Control Engineering
Regeltechniek

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Teletop: 121044 Regeltechniek

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Introduction

- Organisation
- Control, Steering
- Feedforward, Feedback

Organisation

Web site:

www.ce.utwente.nl/amn (Student info)

TELETOP: 121044 Regeltechniek

Study material:

- Cursus Regeltechniek van de OU (via Union Shop)
- Content of the lectures: (copies of these slides)

Organisation (2)

Software (20-sim 3.5):

Use license file of Dynamic Systems or download the file from the teletop site

(Matlab)

Organisation

- Exam:
- No open book !!
- One sheet of A4 with notes allowed

Control

Control is everywhere

- Domestic:
  - Central heating system
  - Freezer
  - Washing machine

Control is everywhere

- Automotive:
  - Air conditioning
  - Cruise control
  - Automated highway (http://www.path.berkeley.edu/PATH/Publications/Videos/auto_truck.ram)
  - ABS
  - Active suspension, ESP
- The more expensive cars have more value in control electronics than in typical ME parts

Control is everywhere

- Air Traffic and Ships:
  - Autopilots
  - Climate control
- Process industry:
  - Temperature control
  - Flow control
  - Level control
  - Voltage and frequency control

Control is everywhere

- Mechatronics
  - an integrated and optimal design of a mechanical system and its embedded control system
  - CD player / Hard disk
  - Robots
  - Production machines

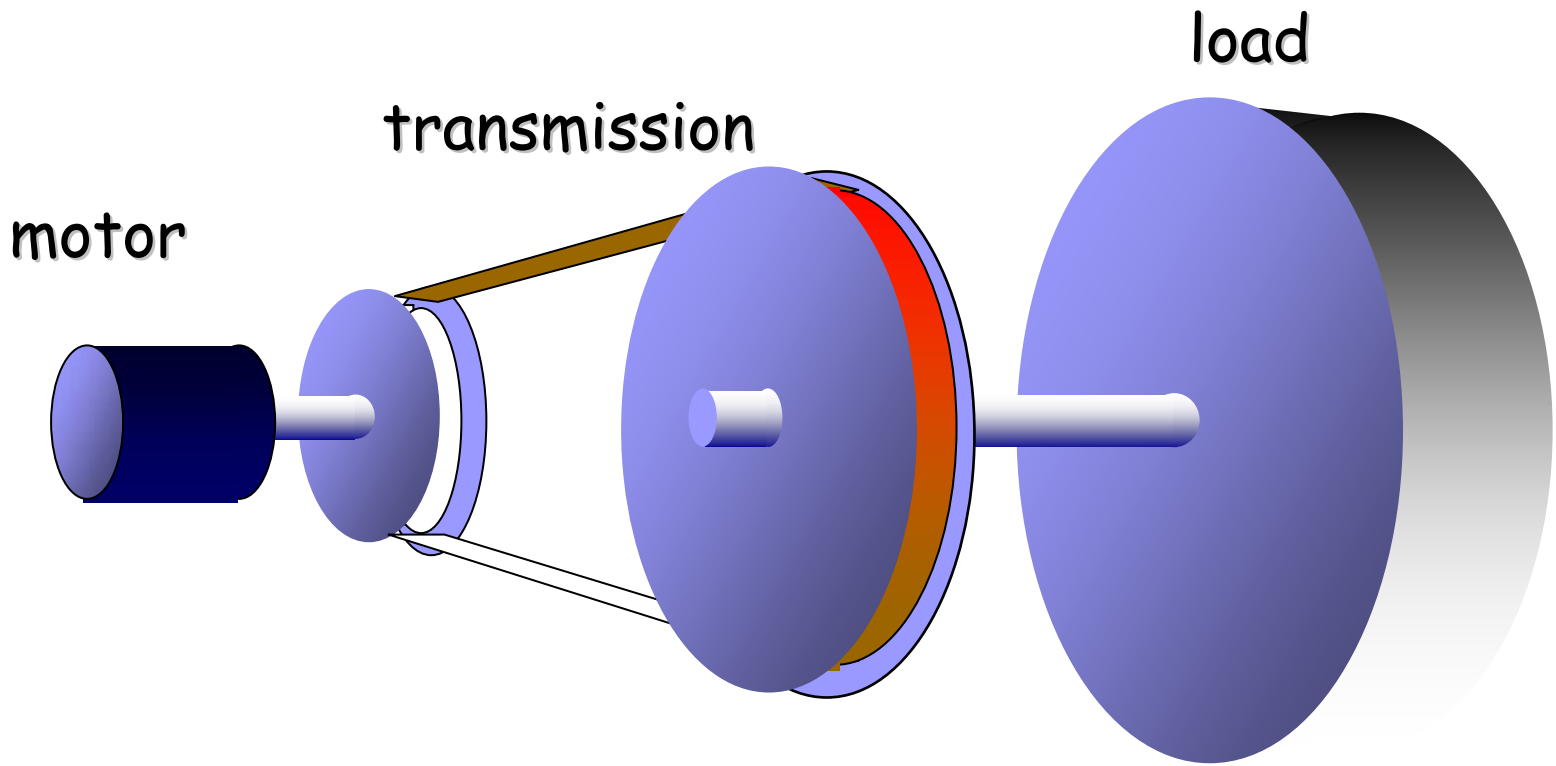
Contents

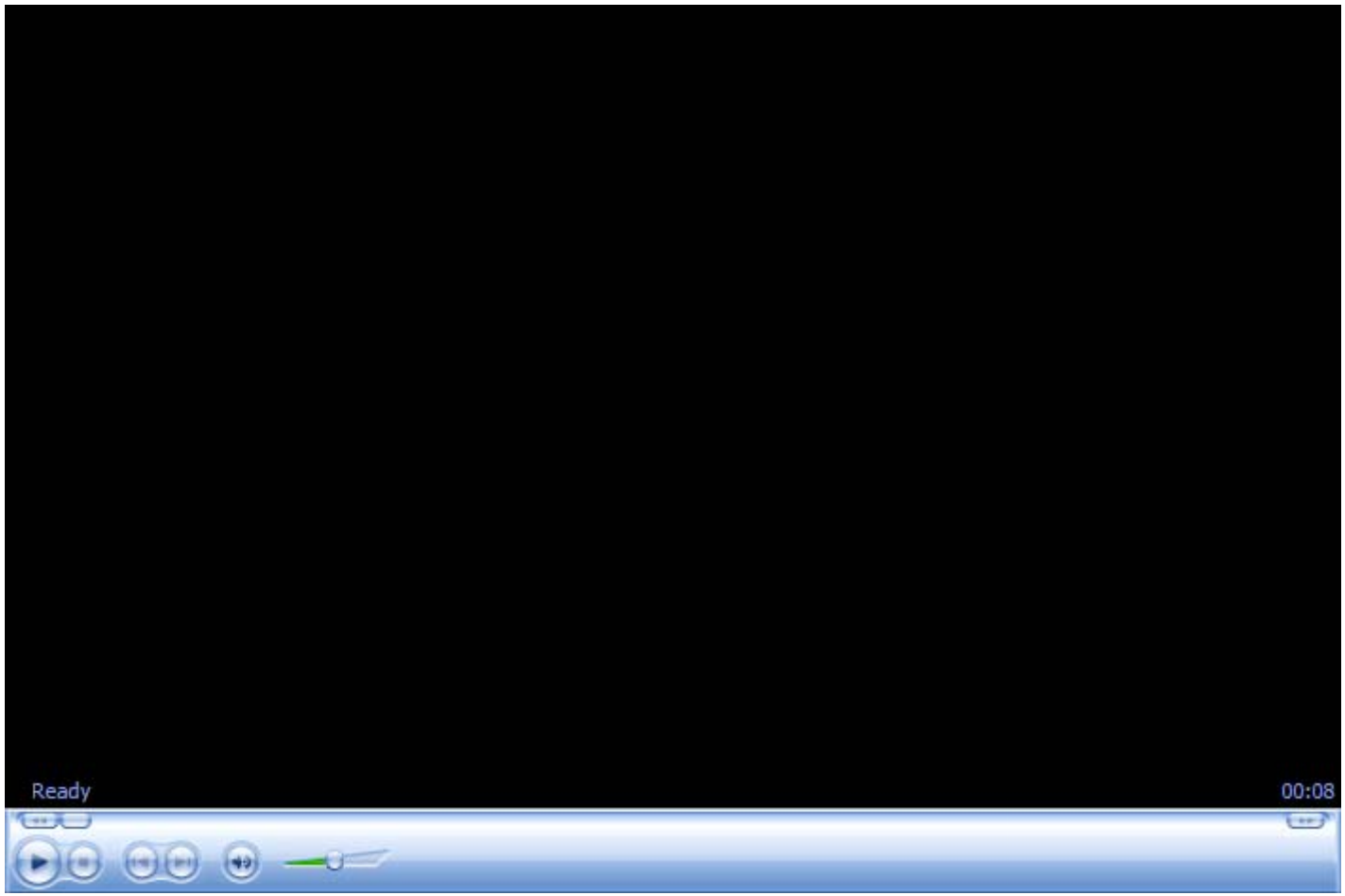
- Introduction to Control
- 'Classical control engineering'
  - modelling
  - simulation
  - Bode, Nyquist
  - Root locus

Control

- Problem definition
  - What do we want to achieve?
- Construct a device, plant, process
- Formulate a clear goal
  - Realise proper 'inputs' that can help to achieve the goal
  - manipulate the inputs, such that the goal is achieved

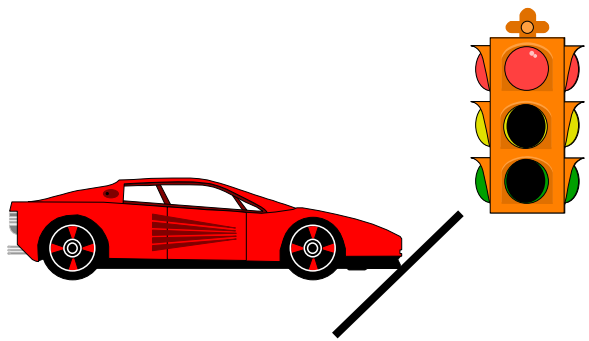
Process (1)





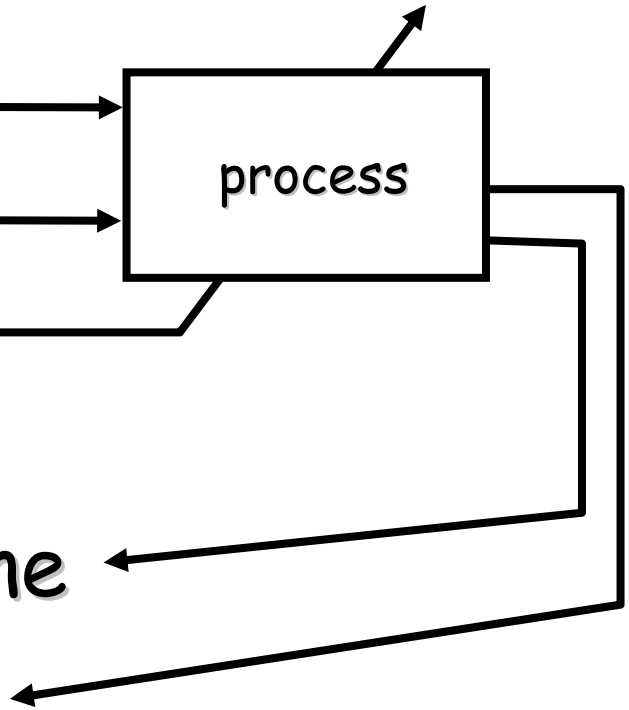
Process (2)

