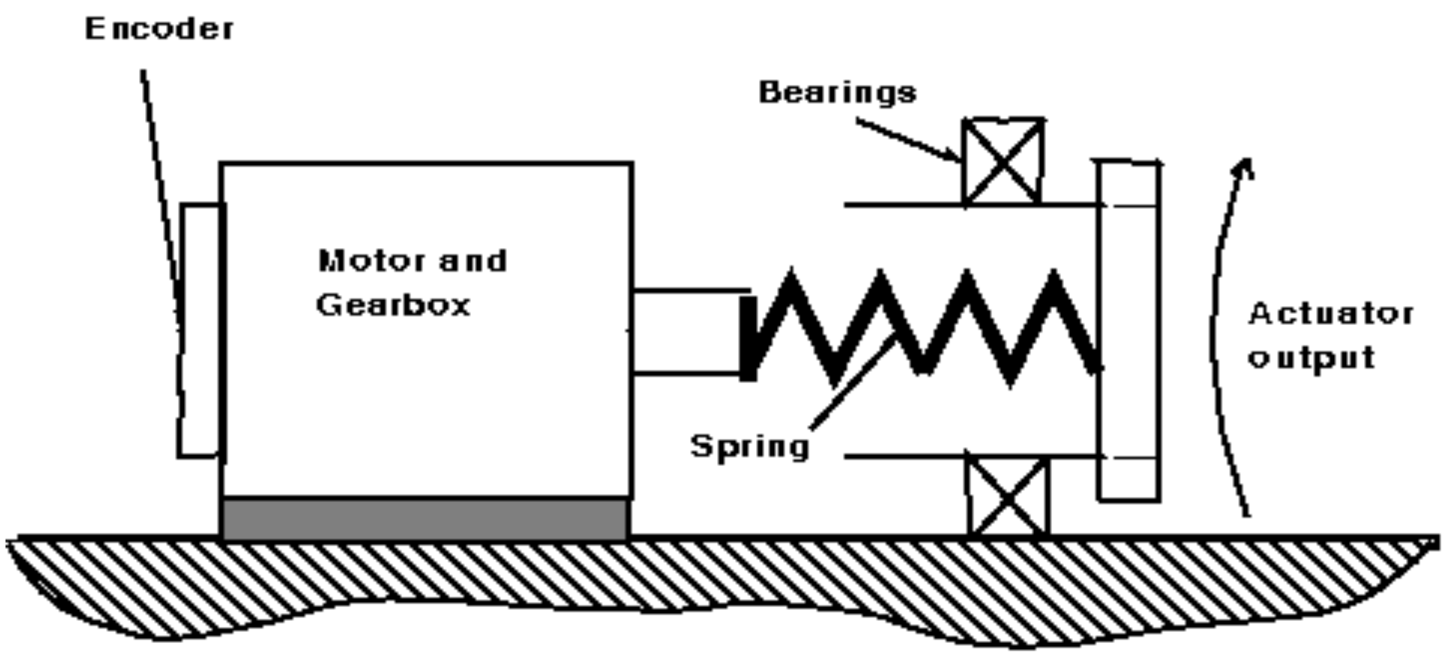
Gomi & Kawato, 1996

Series elastic actuation



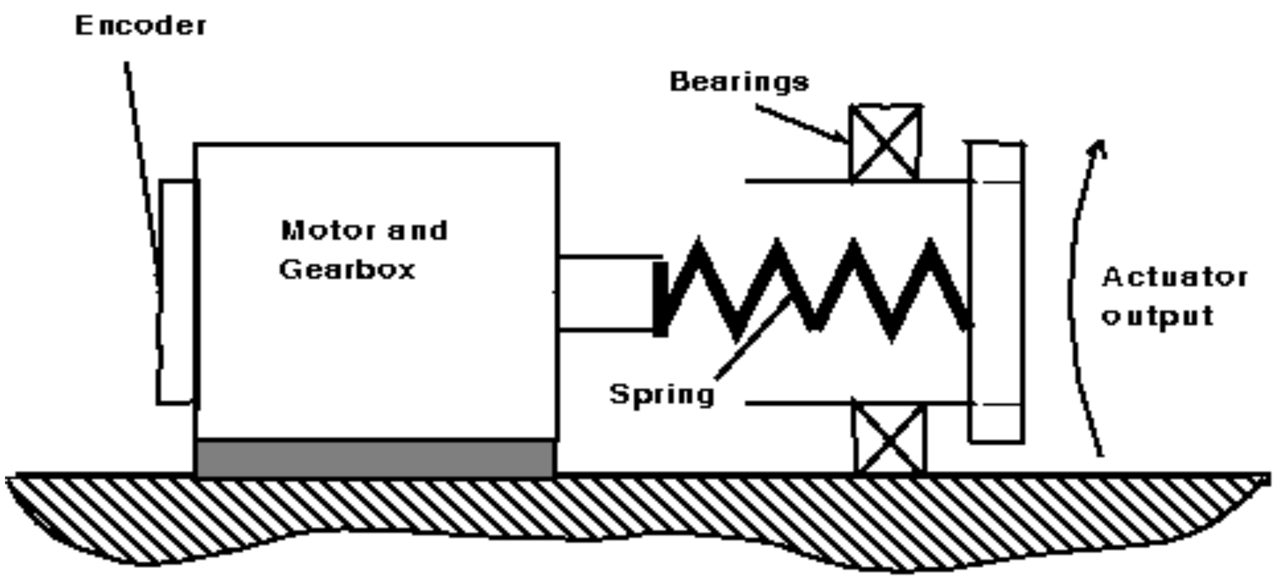
Series elastic actuation details

- The spring converts the force control problem into a position control one, which is better suited to the abilities of the motor-gearbox combination
- The spring naturally low-pass filters the noise and backlash of the gearbox, giving a low-noise force output

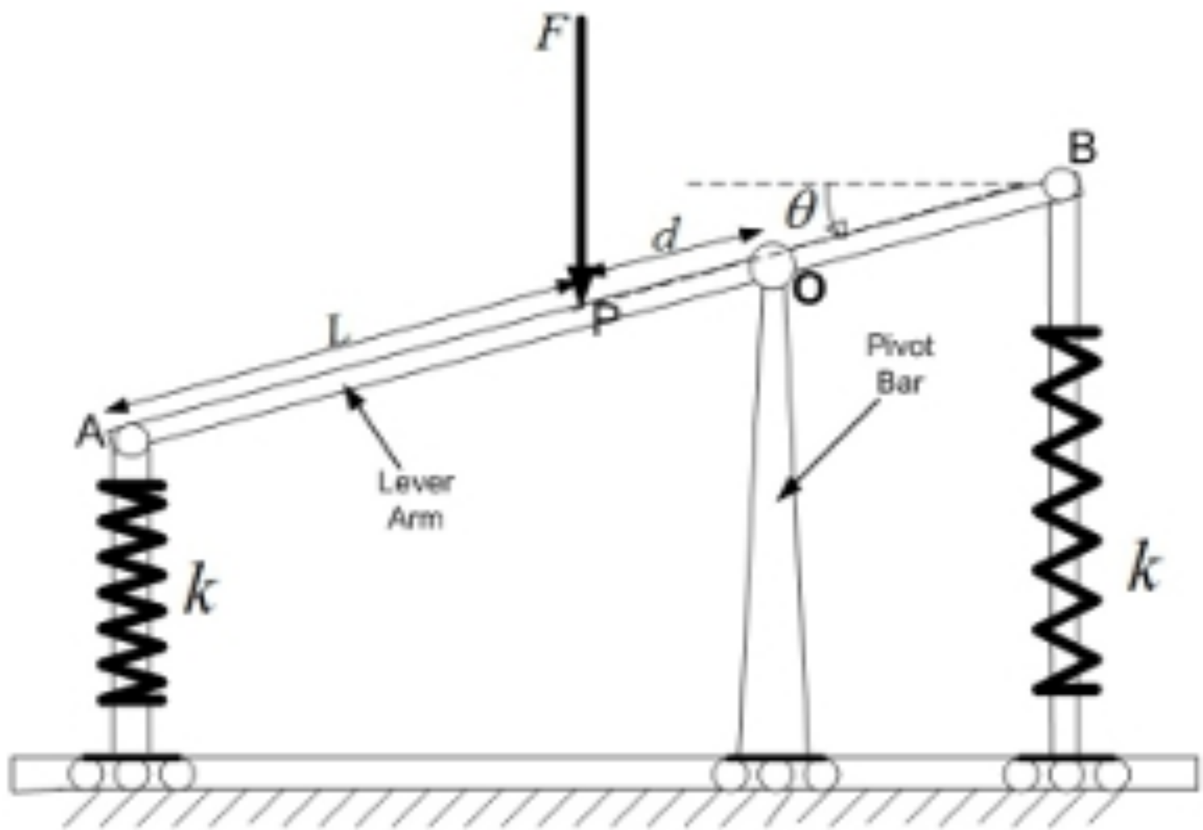


Series elastic actuation details

- Shock loads are absorbed by the spring, protecting the motor gear teeth
- Overall system bandwidth is low due to the spring.
- Can make the actuator behave in a passive manner, making it stable while interacting with all environments
- Actuator will not go unstable when touching a hard surface



Variable Stiffness Mechanism



- implementation of concept 1 in a car suspension.

Variable stiffness actuator