MAE 6291
Internet of Things for Engineers

Prof. Kartik Bulusu, MAE Dept.

	Topic(s)	μ-LABs and Assignment(s) due
Week 0 [01/15/2025]	• IoT and Edge Computing [The big pictures] • Introduction to Raspberry Pi and Python programming • Course overview, policies and deliverables	• Getting familiar with the Raspberry Pi 4B • Python programming using Thonny • Recap of Week-0

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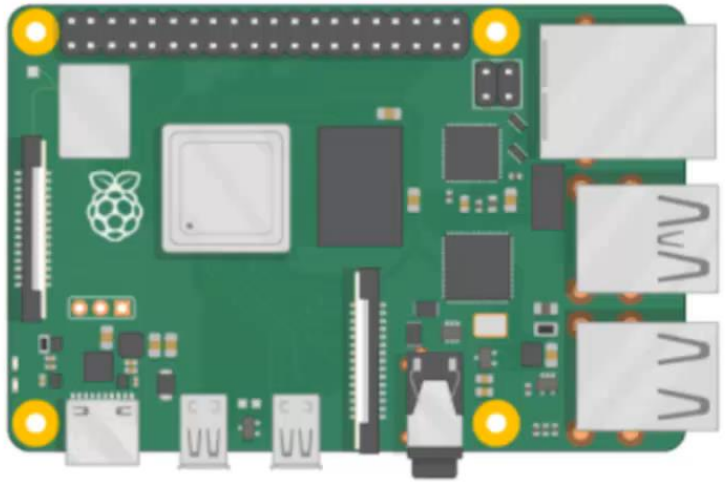
Spring 2025

Photo: Kartik Bulusu

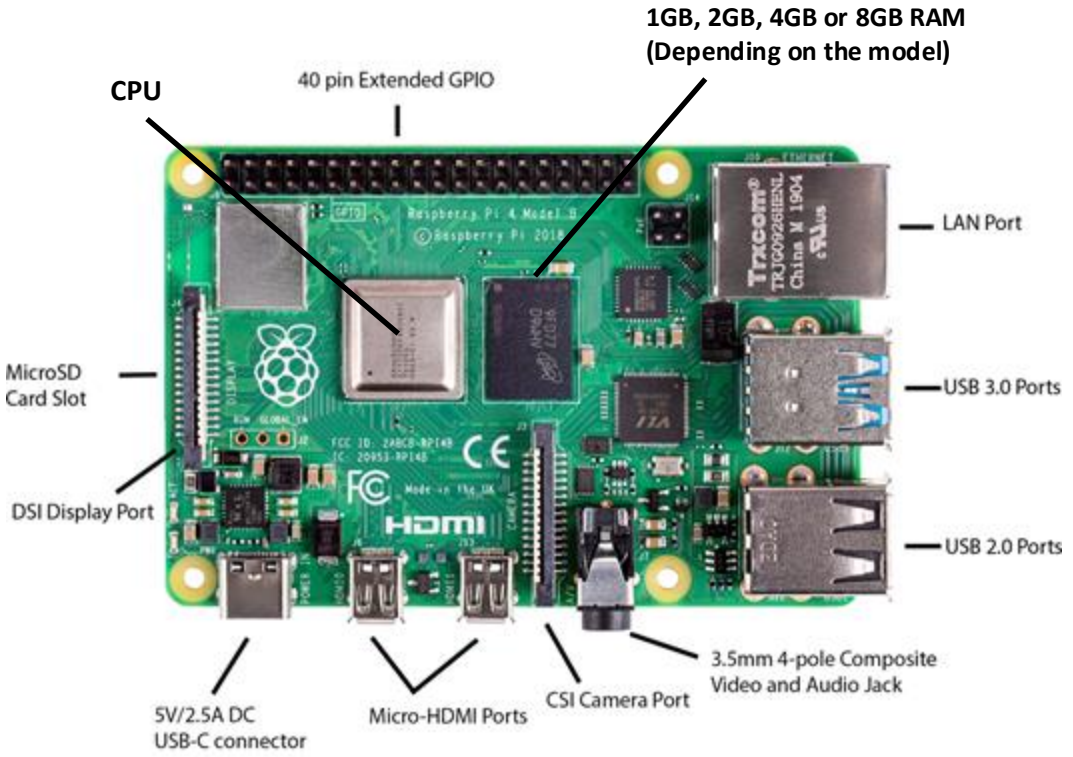
Sneak preview of hardware and the Edge-lab

