

CSCI 4907

Introduction to IoT and Edge Computing Applications

Prof. Kartik Bulusu, CS Dept.

	Topic(s) and readings	μ-LABs and Assignment(s) due
Week 0 [01/19/2024]	<ul style="list-style-type: none">• IoT and Edge Computing [The big pictures]• Introduction to Raspberry Pi and Python programming• Course overview, policies and deliverables	<ul style="list-style-type: none">• Getting familiar with the Raspberry Pi 4B• Python programming using Thonny• Week 0 (no deliverables)

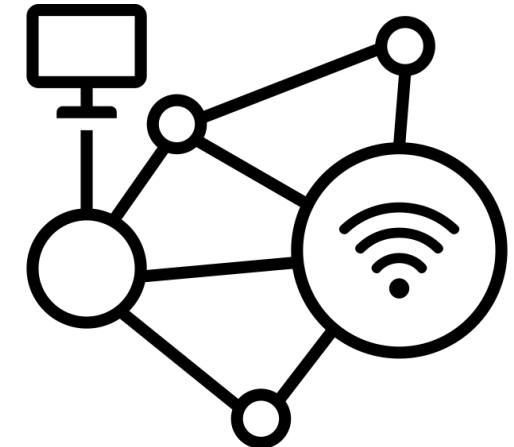


School of Engineering
& Applied Science

How do we begin ...

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

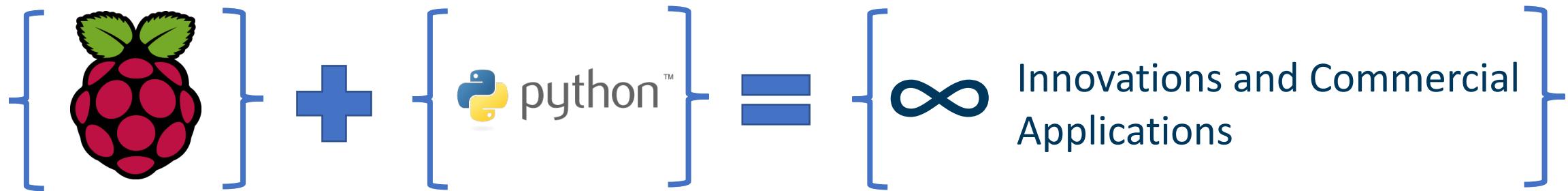
Sources:
K. Schwab. The Fourth Industrial Revolution



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**”

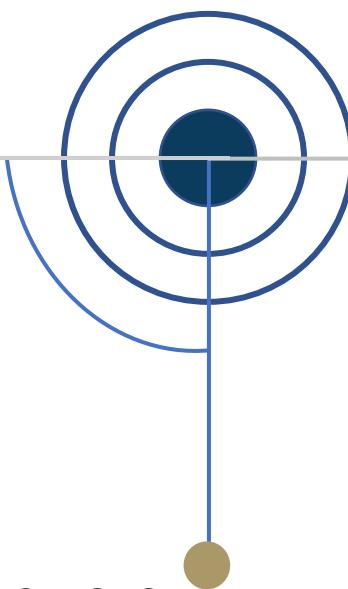


Communication hasn't been the same!

Antje Danielson and Robin Chase
Cambridge, circa 2000

Telephone

Boston
March 10, 1876



Tim Berners-Lee
CERN
www-browser and
HTTP server
August 23, 1991



Zipcar

Internet was through dial up and ethernet cables
AOL Time Warner (2001–2003)
Amazon had yet to turn a profit
Microsoft was selling office productivity suites

Mark Zuckerberg *et al.*,
Facebook
January 4, 2004

Apple
First-generation iPhone
January 9, 2007

“Things” haven’t been the same!

Zipcar discussion in an IoT course ?

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



transponder by Stanislav Levin from <https://thenounproject.com/browse/icons/term/transponder/>

Key by Lars Meieroberens 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 == IoT in Vehicular Applications



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

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...

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/>



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”



