Motors and Actuators in Robotics

What are motors and actuators and how they work?

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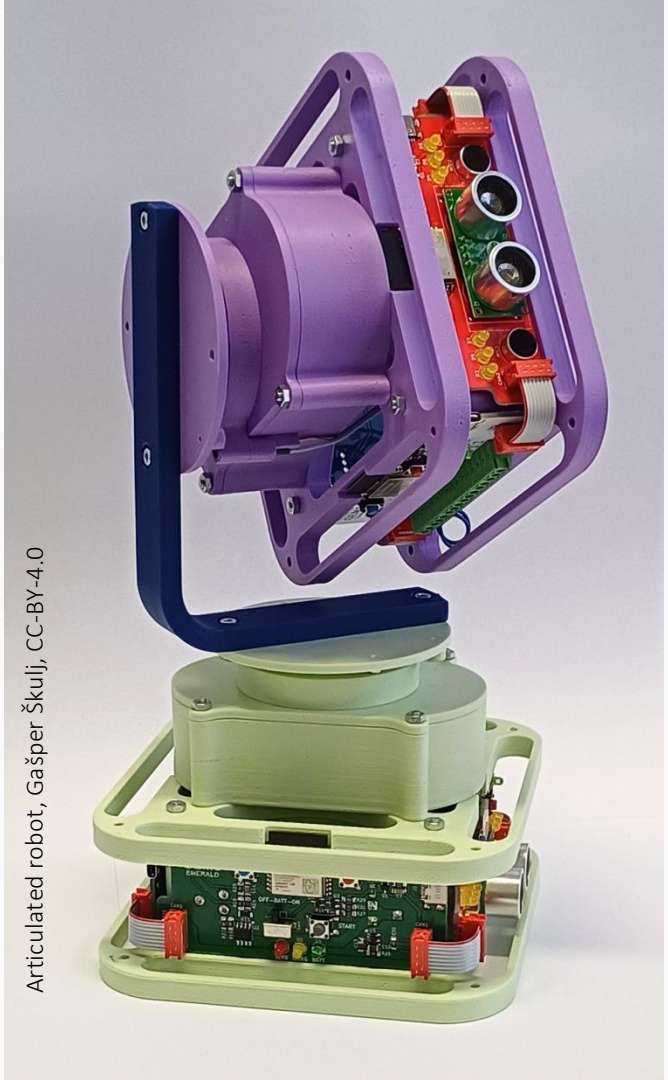
TU Delft



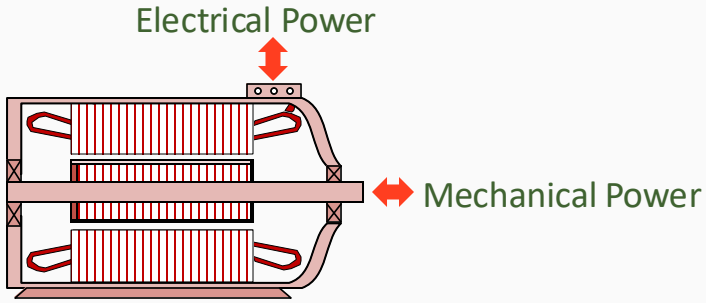
Lecture Outline

1. Definitions
2. Principles
3. Motor types
4. Actuator types
5. Motor in this course

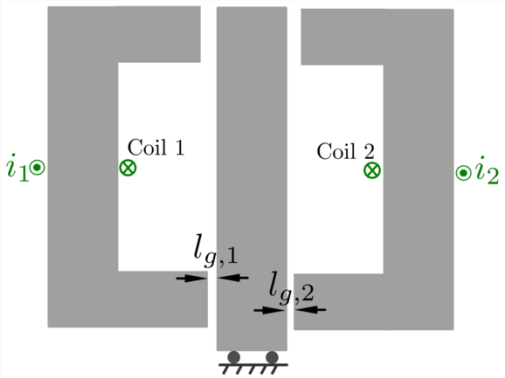
What are motors and actuators?

Electric motor: a component that converts electrical power into mechanical power.

In most cases, motors can also operate as a generator, i.e., with a reversed flow of power.



