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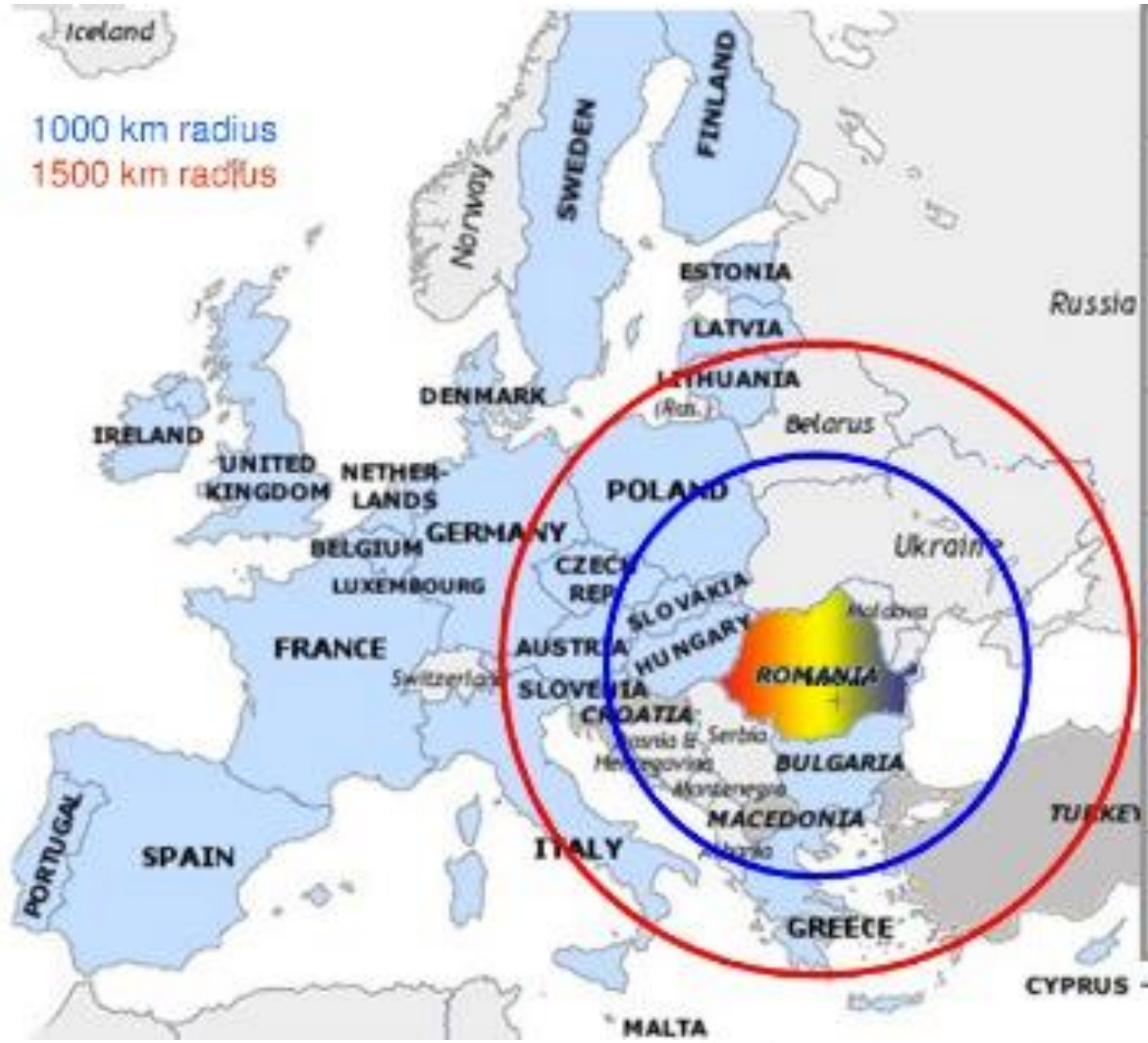
Cyber-Physical Industrial Systems

Tom SAVU, Rui SOUSA, Sawat PARARACH

Curriculum Development
of Master's Degree Program in
Industrial Engineering for Thailand Sustainable Smart Industry

Romania?



Area:	238,391 km² (9th largest in EU)
Population:	21.6 million (7th largest in EU)
Capital city:	Bucharest 2.1 million
European Union status	Member since January 1st, 2007
Affiliation:	NATO, WTO, WB, IMF.
Domestic currency:	LEU (RON) 1EUR=4.25 RON 1USD=3.20 RON (beginning of 2011)
Administ. division:	41 counties and Bucharest

www.romaniaIT.com

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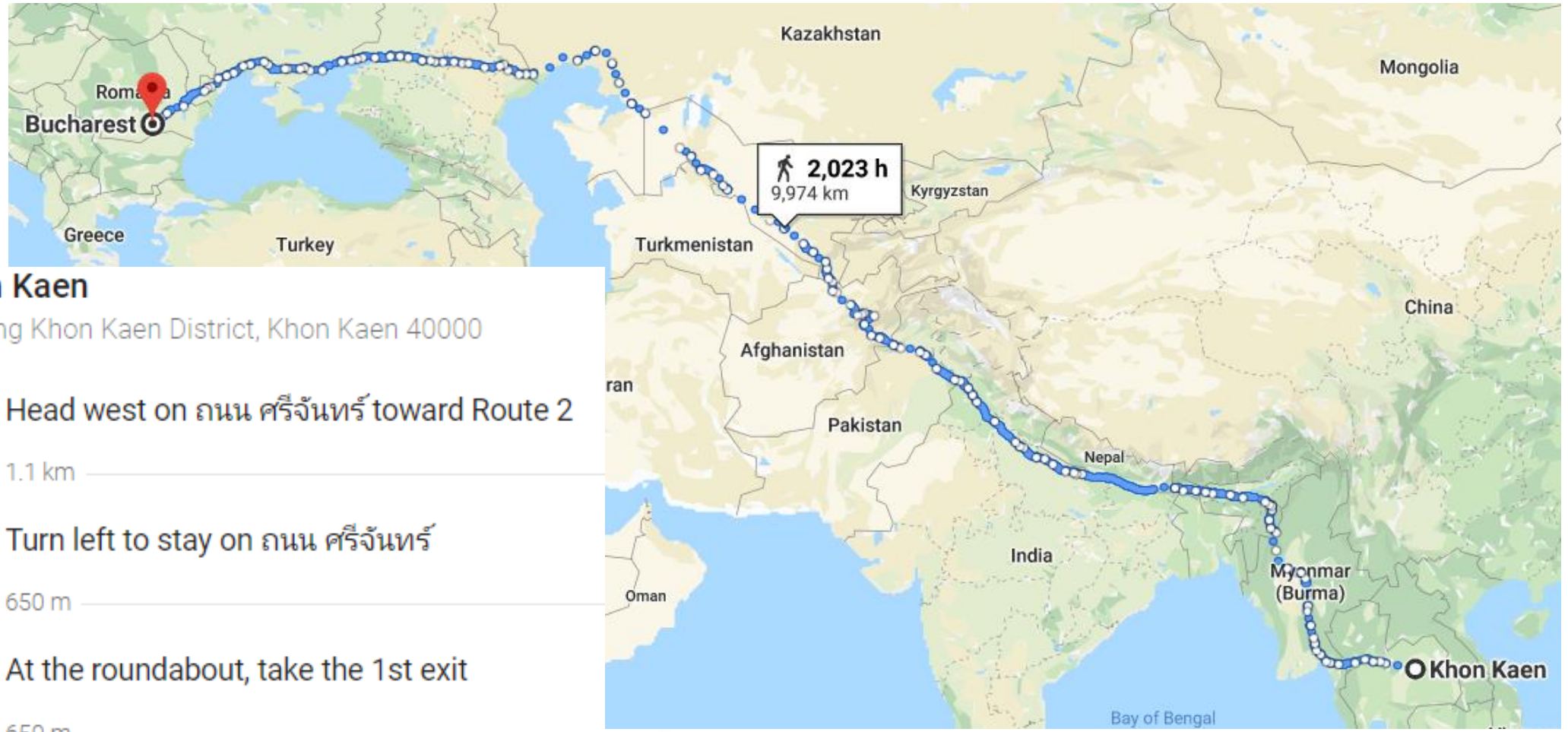
Romania?



Khon Kaen

Mueang Khon Kaen District, Khon Kaen 40000

- Head west on ถนน ศรีจันทร์ toward Route 2
  1.1 km
- Turn left to stay on ถนน ศรีจันทร์
  650 m
- At the roundabout, take the 1st exit
  650 m

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Country of Dracula

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Bucharest

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Bucharest

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Kunnai

Tuk Tuk

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Broadband speed – December 2019

#		Country	Mbps
1	-	Singapore	200.12
2	+1	Hong Kong (SAR)	164.88
3	+1	Monaco	148.91
4	+1	Romania	144.92
5	-3	South Korea	144.41

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Romanian academic system

56 state universities
28 private universities

Bucharest

- **POLITEHNICA University**
- **Civil Engineering University**
- **Architecture University**
- **Agronomy and Vet Medicine University**
- **The Bucharest University**
- **Medicine and Pharmacy University**
- **Economic Studies Academy**
- **National Music University**
- **National Arts University**
- **Theater and Movie National University**
- **National Sport Academy**
- **National School for Political Studies**

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UPB in figures

Undergraduate studies in 15 fields with 66 curricula (distinct specializations);
M.Sc. studies in 15 fields with 97 curricula (distinct specializations);
Ph.D. studies in 19 fields

18.382 undergraduate students
2.848 Master students
2.185 Ph.D. students
Post-graduate and post-doc trainees

2.234 academic staff positions
1.110 administrative staff
111 senior professors

38 research centers (57 % of the PUB's income)

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UPB Faculties

ELECTRICAL ENGINEERING
POWER ENGINEERING
AUTOMATIC CONTROL AND COMPUTER SCIENCE
ELECTRONICS, TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY
MECHANICAL ENGINEERING AND MECHATRONICS
INDUSTRIAL ENGINEERING AND ROBOTICS
BIOTECHNICAL SYSTEMS ENGINEERING
TRANSPORTS
AEROSPACE ENGINEERING
MATERIAL SCIENCE AND ENGINEERING
APPLIED CHEMISTRY AND MATERIALS SCIENCE
ENGINEERING TAUGHT IN FOREIGN LANGUAGES
APPLIED SCIENCES
MEDICAL ENGINEERING
ENTREPRENEURSHIP, BUSINESS ENGINEERING AND MANAGEMENT

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What CPS means?

