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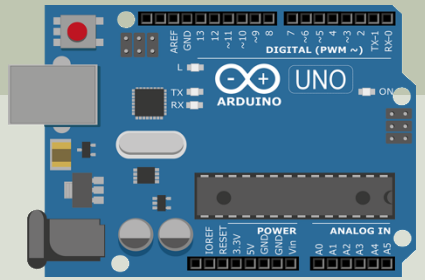
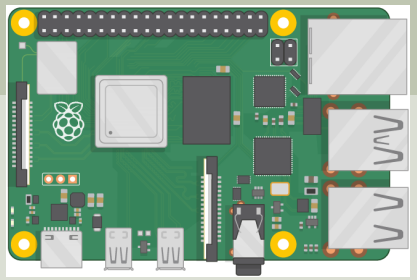
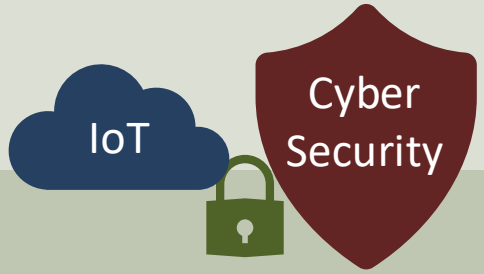


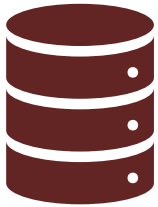


Internet of Things and Cyber Security



Hans-Petter Halvorsen

Internet of Things (IoT) and Cyber Security



Database Systems

Datalogging and Monitoring

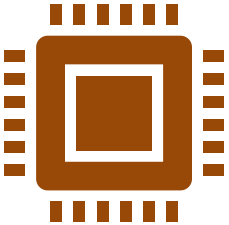
Sensor Technology

DAQ

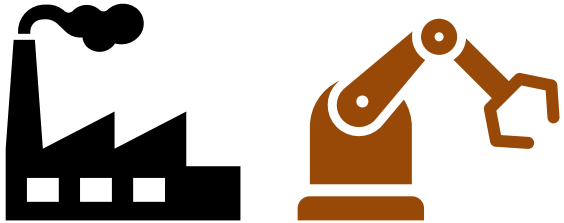
Artificial Intelligence (AI)

Internet of Things (IoT)

Cloud Computing



Microcontrollers



Industrial Internet of Things (IIoT) and Industry 4.0

Cyber Security

Contents

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Course Introduction

Hans-Petter Halvorsen

What is Internet of Things (IoT)?

- The Internet of Things (IoT) is a network of physical objects – "things" – that are embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet.
- These devices can be anything from common household items like refrigerators, washing machines to more advanced things like drones or sensors used in industrial settings.
- IoT allows these devices and other related systems to interact and share data.
- This opens new possibilities for how devices can function and communicate, often resulting in improved efficiency, accuracy, and economic utility.
- An example of IoT could be a smart home system, where the home's lighting, temperature, security systems, and even appliances can be connected in one system, which can be controlled remotely via a mobile device.

Goal and Learning Outcome

- Design and planning of IoT systems.
- Get a good overview of IoT hardware, software, components, sensors and protocols.
- Practical implementation of IoT systems using diverse programs, programming languages and protocols.
- Focus on cybersecurity and implementation of cybersecurity in IoT systems.

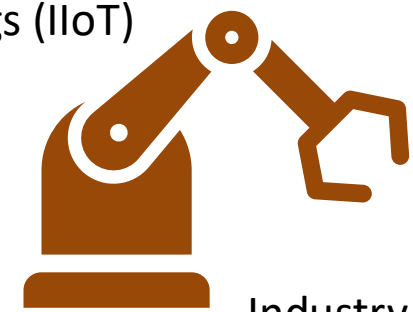
What will you Learn?

- **Internet of Things (IoT)**
- IoT **Hardware** and components, IoT **Software**
- **Microcontrollers** and Singe-Board Computers (SBC), Embedded systems
- **IoT Communication Protocols**, SPI, I2C, MQTT, ..
- Industrial Internet of Things (IIoT)
- Industry 4.0 and Next Generation Industrial Automation Systems
- Implementation and use of **Cloud** services and Cloud Computing
- Implementation of Data and **Cyber Security**
- Applied Automation and Control Engineering
- Implementation and use of **Database Systems**
- **Web** Technology and Web Programming
- Software Engineering
- **Digitalization**
- Use of various Programming Languages and Industrial Software

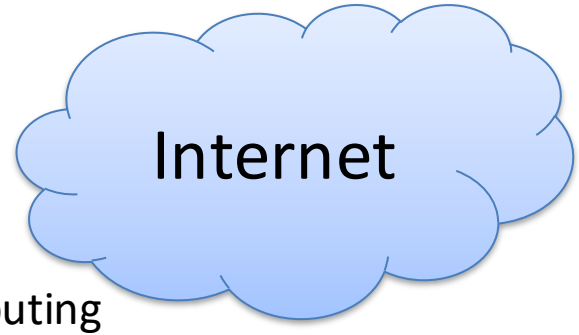
Internet of Things and Cyber Security

Cyber Security

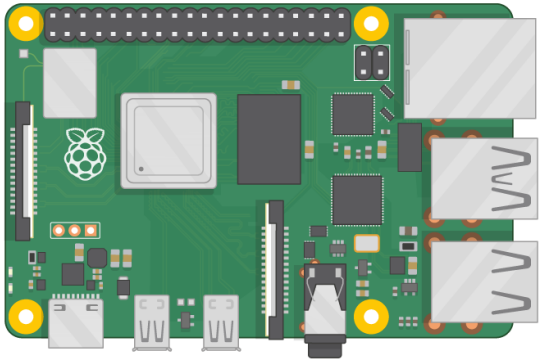
Industrial Internet of Things (IIoT)



Industry 4.0

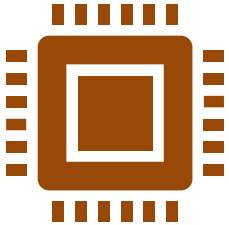


Cloud Computing

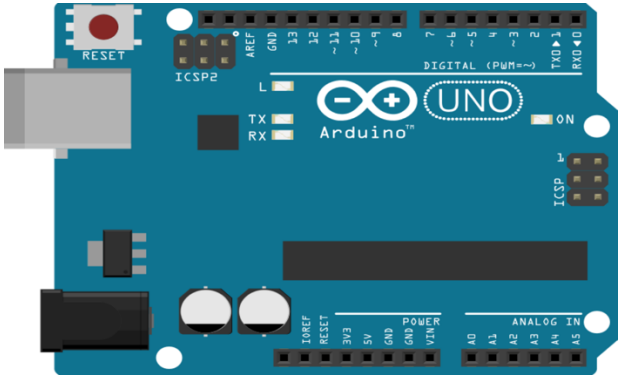


Embedded Systems

Internet of Things (IoT)



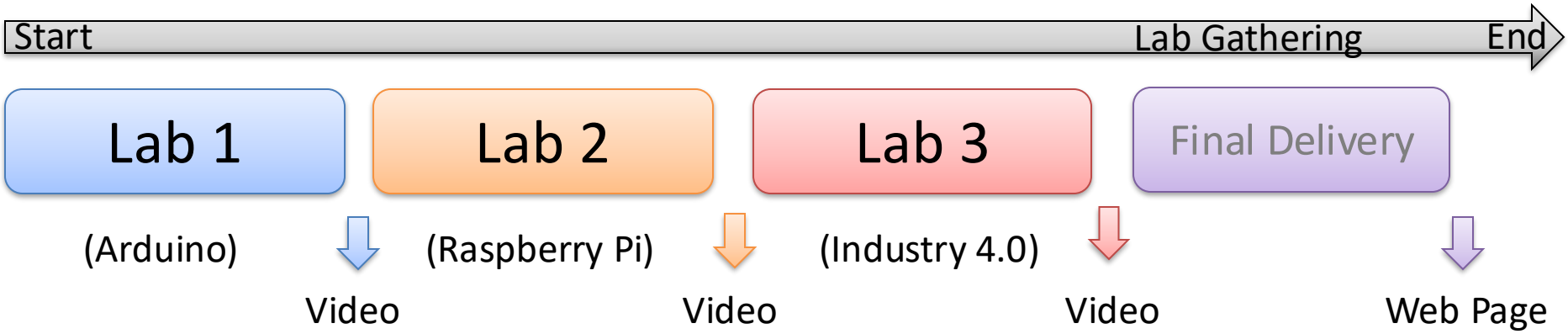
Internet of Things Hardware



Microcontrollers

Lab Assignments

The contents and topics of this course will be learned through practical work and implementation in form of a set of Lab Assignments. There will be no ordinary lectures. It will be focus on practical implementations and less theory.



