



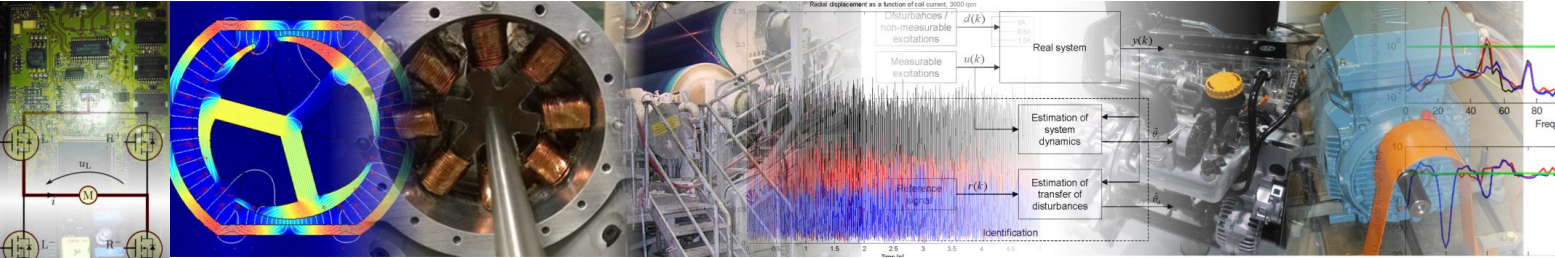
Aalto University  
School of Engineering

# Mechatronics Machine Design (MMD)

*MEC-E5001*

*Lecture 1*

*Kari Tammi, Associate Professor*



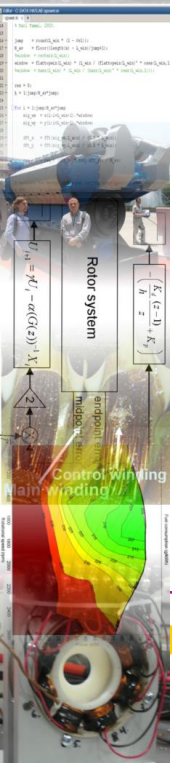
# Background info

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 ~80 MSc and 12 DSc theses 2015-2021

Courses on the new Master's program:

- MEC-E5001 Mechatronic machine design (5 cr, p. III)
- MEC-E5012 & E5011 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

# Answers to some questions

**No mandatory background requirements, but good command or ability to learn quickly Matlab and Simulin is must**

**Mechatronics basic, Mechatronics project courses are recommended, but not required**

**Possible to complete this course online**

**Preliminary exam must be passed**

# 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**

**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



Remote door controller

Type writing gloves



Arduino mini bulldozer



# 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
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# Your expectations on the course?

**Lot of work**

**How to build what a want to build**

**Learning about control and signal processing**

**Insight about future jobs**

**Also: use mycourses forum for discussion**

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# 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)

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# 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

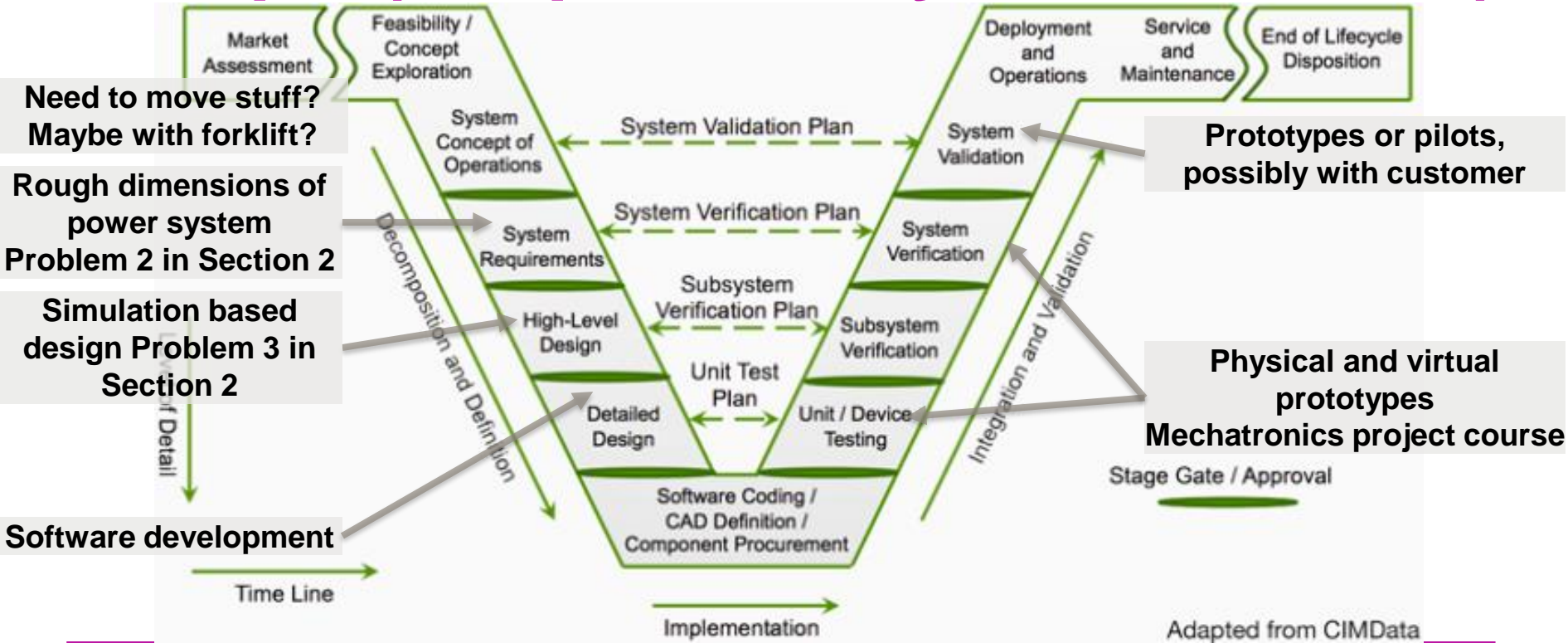
Waterfall, wiki, classical definitions chain