A cyber-physical system (CPS) refers to the combination of computer-aided, **software components** with **mechanical and electronic parts**, which can be accessed via a **data infrastructure**, such as data centers where the Internet communicates.

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CPS examples

automated driving

source: Carnegie Mellon University

human-robot collaboration

source: Rethink Robotics

Smart grids

source: Siemens

automated farming

source: Kesmac

surgical robots

source: daVinci

Air traffic control

source: NASA

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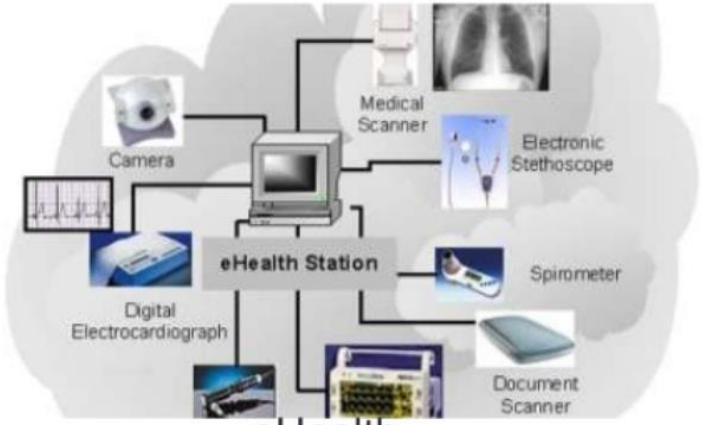
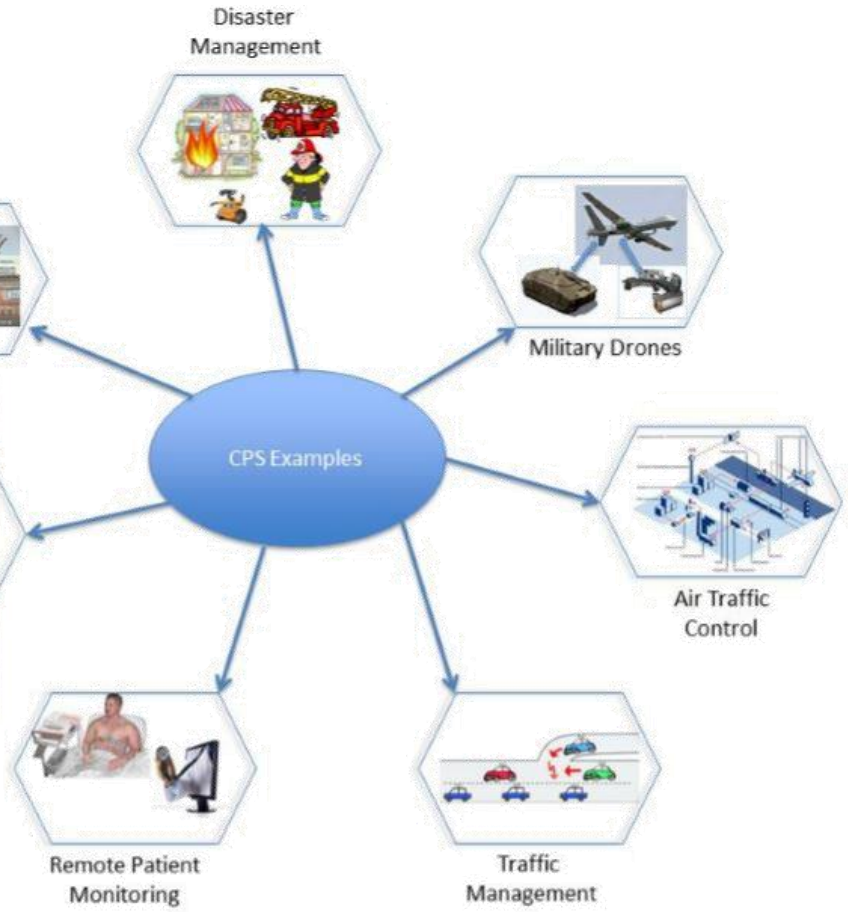
CPS examples



eHealth

Smart Home

Military



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Key functionalities

- Sensing;
- Processing;
- Physical Action;
- Communications;
- Energy;
- Coordination & Collaboration

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Course Objective

Gaining knowledge about: the main characteristics of the Cyber-Physical Systems, their application areas, components selection rules, programming methodology, specific aspects related to different measured physical parameters, data storage, reporting and communications.

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Course Learning Outcomes (CLOs)

The students, on the completion of this course, would be able to

- **CLO 1**: Identify links between industrial engineering knowledge and methods, on one side, and the design, modeling and management activities related to CPIS, on the other side (Analyze)
- **CLO 2**: Implement smart production and co-created product design & development concepts in CPIS related activities (Create)
- **CLO 3**: Identify use cases of big data and real time data analytics applied for CPIS, for supporting smart production, product design & development and advanced manufacturing process (Evaluate)
- **CLO 4**: Exploit the CPIS online connectivity for strengthening business capability (Apply)
- **CLO 5**: Applying CPIS related knowledge and competences for improving sustainability (Apply)

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Course content

Introduction - concept of CPS, basics, model	Lecture
Establishing the projects' subjects and forming the teams	Discussion
Identify the physical quantities to be measured or the datasets to be acquired and computed	Teamwork
Types of transducers, characteristics, application fields, selection criteria	Lecture
Choose or design the sensors and/or the transducers for measuring or for data collection	Teamwork
Signal conditioning basics	Lecture
Data acquisition basics	Lecture

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Projects' subjects

- Studying the variation of temperature, rotational speed and vibration frequency on several points of a lathe
- Measurement of the pressure generated at the compressor air outlet of a turbocharger
- Orthosis pressure measurement
- Bottle manipulator
- Analyzing the accuracy of distance ultrasonic transducers

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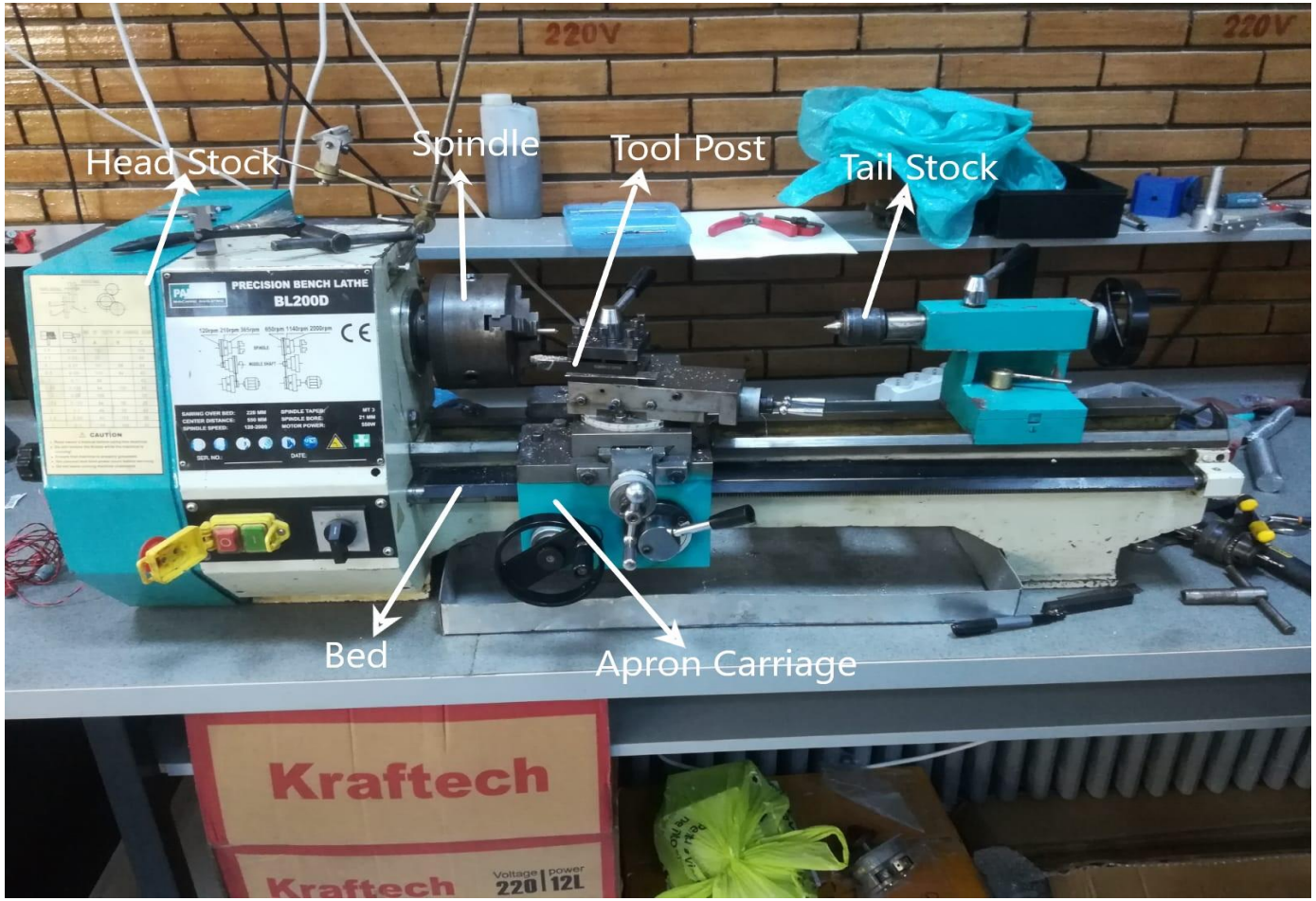
Identify phisycal quantities