Actuator: component of a machine responsible for moving and controlling a mechanism or system, i.e. a "mover", and the movement is usually over a limited linear or rotational range.

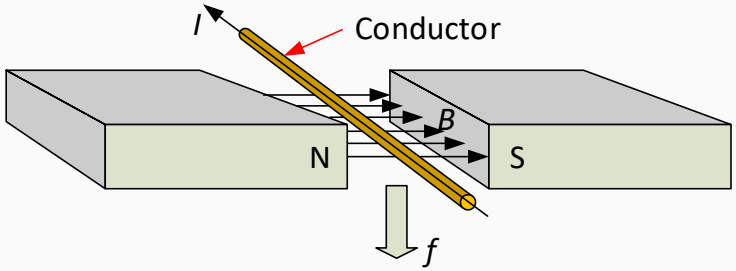


An electromagnetic actuator is a special type of electric motor

Actuators can be electromagnetic, hydraulic, pneumatic ...

How electric motor and actuator work?

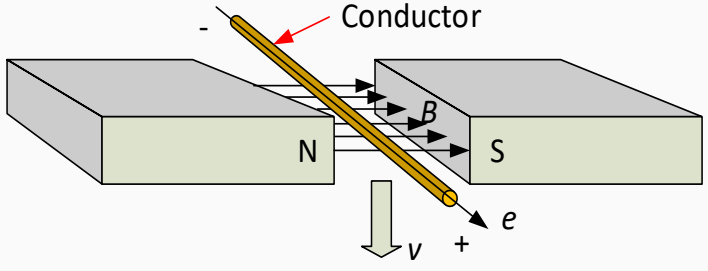
Electromagnetic force



$$\vec{f} = i\vec{l} \times \vec{B}$$

- Current through conductor in magnetic field leads to electromagnetic force (torque)
- Force or torque enables mechanical motion

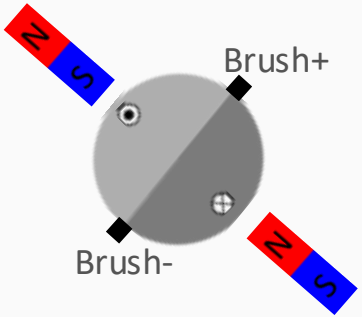
Faraday's law



$$e = (\vec{v} \times \vec{B}) \cdot \vec{l}$$

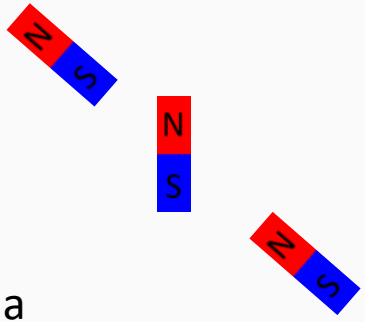
- Motion of conductor lead to induced voltage
- Induced voltage takes (delivers) electrical power

Various structures and various operation principles



Lorentz torque

DC motor



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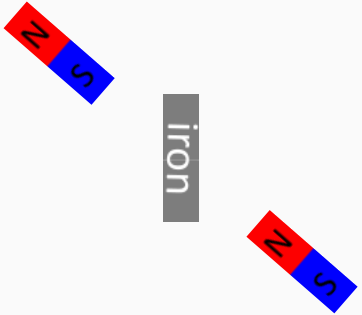
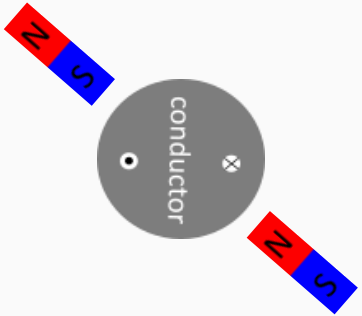
Alignment torque