For each of the Lab Assignments, you shall deliver a **video** (about 10-15 min) where you give an overview of your work. Final delivery ("Exam"): When you have done and delivered a video for each of the assignments, you shall create a final Web Site for one of the Lab Assignments.

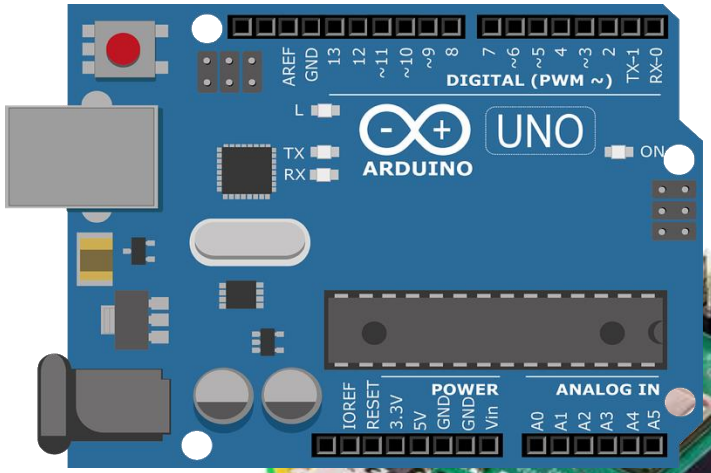
Recommended Workload

Work	Weeks	Workload	Comments
Lab 1 Arduino	5	~40h	I can guarantee that you get this lab Approved if you work these estimated hours. It is possible though to put in extra hours for deeper learning, but that is an individual choice.
Lab 2 Raspberry Pi	4	~40h	I can guarantee that you get this lab Approved if you work these estimated hours. It is possible though to put in extra hours for deeper learning, but that is an individual choice.
Lab 3 Industry 4.0	4	~40h	Here you can reuse some work from previous work and save some time.
Lab Gathering	1	~8h	1-2 days gathering at the end of the semester. Only for online and industry students.
Final Website		~8h	Make a "web report" based on one of the previous labs. No new lab work.
Total	14	~136h	I can guarantee that you PASS this course if you work these estimated hours. You get 100% paid for what you do in the semester. There is **no final exam** that you need to prepare for.

- **Workload**: USN and the educational department recommends about **135h** of work for a 5 credits course. Depending on individual skills, desired learning outcome and goals you may work less, or a bit more compared to the recommended hours.
- **Labs**: The 3 labs need to be delivered in Canvas according to the deadlines given and approved to pass this course.
- **Practical work/Learning by doing**: The focus and goal in this course is to do the assignments/lab work. It is recommended to only use the video resources, etc. if you need them to solve the assignments or if you want a deeper understanding.
- This is a practical course compared to many other courses. Depending on your skills it may need more effort than more traditional lecture-based courses, but the knowledge will go deeper and be directly applicable. You control your own time usage.
- **Folder assessment**. The grade is 100% based on work done during the semester. There is **no final exam** that you need to prepare for or join.

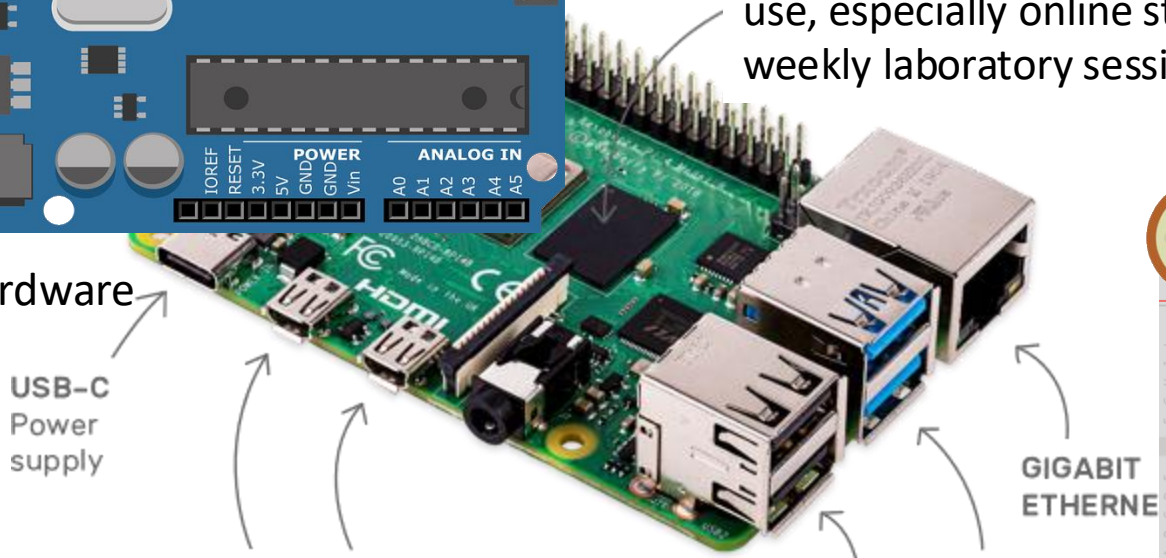
Hardware

Arduino



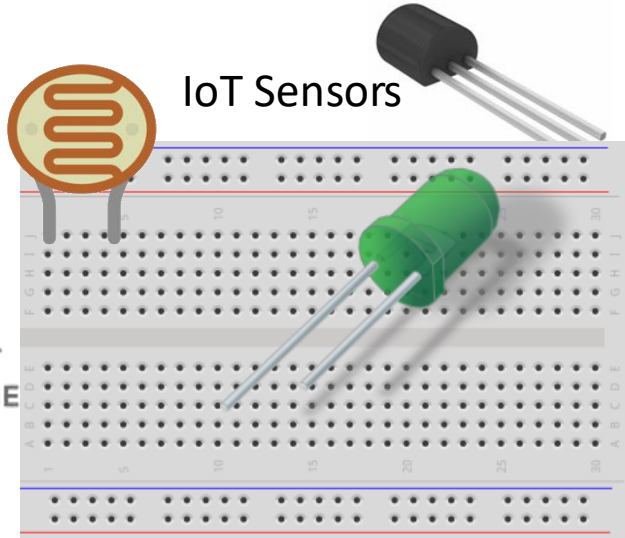
You will need an **Arduino** and a **Raspberry Pi** and some electronic components and small sensors. The equipment will be available in the laboratory, but it is recommended that you buy the hardware for personal use, especially online students that will not join the weekly laboratory sessions.

IoT Hardware



Raspberry Pi

IoT Sensors



Recommended Hardware

- **Arduino UNO R4 WiFi** (or similar)
  - In addition, you need a **USB-C cable** (or USB-B) to connect to a PC
- **Raspberry Pi 4 or 5** (or similar)
  - In addition, you need a **Micro SD card** (+ PC Adapter if needed) and a **Power Supply**.
  - If you want to connect to a Monitor, you also need a **Micro HDMI to HDMI Cable** (+ Keyboard and mouse)
- Additional Electronic Components: Breadboard, wires, resistors and small IoT sensors are also needed.
- Other options are possible if you already have some devices and components, older versions, etc.