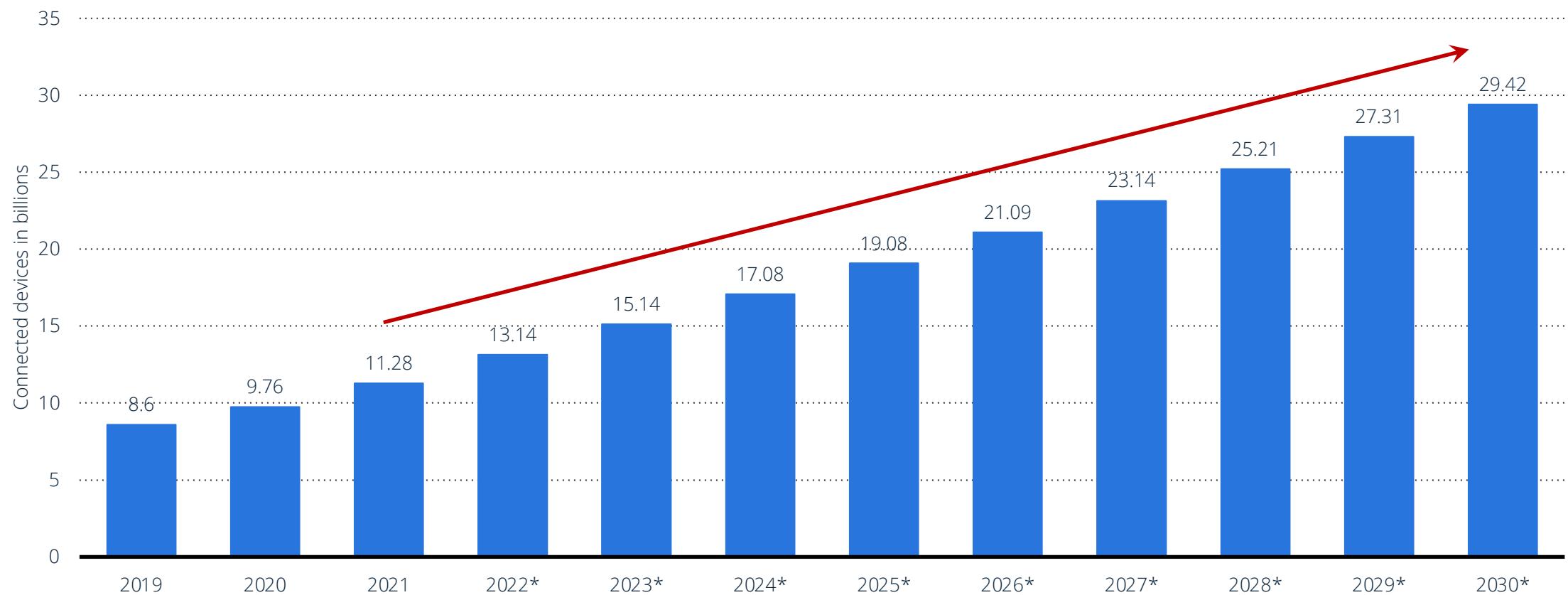
Number of Internet of Things (IoT) connected devices worldwide from 2019 to 2021, with forecasts from 2022 to 2030 (in billions) [Graph], Transforma Insights, July 1, 2022. [Online]. Available: <https://www.statista.com/statistics/1183457/iot-connected-devices-worldwide/>

TELECOMMUNICATIONS

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



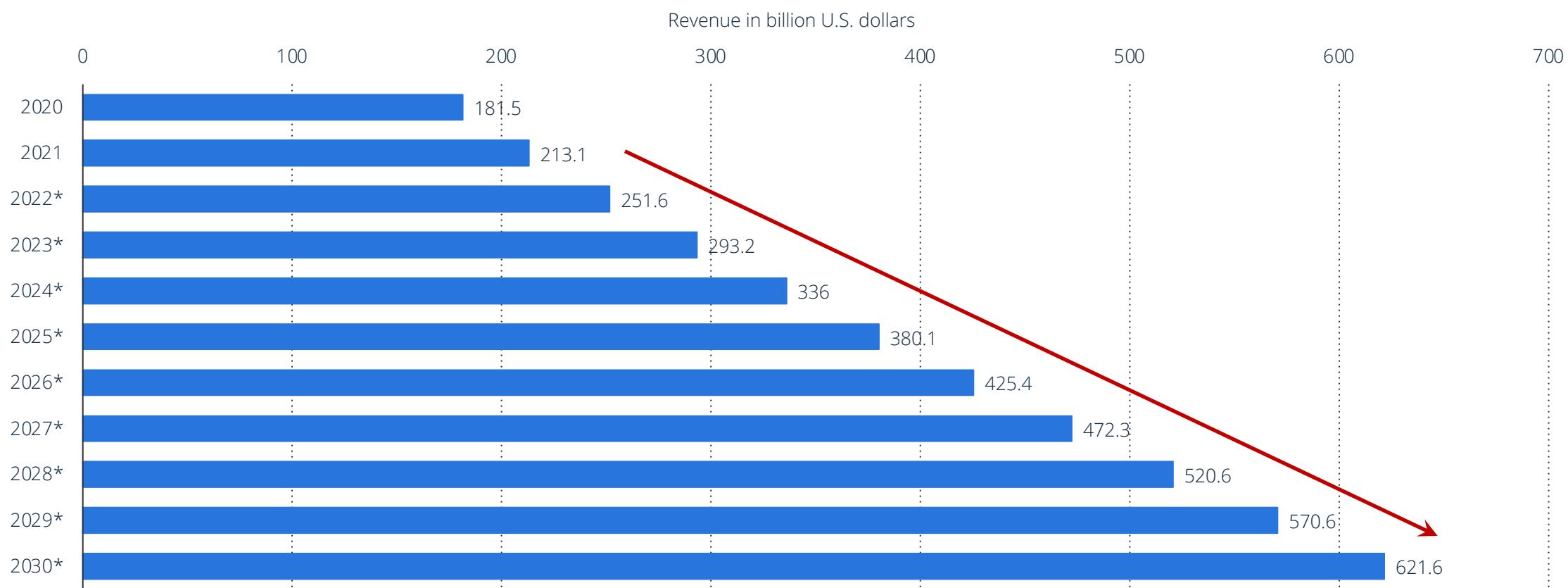
Internet of Things (IoT) total annual revenue worldwide from 2020 to 2030 (in billion U.S. dollars) [Graph], Transforma Insights, July 1, 2022. [Online]. Available: <https://www.statista.com/statistics/1194709/iot-revenue-worldwide/>