Synchronous motor



Reluctance torque

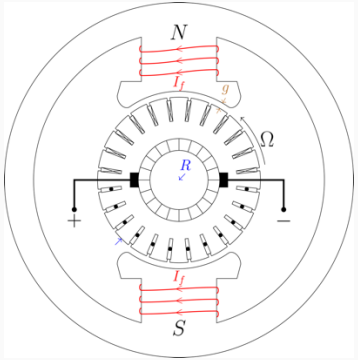
Synchronous reluctance motor



Induced current torque

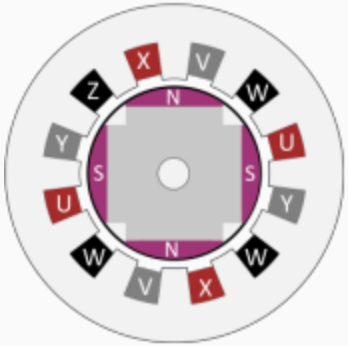
Induction motor (asynchronous motor)

AC motor

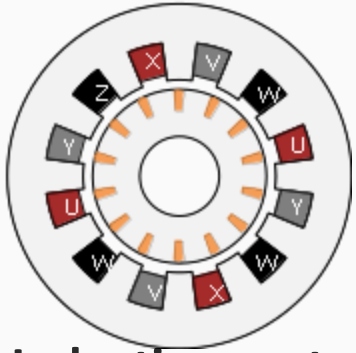


DC motor

Synchronous reluctance motor



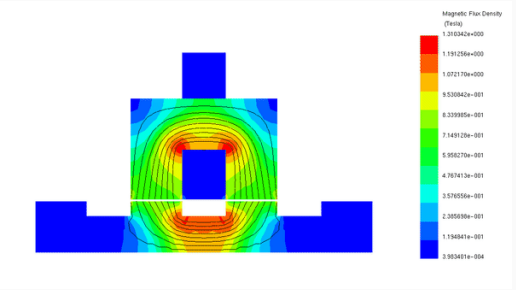
Synchronous motor



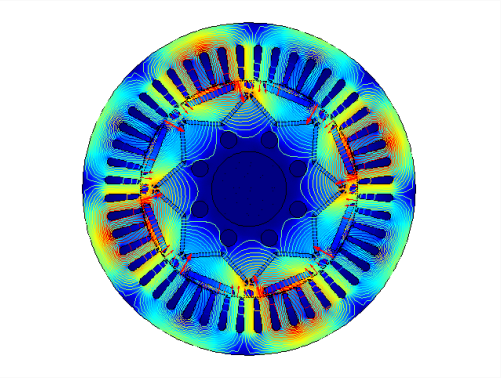
Induction motor

How about electromagnetic actuators?