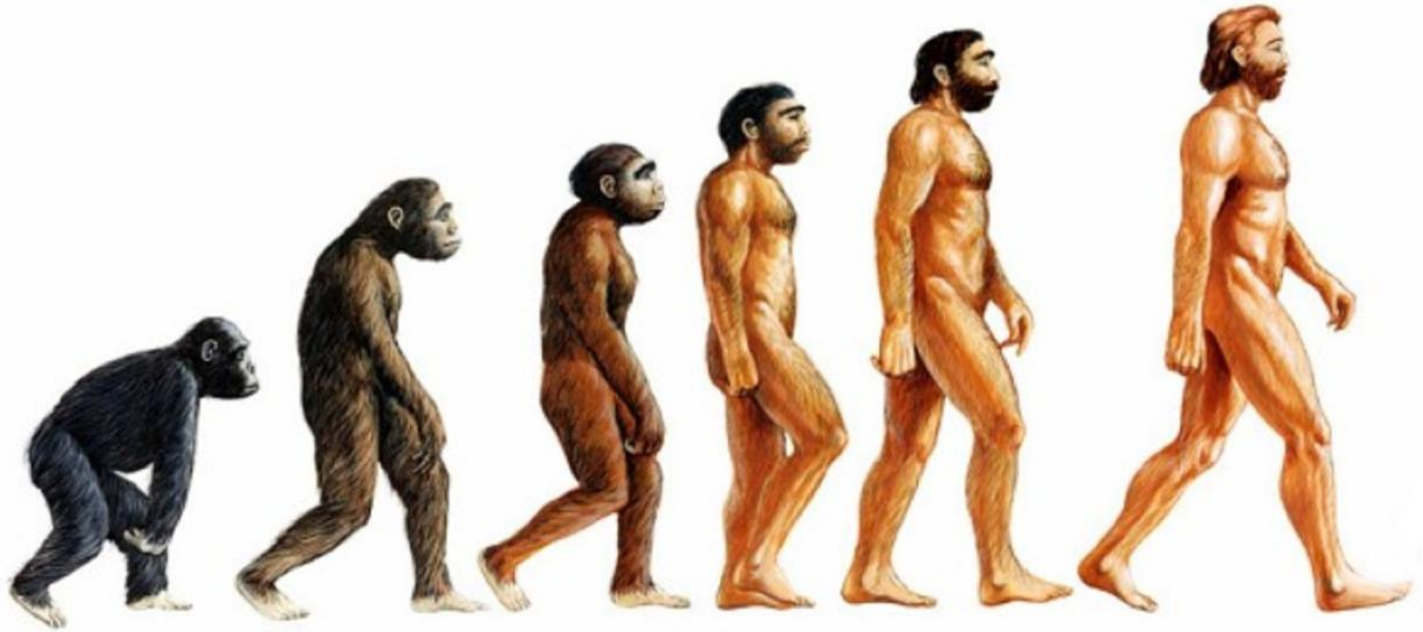
It is recommended that you buy these devices and components as soon as possible, since there are some delivery time. It is strongly recommended that you buy some of the recommended hardware for personal use. The total price will be the same as you pay for an ordinary textbook which you need to buy in other courses.

Internet of Things (IoT)

Hans-Petter Halvorsen

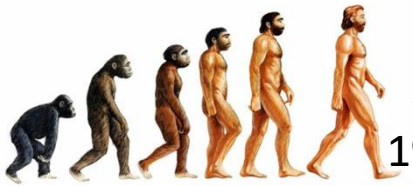
Internet of Things (IoT)

IoT – Consumer oriented, Smart Home Solutions, etc.
IIoT – Industrial use of IoT Technology.
Industrial Internet of Things (IIoT) is another word for Industry 4.0



The Digital Age

Digitalization



1930

The first Computer
The Turing machine, 1936

Internet, 1968-91

The Microprocessor, 1971

1976: Apple I

1984: Macintosh

PC, 1981 (IBM)

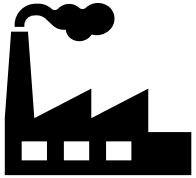
Smartphone, 2007

World Wide Web, 1989-93

Internet of Things (IoT), Machine Learning and Industry 4.0

2016

Internet of Things (IoT)



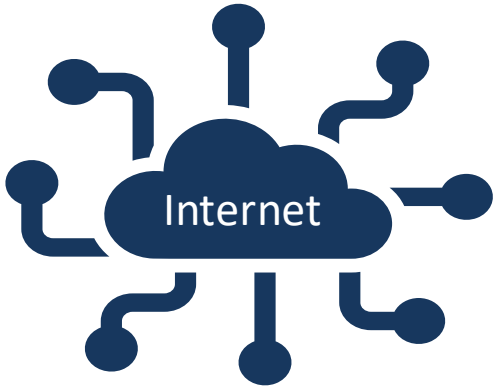
Process Industry

Computers and Devices

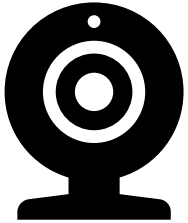
Cars and Vehicles

Smartphones

IT



Artificial Intelligence (AI)



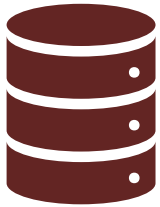
Data Security

People

Home

Soon everything will be connected to the Internet – even your Coffee Maker

Internet of Things (IoT)



Database Systems

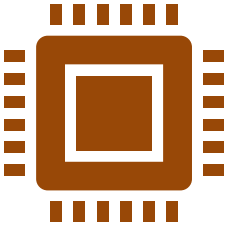
Sensor Technology

Datalogging and Monitoring

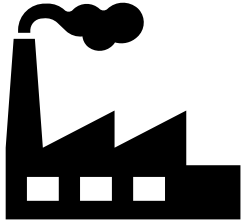
Artificial Intelligence (AI)

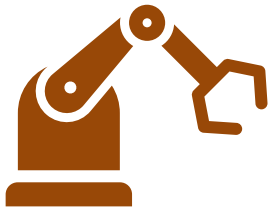
Internet of Things (IoT)

Cloud Computing



Microcontrollers





Industrial Internet of Things (IIoT) and Industry 4.0

Cyber Security

Artificial Intelligence of Things (AIoT)

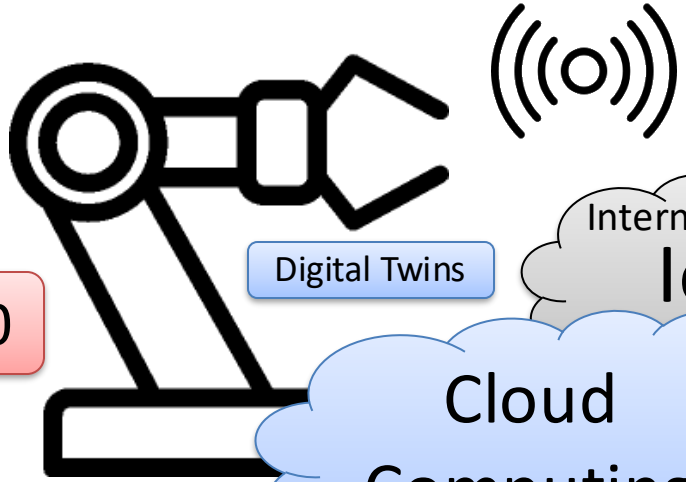
- IoT + AI + ML
- AIoT is Internet of Things (IoT) combined with Artificial Intelligence (AI) and Machine Learning (ML)
- We will see lots of Applications within the AIoT area the next decade

Industry 4.0 (IIoT)

Hans-Petter Halvorsen

Next Generation Industry

We will learn the latest technology and terms used in the industry today and tomorrow