TELECOMMUNICATIONS

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

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](#).

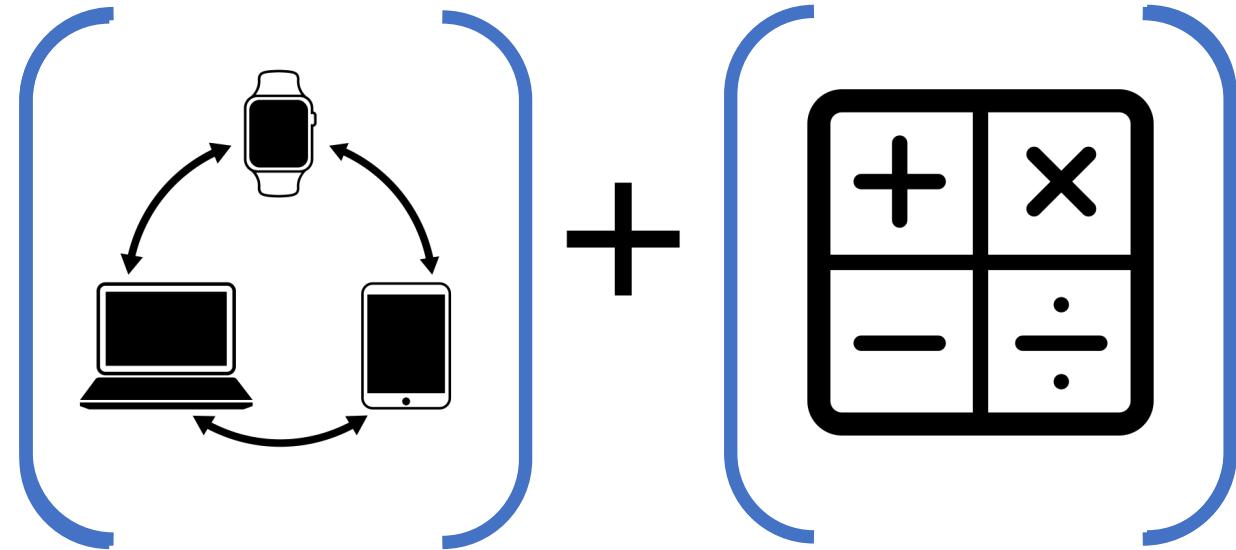
Source(s): Transforma Insights; ID 1194709

What's the “thing”?

Paradigm #1

- A **thing** is self-contained and only operates within the confines of its physical shell.
 - **Thing** carries out only those functions that its designer envisioned when it was fabricated.
- The **thing** contains a powerful computer inside but is completely hidden from the user.
- The **thing** has firmware (not called software).

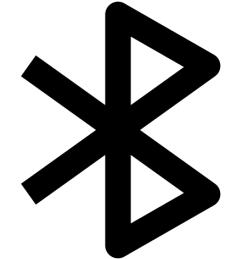
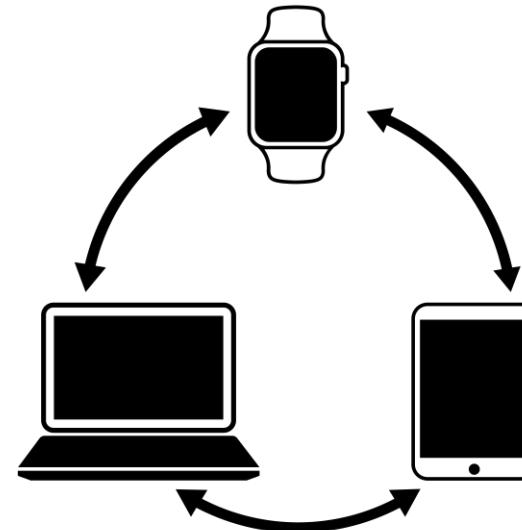
Paradigm #2