Raspberry Pi Hardware and Connections



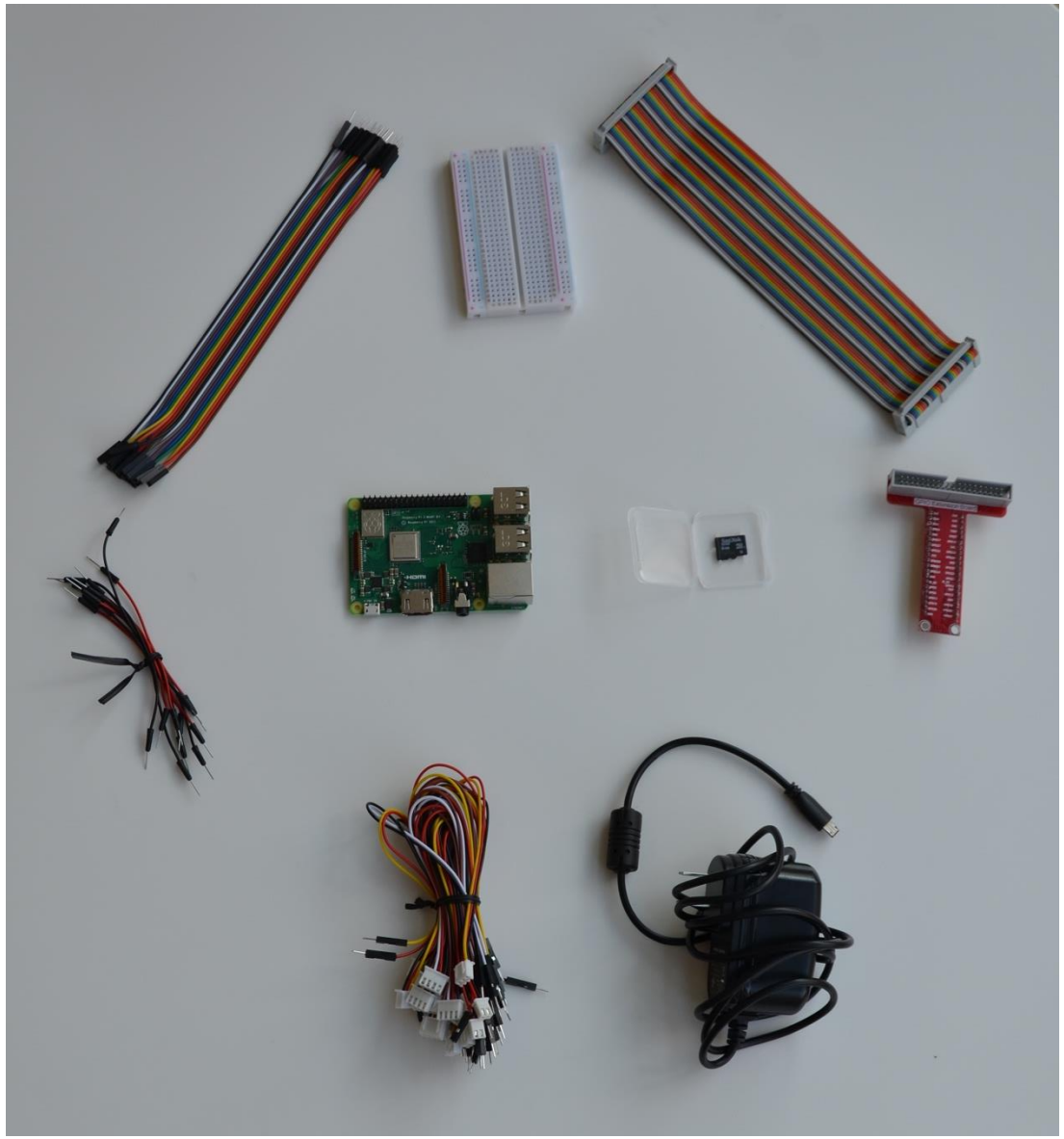
Source: https://www.raspberrypi.org/help/

