MECE 3350
Control Systems

Lecture 1

Introduction to Linear Control Systems

Videos in this lecture

Lecture 1: `https://youtu.be/TyJSMVarQZQ`

Exercise 1: `https://youtu.be/xHRKLbFdjvw`

Exercise 2: `https://youtu.be/Up_FpeS5zUI`

Applications of Control System

Autonomous robots

https://www.youtube.com/watch?v=fRj34o4hN4I

Applications of Control System

Autonomous cars

https://www.youtube.com/watch?v=cdgQpa1pUUE

Applications of Control System

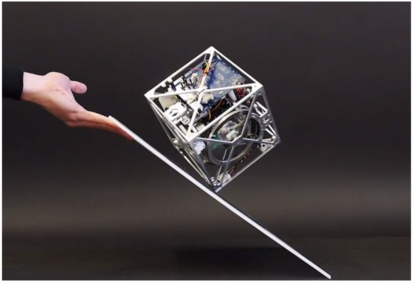
Control of quadcopters

https://www.youtube.com/watch?v=w2itwFJCgFQ

Applications of Control System

Self-balancing robots

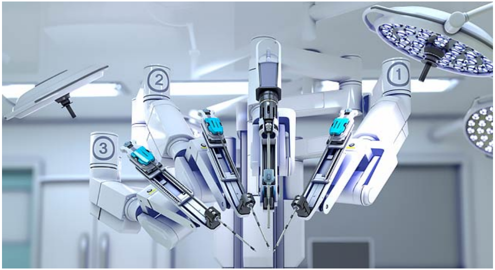
https://www.youtube.com/watch?v=n_6p-1J551Y



Applications of Control System

Robotic surgery

https://www.youtube.com/watch?v=-5lzGk7dgCQ



Anything else?

More applications

→ Automatic assembly line

→ Machine tool control

→ Space technology and satellite control

→ Power Systems

→ Micro electro mechanical systems (MEMS)

→ Smart transportation systems

→ Ship stabilization systems

→ Temperature control systems

→ Missile launching systems

→ Voltage stabilizer systems

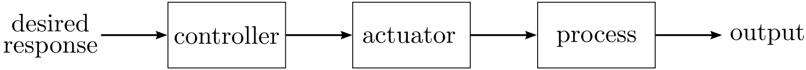
→ Sun tracking control of solar collectors

→ ...

Control engineering

The first step in control engineering is to understand the system we want to control.

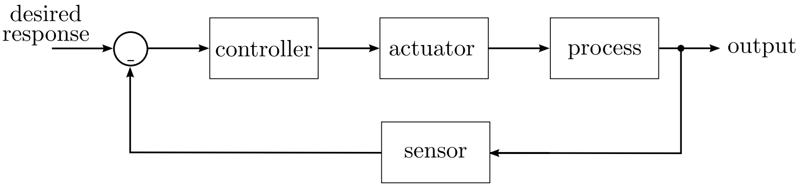
Then, we design a secondary system that controls the behaviour of the first system



This is called **open-loop control**.

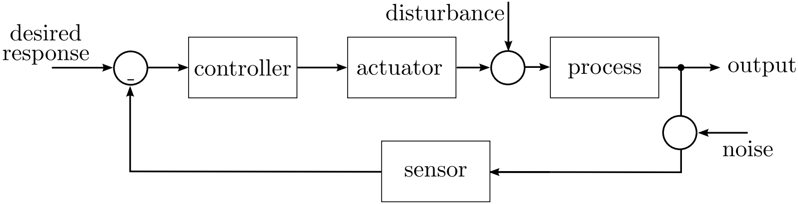
Control engineering

A **closed-loop** control system uses a measurement of the output and feedback of this signal to compare it with the desired output.



