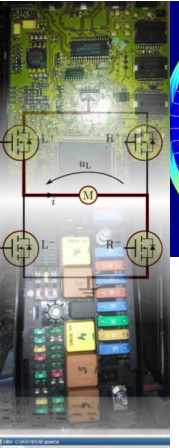
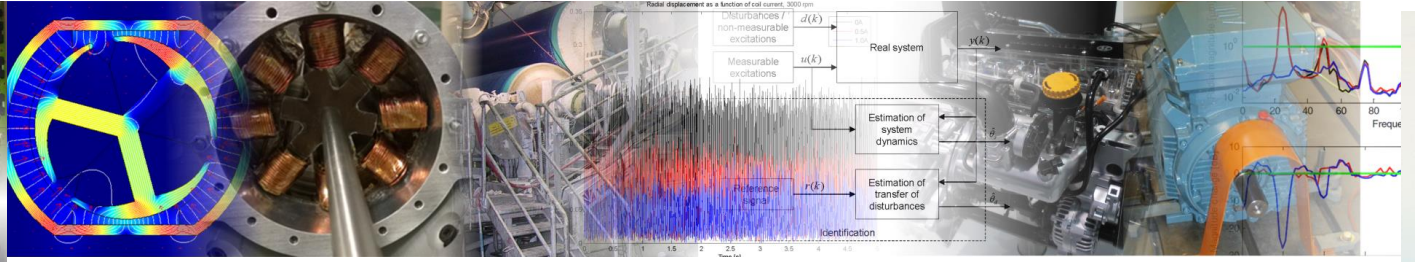
Aalto University
School of Engineering

Mechatronics Machine Design (MMD)

MEC-E5001, 7.1.2020-
Lecture 1
On Jan 7, 2020
Kari Tammi, Associate Professor

Background info

Kari Tammi, started with Aalto on Aug 17, 2015

- **Earlier with VTT: electric machines, energy efficiency, control, rotor dynamics. Even earlier with CERN**
- **Taught Kon-41.4151 and Kon-16.4001 in 2015-2016**
- **Supervised ~50 MSc and 8 DSc theses 2015-2019**

Courses on the new Master's program:

- **MEC-E5001 Mechatronic machine design (5 cr, p. III)**
- **MEC-E5006 Vehicle mechatronics (5 cr, p. II)**

6 week spurt, stay active!

1) Introduction to the course and background of mechatronics, Mechatronic design process, Matlab re-cap
2) Laplace transform, Transfer function, Impulse and step responses, Basics dynamic models, **Preliminary exam** deadline
3) Operational amplifier circuits, AD & DA conversion, Bode diagram, Release of **project work**
4) Common control topologies, PID controller, Control applications, Laboratory exercise
5) Mechatronic machine design with case example, Visiting lecturer
6) Summary of the course, Students' reflections: what we learnt, Mutual feedback, Project work deadline
7) Project work wrap up /gala

Take it seriously!

5 credit means more than 100 hours work!

Preliminary Exam: easy, if you read, but must pass

Average hours spent for exercises

1st	2nd	3rd	4th	5th	Lab.	Project
4 h	9 h	7 h	7 h	8 h	4 h	23 h

How to complete the course?
See Mycourses

0) Preliminary exam: pass/fail (19 answers correct → pass)

1) Grade from lecture quiz: weight 20 %

2) Grade from exercises including lab exercises: weight 50 %,

3) Grade from project work: weight 30 %

Min 50 % required in each 1), 2), and 3)

Questions?

Why to complete the course?

My mom told to me? University offers a course?

Meet interesting people? A (potential) friend studies?