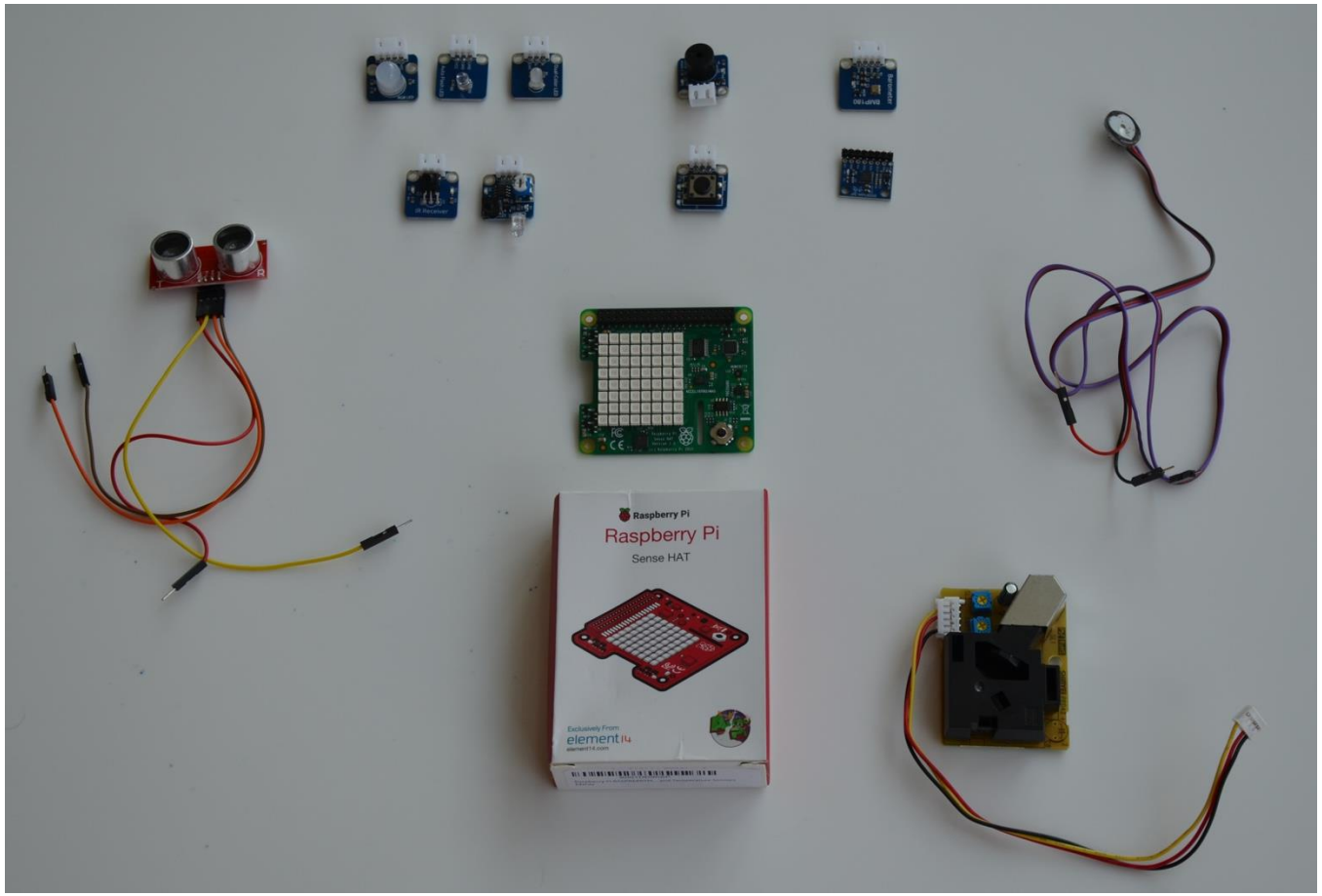
GET STARTED WITH RASPBERRY PI



- Raspberry Pi OS (previously called Raspbian) is the recommended operating system for normal use.
- Raspberry Pi OS is a free operating system based on Debian, optimized for the Raspberry Pi hardware.
- The OS comes with over 35,000 packages: pre-compiled software bundled in a format for easy installation.

python™ == “batteries included” programming language





Components and sensors in your kits

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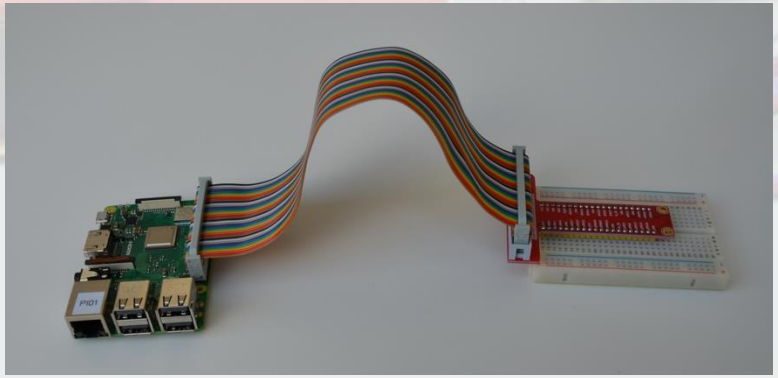
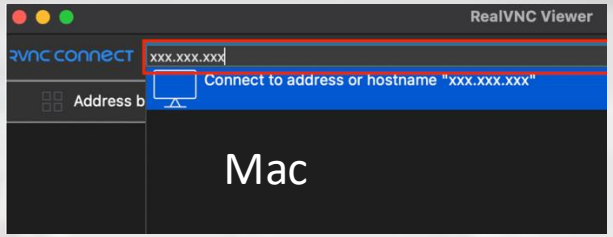
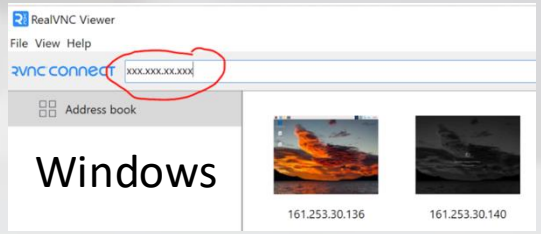
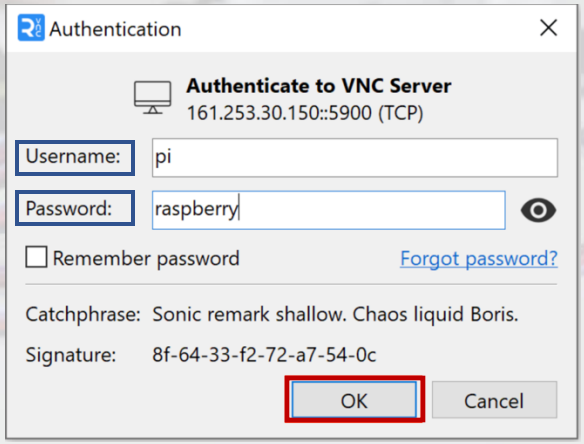
Connect the Raspberry Pi Model 4B (RPi) to a bread board