V cycle, wiki, modern variation, emphasises validation

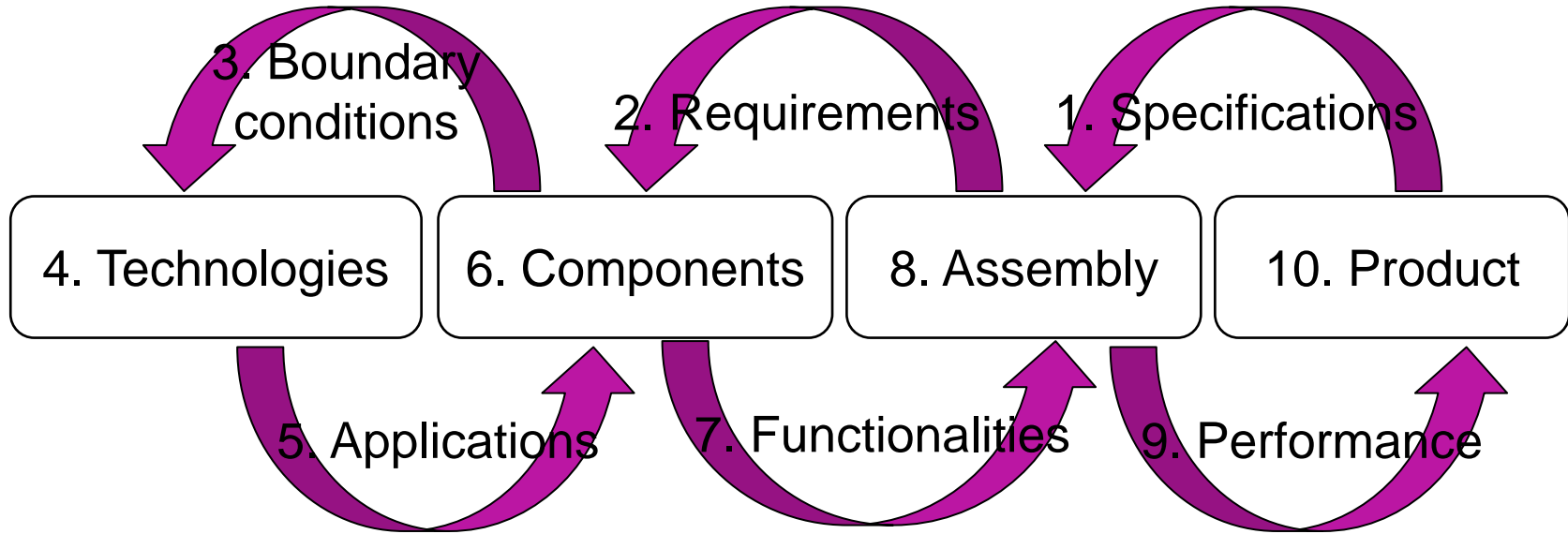
Spiral, wiki, sequences of waterfall chains

Scrum, wiki, modern, modern emphasises customer perspective

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



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



# Group work (and lecture quiz)

# Group work & lecture quiz 1 – check up-to-date questions and return in Mycourses

Consider formalised R&D processes and consider the roles you are likely to have during your careers. Answer the return lecture quiz.

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  $x''(t) + 0.1x'(t) + x(t) = \sin(10t)$ . The initial conditions are all zeros, plot x from 0 s to 10 s. (1 point)**