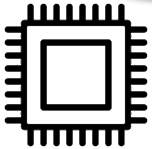


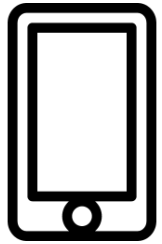
Big Data

Internet of Things
IoT

Digital Twins

Industry 4.0





Cloud Computing

IIoT
Industrial Internet of Things

Artificial Intelligence

Mobile and Web Technology

OPC UA™

Digitalization

MQTT

Cyber Security

Software Engineering

Industry 4.0

Internet of Things

Industry 3.0

Industry 4.0

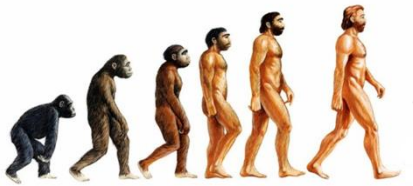
Robotics

Water, Steam and
Mechanical production

Industry 2.0

Electronics, IT and Automation

Industry 1.0



Electricity and mass production

Today

20 mill Years ago

Year Zero

~1784

~1870

~1969

~2011->

Industry 4.0

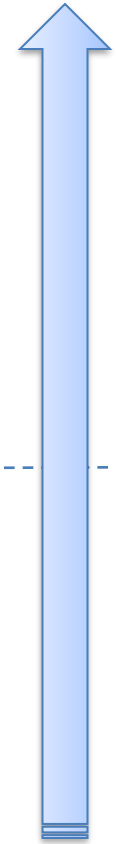
- Industry 4.0 is the buzzword for the combination of industry, automation and the current Internet of Things (IoT) technology.
- IIoT – Industrial use of IoT Technology. Industrial Internet of Things (IIoT) is another word for Industry 4.0.
- You could say that IoT is consumer oriented with applications like Smart Home, Home Automation, etc., while IIoT has more industrial focus and applications.
- The term "Industrie 4.0" was first used in 2011 in Germany.
- Industry 4.0 is also called the fourth industrial revolution.

Industry 4.0

Industry 4.0 is also called the fourth industrial revolution.

- **Industry 1.0**: Mechanization of production using Water and Steam Power.
- **Industry 2.0**: Mass production with the help of Electric Power.
- **Industry 3.0**: The Digital Revolution. From Analog to Digital Devices and Signals. Use of Electronics and IT to further Automate Production
- **Industry 4.0**: The combination of industry, automation, digitalization and the current Internet of Things (IoT) technology.

Industry 4.0



More Intelligent Systems

Industry 4.0

Its all about intelligent algorithms and models implemented in a computer, either locally or in the cloud, so-called Cloud Computing.
Data Analysis: These algorithms work with large amounts of data ("Big Data") in order to make intelligent decisions and Predictions

Big Data

Machine Learning

Mobile Technology

Web Technology

Cloud

IoT

All devices are connected to Internet

"Industry 4.0"

"Industry 3.0"

Industrial IT

Automation

Database Systems

OPC

Control Engineering

...

...

...

Industry 5.0

- We are in the “Industry 4.0” era, the next era is the upcoming “Industry 5.0”.
- The term Industry 4.0 refers to the integration of automation and data exchange in manufacturing.
- The Artificial Intelligence breakthrough has been a game changer, like ChatGPT, etc.
- Industry 5.0 is a new concept that focuses on collaboration between humans and machines

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Data and Cyber Security

Hans-Petter Halvorsen

Cyber Security

Cyber Security

- Data Security: Protect digital data (e.g., data in a database) from destructive forces and from the unwanted actions of unauthorized users (e.g., hackers, etc.)
- Cyber Security is the practice of protecting systems, networks, and programs from digital attacks
- Data Privacy: Issues regarding your personal data stored on Internet
- GDPR - General Data Protection Regulation

Cyber Security

- Basic Overview of Data and Cyber Security
- Data Security in IoT Applications
- Cyber Security in IACS Systems
- How can you secure your Software against threats and vulnerabilities?
- What can you do to protect your Software?

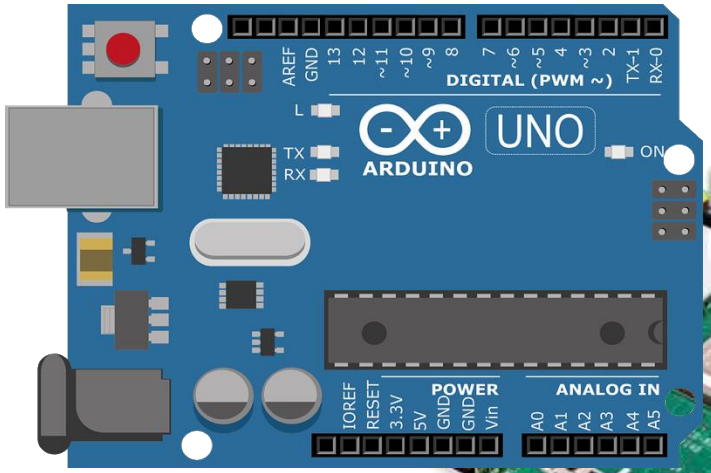
=> Practical Implementation and Reflection regarding these topics