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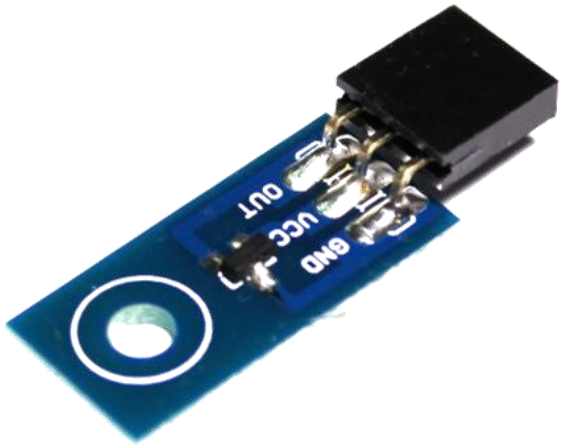
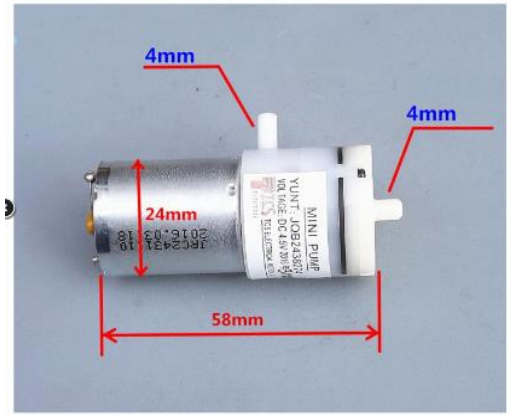
Choosing sensors and transducers





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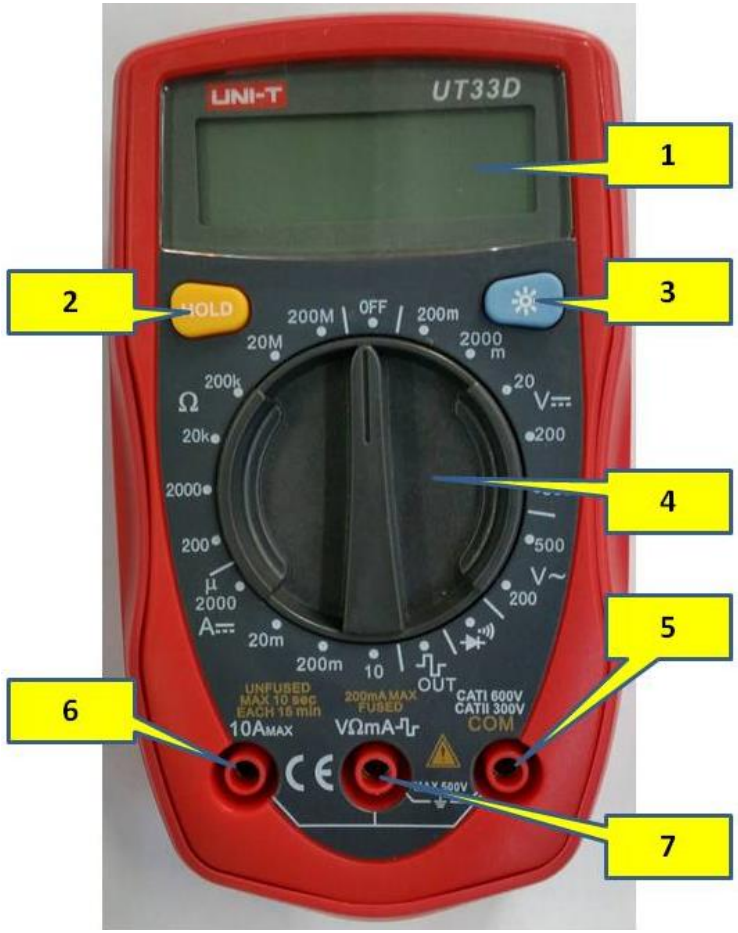
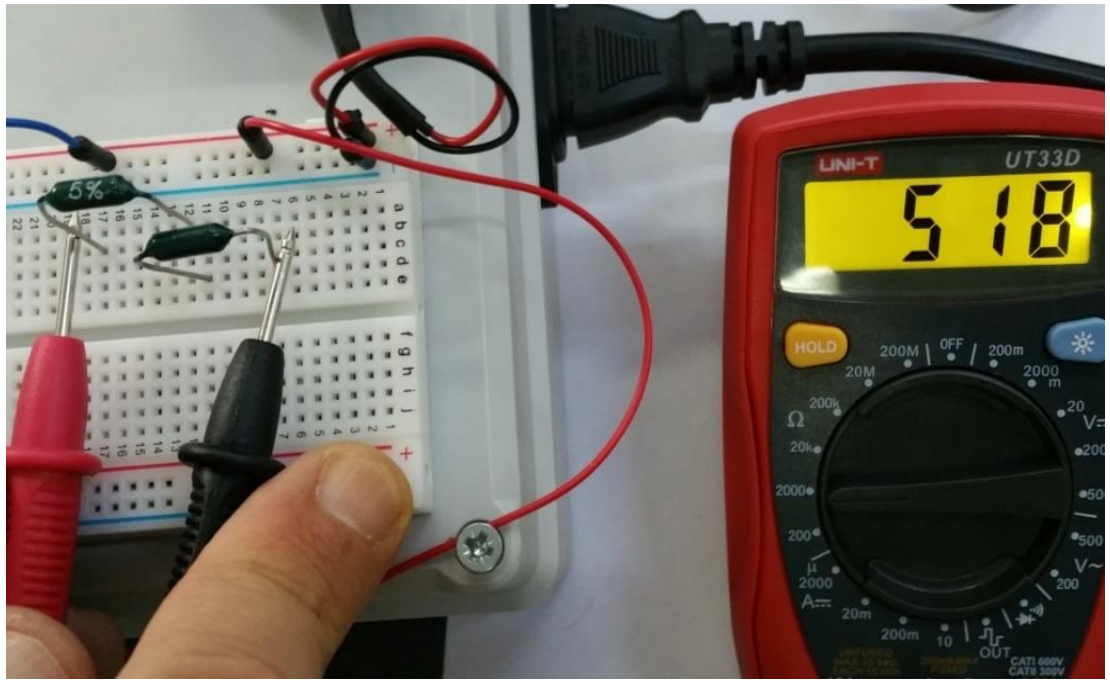
Data acquisition basics