Mechatronics engineer gets a job:

- **Mobile machinery, hoisting systems**
- **Marine, automotive, aerospace & military**
- **Process industry, manufacturing, assembly**
- **Medical, consumer electronics**
- **Construction, logistics**

Mechatronics is fun

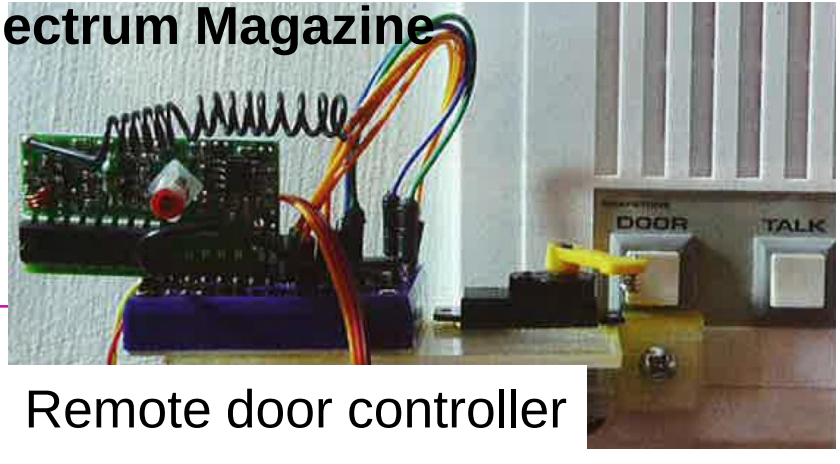
- Have interesting projects
- Learn & innovate together
- Create new without limits

This course offers more theoretical insight in mechatronic machine design

Pics by IEEE Spectrum Magazine

Type writing gloves

Arduino mini bulldozer



Remote door controller

Learning goals, the student…

1) can recognise mechatronic machines and analyse the fundamental functions of mechatronic machines: sensing, actuation, and control (should be already achieved and pre-exam is to check it).

2) can analyse the prevailing physics in common mechatronic machines including rigid-body mechanical systems, basic electrical systems, power transmission, and control.

3) can design and realise control systems for mechatronic machines.

4) can work in a team carrying out design and numerical simulations of a mechatronic machine.

5) can evaluate scientific publications on a selected mechatronic system.

6) can report and present functionalities of the selected mechatronic machine.

Your expectations on the course?

Use mycourses forum for discussion

Extension to mechatronic basics

Challenging problem solving

Design considerations, what kind of controllers to be used?

Connection between the theory and applications

How to utilise control theory in practise?

Learning goals, this lecture, this week

Introduction to the course and background of mechatronics

Mechatronic design process

Learning / re-cap of numerical methods with Matlab

Mechatronics

Q: What is mechatronics?

A: ”… design process that includes a combination of mechanical engineering, electrical engineering, telecommunications engineering, control engineering and computer engineering…

… multidisciplinary field of engineering, that is to say, it rejects splitting engineering into separate disciplines…” (source: Wikipedia)

Q: Something missing from Wikipedia definition?

Kari's A:

- **Simply just: sensing, control, actuation**

But remember

- **Design engineering**
- **Product development**
- **Human – machine interface**

Why to increase machine complexity with mechatronics?

- **Improve safety and efficiency**
- **Comply the law and regulations**
- **Add intelligence, ergonomics, and services**

Can you give more specific examples?

Mechatronics improves machines

- **Safety: movement limiters, radar, stability control, operator surveillance**
- **Efficiency: engine control, electrification**
- **Law and regulations: emission, noise**
- **Intelligence: partially/fully automatic functions**
- **Ergonomics: remote control, driver's aid, vibration control**
- **Services: maintenance, fleet management**