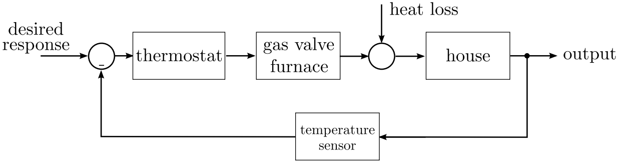
Control engineering

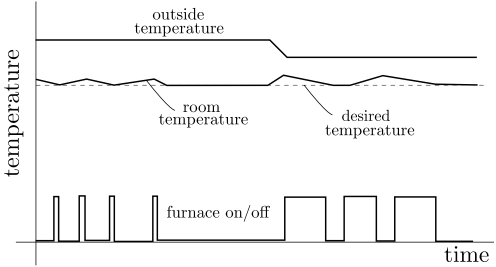
A **closed-loop** control system uses a measurement of the output and feedback of this signal to compare it with the desired output.



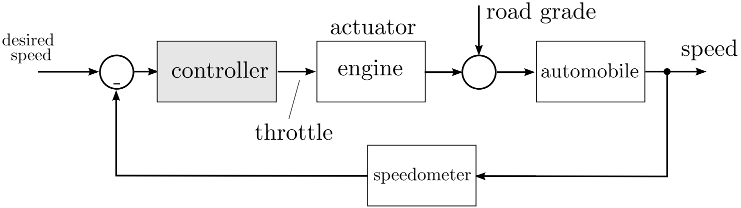
A simple feedback system

The variable being controlled is measured by a sensor and fed back to the controller to influence the controlled variable.





Example - cruise control



From measurements, we determined that:

$\rightarrow$ A 1° change in the throttle angle causes a 10 km/h change in speed.

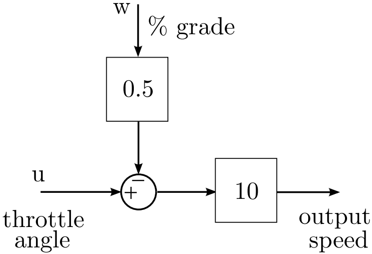
$\rightarrow$ When the road grade changes by 1%, the speed changes by 5 km/h

Example - cruise control

Step 1 - Model the system to be controlled

→ A 1° change in the throttle angle causes a 10 km/h change in speed.

→ When the road grade changes by 1%, the speed changes by 5 km/h

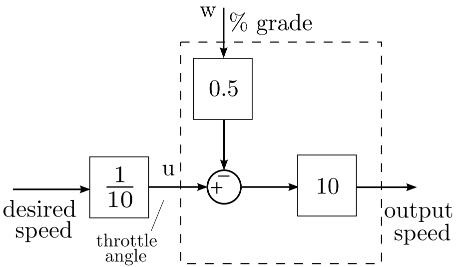


Example - cruise control

Step 2 - Find a suitable controller

→ A 1° change in the throttle angle causes a 10 km/h change in speed.

→ When the road grade changes by 1%, the speed changes by 5 km/h

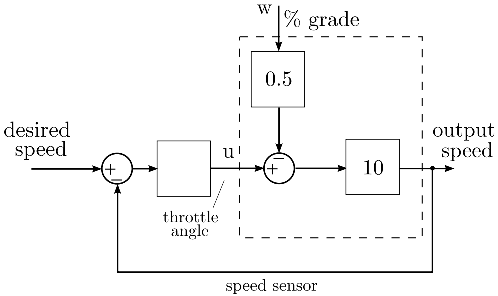


Example - cruise control

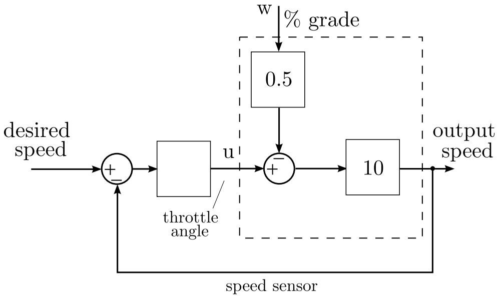
Step 2 - Find a suitable controller

→ A 1° change in the throttle angle causes a 10 km/h change in speed.

