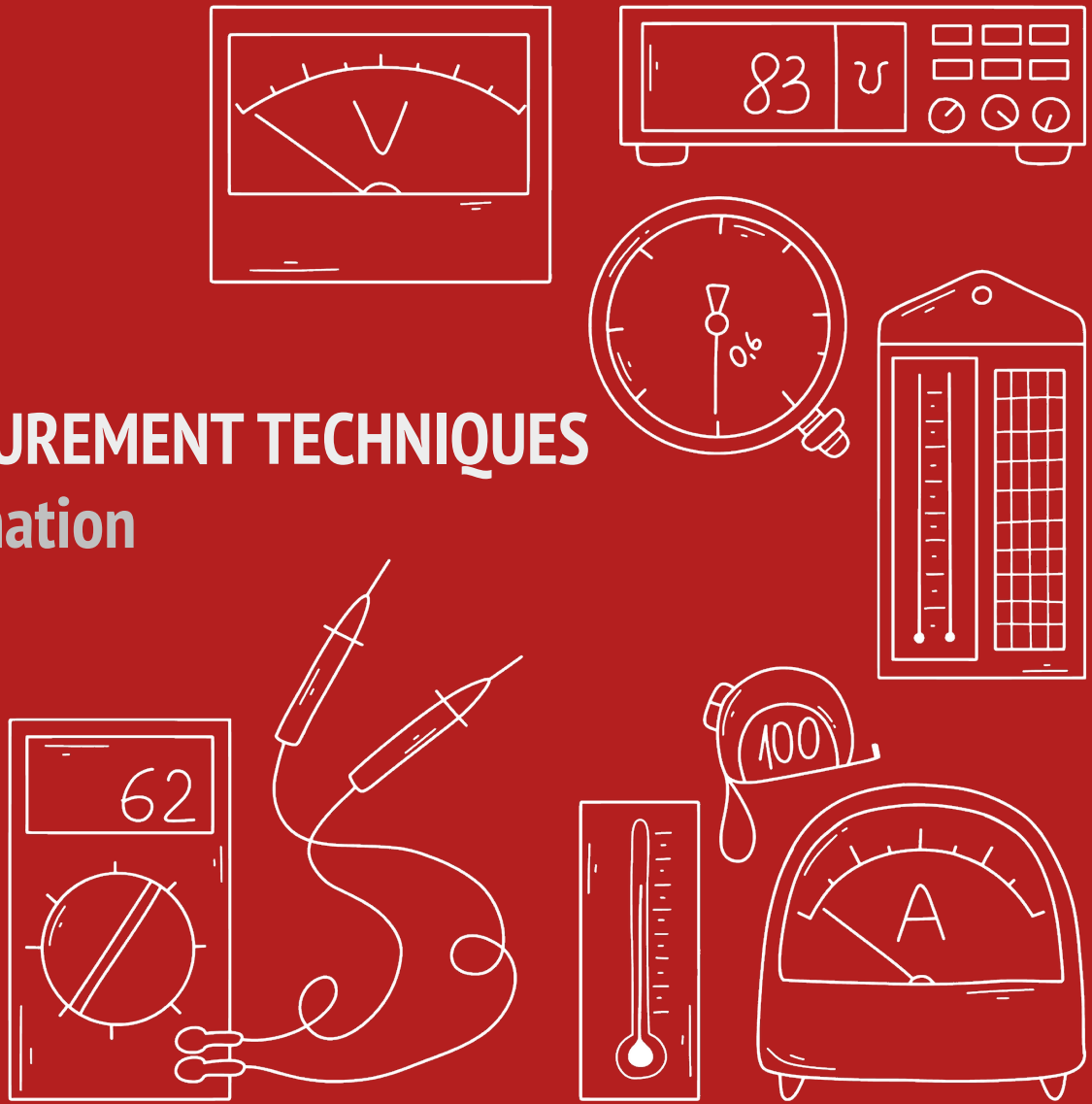
ME-301 MEASUREMENT TECHNIQUES

General information



last compiled by K. Mulleners - February 20, 2025

General information

Course description

Theoretical part

Practical part

Questions

ME-301 Measurement techniques

Nowadays, data science and data-driven methods are widely used in many aspects of our personal and professional lives. Yet, the success of many of these methods is limited by the quality of the data that they are driven by. As future engineers, it is essential not only to learn how to apply, implement, and develop data-driven methods, but also to understand how data is generated, how to accurately measure key quantities, the working principles and limitations of commonly used measurement techniques, the physical limitations of measurement systems, potential sources of error and uncertainty that may arise, and how to debug a measurement system.