- Stopping a car at a traffic light
- Goal
  - Stop in time at the white line



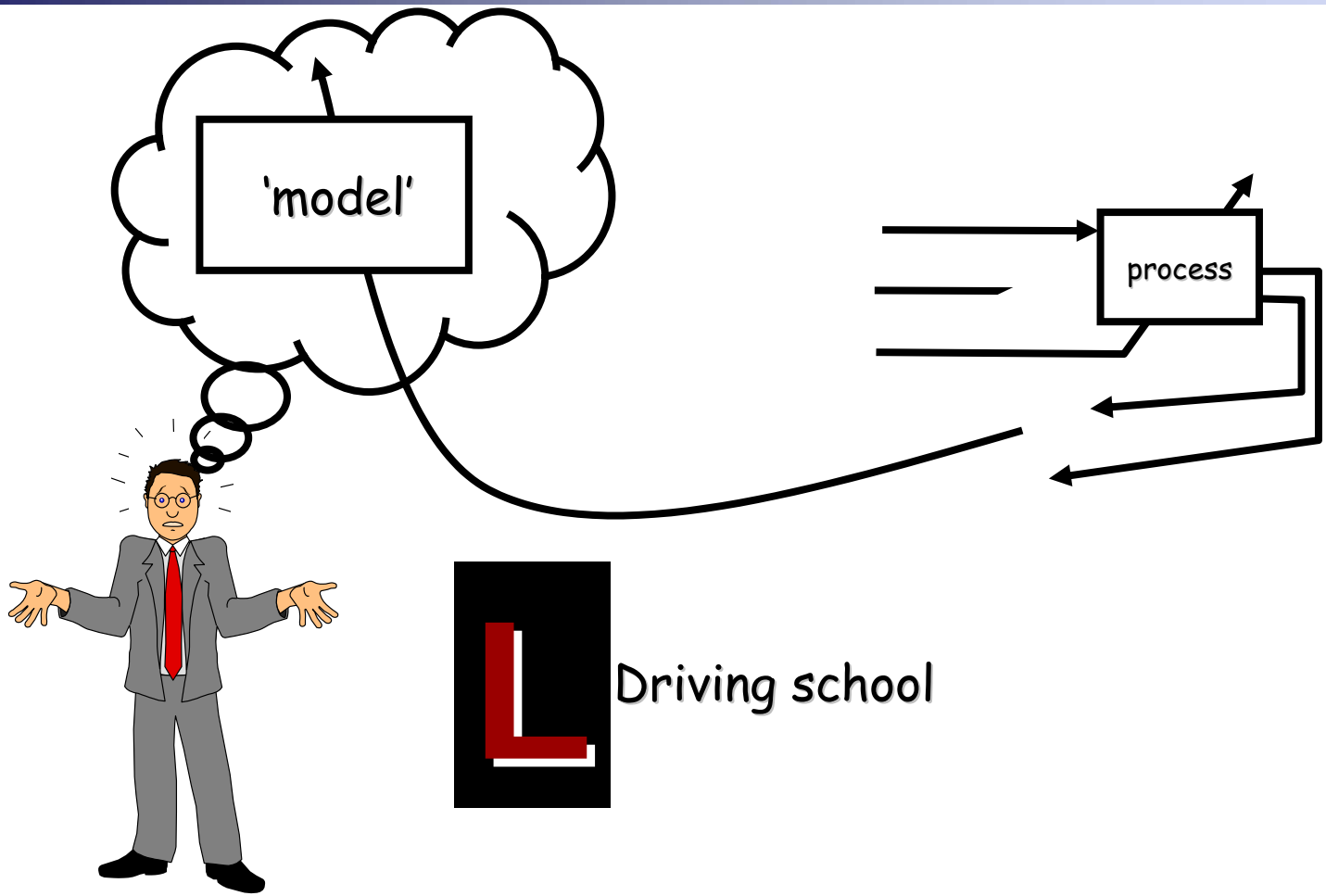
Variables

- Gas pedal
- Brakes
- Road condition

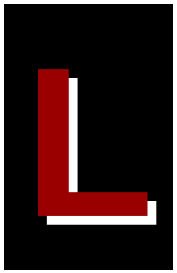


- Distance to white line
- Speed of the car

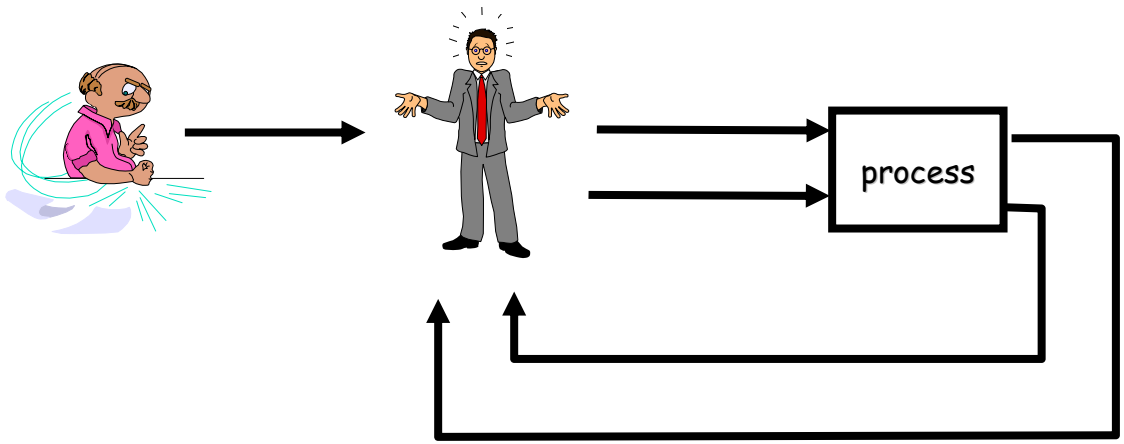
Modelling



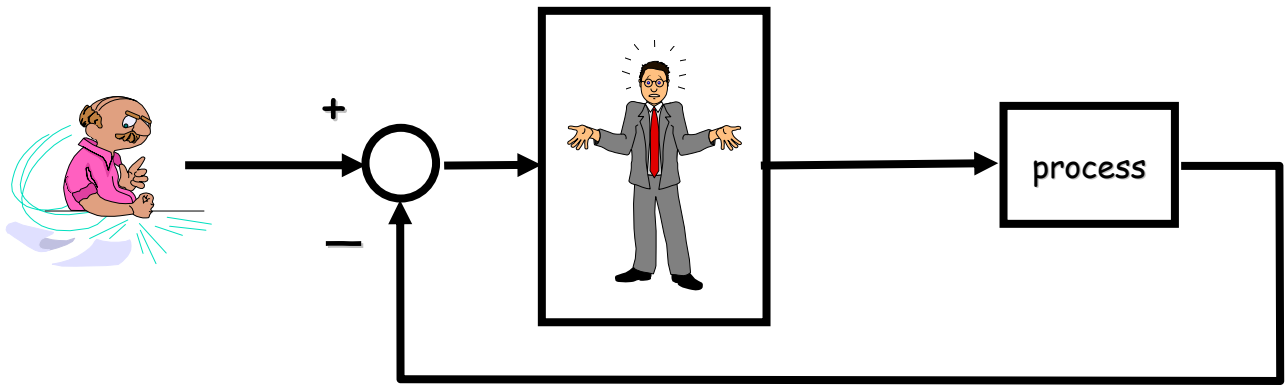
Modelling



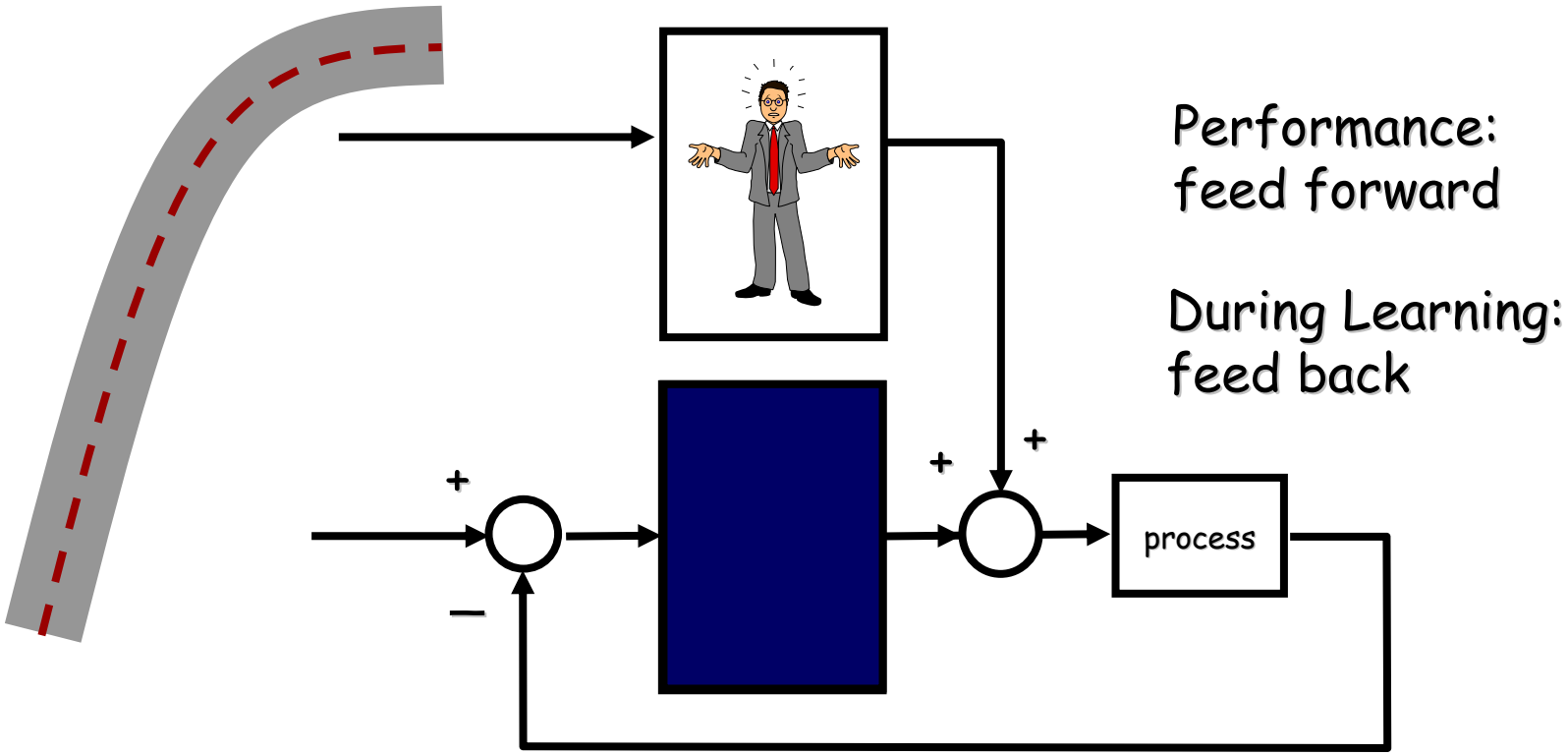
Driving school



Modelling



Modelling



(Human) Models

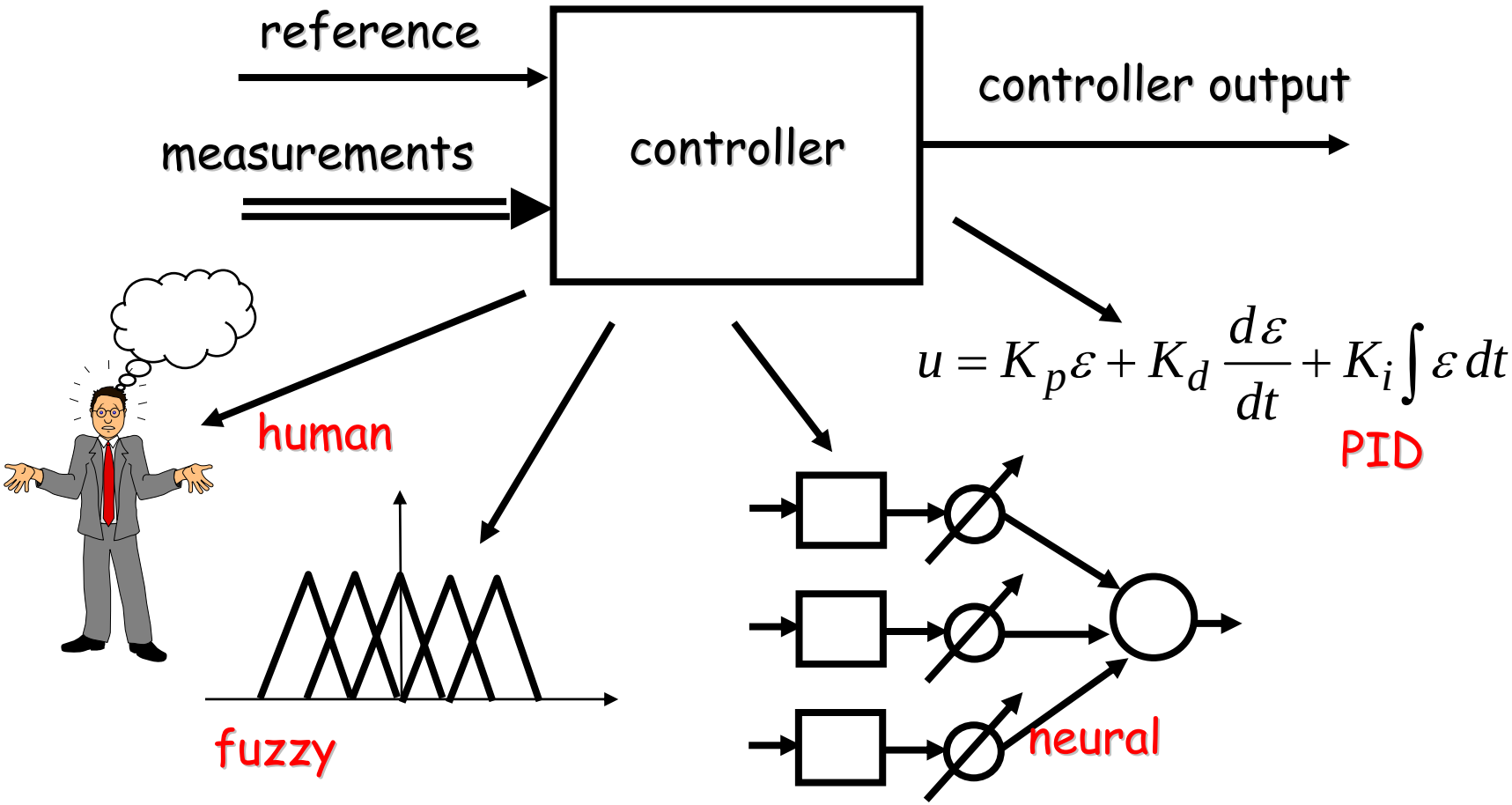
- Psychology
  - internal model
- Fuzzy Logic
  - membership functions
- Neural Networks
  - weights
- Classical control approach