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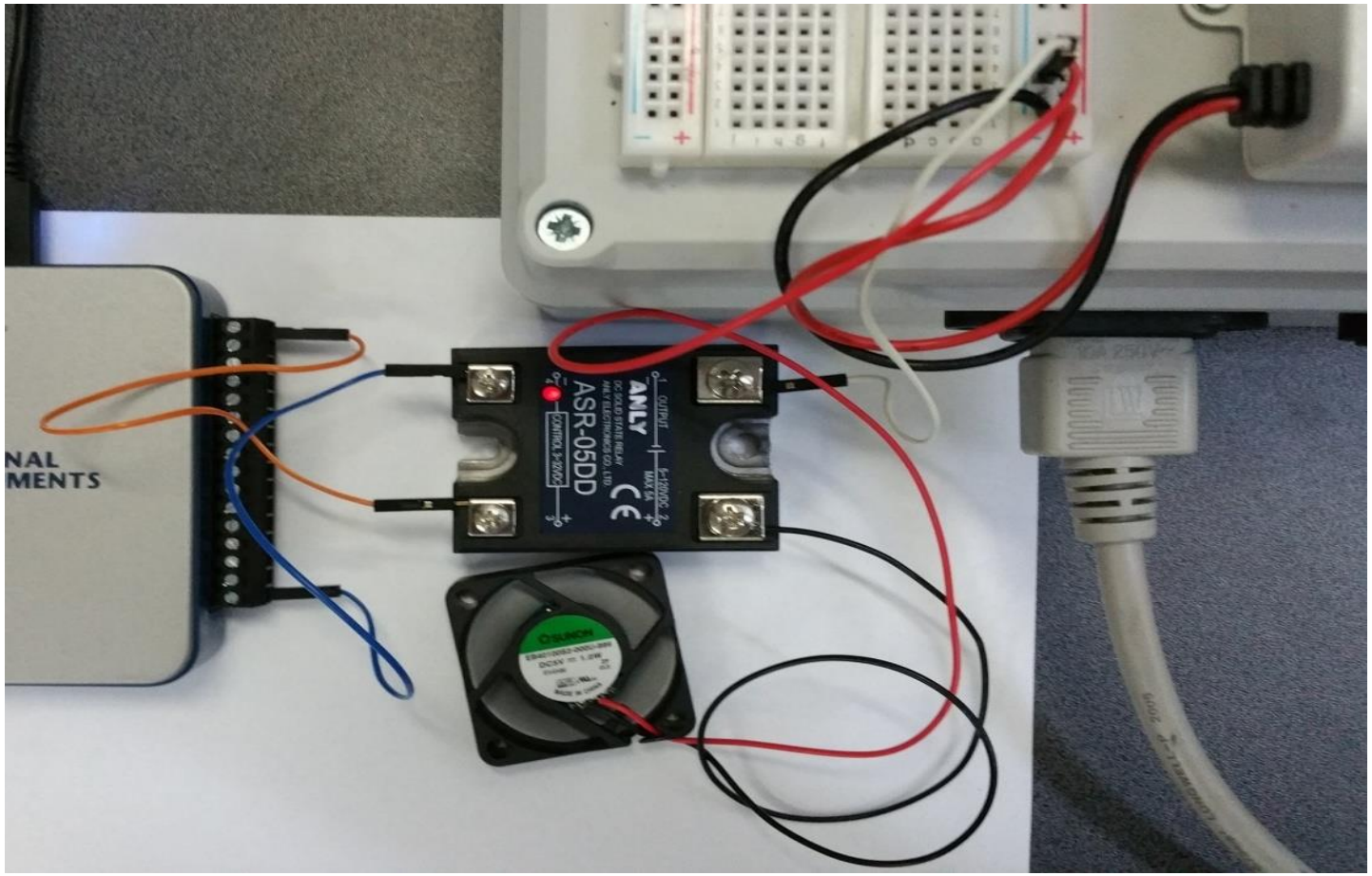
Data acquisition basics



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Course content

Choose or design the needed electronics (power supplies, signal conditioning, analog to digital converters, multiplexers, communication subsystems)	Teamwork
Connect the CPS components	Teamwork
Test the CPS assembly	Teamwork
Data acquisition programming basics	Lecture
Develop the CPS data acquisition software components	Teamwork
Data processing basics	Lecture

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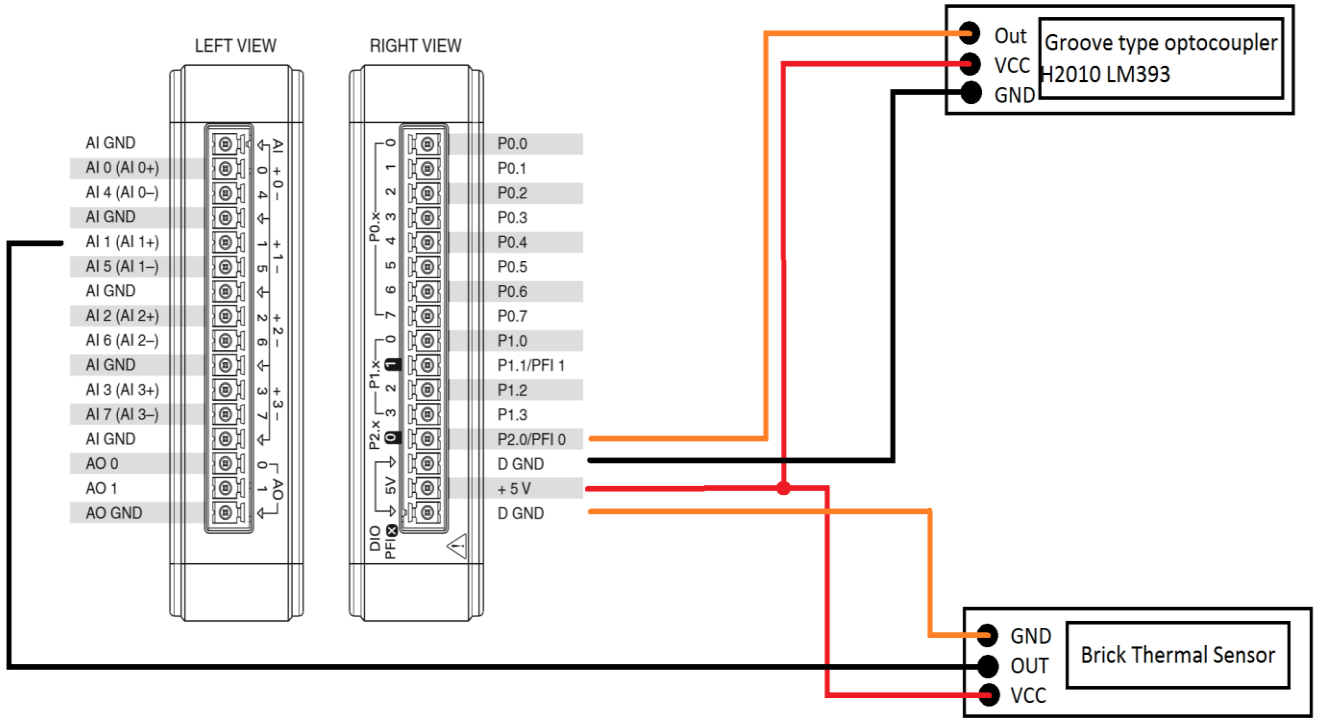
Connect and test CPS components



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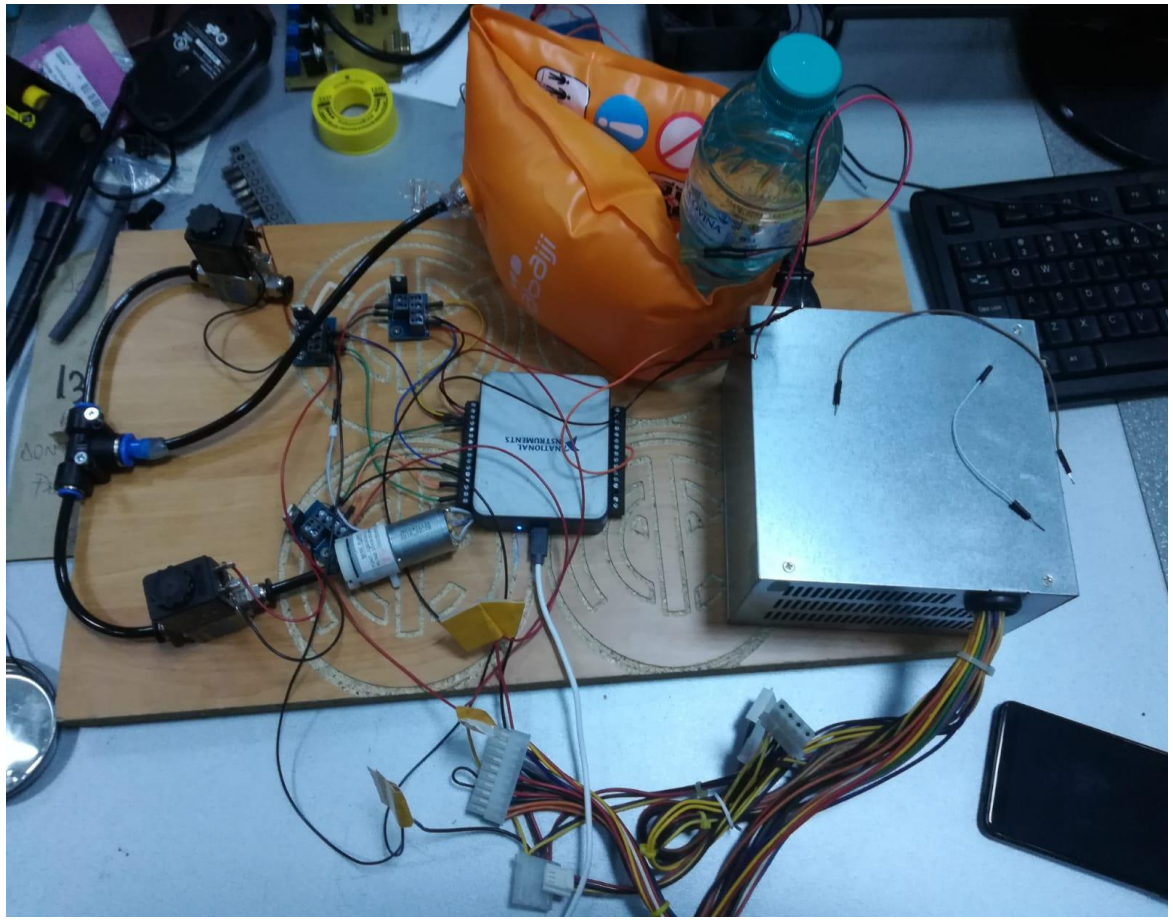
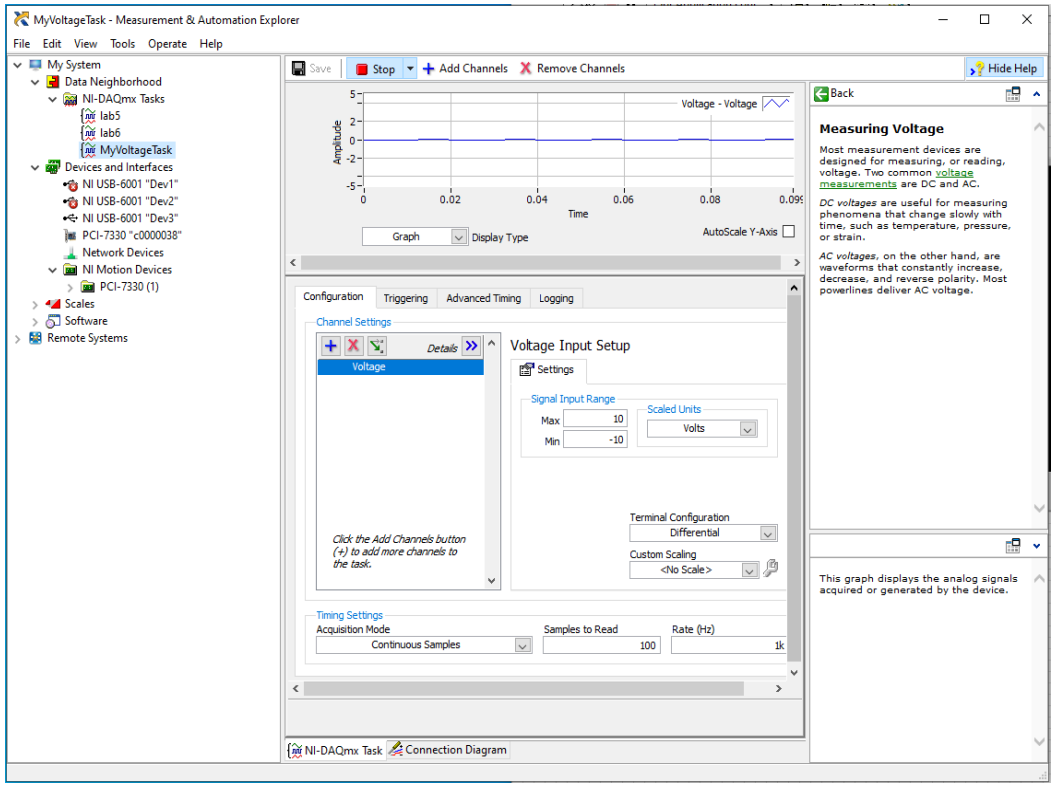
Connect and test CPS components