Mechatronic machine product development

Research and development (R&D) in industry, several formal processes exist

Incremental, wiki, classical development circle

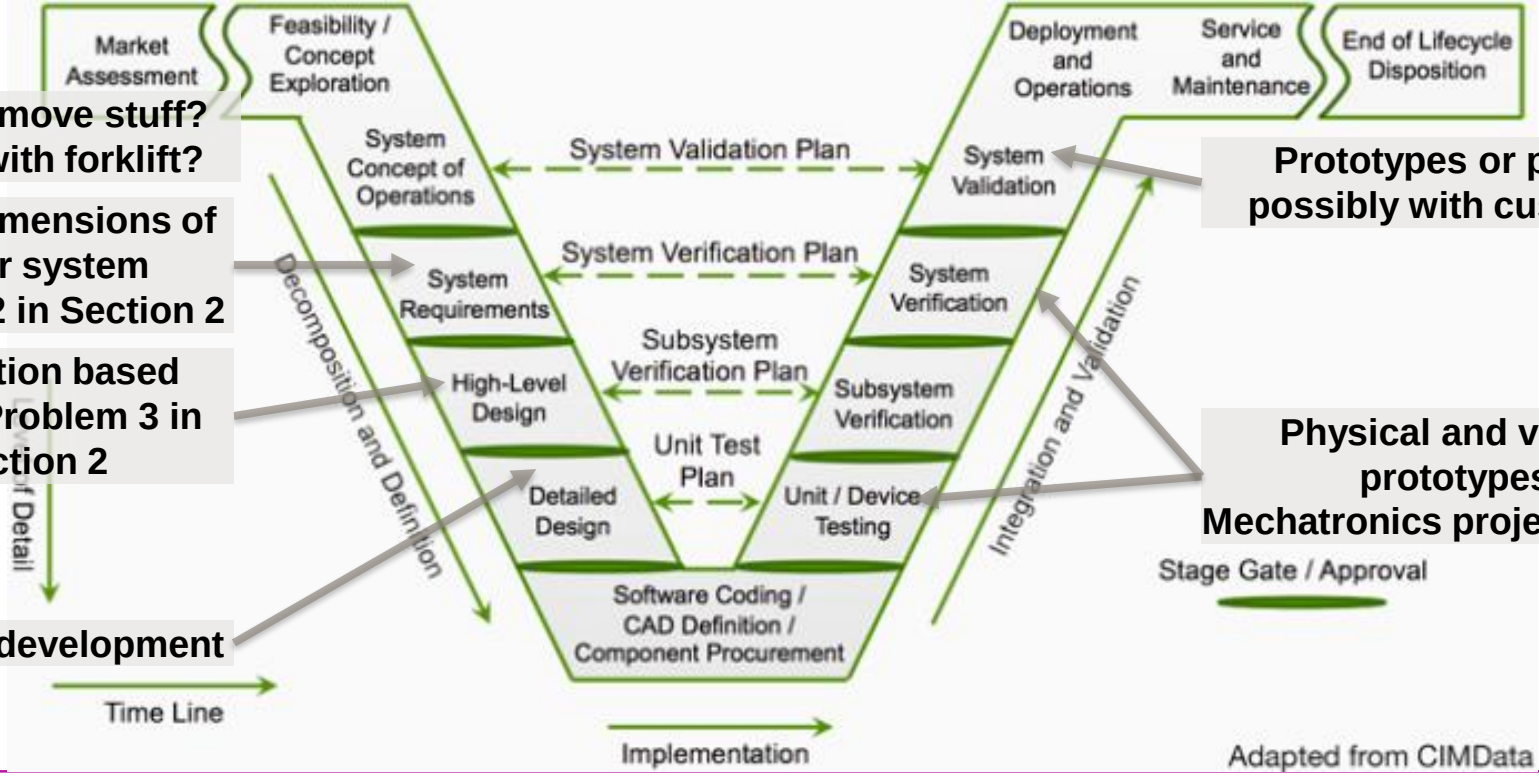
Waterfall, wiki, classical definitions chain

V cycle, wiki, modern variation, emphasises validation

Spiral, wiki, sequences of waterfall chains

Scrum, wiki, modern, modern emphasises customer perspective

V cycle in context of forklift truck example (see preliminary exam material)



Need to move stuff? Maybe with forklift?