  - differential equations

Controller models

Human modelling:

- No explicit modelling of the process

Types of control



Fuzzy (1)

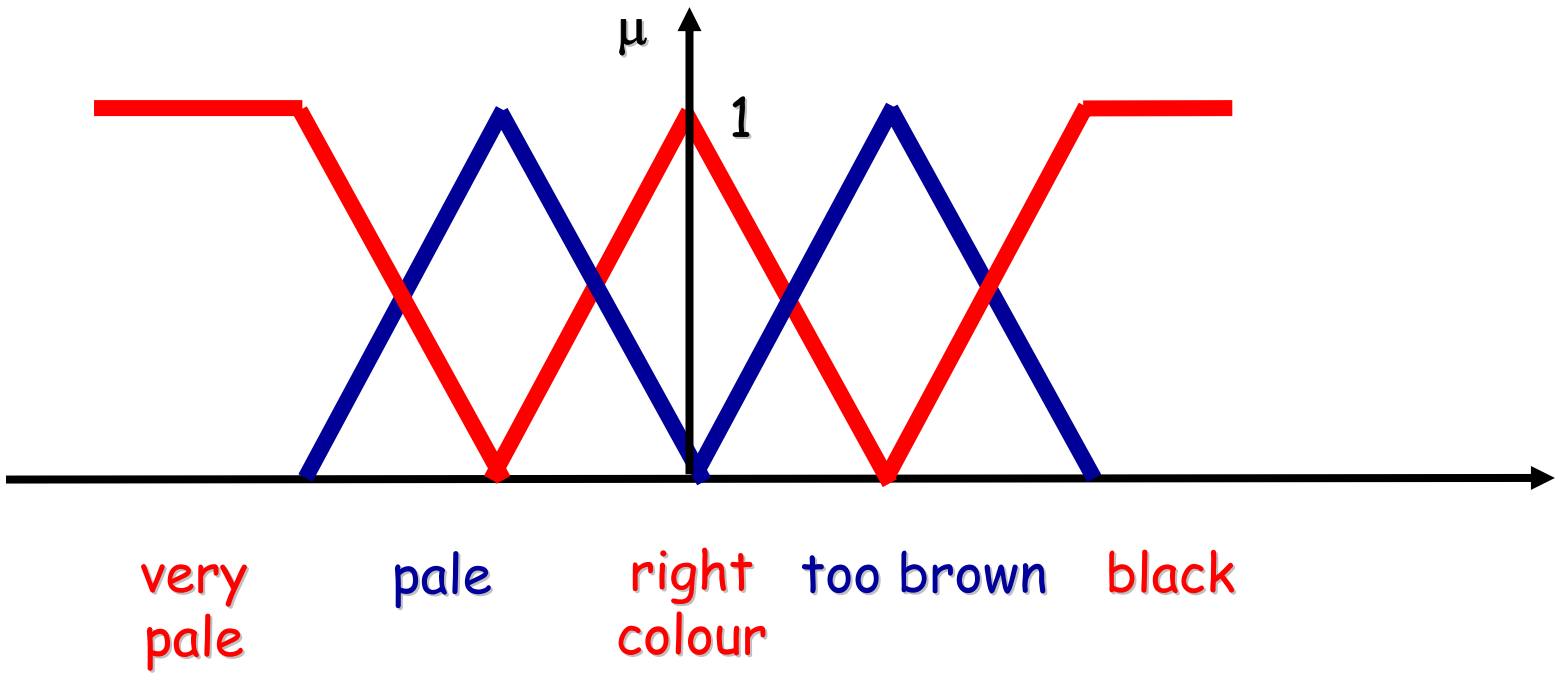
Example: baking a cake

- If the cake is still "rather pale"

  AND
- If the cake is still "a bit wet"

  THEN
- increase the temperature a little

Fuzzy sets for colour:



Neural network

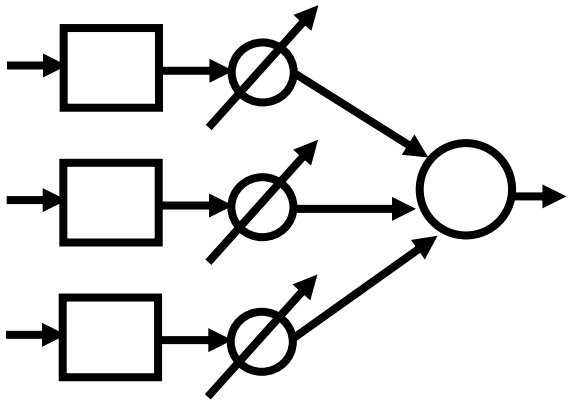


Table with interpolation

Table

Table with linear interpolation

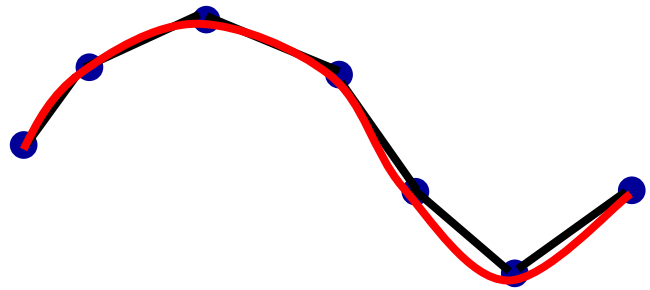


Table with higher-order interpolation

Mapping

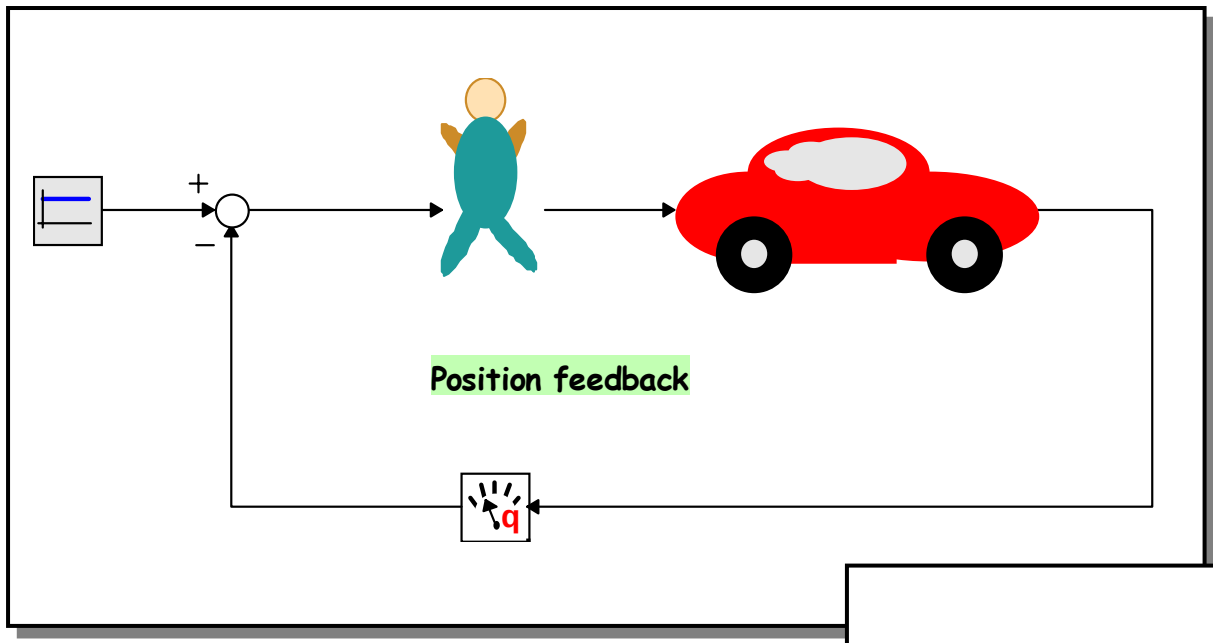
A controller maps input signals
to output signals