Paradigm #3

Connected “things”

By Connectivity Standards Alliance - <https://zigbeealliance.org/solutions/>, Public Domain: <https://commons.wikimedia.org/w/index.php?curid=106668572>
By Connectivity Standards Alliance - buildwithmatter.com, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=114216376>
internet of things by Davo Sime from <https://thenounproject.com/browse/icons/term/internet-of-things/>



5G



The Evolution of Things

IoT

Internet of Things

- Devices connected to internet
- Breaking the boundaries of form

IoT

Intelligence of Things

- Devices that host software applications
- Breaking the boundaries of function

IoT

Innovation of Things

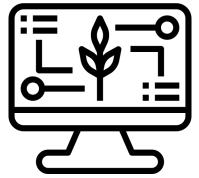
- Devices that become experiences



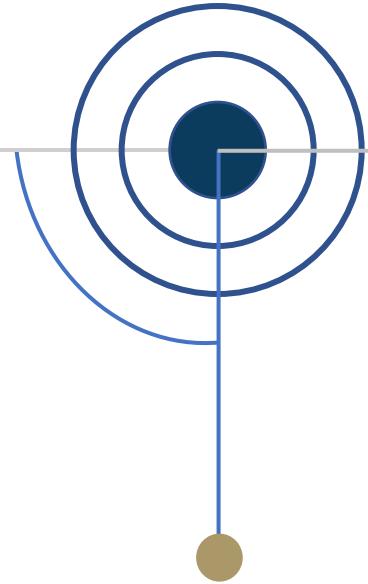
How do we move forward?

I like to democratize science and this course too

Course Objectives

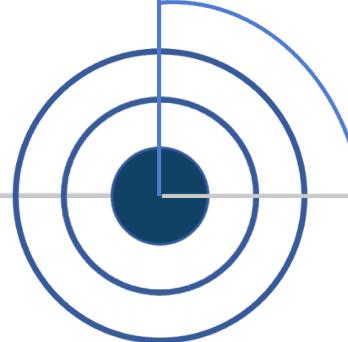


Understand

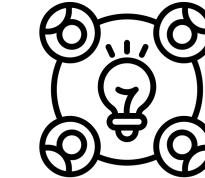
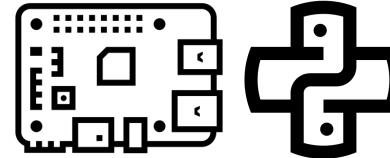