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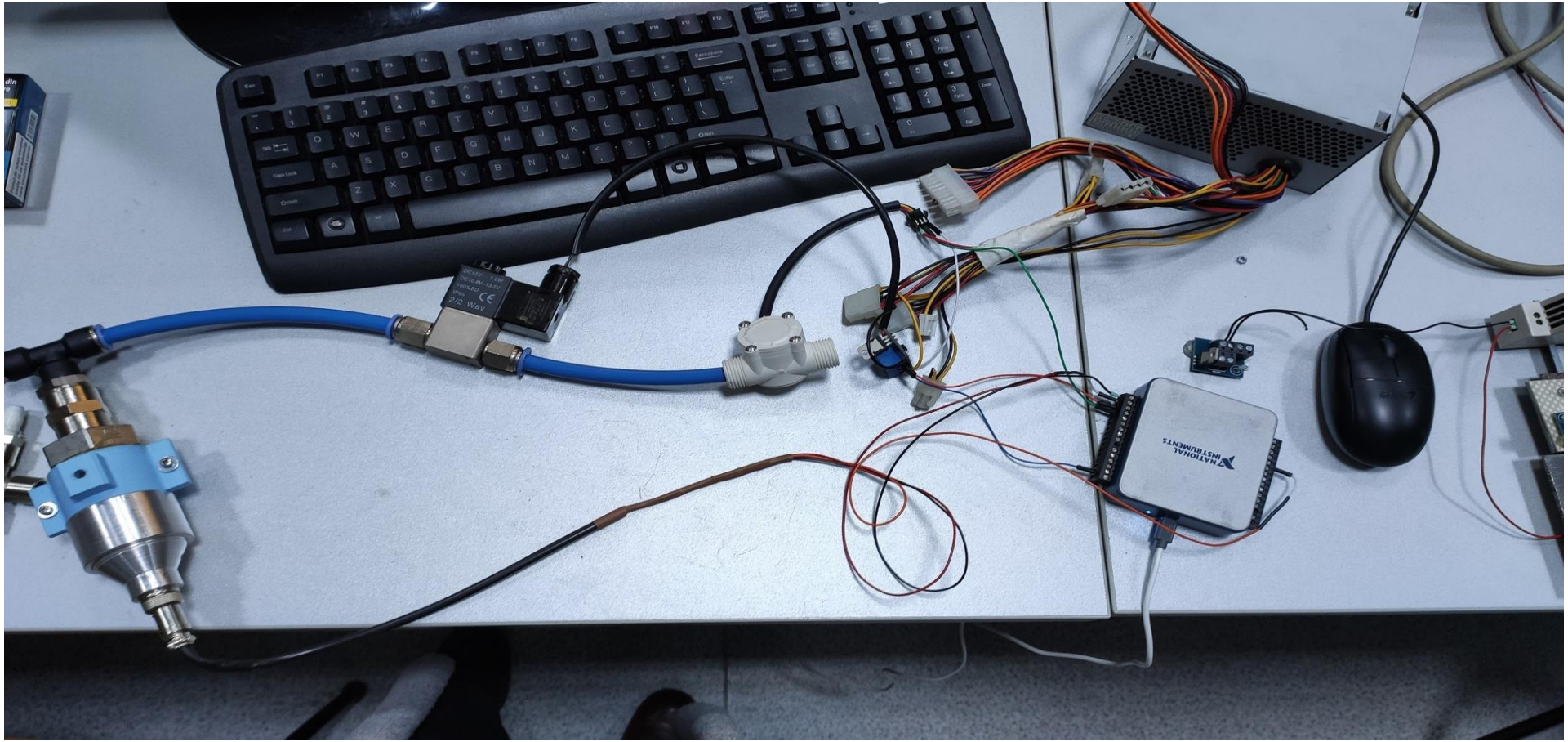
Connect and test CPS components



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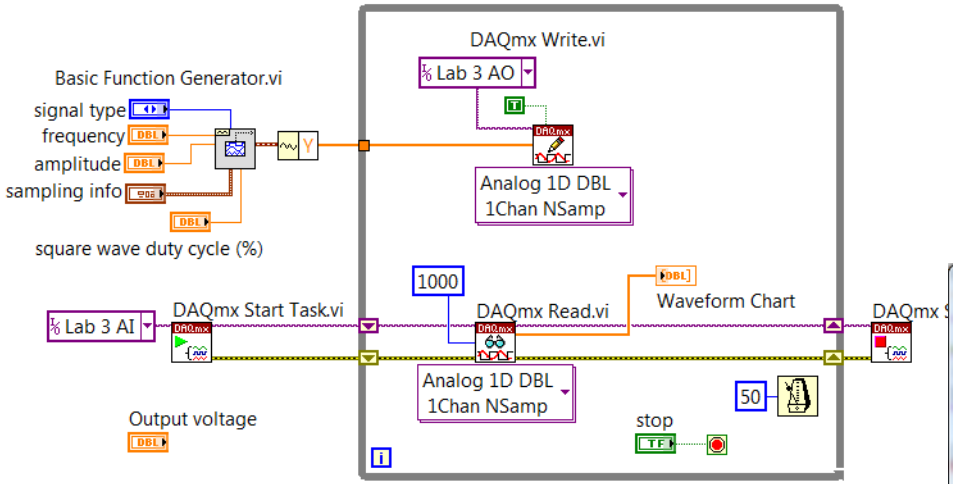
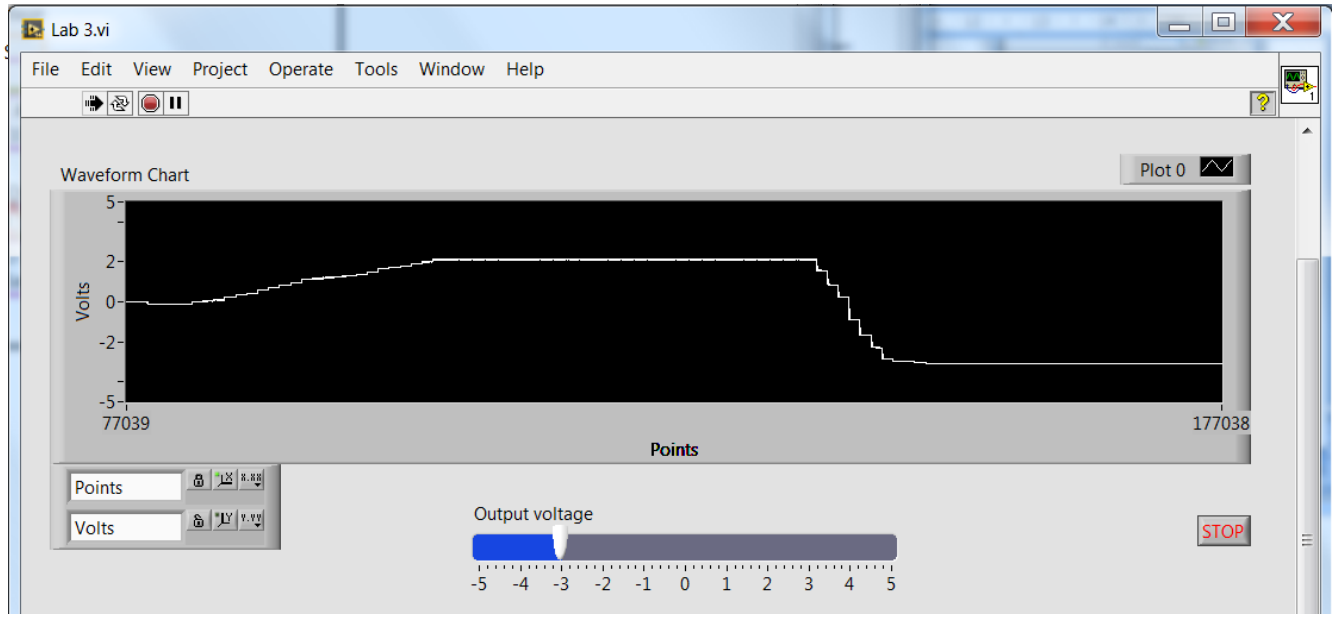
DAQ programming basics