Mapping can be coded as:

If model of process is available

- differential equation
- table
- table with interpolation (fuzzy and neural)

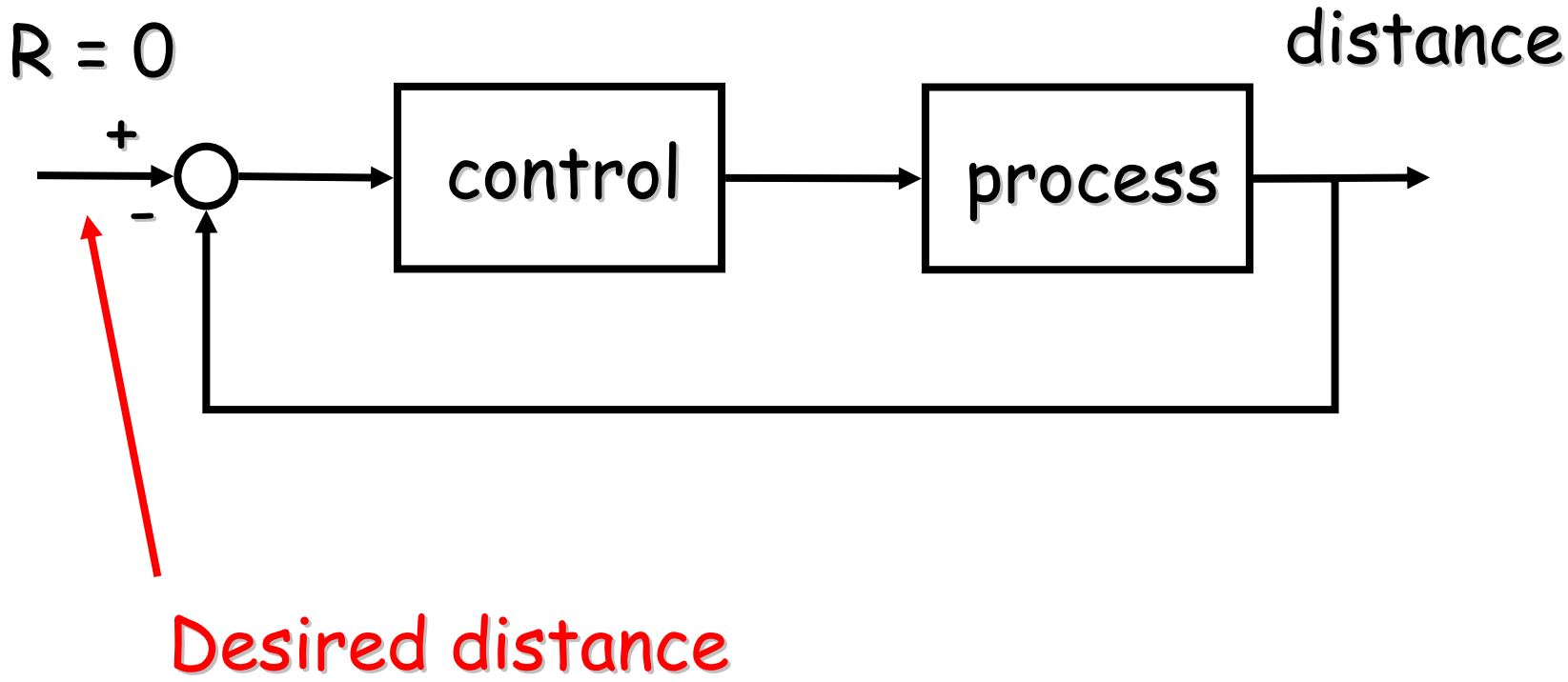
Demonstration



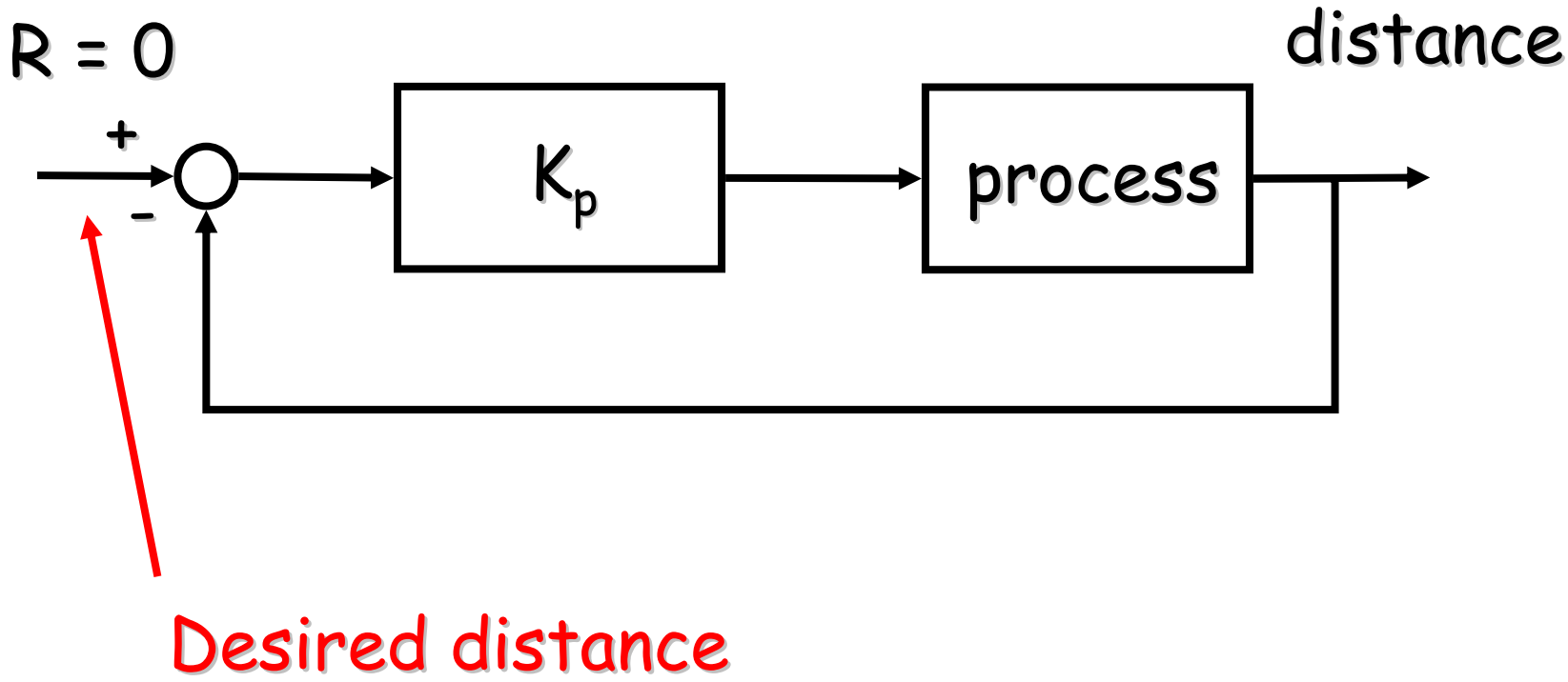
start
20-sim demo

20-sim
car_model

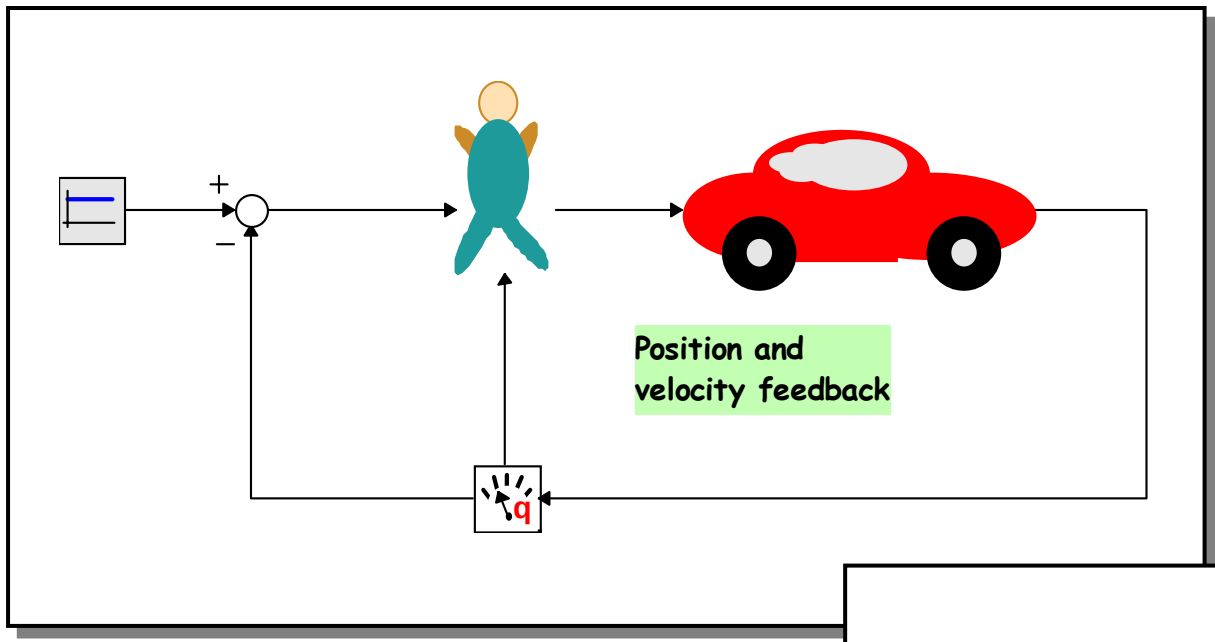
More abstract



More abstract



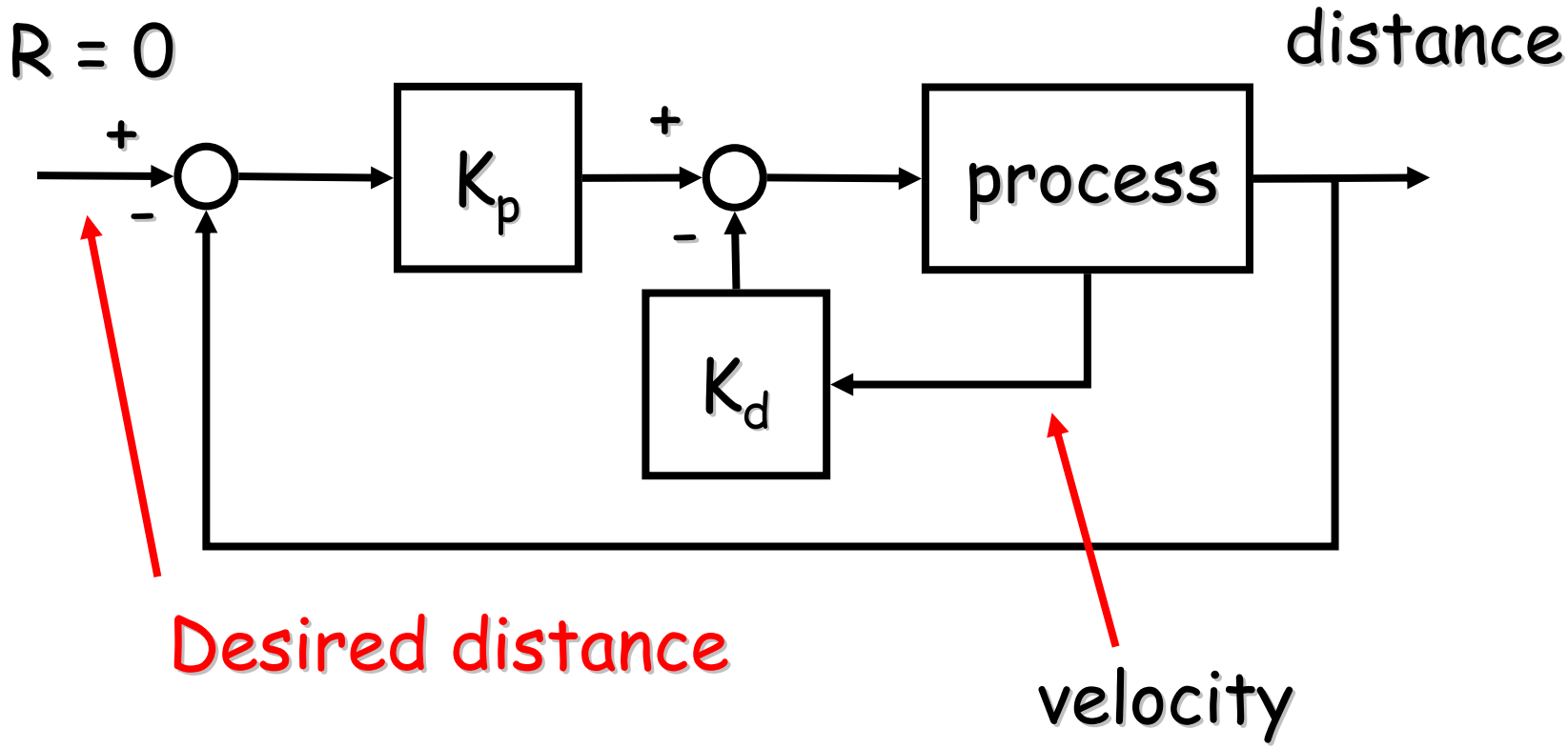