Hardware and
Procedural programming Language

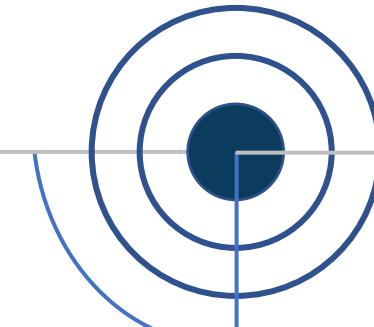
Key concepts and constructs



Familiarize



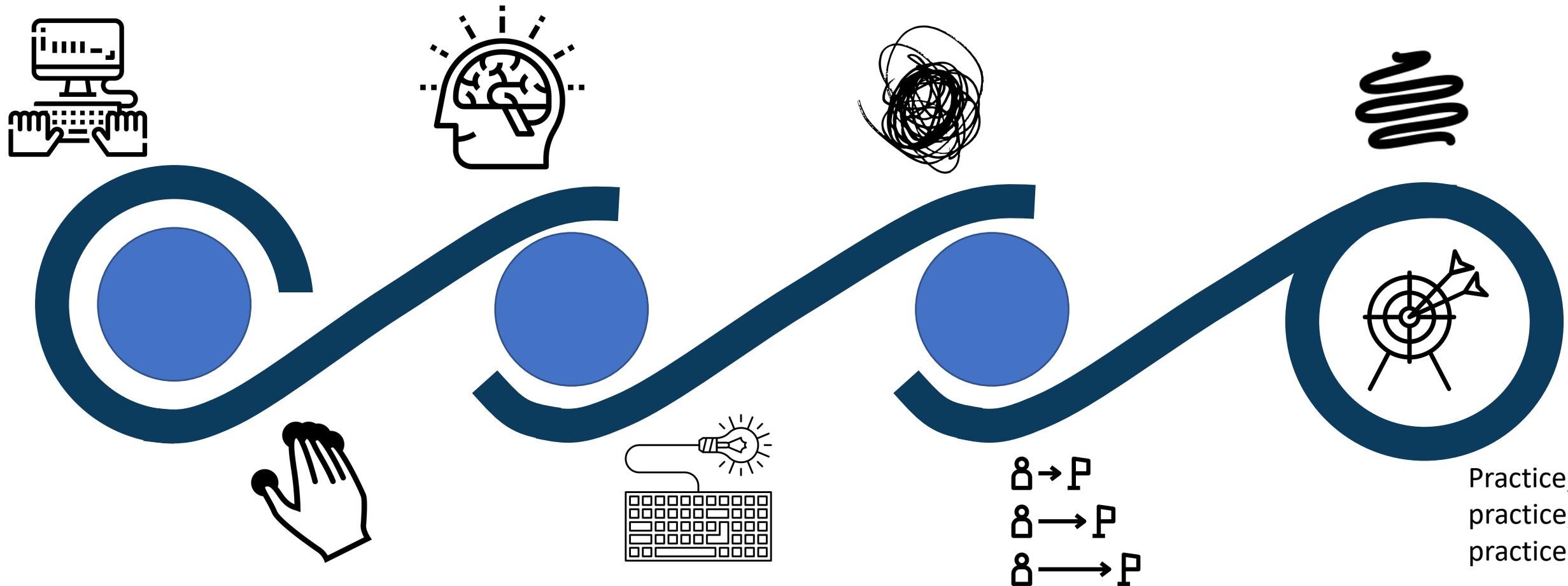
Practice



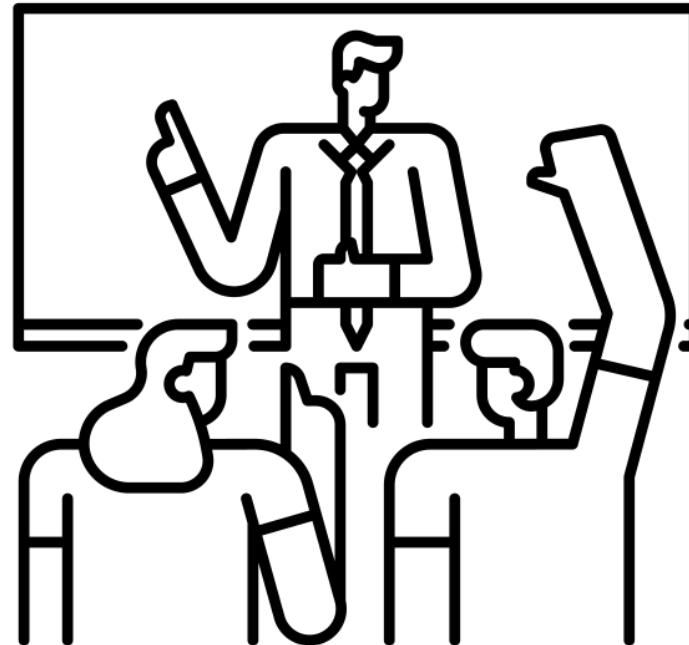
Solve problems at the beginner-level

typing by monkik from <https://thenounproject.com/icon/typing-3382155/>
practice by Kamin Ginkaew from <https://thenounproject.com/icon/practice-4829034/>
touch by Julie Muckensturm from <https://thenounproject.com/icon/touch-26836/>
messy scribble by ochre7 from <https://thenounproject.com/icon/messy-scribble-228748/>
Scribble by Goodfather from <https://thenounproject.com/icon/scribble-363760/>
practice by ProSymbols from <https://thenounproject.com/icon/practice-1876457/>
code idea by Danil Polshin from <https://thenounproject.com/icon/code-idea-597303/>

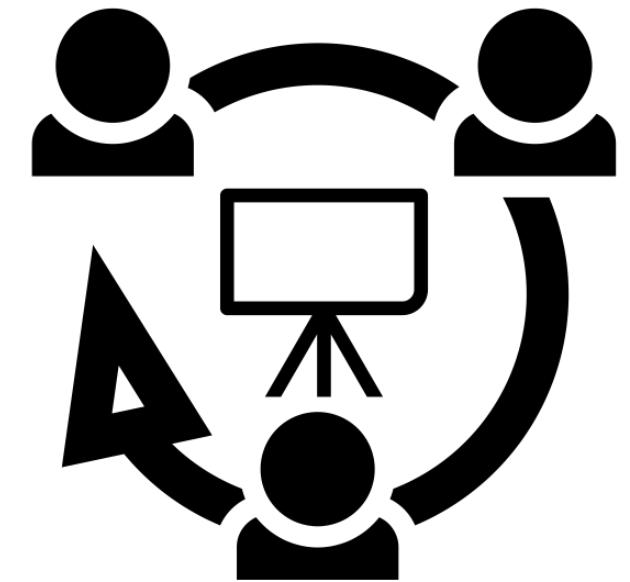
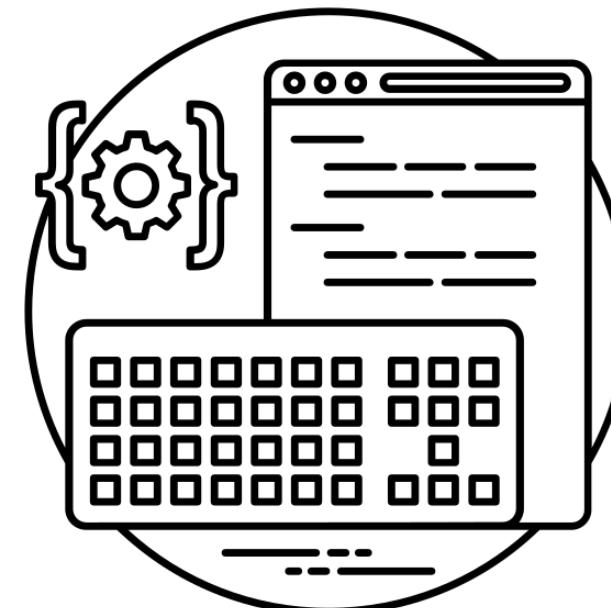
Teaching and learning environment