→ When the road grade changes by 1%, the speed changes by 5 km/h



Example - cruise control



$$y = 10(u - 0.5w)$$
$$u =$$

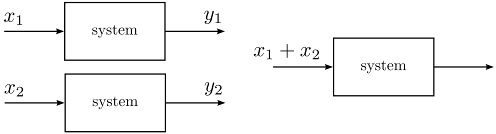
Combining the equations:

$$y = \frac{100}{101} r - \frac{5}{101} w$$

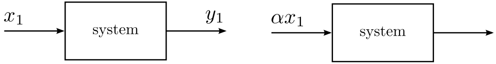
Linear systems

A linear system satisfies the properties of superposition and homogeneity

Superposition: x_i provides a response y_i, thus:

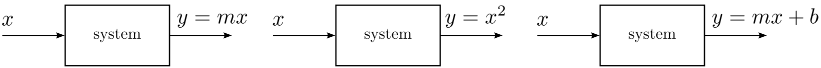


Homogeneity: x_1 provides a response y_1, the response to αx_1 is:

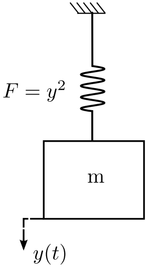


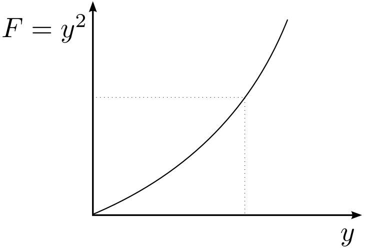
Linear systems

Are these systems linear ?



Linear approximations

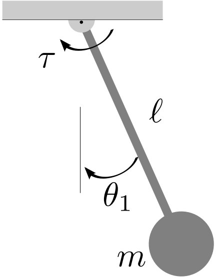




Pendulum example

Torque *vs* angle θ

$$\tau(t) = mg\ell\sin(\theta)$$



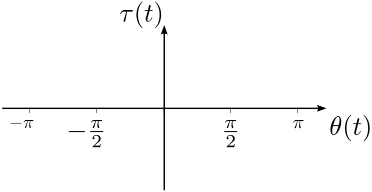
Is this system linear?

Taylor's series around $\theta = 0$:

$$\sin\theta = \theta - \frac{\theta^3}{3!} + \frac{\theta^5}{5!} - \frac{\theta^7}{7!} + \dots$$

For $\theta \approx 0$, we have:

$$\tau(t) \approx$$



Exercise 1

Sketch a block diagram fro a manual steering system of an automobile. Indicate the location of the following elements and signals:

The process

The desired output signal

The sensor

The actuator

The actuator output signal

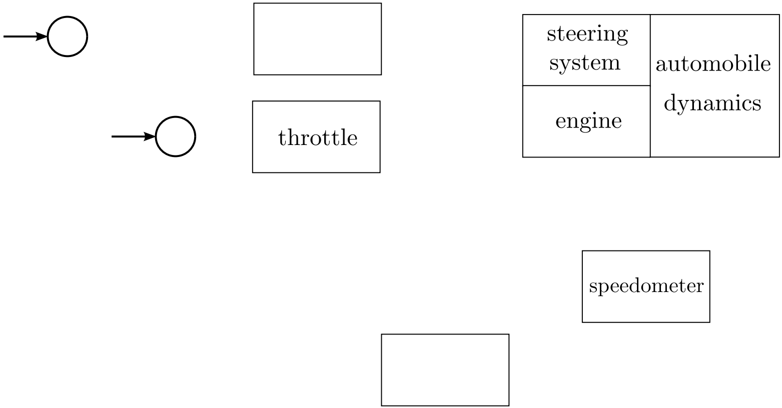
The controller

The controller output signal

The reference signal

The error signal

Exercise 1 - continued



Exercise 2

Sketch a block diagram fro a manual steering system of a water level controlled by a float and valve. Indicate the location of the following elements and signals:

The process

The desired output signal

The sensor

The actuator

The actuator output signal

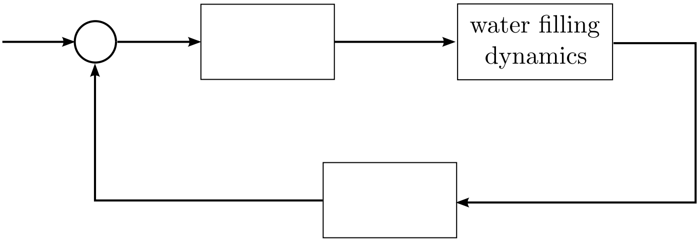
The controller

The controller output signal

The reference signal

The error signal

Exercise 2 - continued



Next episode...

- Dynamic models