Demonstration



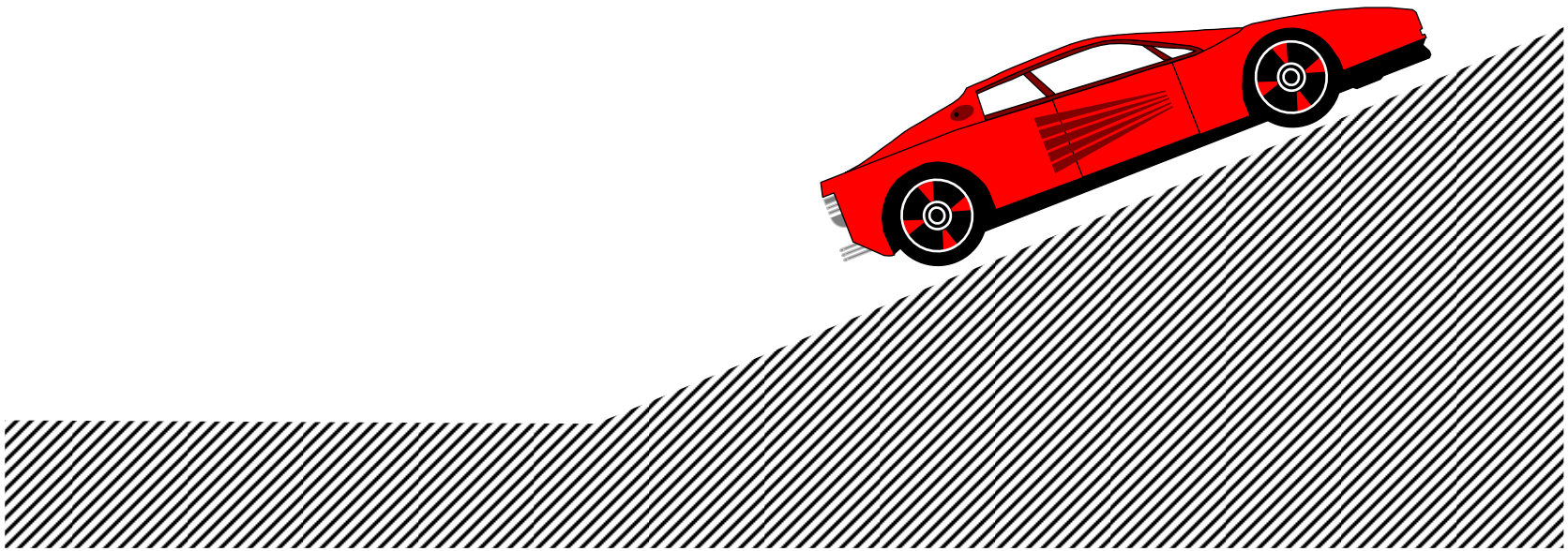
start
20-sim demo

20-sim
car_model2

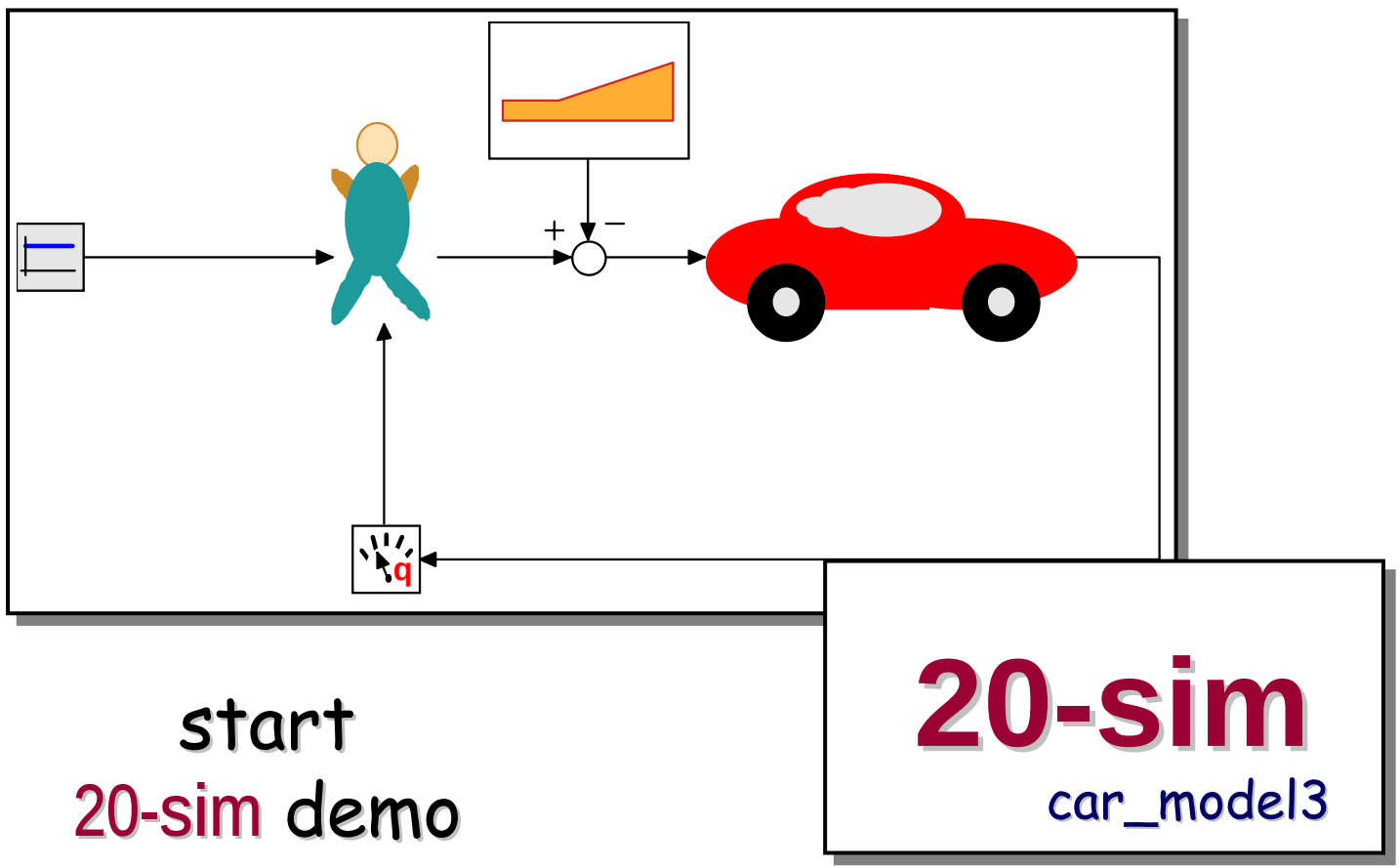
More abstract



Cruise Control

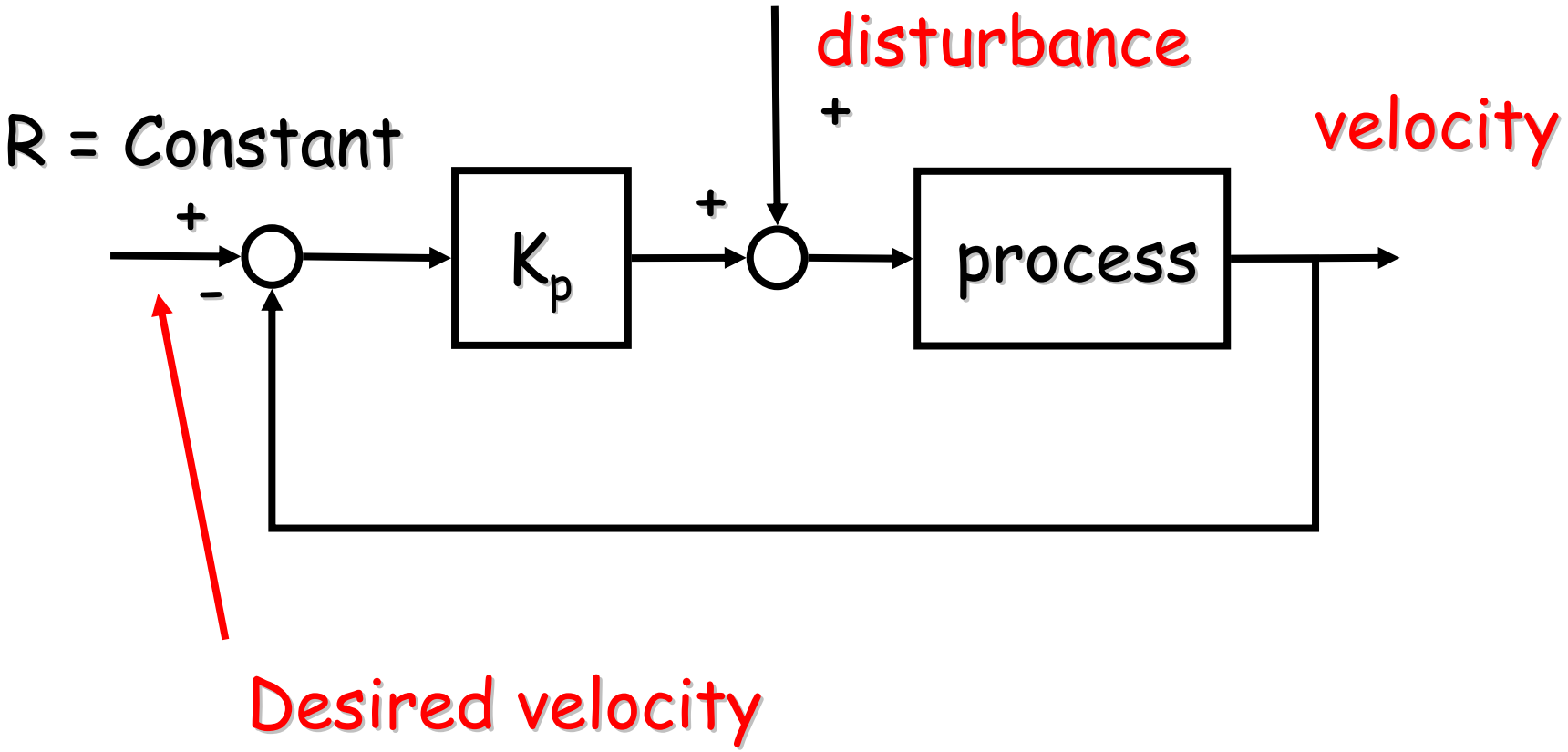


Demonstration



start
20-sim demo

More abstract cruise control



Conclusions (1)

For accurate feedback control

- high gains
- integrators

But

- high gains and integrators give lead to