In general, electromagnetic actuators are electric motors move in limited ranges

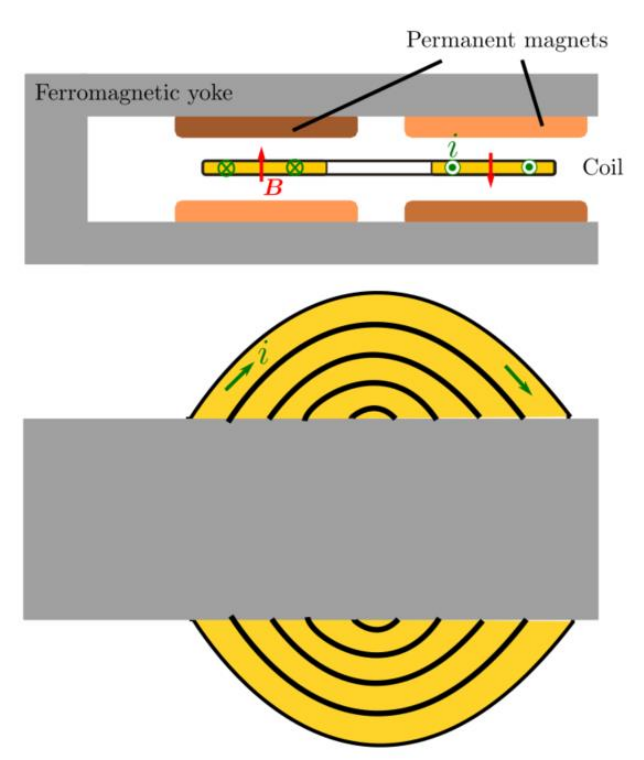


A linear actuator



A rotational electric motor

Lorentz actuator



Flat type Lorentz actuator

Lorentz force occurs on the coil

$$f = Bil$$

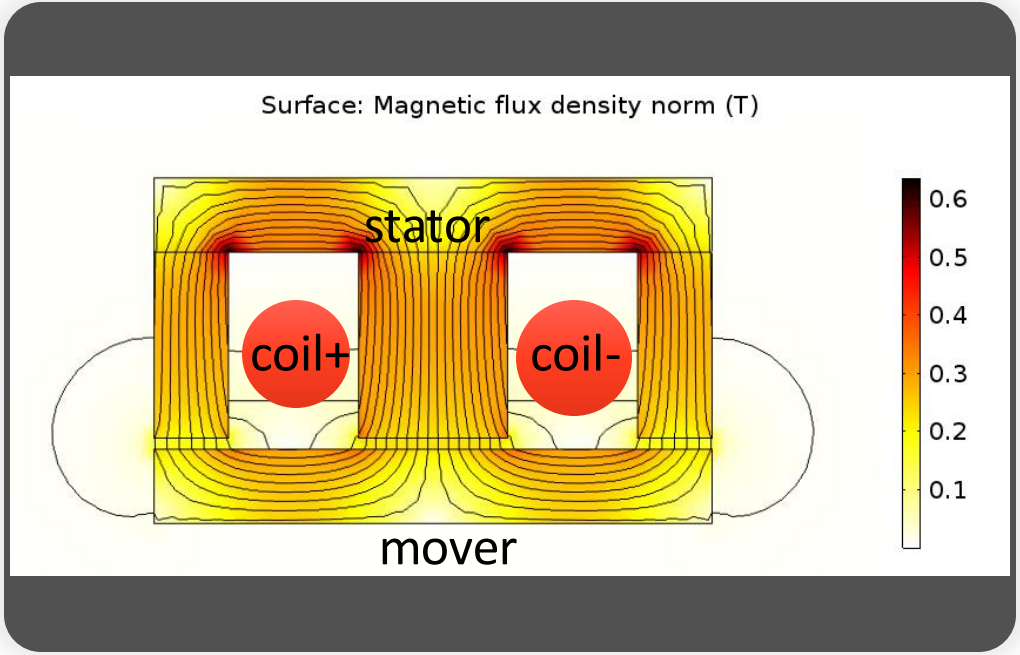
- Linear relationship between force and current
- Low force density