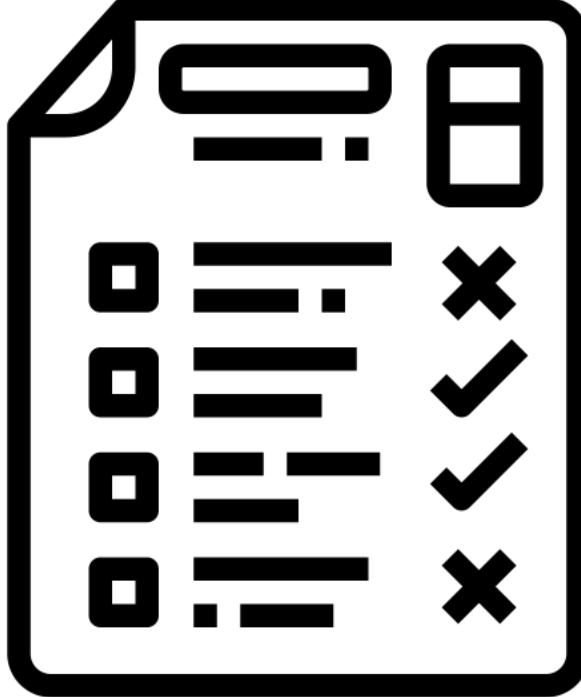
Reading, report writing and presentations



Coding on hardware



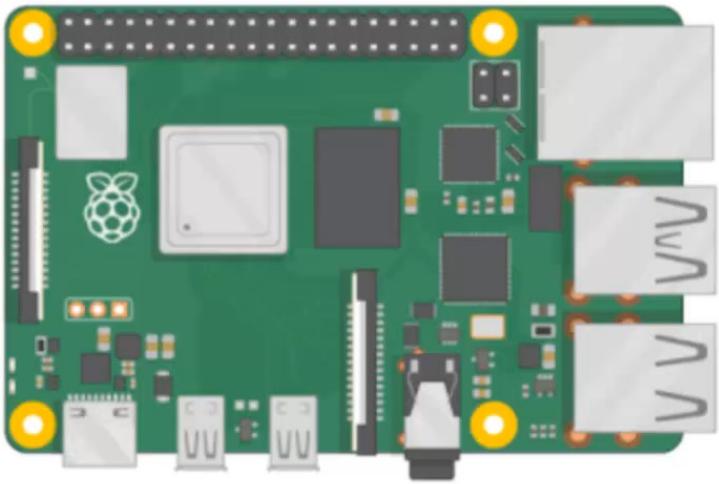
Democratizing the grading and other course policies



- Attendance and/or peer-to-peer and instructor interactions 10%
- In-class work and/or Weekly Quizzes 10%
- Project reports, paper reviews and in-class presentations 10%
- Python programming and other Homework 20%
- Projects (including code, demo, written report and presentation) 50%
 - 20% midterm project; 30% final project