  - oscillatory behaviour
  - instability

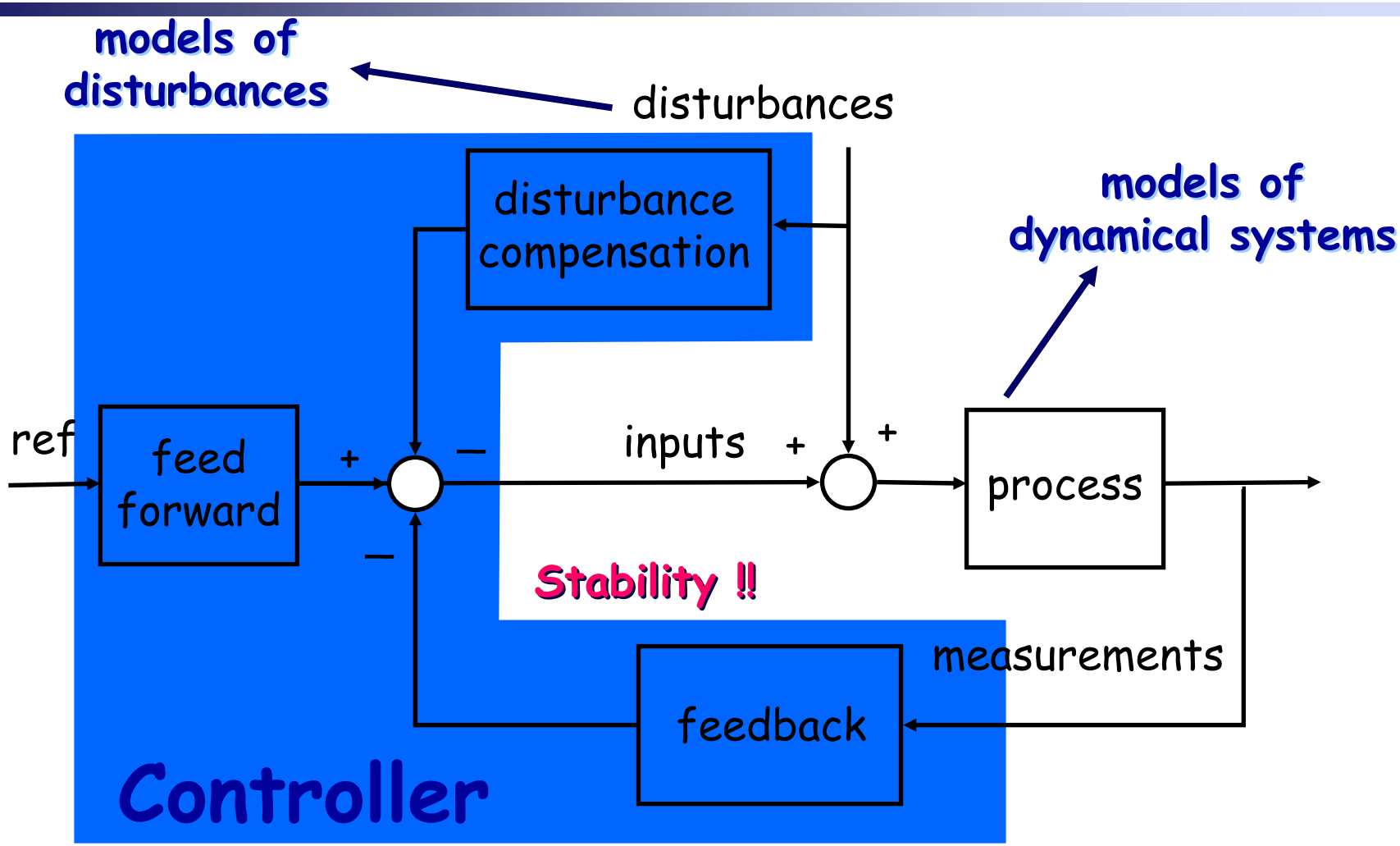
Conclusions (2)

- In the examples we did not use explicit knowledge of the models
- Better performance can be achieved when we use such knowledge

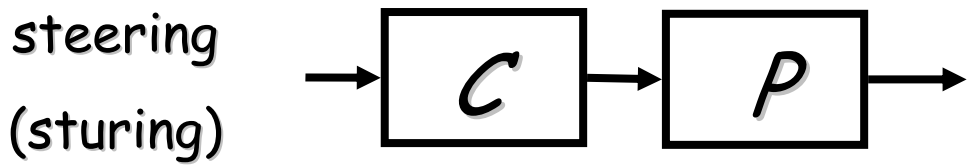
Movie

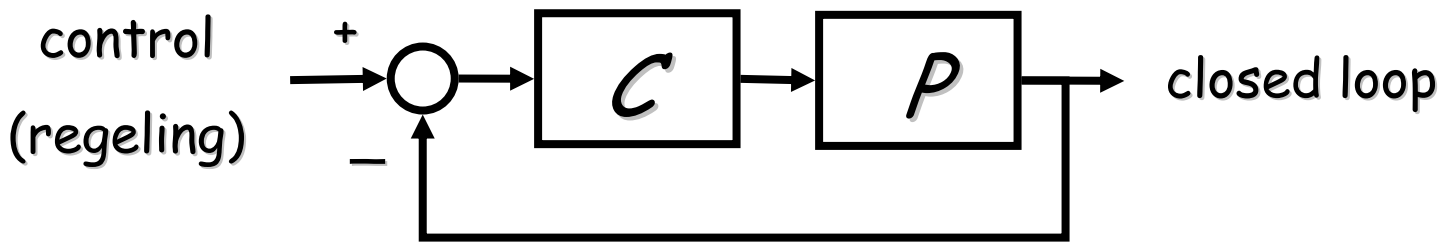
P22 project
(Mechatronica project)
experiences:
"Feedback"