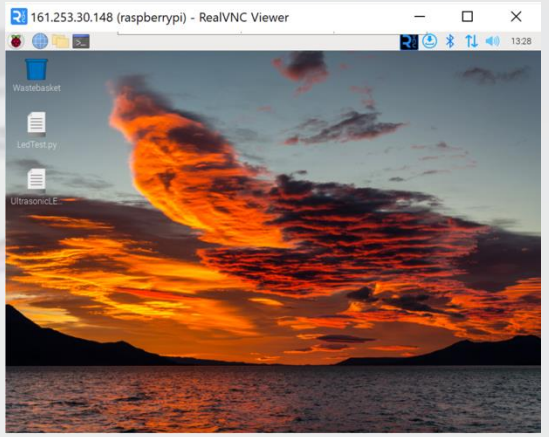


Access to the RPi in the laboratory









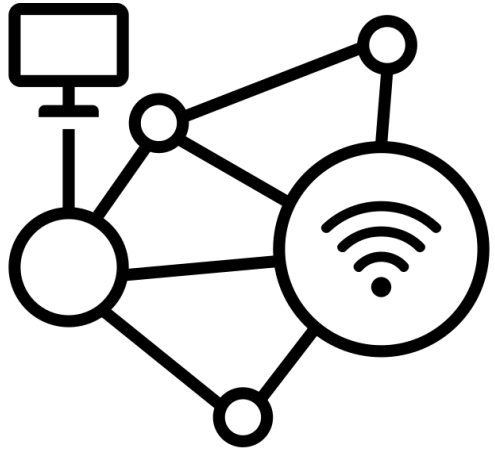
IoT and Edge Computing [The big pictures]

A brief history of IoT, the context and some examples

How do we begin …

- **1st industrial revolution:** *1760 to 1840* -> Railroads
- **2nd industrial revolution:** *Late 19th centaury to 20th centaury* -> Mass production and electricity
- **3rd industrial revolution:** *1960s* -> Digital and revolution
- **4th industrial revolution:** *NOW* -> Ubiquitous and mobile communication

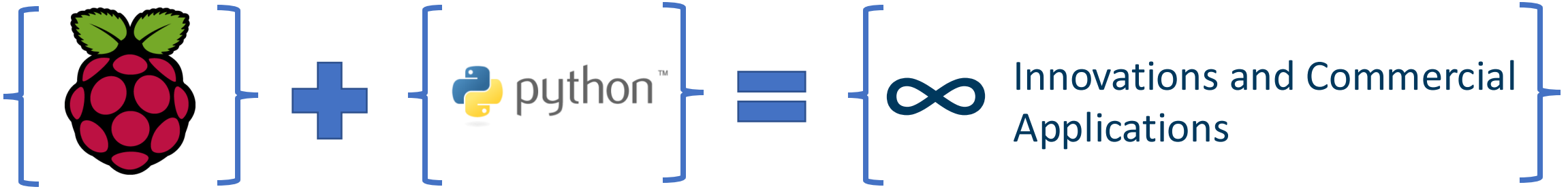
Sources:
K. Schwab. The Fourth Industrial Revolution



Icon Source: IoT by Alla Zaleuska from Noun Project

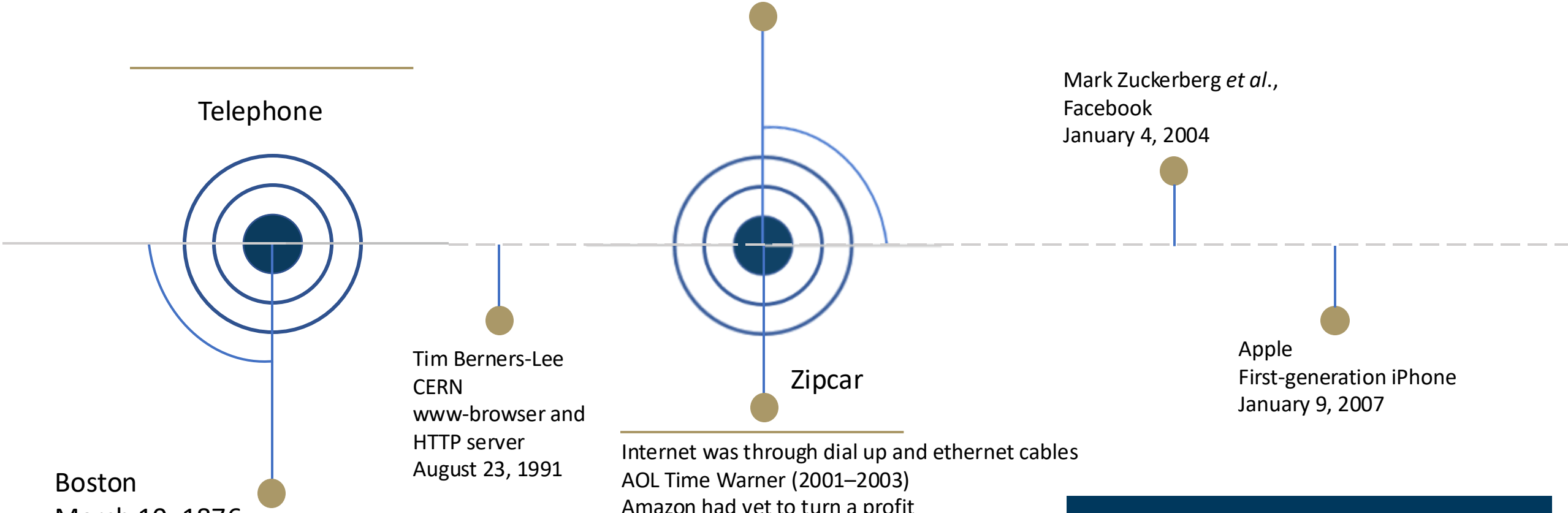
IoT with edge computing capability is going to be the backbone of the Industry 4.0.