Reluctance actuator

Attraction between mover and electromagnet

$$f = -\left(\frac{ni}{l_g}\right)^2 \frac{\mu_0 A_g}{4}$$

- Nonlinear relationship between force and current
- High force density

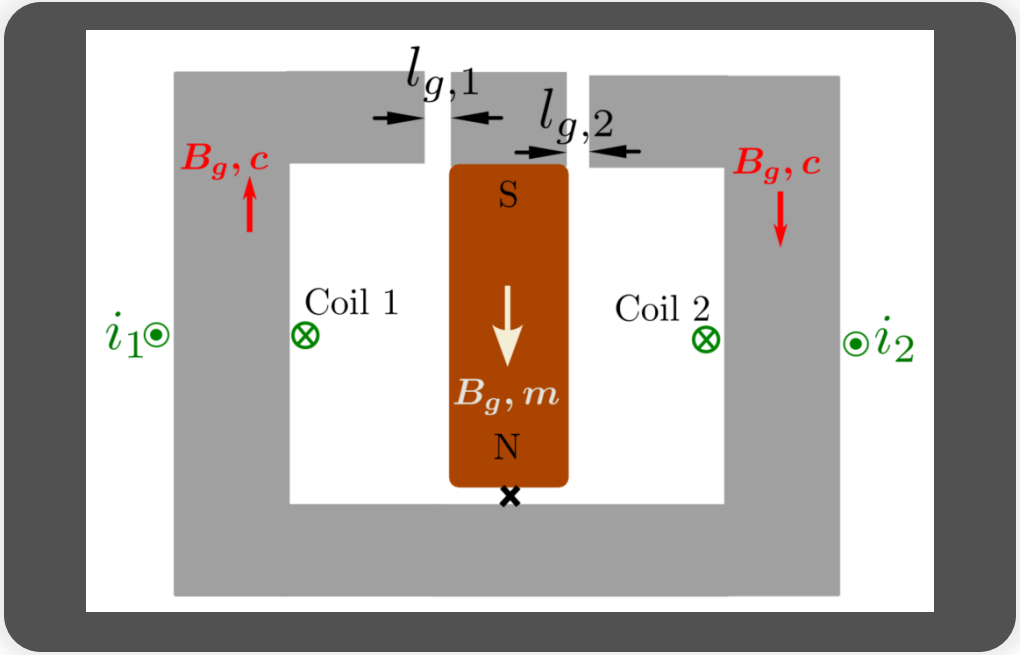


Hybrid reluctance actuator

Combines the advantage of both

$$f = -A_g B_{g,m} \frac{2ni}{l_g}$$

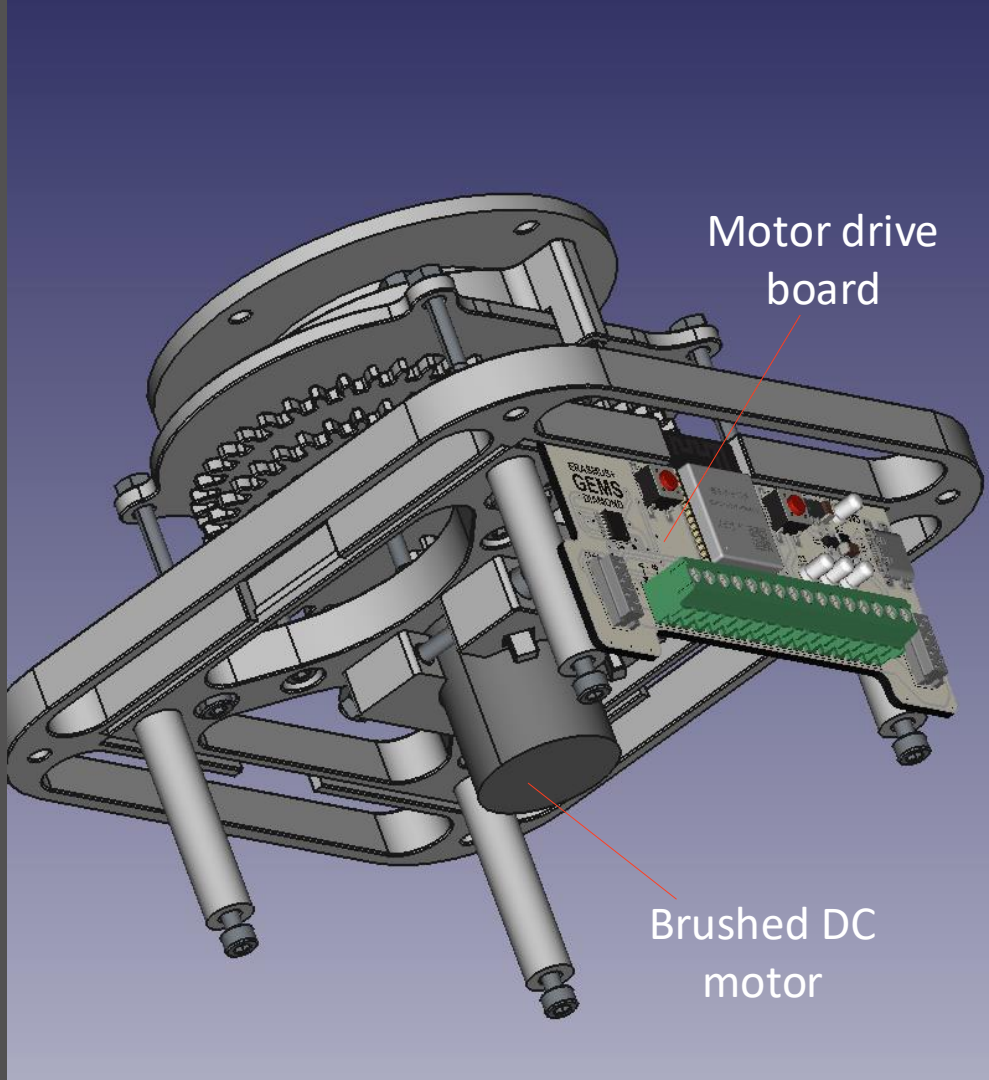
- Linear relationship between force and current
- High force density