IACS – Industrial Automation and Control Systems

Hardware and Software

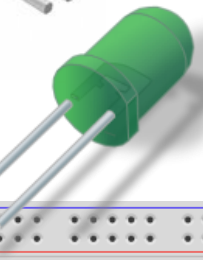
Hans-Petter Halvorsen

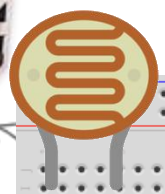
Hardware Examples



Arduino

IoT Sensors





Choice of RAM

2GB 4GB 8GB

Raspberry Pi

IoT Hardware

USB-C
Power
supply

MICRO HDMI PORTS
Supporting 2 x 4K displays

USB 2

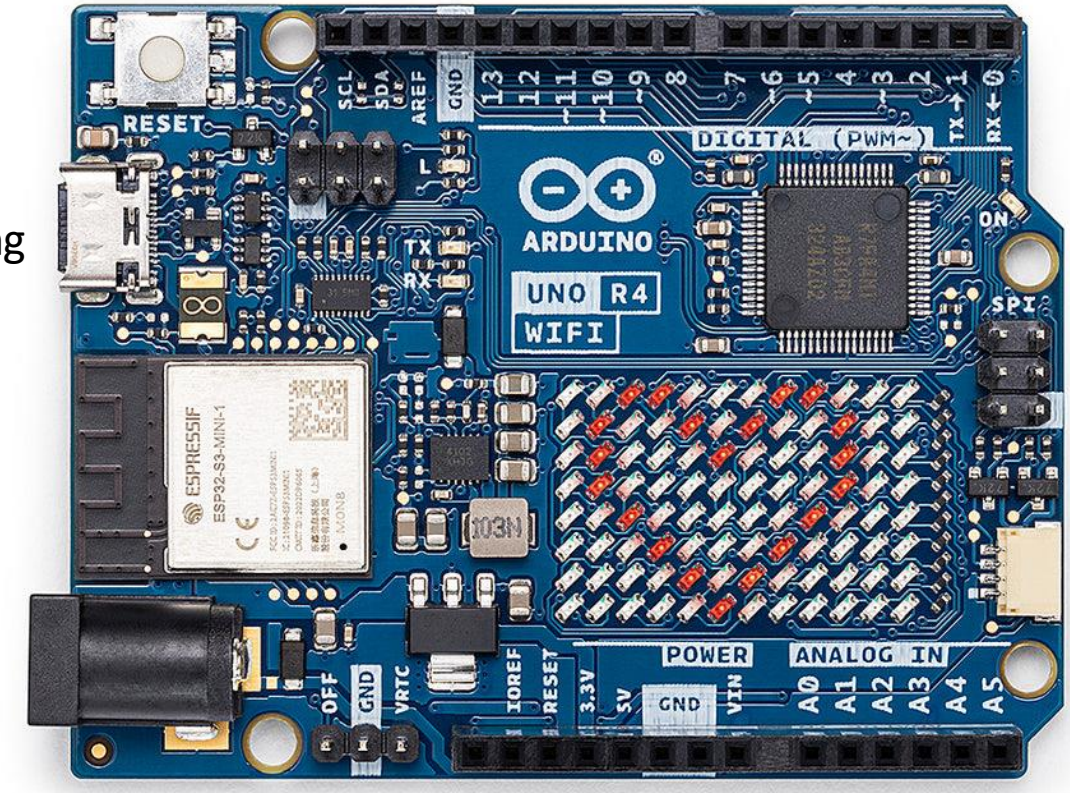
USB 3

Hardware used in the course may vary from year to year

Arduino UNO R4 WiFi

Digital I/O and PWM

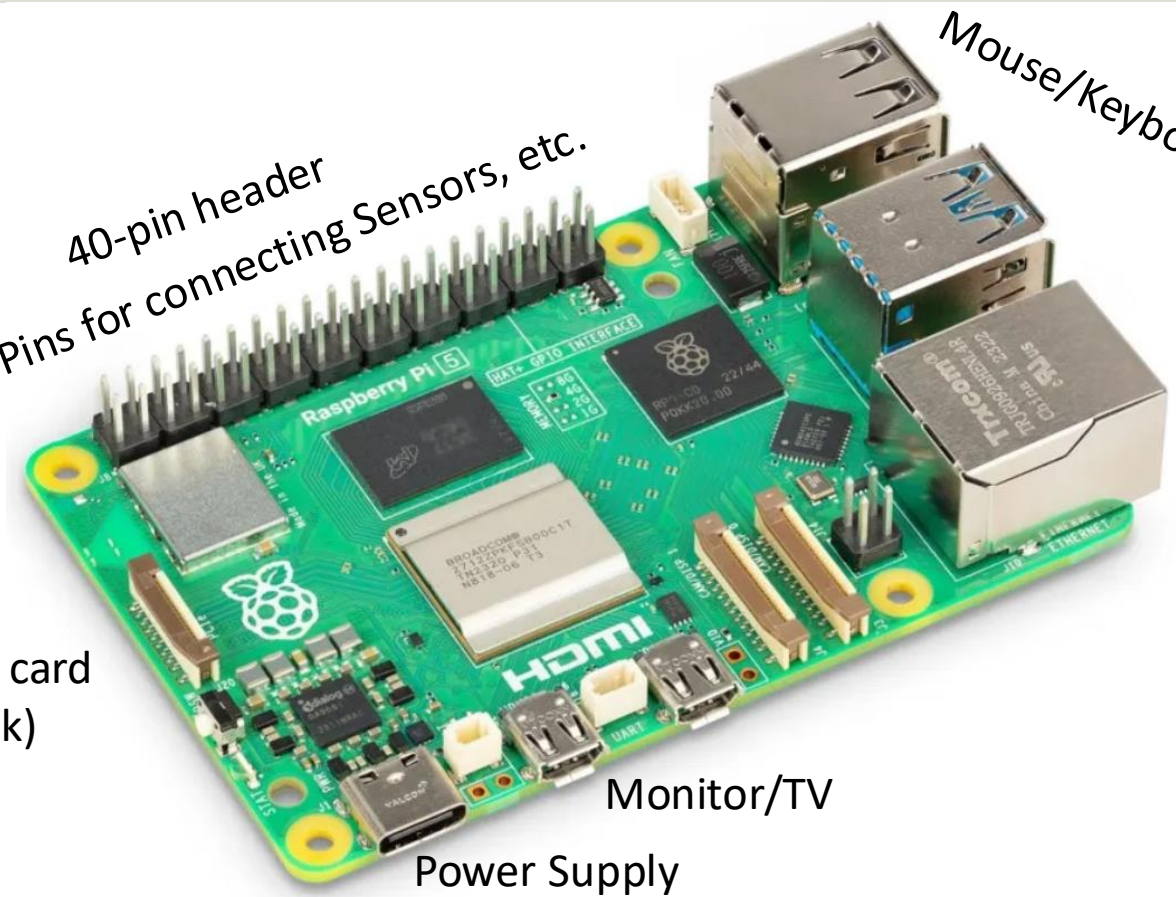
USB-C for connecting to PC



LED Matrix

Analog In/Out

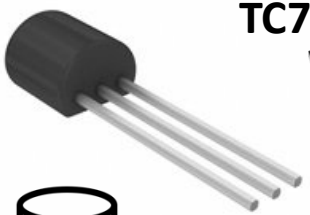
Raspberry Pi 4/5



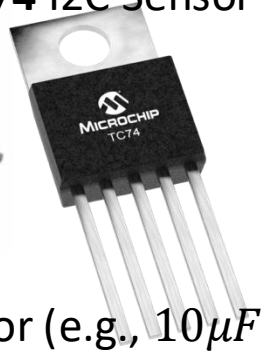
IoT Sensors and components

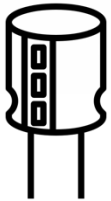
Here are some examples of relevant IoT sensors and other electronic components:

TMP36 Temperature Sensor



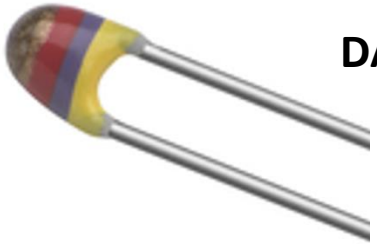
TC74 I2C Sensor



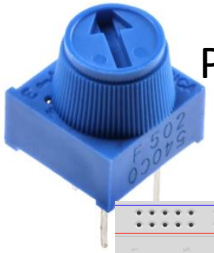


Capacitor (e.g., $10\mu F$)

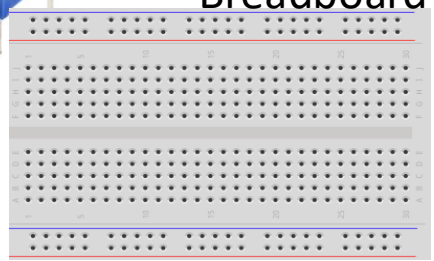
10K **Thermistor** Temperature Sensor



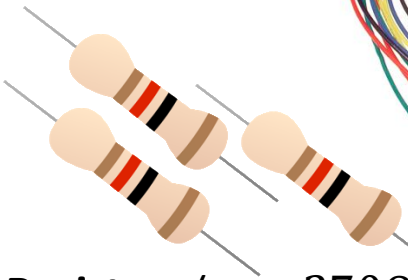
Push Buttons



Potentiometer

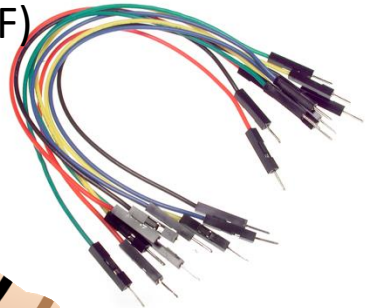


Breadboard

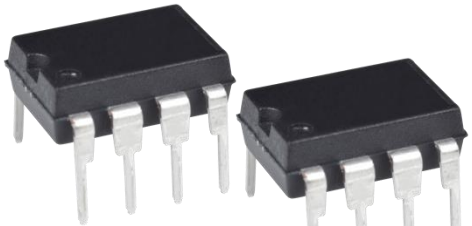


Resistors (e.g., $270\Omega, 330\Omega, 10k\Omega$)

Wires (M-M and M-F)



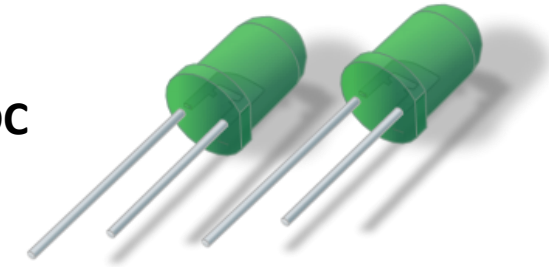
DAC



(MCP4911)

ADC

(MCP3002)



LEDs (red/green)

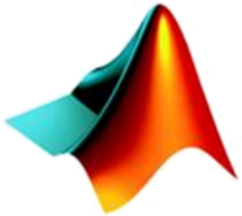
Software Examples

Programming Languages

NATIONAL INSTRUMENTS LabVIEW™

python™

Microsoft® SQL Server®



MATLAB®

Visual Studio

Software and Programming Languages used in the course may vary from year to year

Software Examples

The Industry 4.0 Implementation of OPC

Raspberry Pi OS

Microsoft Azure

mongoDB.