- We will explore the **IoT** framework
- Expand it with **edge computing** ideology
- Gain practical and hands-on exposure in "**µ-Labs**"



Communication hasn't been the same!

Sources:
L. Bernardi, S. Sarma and K. R. Traub, The Inversion Factor: How to Thrive in the IoT Economy



"Things" haven't been the same!

Zipcar discussion in an IoT course ?

Sources:
Adam Richardson, 2011, The Four Technologies You Need to Be Working With, https://hbr.org/2011/09/the-four-technologies-you-need
Zipcar: https://en.wikipedia.org/wiki/Zipcar#Embedded_technologies
L. Bernardi, S. Sarma and K. R. Traub, The Inversion Factor: How to Thrive in the IoT Economy

- **Zipcar** is an American car-sharing company and a subsidiary of Avis Budget Group.
- Zipcar was founded in 2000 by Antje Danielson and Robin Chase.

RFID cards

- Located on the windshield to lock and unlock

Smartphone app

- **"Kill" function**
  - sound the vehicle's horn and flash the lights
  - unlock or lock the vehicle
- **Global Positioning System**
  - To locate the vehicle in a parking lot
  - GPS location

Zipcar == IoT in Vehicular Applications

Icon sources:
transponder by Stanislav Levin from https://thenounproject.com/browse/icons/term/transponder/
Key by Lars Meiertoberens from https://thenounproject.com/browse/icons/term/key/
Internet Connection by Jackvisual from https://thenounproject.com/browse/icons/term/internet-connection/
Talking Tech: Zipcar and iPhone, https://www.youtube.com/watch?v=rCO0jFoJ1xY

Zipcar

- Pioneer of IoT technology; cornerstone of its business

Fundamental questions Zipcar asked or not

✗ **"What new technology can we build and sell to people to transport people?"**

✓ **"How can we reinvent how people get where they need to go, using technology?"**

On March 14, 2013, Avis Budget Group acquired Zipcar for approximately US$500 million.

Think (or thing) outside the box

Source:
Combining AI, 5G, And Machine Vision To Transform Fish Farming, https://youtu.be/PzQ_iWKFsxE

IoT in Fishing and Aquaculture

Reimagining fisheries industry

- How can Artificial Intelligence (AI) and Machine Learning (ML) transform the IoT technologies ?

Fundamental questions

- Can over-fishing be controlled in a sustainable manner ?
- Fish feeding optimization
- Can IoT + AI/ML optimize fishing location, sorting and monitor health of fish farms?

IoT in Smart cities…

Reimagining the landscape

- Connected sensors, lights, and meters to collect and analyze data
- **Improve infrastructure, public utilities and services, and more**.

Fundamental challenges

- Infrastructure
- Security and Hackers
- Privacy concerns
- Community education and engagement
- Being social inclusive

(Re)defining “things”

Number of Internet of Things (IoT) connected devices worldwide from 2019 to 2021, with forecasts from 2022 to 2030 (in billions) [Graph], Transforma Insights, July 1, 2022. [Online]. Available: https://www.statista.com/statistics/1183457/iot-connected-devices-worldwide/

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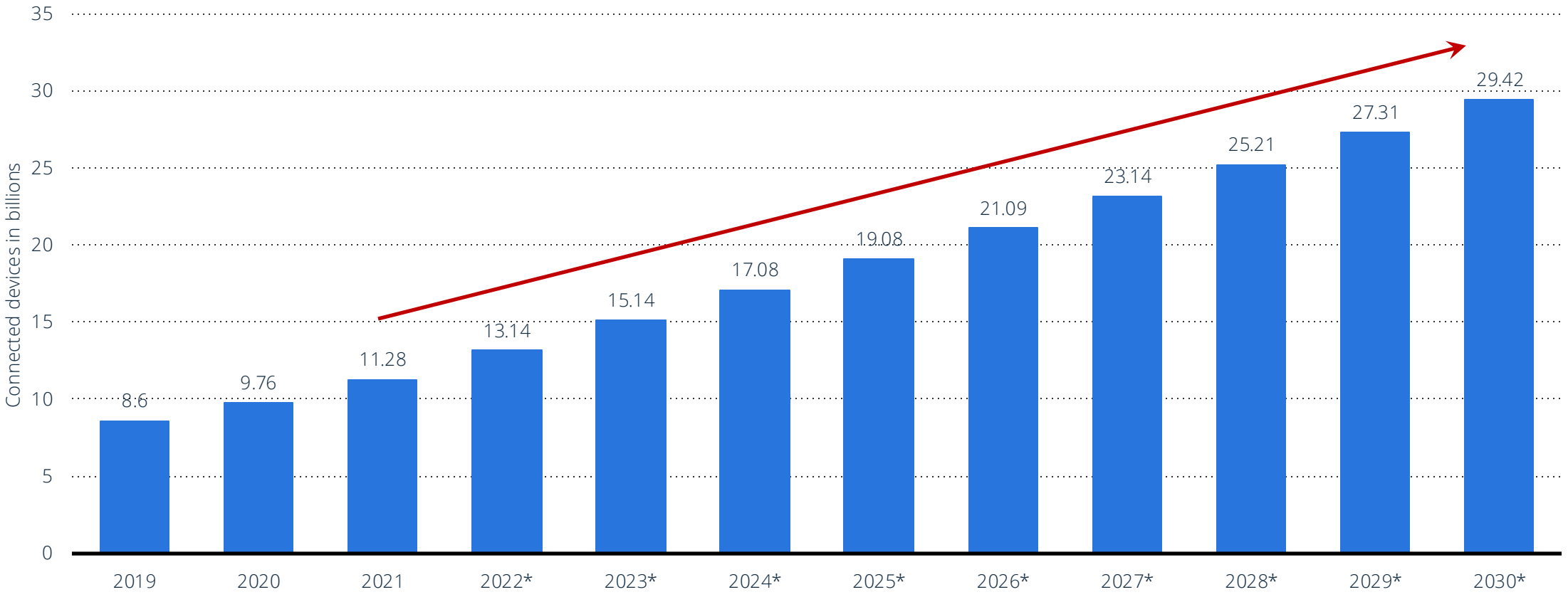
Number of Internet of Things (IoT) connected devices worldwide from 2019 to 2021, with forecasts from 2022 to 2030 (in billions)