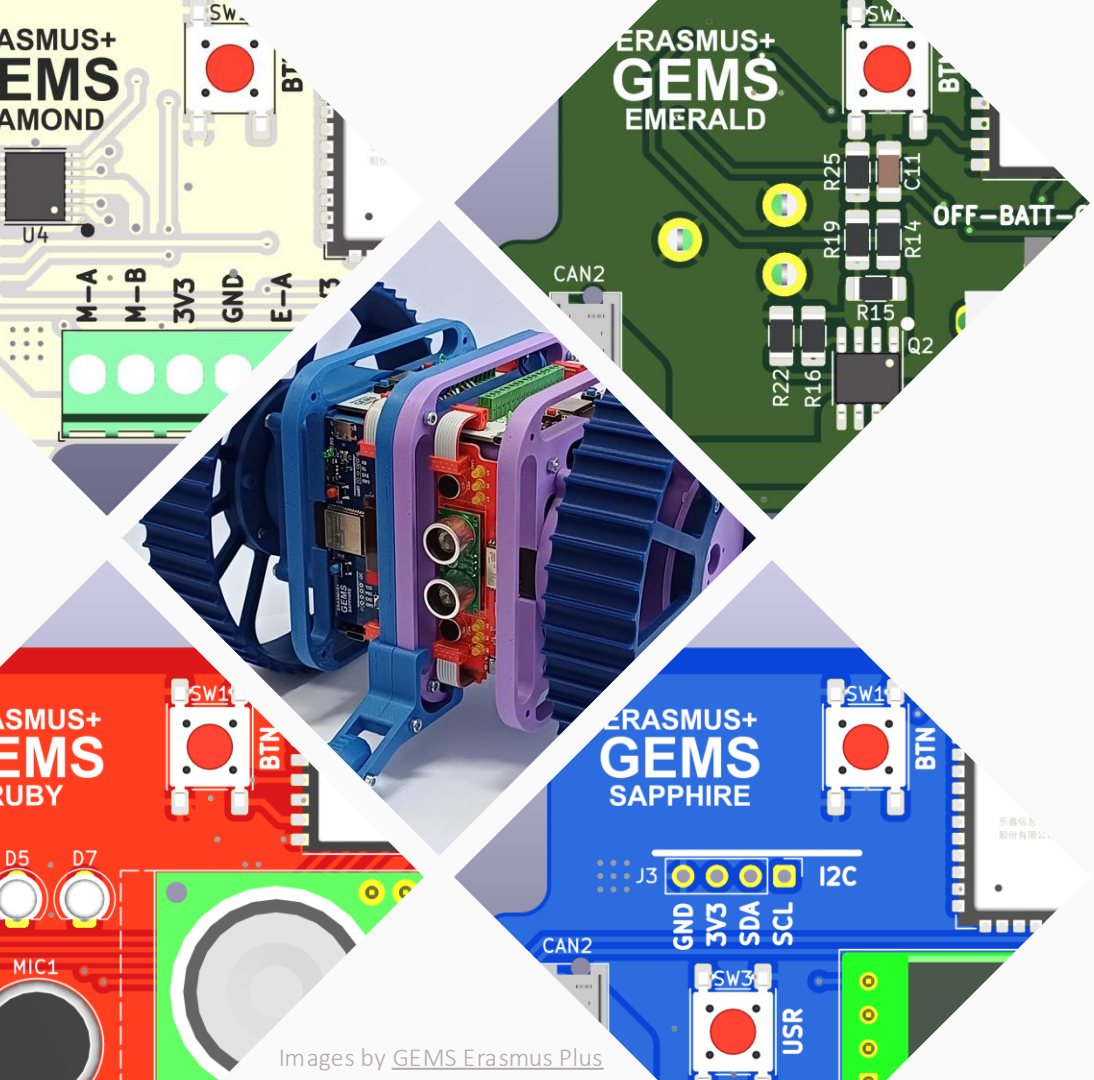


What motor to control in this course?

Brushed permanent magnet DC motor

Servo motor module inthis course: a brushed dc motor with gears to reduce the speed





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Thank you for watching!

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