Rough dimensions of power system Problem 2 in Section 2

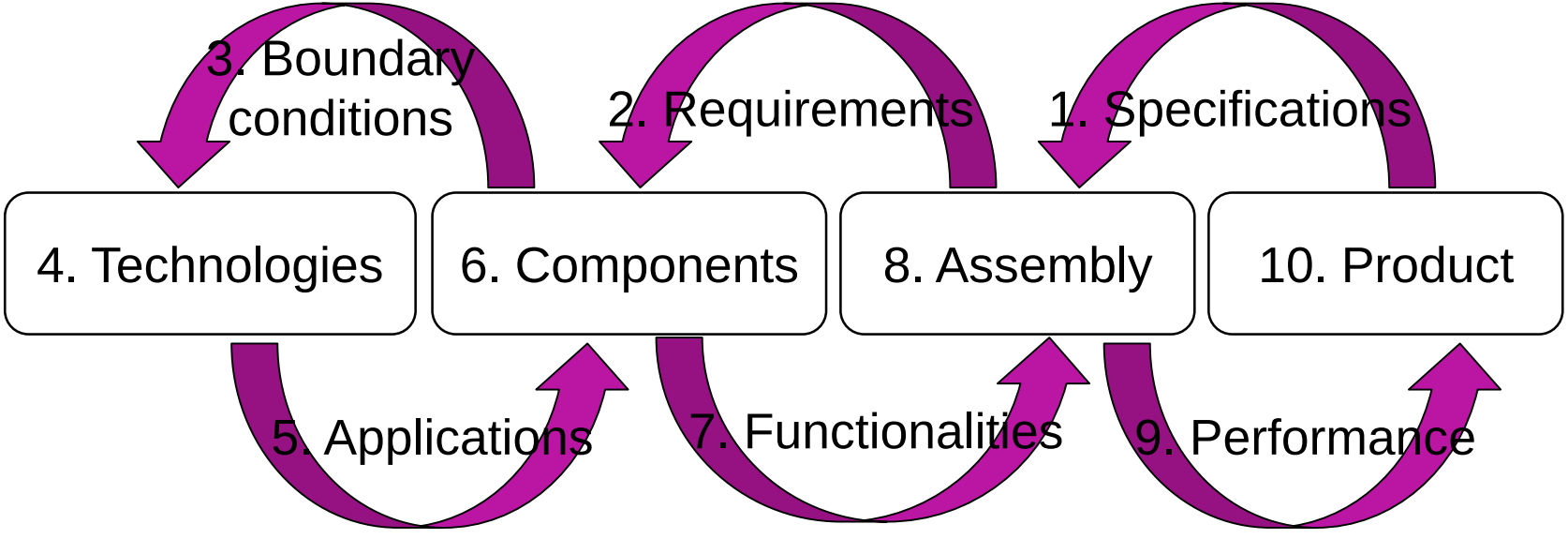
Simulation based design Problem 3 in Section 2

Software development

Prototypes or pilots, possibly with customer

Physical and virtual prototypes Mechatronics project course

How to think design process simply? ("Kari's simple R&D process")



Group work (and lecture quiz)

Group work & lecture quiz 1

Consider formalised R&D processes and consider the roles you are likely to have during your careers. Answer the lecture quiz today Jan 7, 2020.

1. **Discuss with your pair: Why the R&D processes are required, What they enable, What they limit? (1 point)**
2. **In larger groups (~4 persons), get roles: sales engineer, quality engineer, R&D engineer, testing engineer. Think about the duties in a given role. Answer the following questions. (1 point)**
   - What I'm expected to do?
   - What I'm expected to report?
   - What is reported to me?
   - When I meet a Sales engineer/ Quality engineer/ R&D engineer/ Testing engineer (choose three other roles you do NOT represent), about what we speak?
3. **Start to familiarise with Matlab/Simulink. Solve differential equation**

$\ddot{x}(t) + 0.1\dot{x}(t) + x(t) = sin(10t)$**. The initial conditions are all zeros, plot x from 0 s to 10 s. (1 point)**