Number of Internet of Things (IoT) connected devices worldwide from 2019 to 2021, with forecasts from 2022 to 2030 (in billions)

Number of IoT connected devices worldwide 2019-2021, with forecasts to 2030



Note(s): Worldwide; 2019 to 2022
Further information regarding this statistic can be found on page 8.
Source(s): Transforma Insights; ID 1183457

Internet of Things (IoT) total annual revenue worldwide from 2020 to 2030 (in billion U.S. dollars) [Graph], Transforma Insights, July 1, 2022. [Online]. Available: https://www.statista.com/statistics/1194709/iot-revenue-worldwide/

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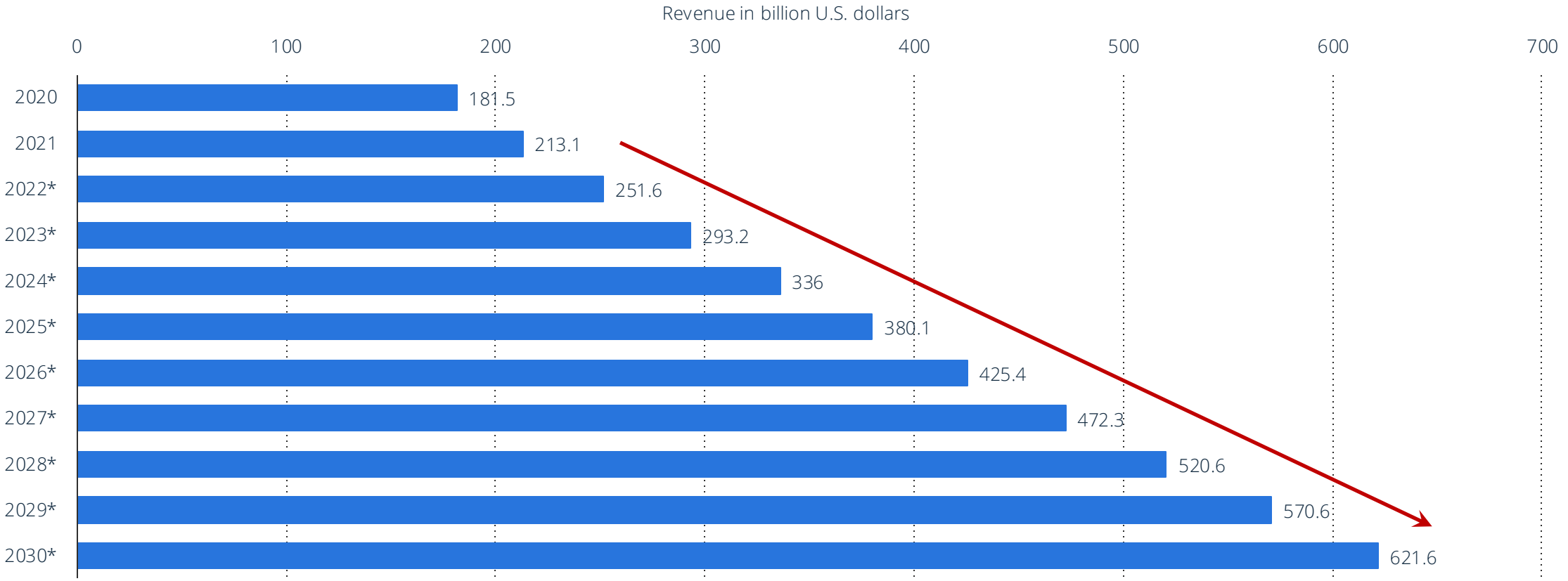
Internet of Things (IoT) total annual revenue worldwide from 2020 to 2030 (in billion U.S. dollars)

statista

Internet of Things (IoT) total annual revenue worldwide from 2020 to 2030 (in billion U.S. dollars)

IoT global annual revenue 2020-2030



Note(s): Worldwide; 2020 to 2022
Further information regarding this statistic can be found on page 8.
Source(s): Transforma Insights; ID 1194709

How do we move forward?