Control Structures

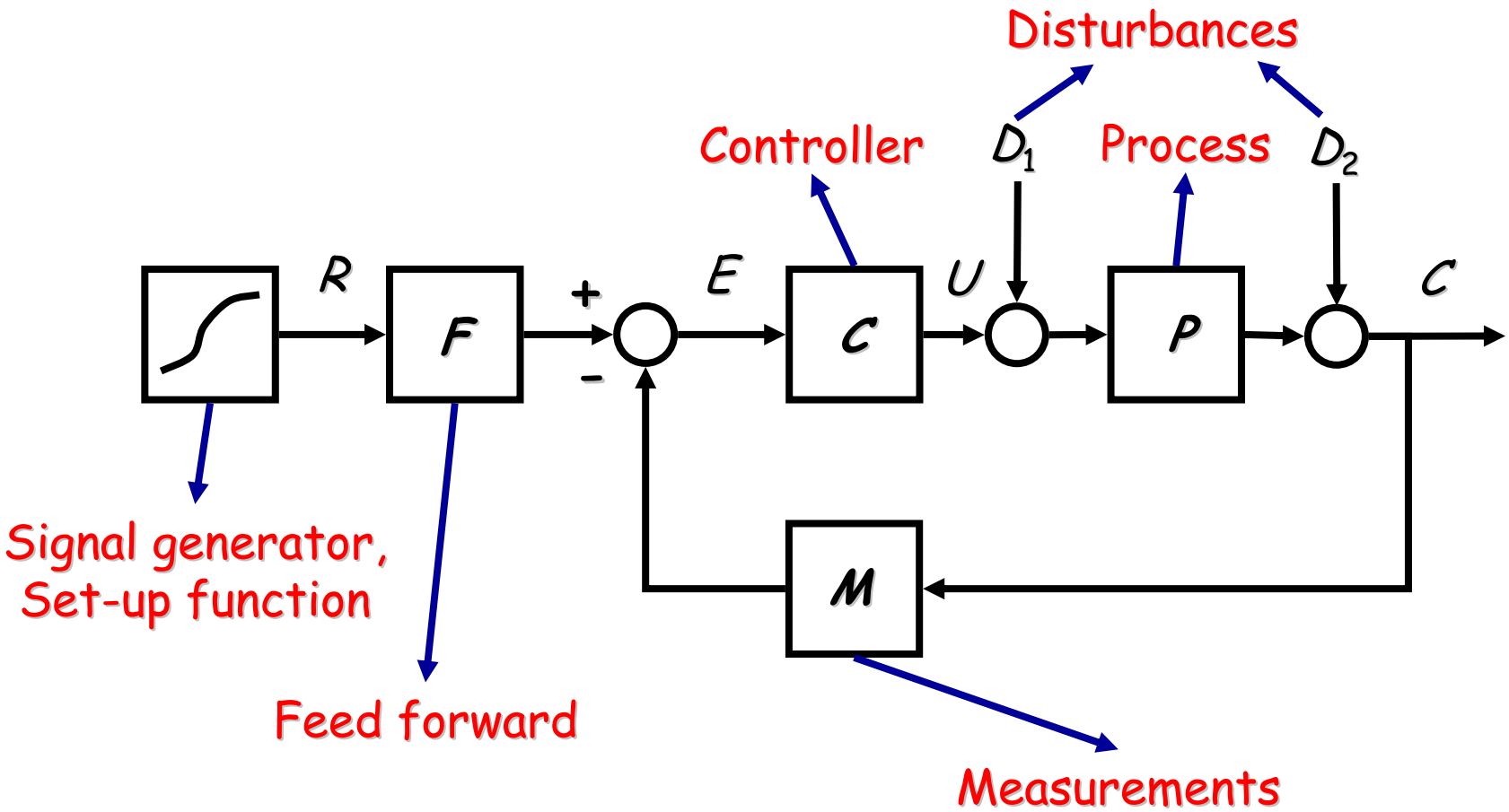


Steering versus Control

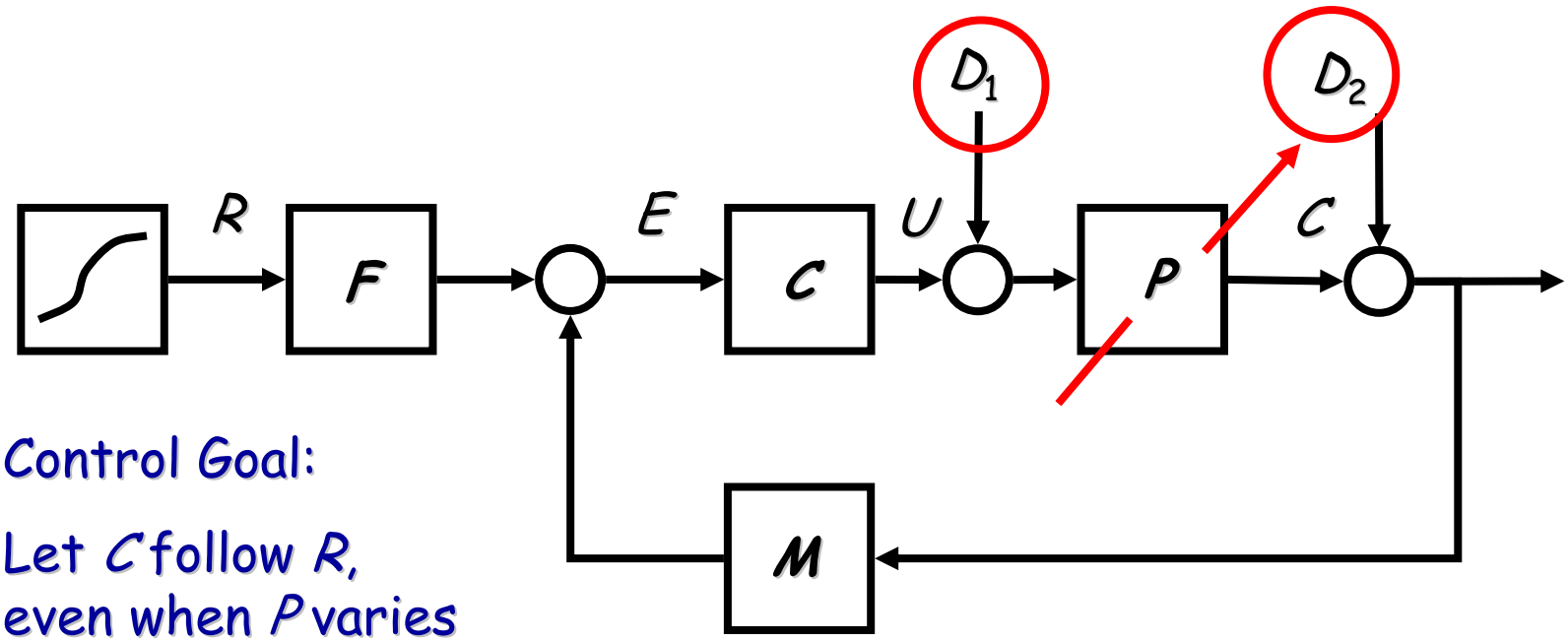




Standard Structure



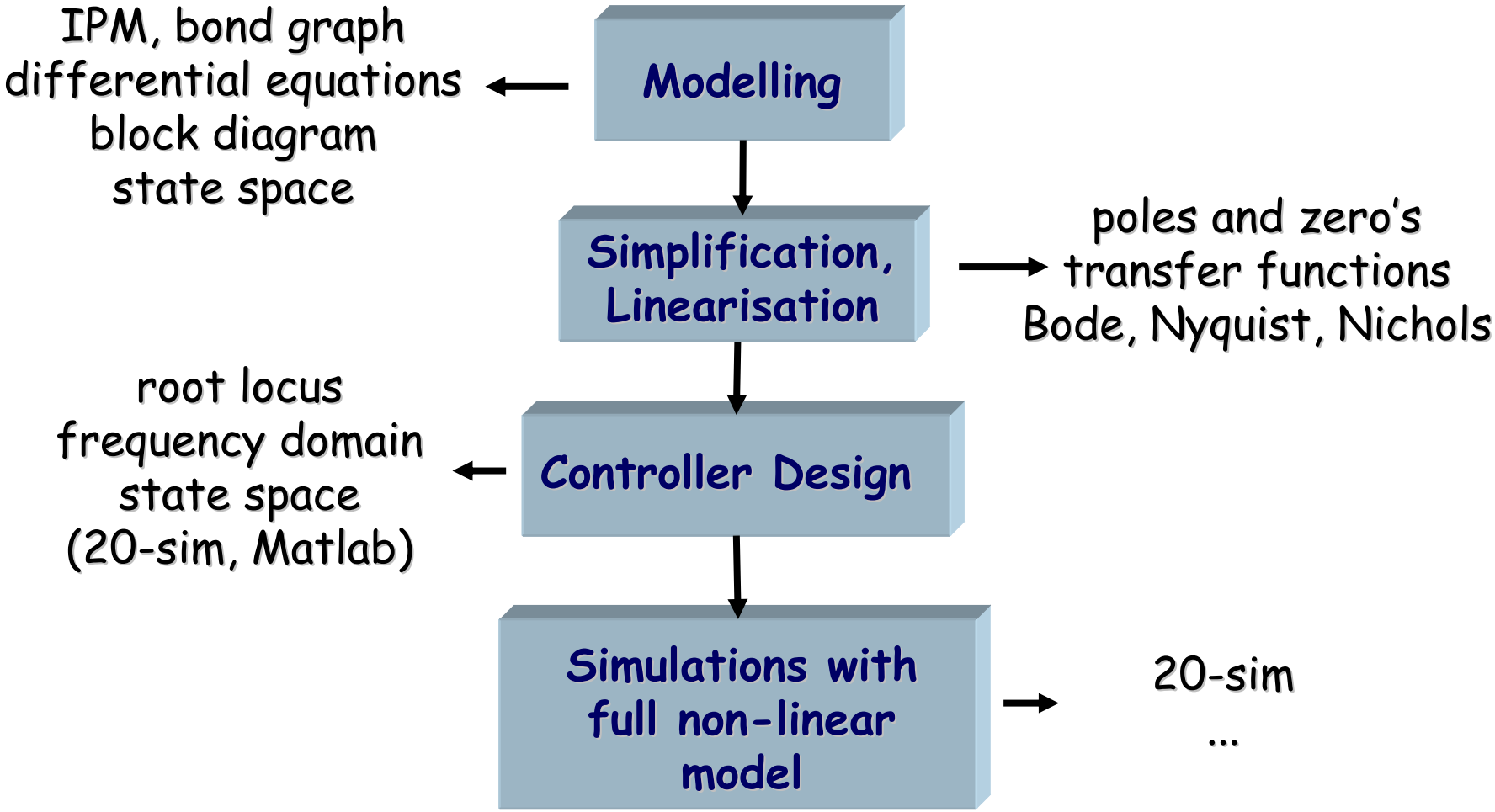
Standard Structure



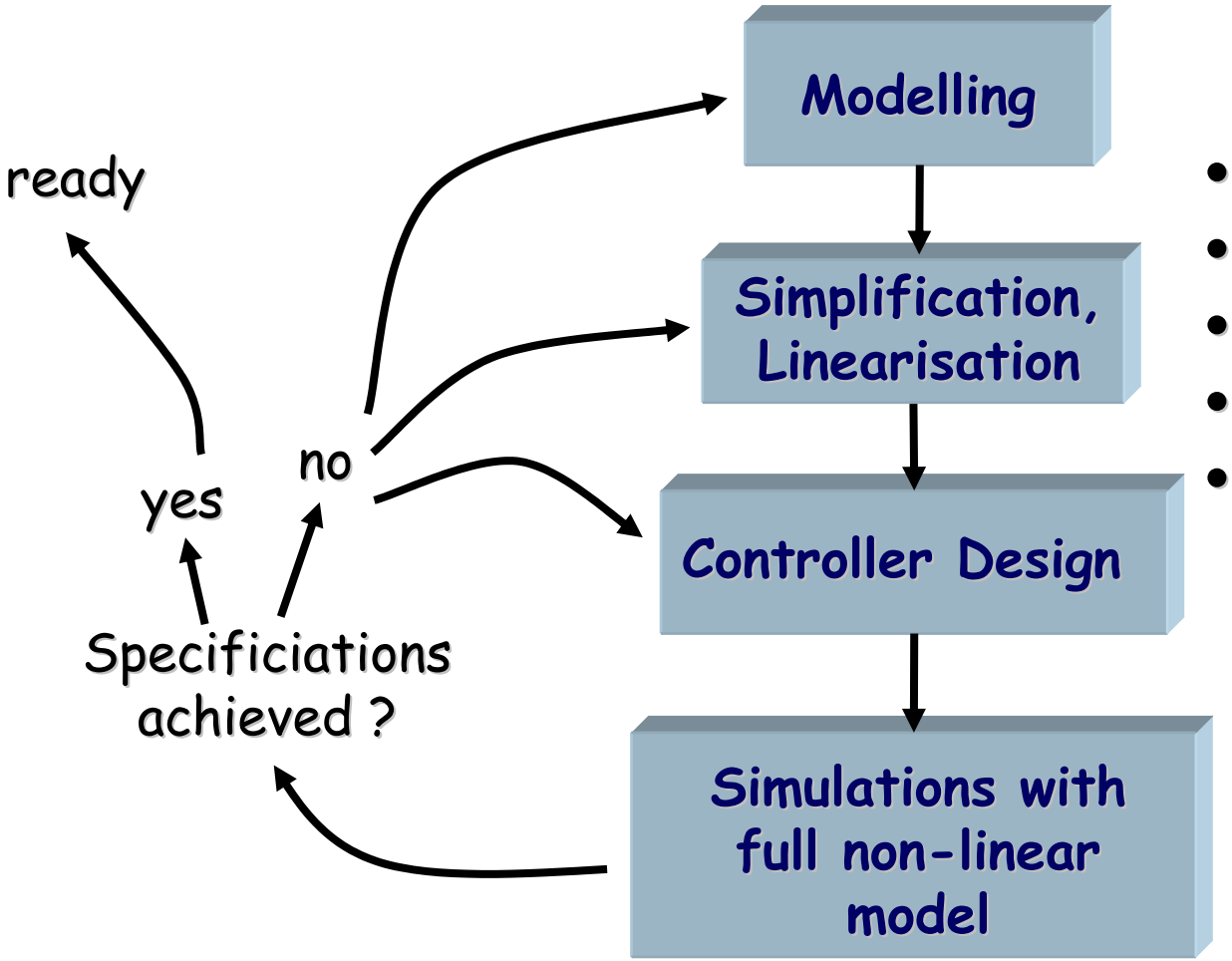
Control Goal:

Let C follow R,
even when P varies
and when D_1 and D_2
are present

Design issues

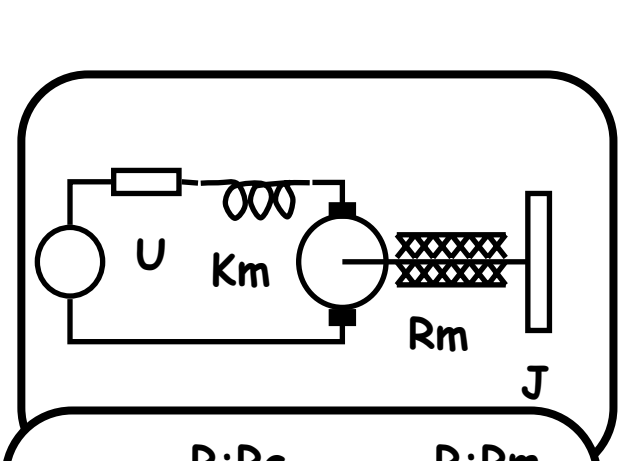


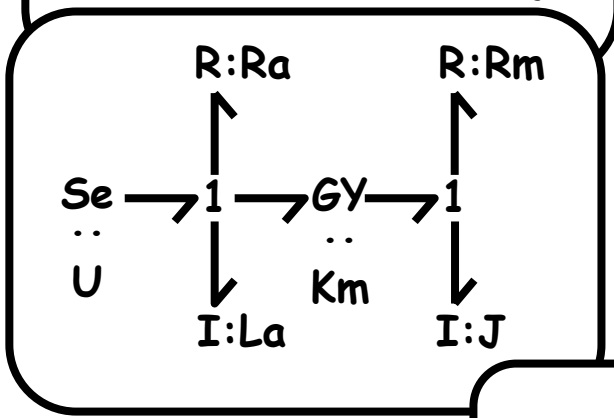
Design issues



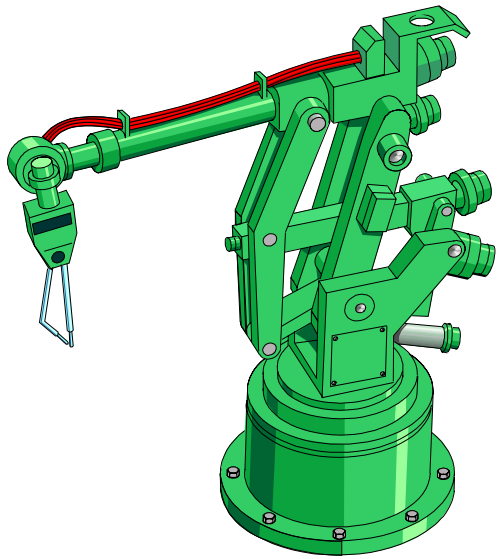
- speed of response
- bandwidth
- stability
- overshoot
- sensitivity for disturbances and parameter variatons

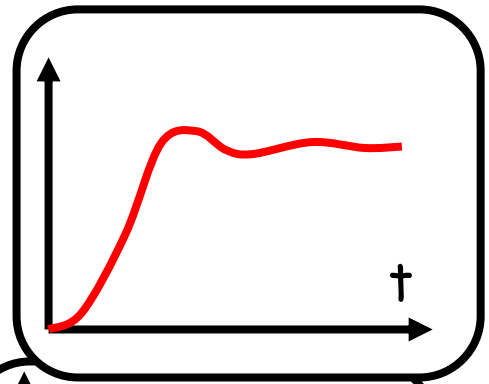
Multiple views

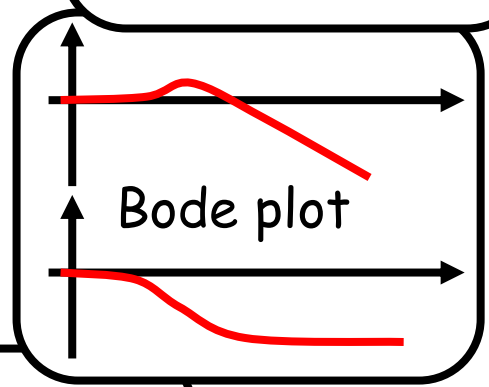


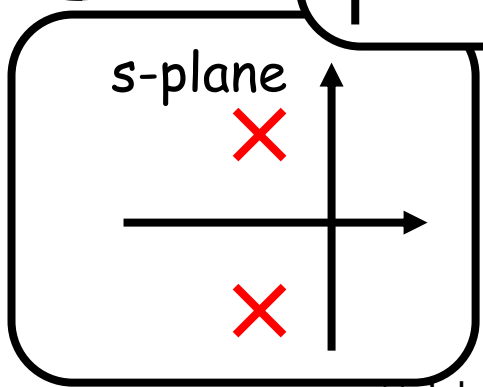


$$\frac{K}{s(s\tau+1)}$$









Relations with other courses

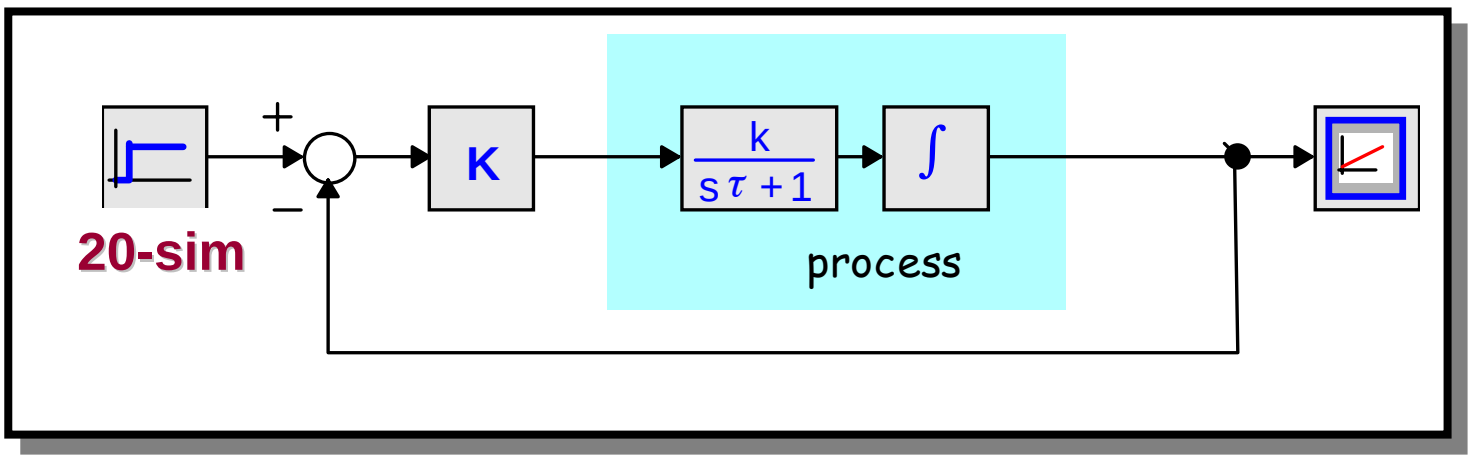
- Electrical networks
- Dynamic Systems
- Linear Systems

Control Engineering

- All kinds of systems with feedback
- Digital Control Systems, Intelligent Control
- MSc Mechatronics
- MSc Measurement and Control Engineering

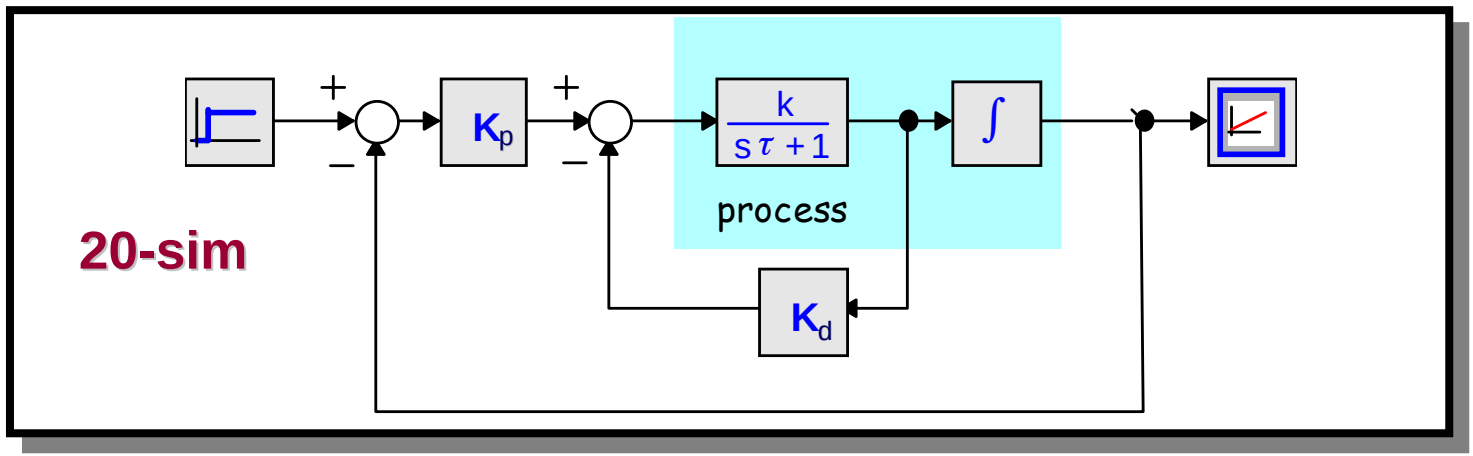
Exercise (1)

- Simulate the following controlled system for various values of K (multiple runs)
- Choose $k = 1$ and $\tau = 1$



Exercise (2)

- Simulate the following controlled system for various values of K_d
- Choose $k = 1$ and $\tau = 1$ and $K_p = 10$



Exercise (3)

- Simulate the following controlled system for various values of K_p
- choose $k = 1$ and $\tau = 1$