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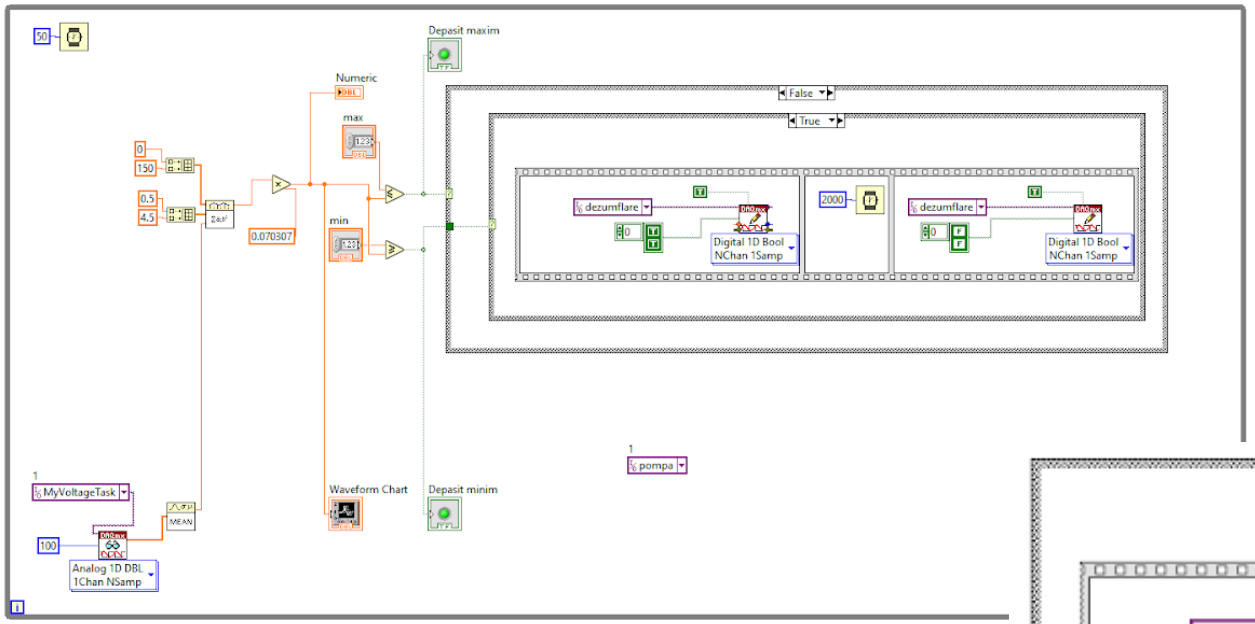
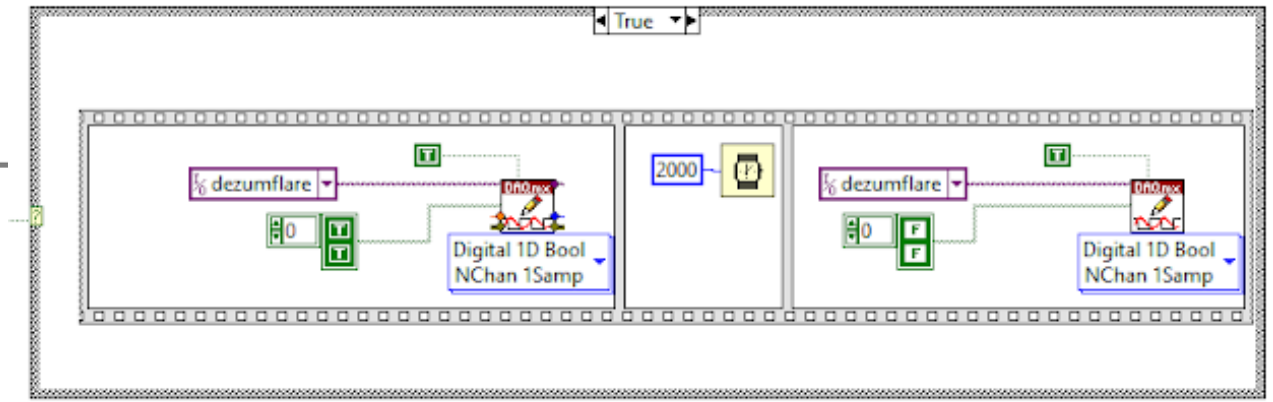
Develop CPS DAQ software





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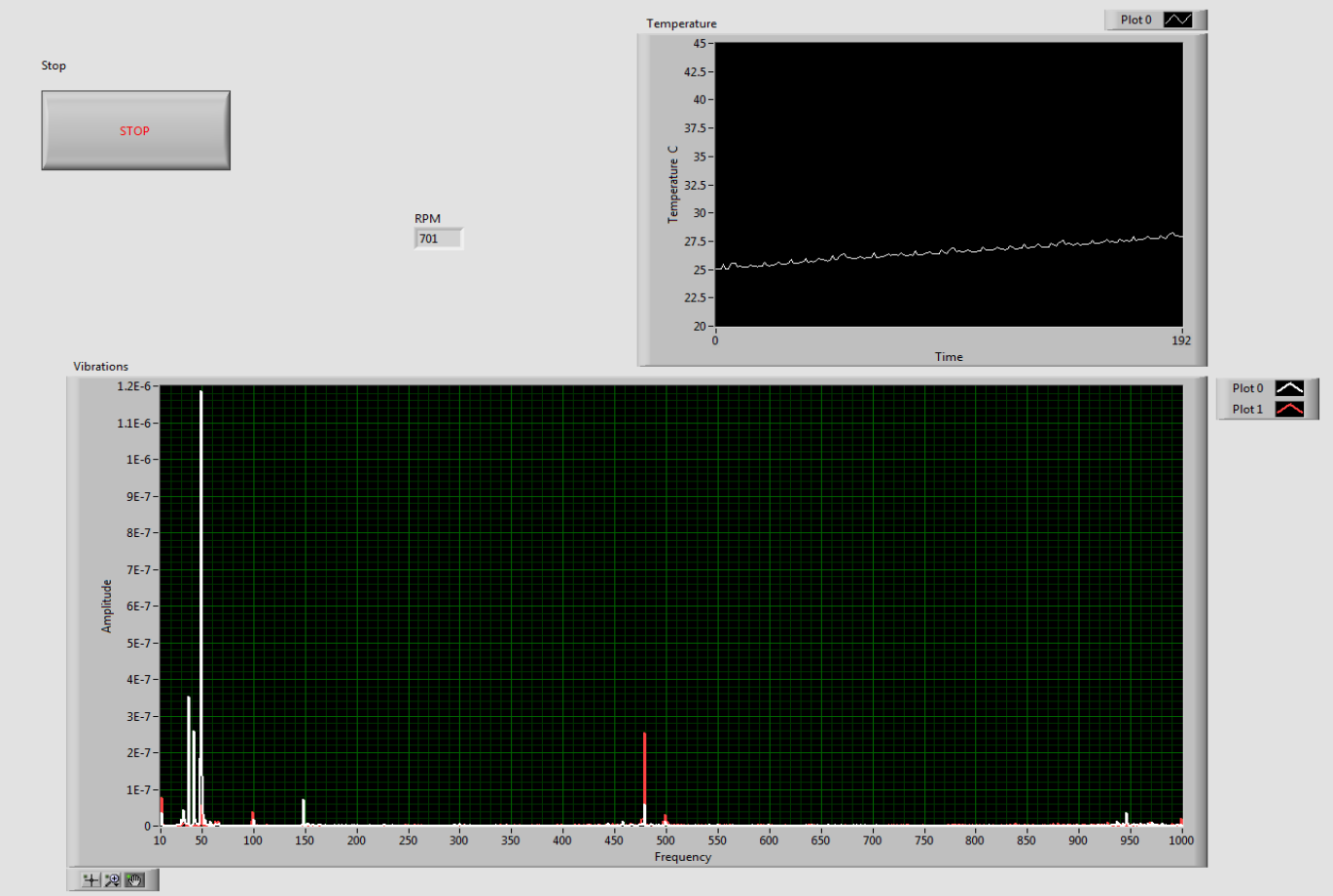
Test H & S setup