We are going to democratizing the technology created in this course

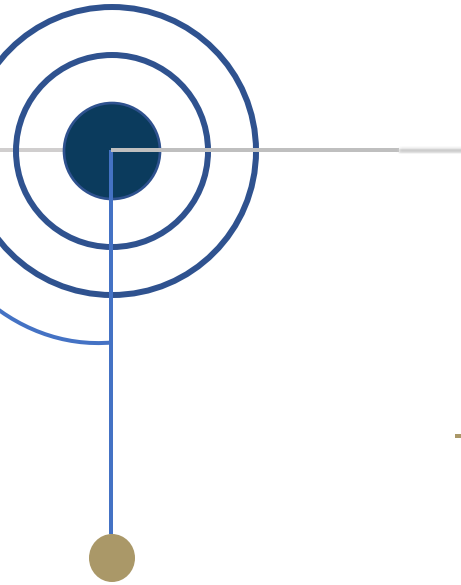
Course Objectives

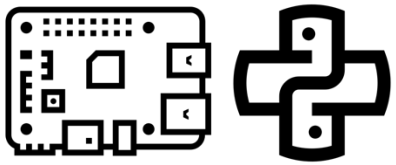
Key concepts and constructs

Understand

Familiarize

Implement





Hardware and
Procedural programming Language

Frame problems and
address them with technology

Teaching and learning environment

Icon sources:
typing by monkik from https://thenounproject.com/icon/typing-3382155/
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touch by Julie Muckensturm from https://thenounproject.com/icon/touch-26836/
messy scribble by ochre7 from https://thenounproject.com/icon/messy-scribble-228748/
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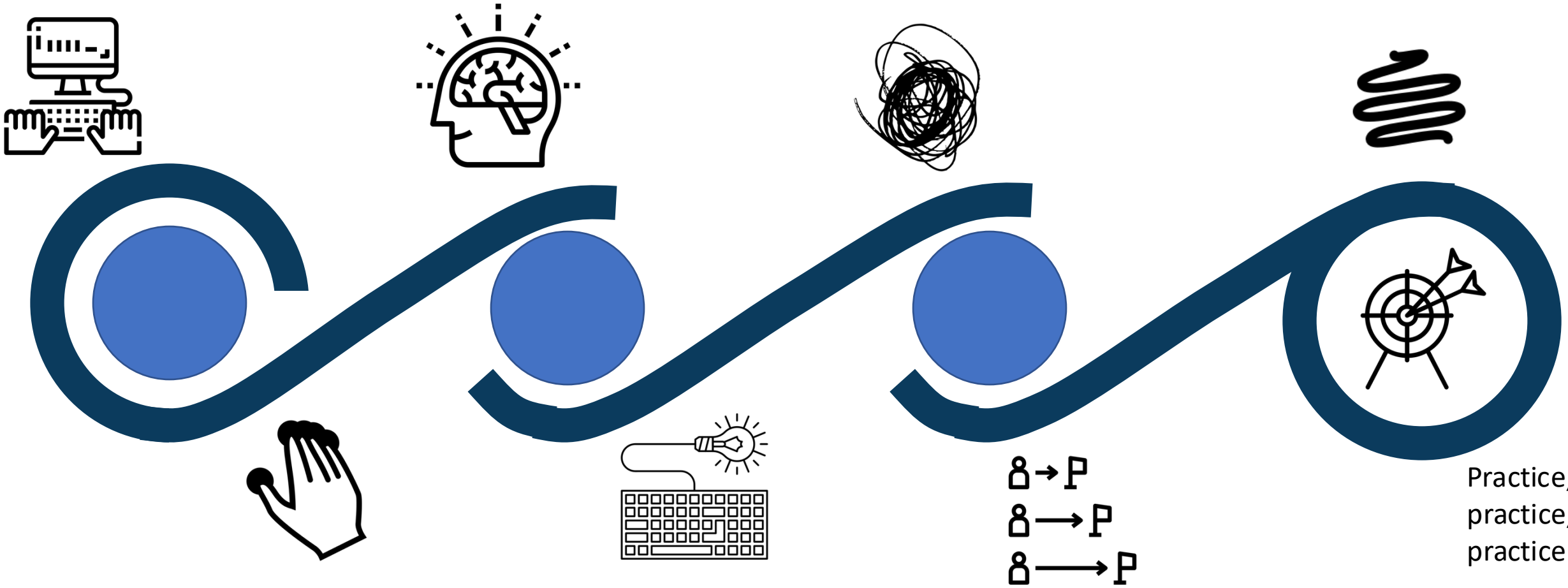

Practice, practice, practice!