Software and Programming Languages used in the course may vary from year to year

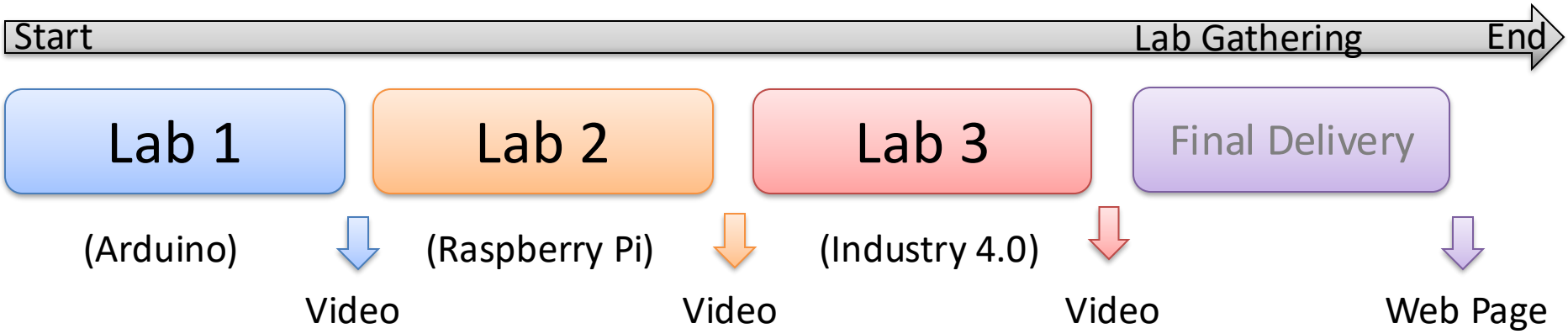
https://www.halvorsen.blog

Course Structure and Assessments

Hans-Petter Halvorsen

Lab Assignments

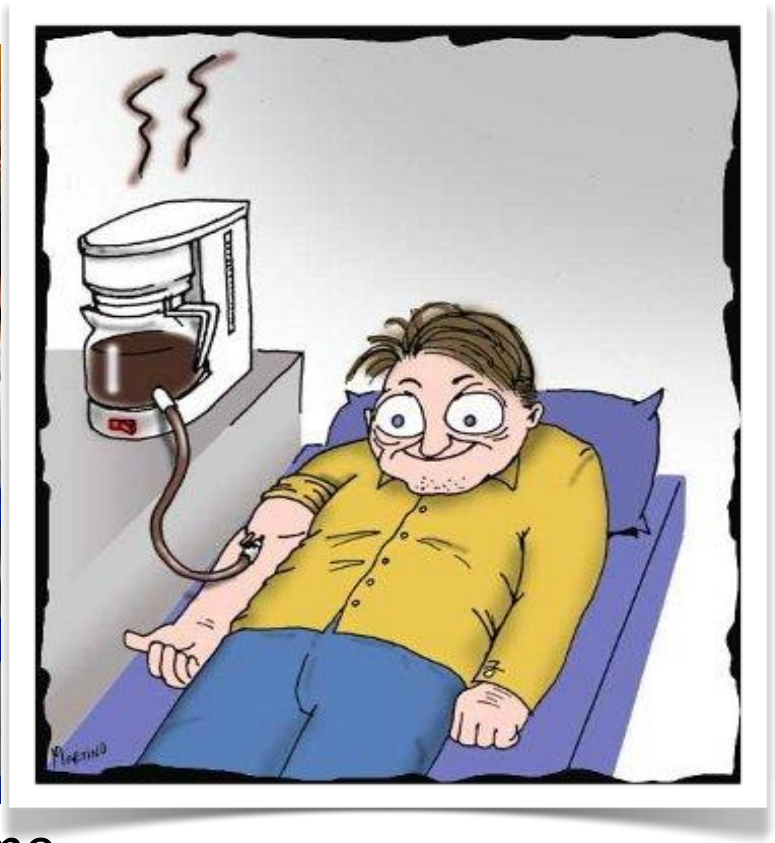
The contents and topics of this course will be learned through practical work and implementation in form of a set of Lab Assignments. There will be no ordinary lectures. It will be focus on practical implementations and less theory.



For each of the 3 Lab Assignments, you shall deliver a **video** (about 10-15 min) where you give an overview of your work. Final delivery ("Exam"): When you have done and delivered a video for each of the assignments, you shall create a final Web Site for one of the Lab Assignments.

Do you learn like this?

Traditional Lectures:



Passive Teaching with little Learning outcome

Theory and Practical Work

The learning activities will be a set of Lab Assignments where we focus on mostly practical aspects, but we see it in combination with relevant theoretical aspects. Just like Yin and Yang from Chinese philosophy.

We learn the topics involved in this course through Problem-based Learning principles

Yin and Yang are a central concepts in Chinese philosophy and religion that express opposites but interconnected that together constitute a whole, and the interaction between them. Yin and yang can be thought of as complementary (rather than opposing) forces that interact to form a dynamic system. https://en.wikipedia.org/wiki/Yin_and_yang

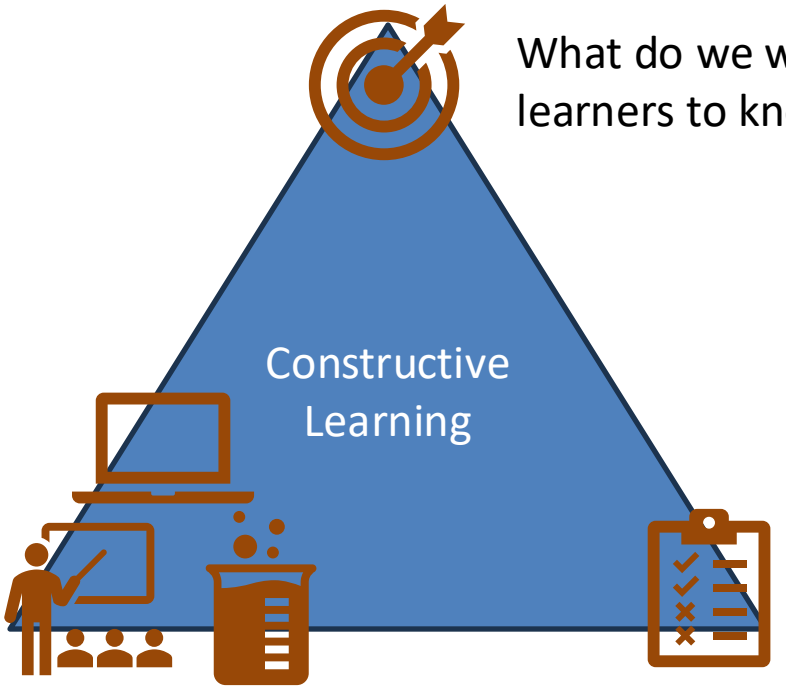
Teaching Principles

Passive Teaching:

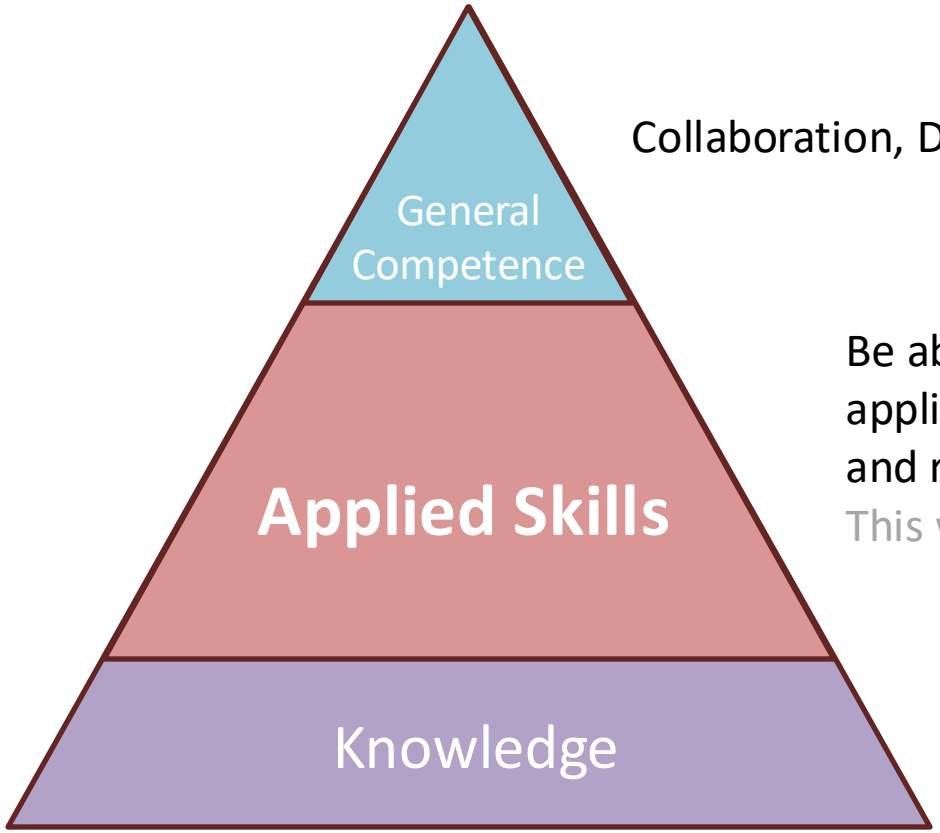
- In universities many courses have focus on traditional lectures
- Learning advanced theory with no foundation in real life applications