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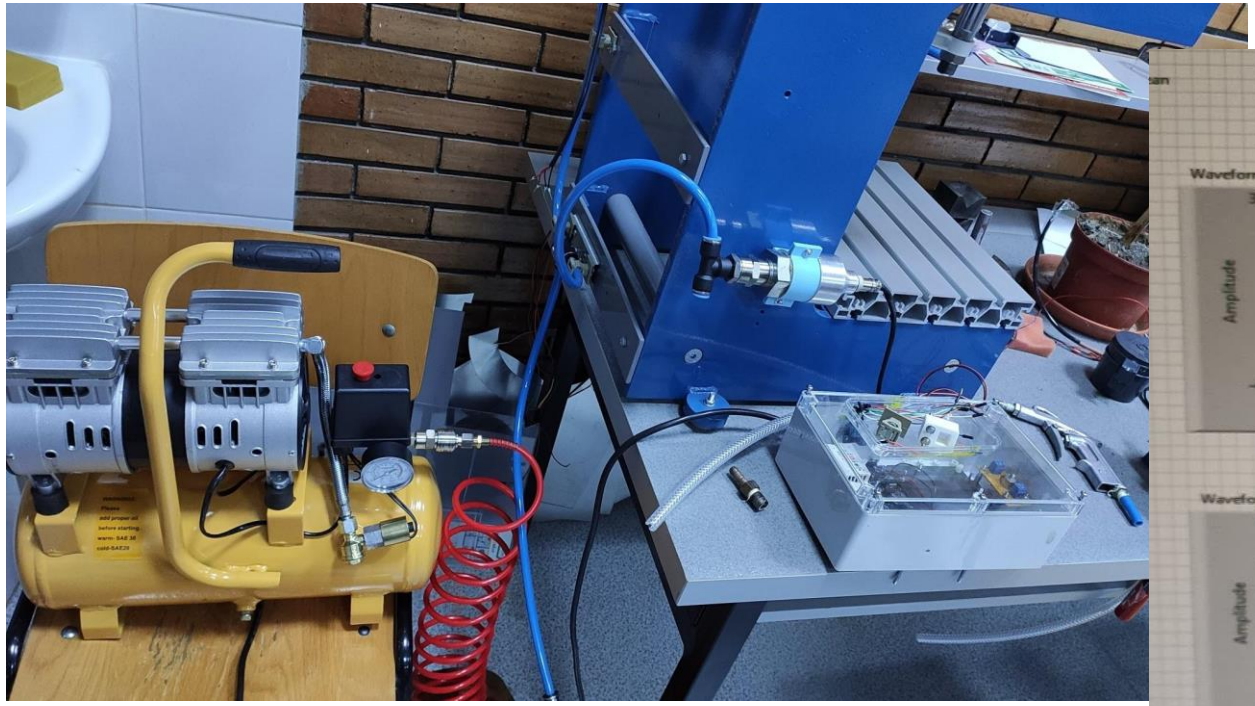
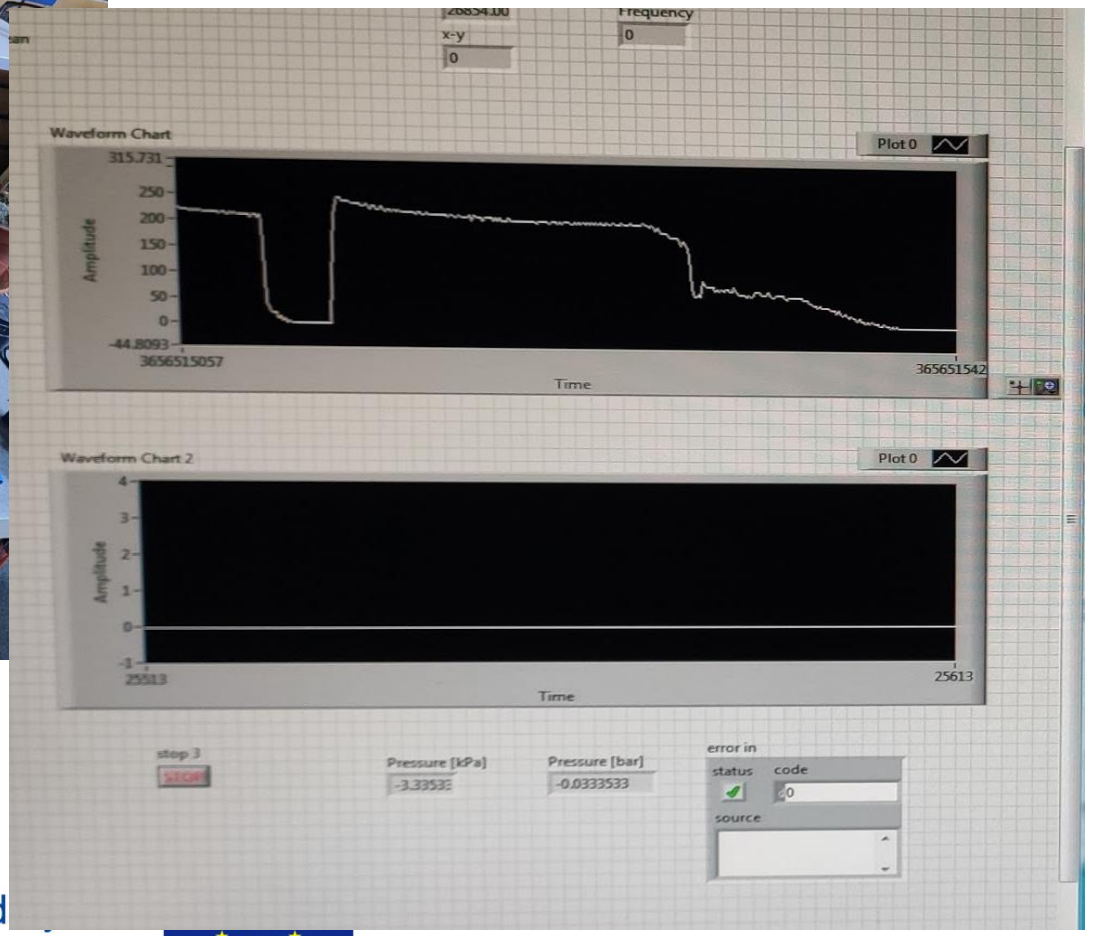
Test H & S setup





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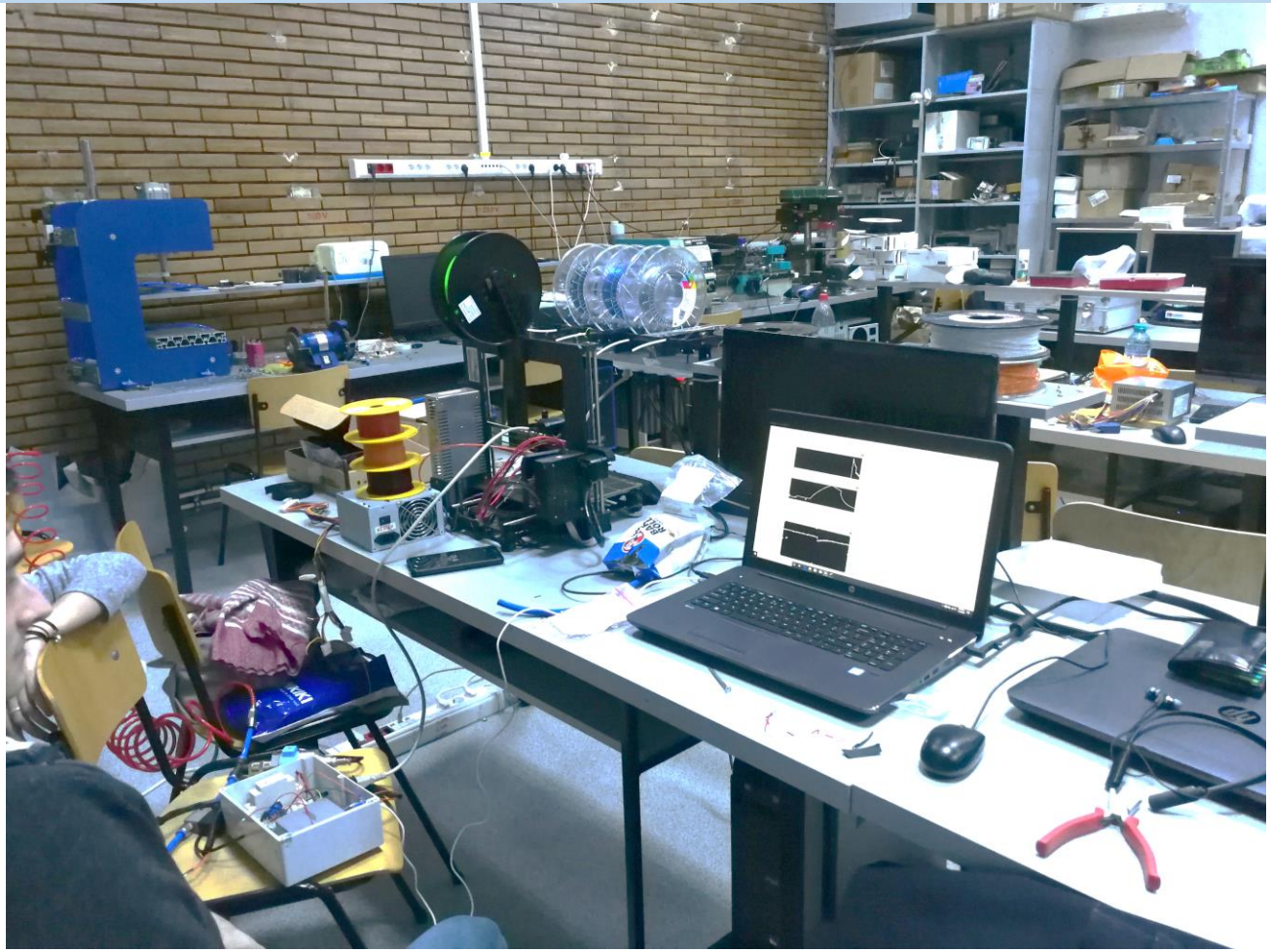
General view of the lab