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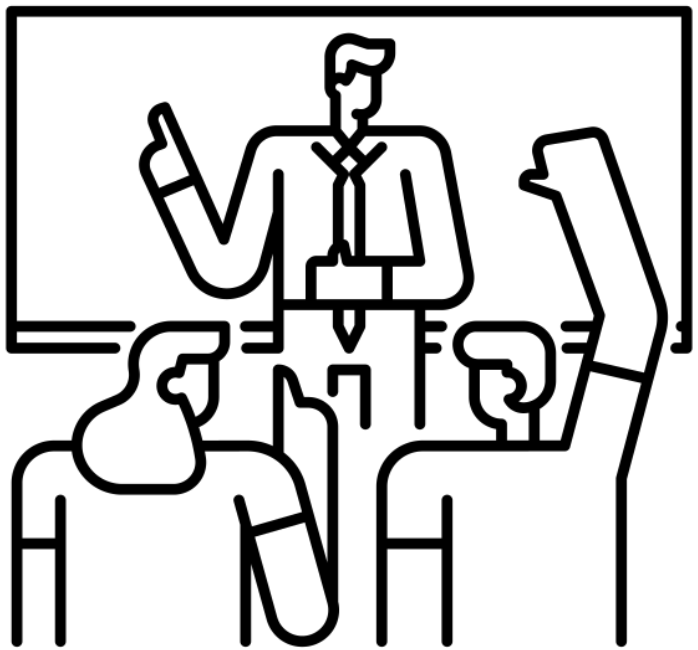
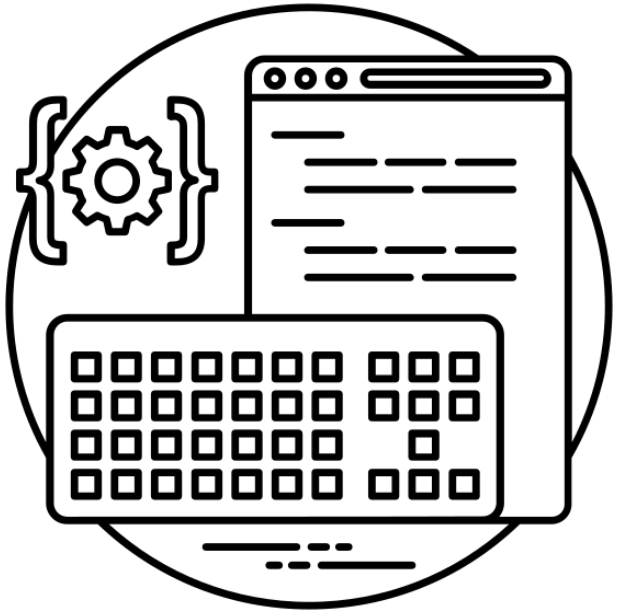
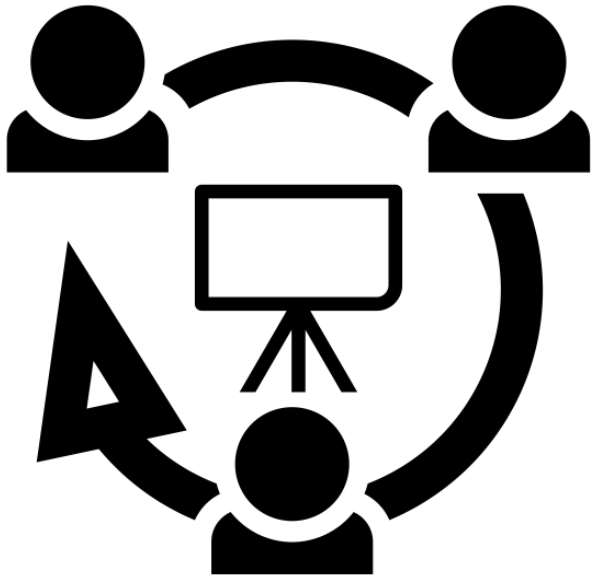
Icon sources:
coding by Vectors Market from https://thenounproject.com/browse/icons/term/coding/
Sprint review by Swen-Peter Ekkebus from https://thenounproject.com/browse/icons/term/sprint-review/

Reading, report writing and presentations

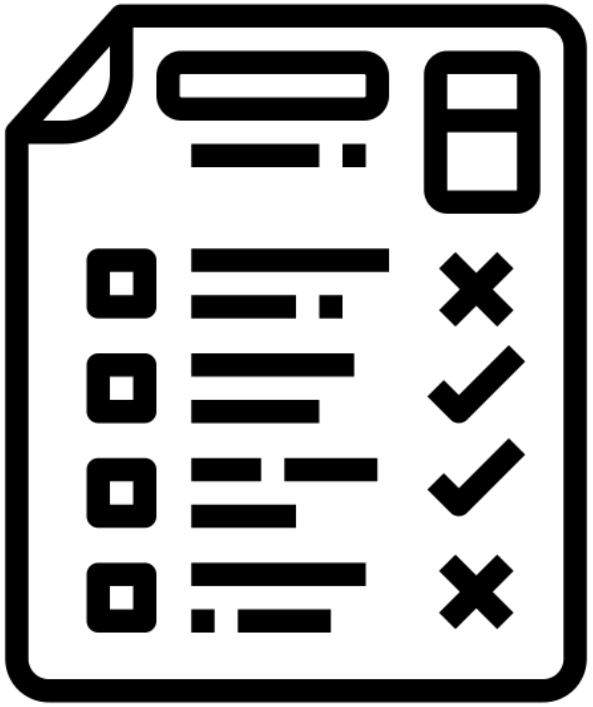




Coding on hardware



Democratizing the grading and other course policies – with your inputs



Undergraduate students

- In-class lab work and/or Weekly Quizzes 10%
- Python programming and other Homework 10%
- In-class or offline presentations 10%
- Guest lecture reports 20%
- Projects (including code, demo, written report and presentation) 50%
  - 20% Midterm project (Group or Individual)
  - 30% Final project (Individual if you chose a midterm group or vice versa)

Graduate students

- In-class lab work and/or Weekly Quizzes 10%
- Python programming and other Homework 10%
- In-class or offline presentations 10%
- Guest lecture reports 10%
- Paper reviews of selected archival journals will be required in formats provided 10%
- Projects (including code, demo, written report and presentation) 50%
  - 20% Midterm project (Individual)
  - 30% Final project (Individual)