The goal of ME301 is to provide you with theoretical understanding and practical experience of:

- experimental methodology and practice i.e. how to do experiments
- sources of error and uncertainty in acquiring data
- working principles behind common experimental systems for the measurement of physical quantities
- signal processing tools for conditioning and analysing measurement data

ME-301 Measurement techniques

Course summary

This is a **theoretical** and **practical** course on basic measurement principles and experimental techniques for observation and measurement of physical variables such as force, strain, temperature, flow velocity, structural deformation and vibrations, etc.

Credits: 4 ECTS

4 ECTS correspond to a total expected workload of 4 x 30 h = 120 h or roughly 8.5 h/week for 14 weeks. We counted roughly a total estimated workload *per person* in the group of 80 h or a little over 6 h/Friday that we are in session this semester for the practical part and 40 h for the theoretical part.

Assessment methods:

- **Final written exam** (30 %)
- **Technical report** (70 %)

Course information:

Theoretical part

CONTENT The theoretical part consists of the following chapters:

1. General measurement principles
2. Signal processing
3. Specialised measurement systems
    a) Flow measurements
    b) Force, torque, and strain measurements (to be updated)
    c) Motion and vibration measurements
    d) Optical absorption measurements (to be updated)
    e) Temperature and thermal property measurements

There will be no in-person lectures, except for a master class on *Signal processing* by Dr Müllhaupt. The schedule is on the ME301 Notion website

LECTURE MATERIAL All course material is presented in form of video lectures by various lecturers that can be found on Mediaspace.

ASSESSMENT A written exam with multiple-choice questions on the theoretical course material will count for 30 % of your final grade.

Practical part

CONTENT You will learn how to use different measurement techniques and conduct an engineering experiment through a semester long practical group project.

You and your group will:

- design a simplified experiment inspired by a mechanical engineering problem
- select suitable measurement devices to measure different physical quantities such as force, strain, temperature, flow velocity, structural deformation and vibrations, etc
- conduct measurements
- condition the data signals
- perform an error analysis
- perform a frequency analysis

SCHEDULE A team of teachers & assistants will be available at the SPOT on Fridays

Room MED 2 2423 is freely available to you unless it is used for meetings that are indicated in the schedule on N. The assistants will only be present in the SPOT.

ASSESSMENT A technical report describing the design and characteristics of the measurements systems used and a summary of the measured data will count for 70 % of your final grade.

Practical part

REQUIREMENTS Each group has to design a simple experiment, preferably inspired by a mechanical engineering problem or question, integrating **THREE** measurement systems. You are free to select the topic and the quantities you want to measure, use your creativity but keep it simple. The three measurement systems should be different, i.e. they should have different signal conditioning elements and/or sensing elements.[a] You will characterise the selected measurement systems and apply them to obtain measurement data. Each group also has to perform a frequency analysis on .

FOCUS Through this course you should gather theoretical and practical knowledge on basic measurement principles and the most commonly used measurement devices. The focus should be on the practical design of the experiment, the selection and correct application of the measurement techniques, and the signal conditioning and analysis. You should not worry about using your data to solve an engineering question or problem (that is for a different course), but we hope you use the engineering question or problem as inspiration for your experiment.

[a] See the video lecture on **General measurement principles** for the description of measurement systems.

Practical part

RESOUCES Each group will receive an Arduino kit and will have access to sensors and motors to design their experiment. A summary of the available material can be found on N. Overall, the resources you have access to overlap with those available in Prof. Hughes' ME320 course on Product development and engineering design (BA5). You can use the resources at SPOT, including 3D printers and laser cutting equipment, according to the SPOT guidelines. Short tutorials to use the most common equipment are also available on N.

SPOT stands for *Student Prototyping and Outreach Tank*. Find a series of videos on how to access and use the SPOT facilities here ▶.

All of you should follow the following mandatory trainings:

1. General training (add project make ME301 when following this tutorial)
2. *General introduction to safety* and *prototyping* on Moodle

When you have successfully passed these trainings, you will see a **green light** when presenting your CAMIPRO card at the SPOT entrance.

It is recommended that at least **one member per team** follows additional training for *laser cutting* and for *3D printing*. These trainings will be organised by the SPOT coaches during the first weeks of the semester.