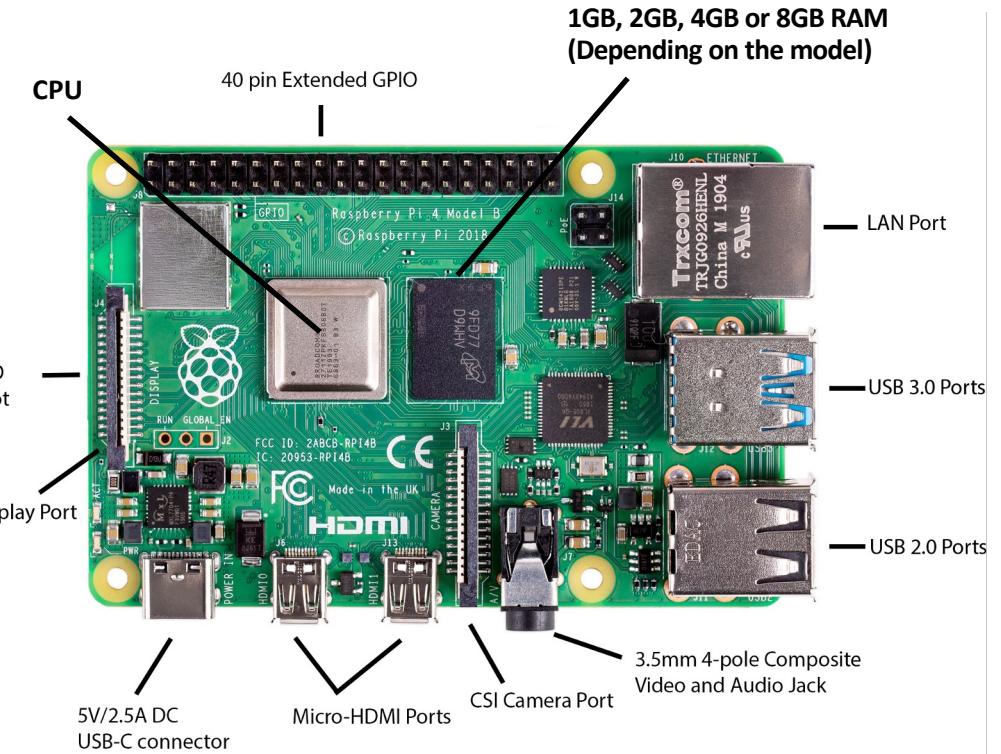
Sneak preview of hardware and the Edge-lab