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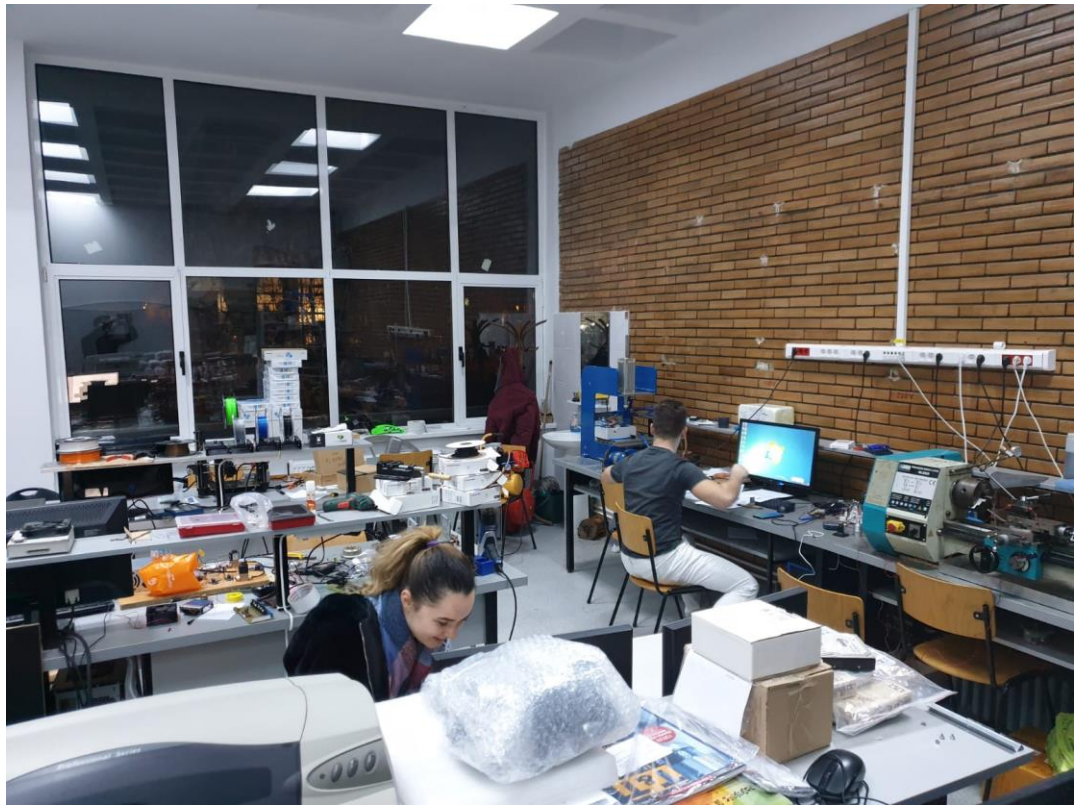
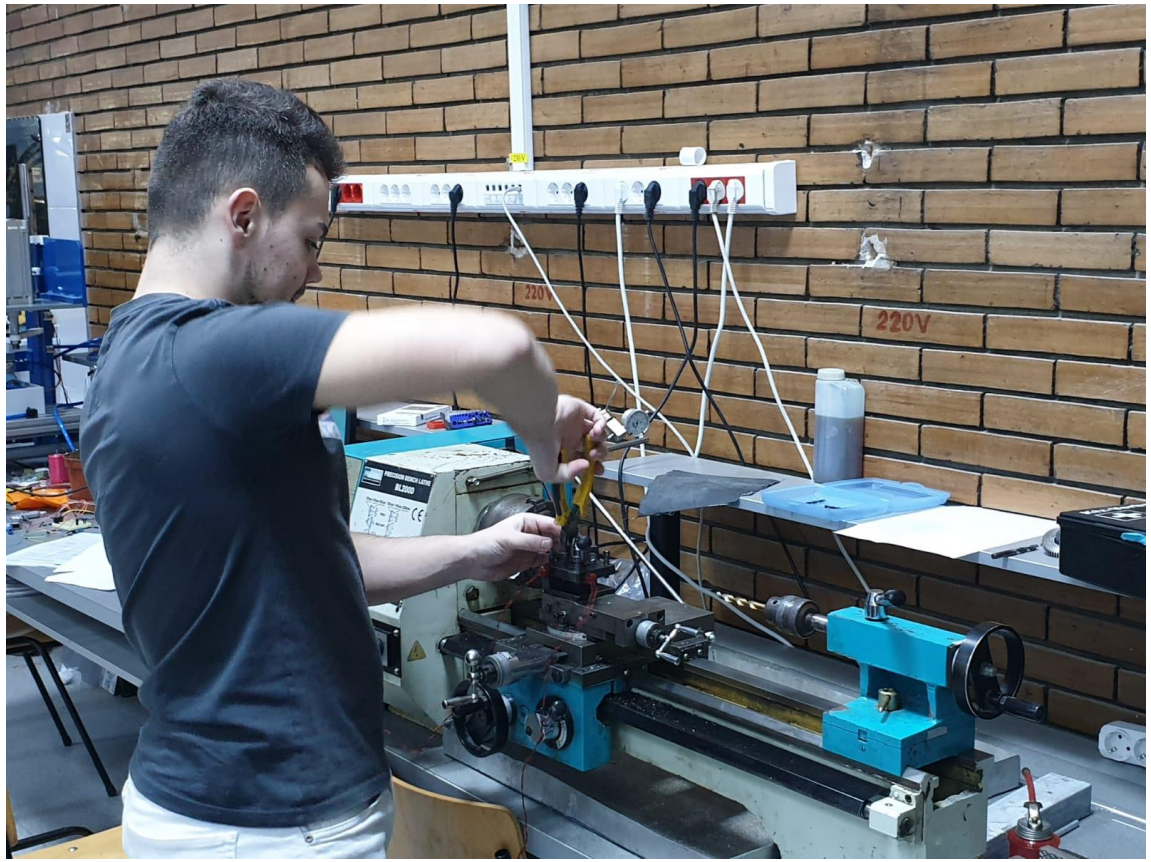
Lathe parameters setup building





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Orthesis pressure setup

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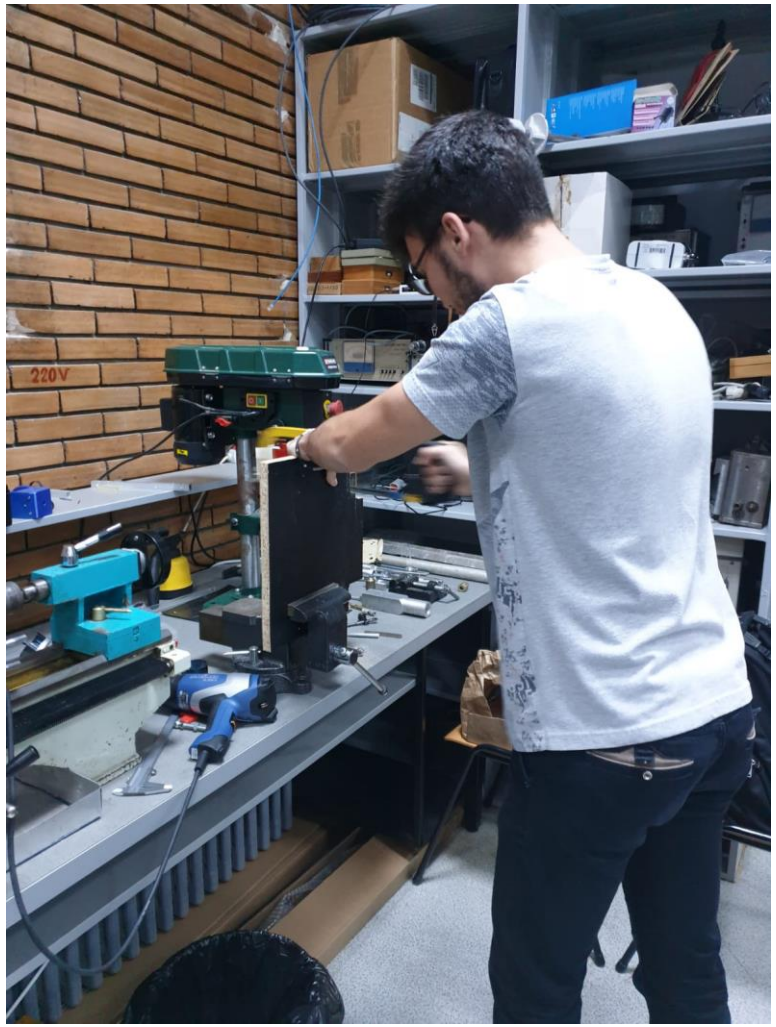
Hardware components development



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Course content

Develop the CPS data processing software components	Teamwork
Data communication basics	Lecture
IoT communication protocols basics	Lecture
Develop the CPS data communication software components	Teamwork
Cloud computing and artificial intelligence basics	Lecture
Feed artificial intelligence component with experimental data	Teamwork
Final project presentation	Evaluation

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Course Outline

I Module 1

- Introduction - concept of CPS, basics, model
- Designing the CPSs structure
- Cloud computing and artificial intelligence basics 1

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Course Outline

II Module 2

- Signal conditioning
- Data acquisition
- Cloud computing and artificial intelligence basics 2

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Course Outline

III Module 3

- Data acquisition programming
- Data processing
- Data communication
- IoT communication protocols
- Cloud computing and artificial intelligence basics 3

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