Practical part

Manage your time For the practical part of the course, we counted roughly a total estimated workload *per person* in the group of 80 h or a little over 6 h/Friday that we are in session this semester. We suggest planning approximately 2 sessions for the design of the experiment + 6 sessions for testing, debugging, and measurements + 3 sessions for data analysis + 2 sessions for report writing (= 13 sessions)

Important dates Two mandatory progress meetings are planned during the semester to discuss your experimental plans, provide feedback, and evaluate progress:

1. During the third session, each group will meet in person with someone from the teaching team to discuss and review the experimental design.
2. Halfway through the semester, a follow-up meeting will be scheduled with the teaching team to discuss progress and challenges.

Each group will be requested to answer a questionnaire in the week prior to the meeting.
The meeting schedule will be available on

Expectations

What can you expect from us?

We do our best to

- provide you with a structure for the course
- expose you to different sources of information to help you understand the core teaching points e.g. course notes, course videos, text books, on-line material etc.
- help you develop critical thinking, problem-solving and debugging skills, and engineering best practice through demonstration (in course videos) and interactive discussion (during the Friday sessions at the SPOT)
- provide an environment where the knowledge and techniques from the course can be developed
- test you on the course material and set a standard that you need to pass

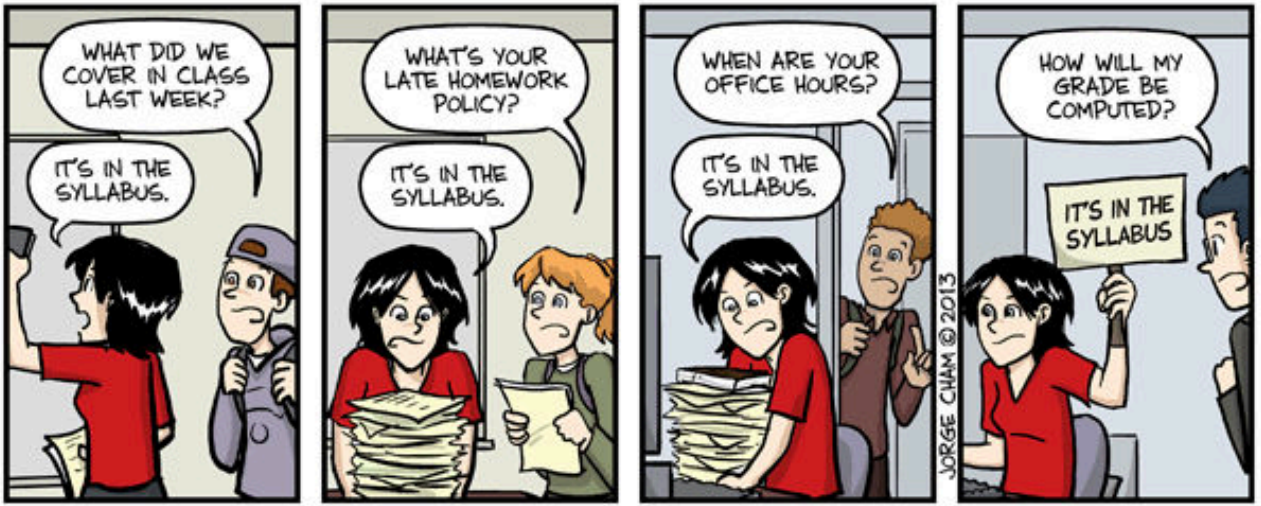
Expectations

What do we expect from you?

Experiments typically do not run flawlessly from the first time you run a test. It is an iterative process. You will learn the most by failing first. One of the most important skills of a modern engineer is the ability to debug, i.e. figuring out why a design/experiment/code does not work as planned and fix it. This course will help you further develop that skill. So, ...

- it is perfectly okay, and it can be productive to get things wrong, but
- understand that we will not show you how to solve every problem; we will however provide tools to help you solve problems and opportunities to bounce off ideas
- try not to be stubborn but be persistent - if something does not work, you might need to rethink your design/code/choices, this is typically not a waste of time, but a valuable learning experience
- allocate time for yourself and your team to process the course material, to fail, and to debug
- remember that feedback is a source for improvement and not a personal attack or criticism
- try not to respond to feedback with feedback; instead focus on understanding and internalizing the feedback received, considering its validity and relevance, and taking appropriate actions to address issues raised or implement suggested improvements
- remember that dividing tasks is not the same as sharing the workload and collaborating; use this course to further develop your team-working skills and use the diverse perspectives within your team to improve your individual skills and your collective results

Questions



For all other questions:

1. Ask the teachers or assistants during the Friday sessions at SPOT
2. Contact us