This Course focuses using Active Teaching Principles such as Problem-based Learning and Practical Application Implementation

Constructive Learning



Learning Levels



Collaboration, DevOps, Write Technical Documentation

Be able to apply the knowledge to practical applications and implementation on some important and relevant topics.

This will be the focus in this course.

Know concepts and topics on a general level.

So that you can make overall decisions and discuss with others within these topics.

Practical Work

Laboratory Work

We will Create, Build, Implement, Test and Explore – and Collaborate!

In this course we will work with Practical Real-life Challenges

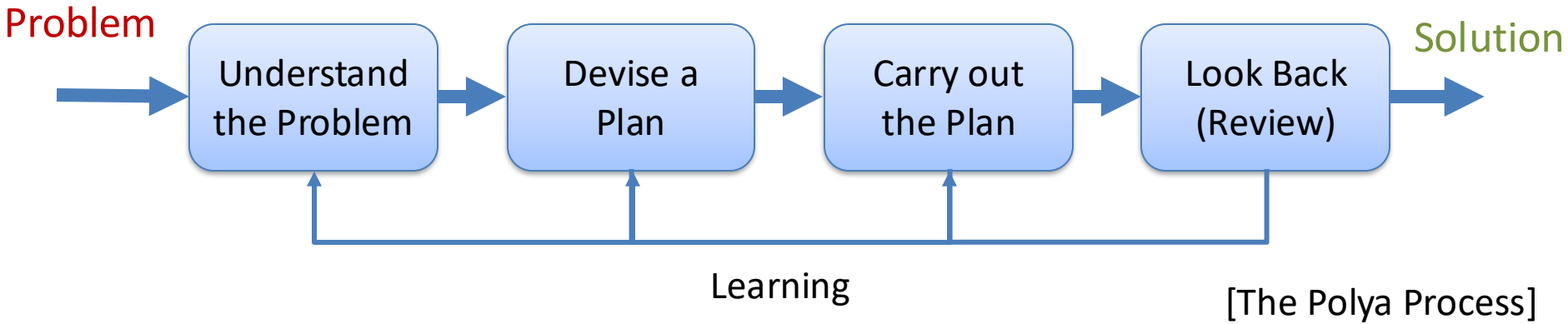
Lab Work and Practical Skills

- Laboratory Work
- Problem-based Learning (PBL)
  - Learning by practical implementations and not focus on theoretical aspects
- Flipped Classroom
  - Prepare at Home. Then do Practical Work at the University
- Authentic Teaching and Learning
  - Real-life Learning. Put the students into a relevant real-life/work scenario
- The 70-20-10 Model
- The Student in center for the Learning Process

Problem-based Learning (PBL)

Learning by Doing

This course will be based on Problem-based Learning principles.
The focus is Practical Implementation.



[The Polya Process]

The PBL students score higher than the students in traditional courses because of their learning competencies, problem solving, self-assessment techniques, data gathering, behavioral science, etc.

Authentic Teaching and Learning

- Learn and practice real-life/work scenarios
- Learning through practical work and less theory
- Put the students into a relevant real-life/work scenario
- The students shall no longer act as they are students but pretend or act that they are actually in a real work situation
- Make the students ready for work from day 1 without the need for months or years of training within the company
- Example: In a Lab Assignment the student shall not be students but act as they are working in a company and executing a real-life project
  - This should also be reflected in the documentation they produce

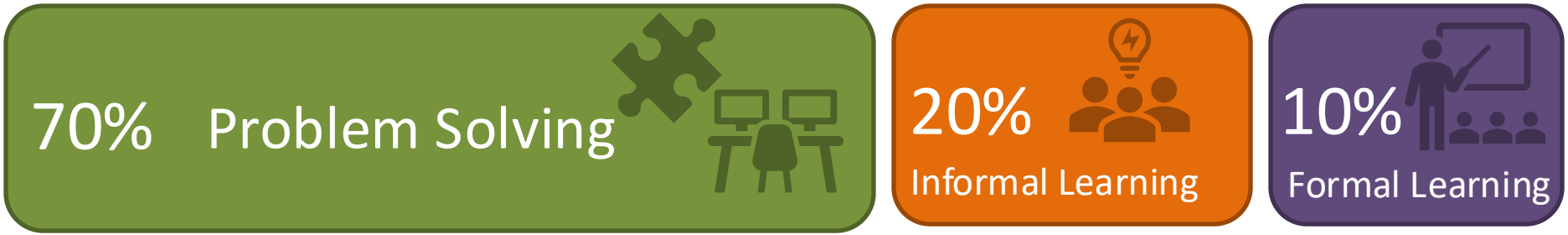
Authentic Teaching and Learning

- Authentic Learning is Real-life Learning.
- It is a style of learning that encourages students to create a useful products to be shared with their world.
- Not only are we teachers bringing in real world context to our classrooms, but our students are taking real world issues and problems and working to solve them and developing solutions applicable to the world or community around them.
- This means that students are not just sitting at their desks listening to lecture after lecture. They are instead solving real problems and issues.
- Problem solving is a key concept.
- This is the future of learning. Students will become adults in a world more complex than our own and will have to solve real world problems creatively and collaboratively.

https://www.onatlas.com/blog/what-is-authentic-learning-and-how-do-i-use-it

70-20-10 Model

The 70-20-10 Model is a learning and development model that suggests a proportional breakdown of how people learn effectively.



Problem Solving, Assignments, Project Work, Work Experience, Challenges, etc.

Teamwork, Collaboration, Guidance, Develop Relationships, etc.

Training, Lectures, Read Books, Videos, etc.

https://en.wikipedia.org/wiki/70/20/10_Model_(Learning_and_Development)

Teaching Outcome

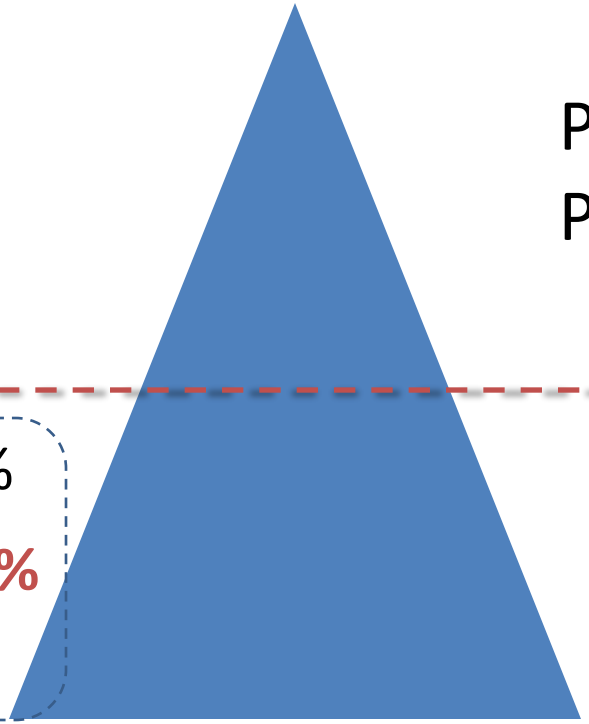
Lectures – 5%

Reading– 10%

Hear and See – 20%

Demonstrations – 30%

Passive Learning Principles



Discuss in Groups – 50%

Practical Exercises – 75%

Teaching others – 90%

Active Teaching Principles

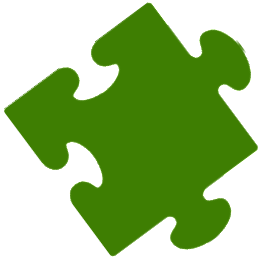
Student centric focus

Problem-based learning (PBL)

Putting the Pieces together

Build Systems

Apply Theoretical Topics from other courses

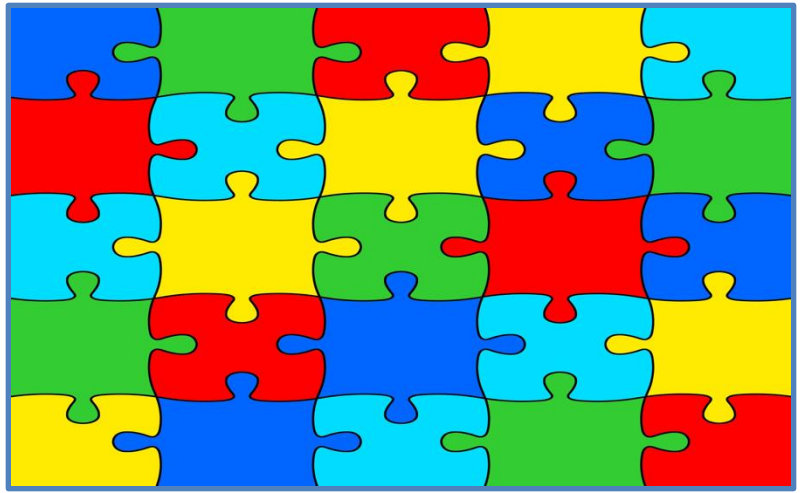


Industrial IT

OPC

Explore Hardware, Software and Programming

"The Big Picture"



Control Engineering

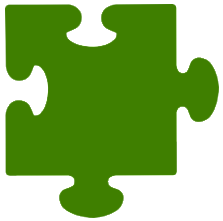
Simulations

Put all the pieces together

Implementation and Practical skills

Practical Problem Solving

PID



Modelling

Programming

Automation

Software Engineering

Instrumentation

Data Communication

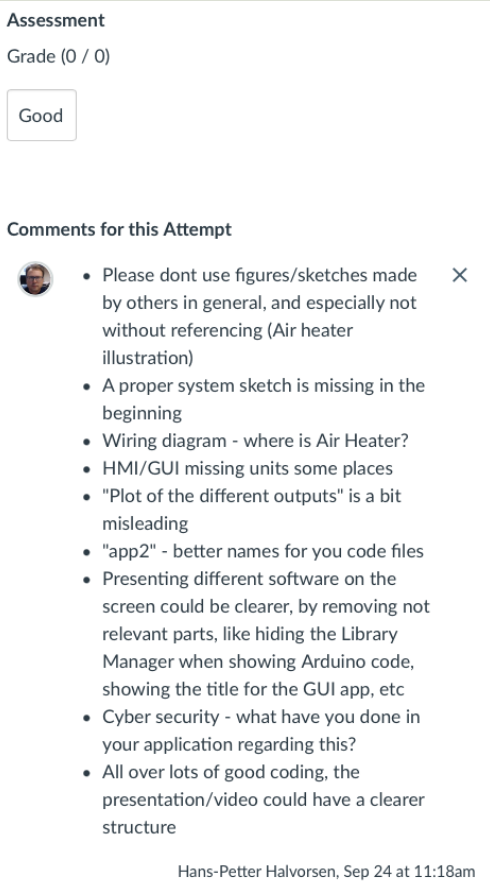
Sensor Technology

Microsoft Teams

- Do you need **Help**? Want to **Collaborate**? Want to **Discuss Technical Issues** with Others? **Share Knowledge**?
- Do you have Questions regarding this Course or some of the Assignments or Lab Work? We will use Microsoft Teams.
- In Microsoft Teams you can get help from one of the supervisors or from other students. You can chat, have video meetings, ask questions, respond to questions, etc. Basically, you can use Teams to communicate with the persons involved in this course.
- Very often someone else is wondering about the same as you - or perhaps someone else has experienced the same thing and found a solution for the problem? Then post information about this in the Teams room.
- Need help outside normal office hours? Perhaps a fellow student can help you if you ask your questions here? For example, if you have installation problems, etc., a fellow student can usually respond better than the supervisor can (outside scheduled hours, evenings, weekends, etc.). You also learn a lot from helping each other.
- You can also use Microsoft Teams for collaboration with other students.

Feedback on your Work

- You get written feedback/comments after each lab in Canvas.
  I spend approx. 30min. per student per submission.
- Du will get a «grade» in addition to the written feedback:
  - “Fail” (Not Approved)
  - “Good” (Approved, average score)
  - “Great” (Approved, above average)
  - “Excellent” (Approved, highest level)
- Fail? You will get one additional chance to get your work approved.
- The feedback should be used as part of the improvement's potential for the next assignments.



Assessment

Grade (0 / 0)

Good

Comments for this Attempt

- Please dont use figures/sketches made by others in general, and especially not without referencing (Air heater illustration)
- A proper system sketch is missing in the beginning
- Wiring diagram - where is Air Heater?
- HMI/GUI missing units some places
- "Plot of the different outputs" is a bit misleading
- "app2" - better names for you code files
- Presenting different software on the screen could be clearer, by removing not relevant parts, like hiding the Library Manager when showing Arduino code, showing the title for the GUI app, etc
- Cyber security - what have you done in your application regarding this?
- All over lots of good coding, the presentation/video could have a clearer structure

Hans-Petter Halvorsen, Sep 24 at 11:18am

Final Lab Gathering

- **Online** and **Industry Master** Students
- Purpose: Finishing the Lab Assignments
  using available Hardware in the Laboratory at the University
- Collaboration and sharing: Learn from each other and get to know each other better
- Activities: Self-paced work in the Laboratory
- It is important that you do as much as possible in advance - otherwise you will be very busy at the Lab Gathering!
- Make sure to update your work based on the feedback given earlier in the semester for each of the assignments
- Demonstrations of the work and results where all the pieces are put together as a fully working system (Hardware + Software)
- The Lab Gathering is compulsory

How many pass this course?

Internet of Things and Cyber Security 2023										
#	Name	Type	Lab1	Lab2	Lab3	Web Site	Attendance	Lab Gathering	Passed Course	Comment
1		Campus	Good	Good	Good	Good			X	
2		Online	Very good	Good	Good	Good		X	X	
3		Campus	Good	Good	Good	Good			X	
4		Campus	Good	Very good	Very good	Very good			X	
5		Campus	Good	Good	Good	Good			X	
6		Industry	Excellent	Excellent	Very good	Very good			X	
7		Exchange	Very good	Very good	Very good	Good			X	
8		Online	Very good	Very good	Good	Good		X	X	
9		Campus	Good	Good	Good	Good			X	
10		Online	Good	Good	Good	Very good		X	X	
11		Online	Excellent	Very good	Very good	Good		X	X	
27		Campus	Good	Very good	Very good	Good			X	
28		Campus	Good	Good	Good	Good			X	
29		Online	Very good	Very good	Very good	Good		X	X	
30		Online	Good	Very good	Good	Good		X	X	
31		Industry	Very good	Good	Good	Good		X	X	
32		Online	Excellent	Very good	Very good	Good		X	X	
		32	32	32	32	32	0	13	30	30 studenter har fått **Bestått**

- **Folder/Portfolio Assessment**. The grade is 100% based on work done and delivered during the semester. There is **no final exam** that you need to prepare for or join.
- About **95%** of the students will pass this course!
- Inactive students who have not participated or submitted anything during the semester is not part of this statistics.
- Basically, If you work according to the recommended course schedule and the recommended workload and deliver according to given deadlines, you will **pass** this course!

Hans-Petter Halvorsen

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