Raspberry Pi Hardware and Connections

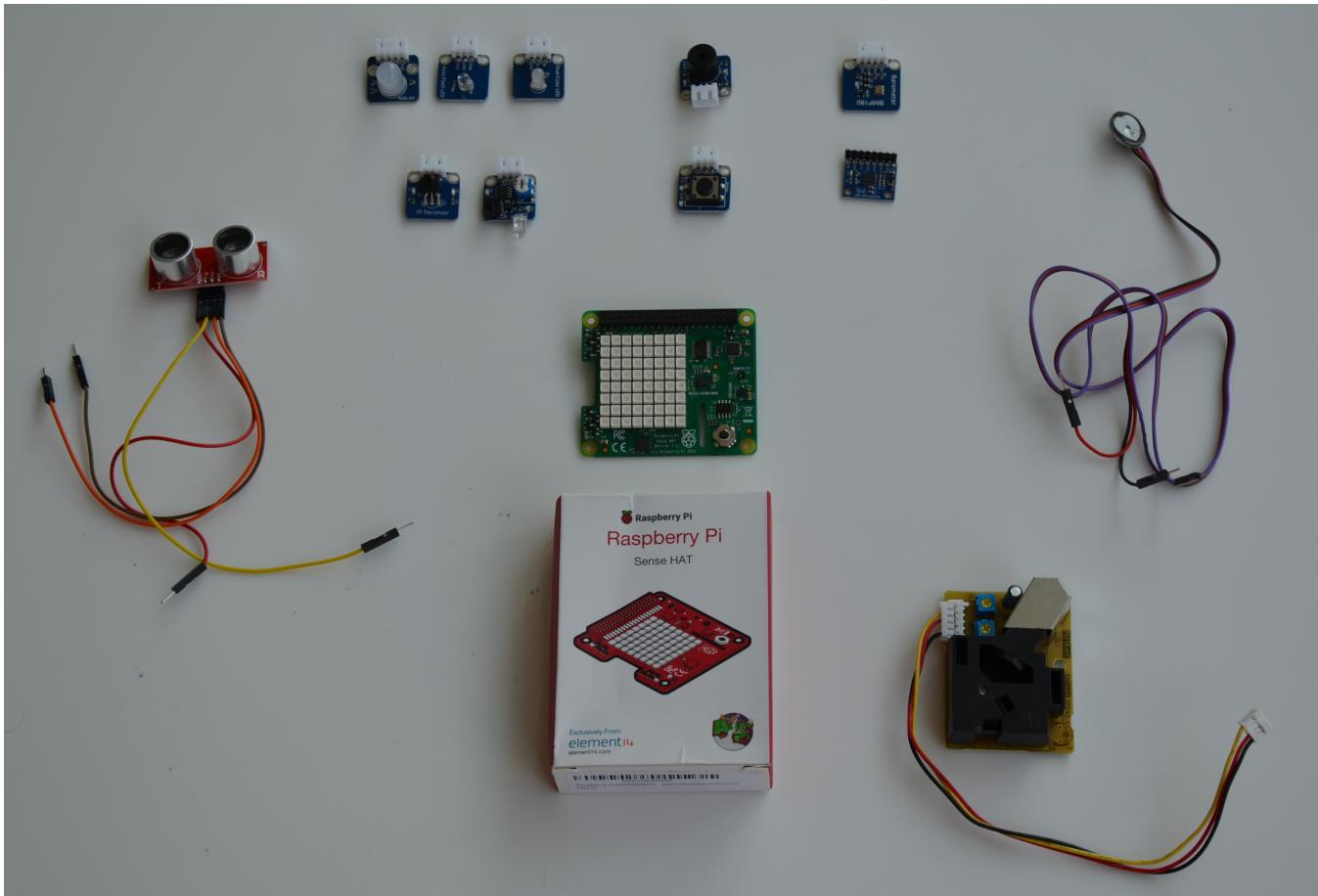
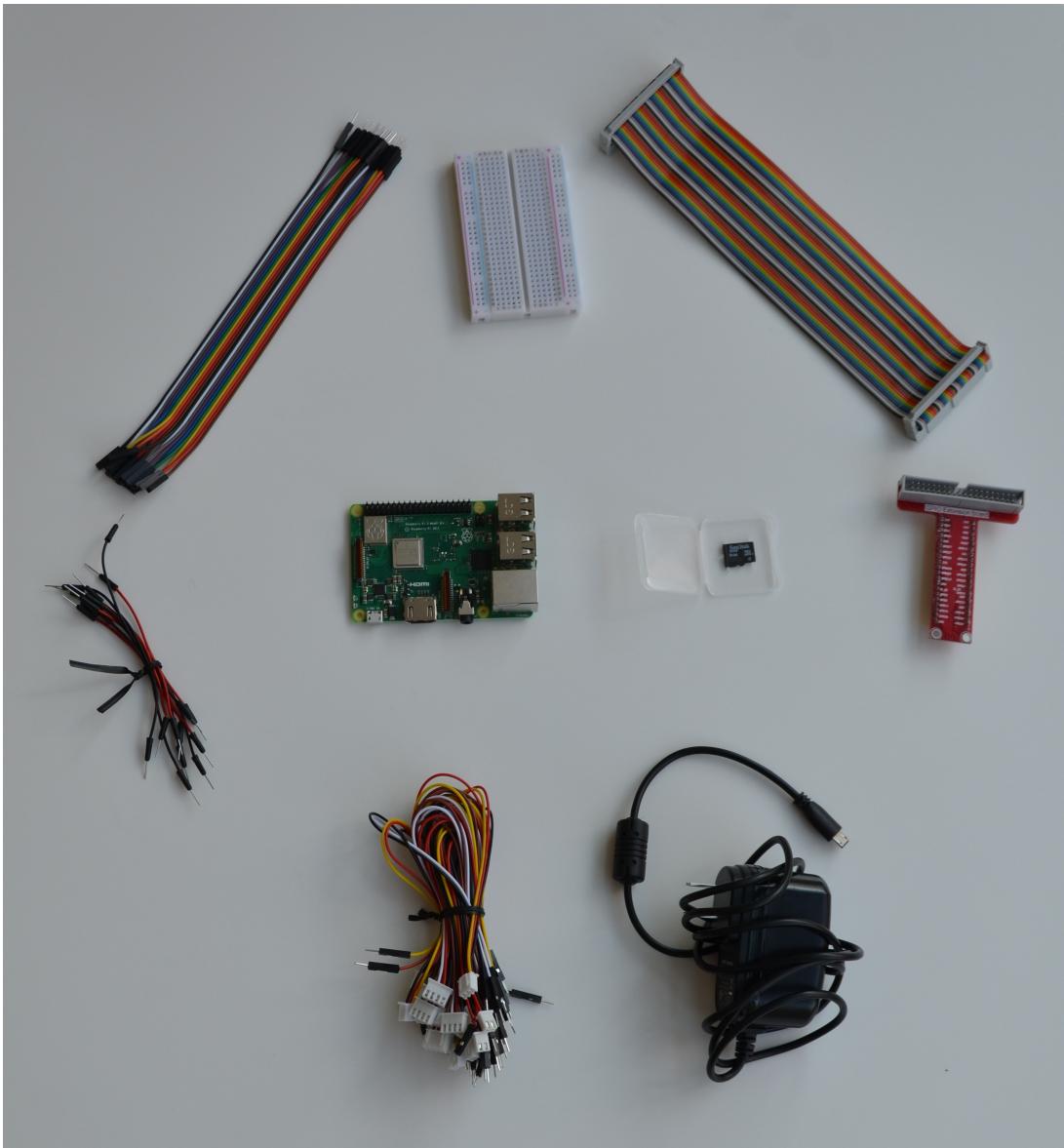


Source: <https://www.raspberrypi.org/help/>

GET STARTED WITH RASPBERRY PI

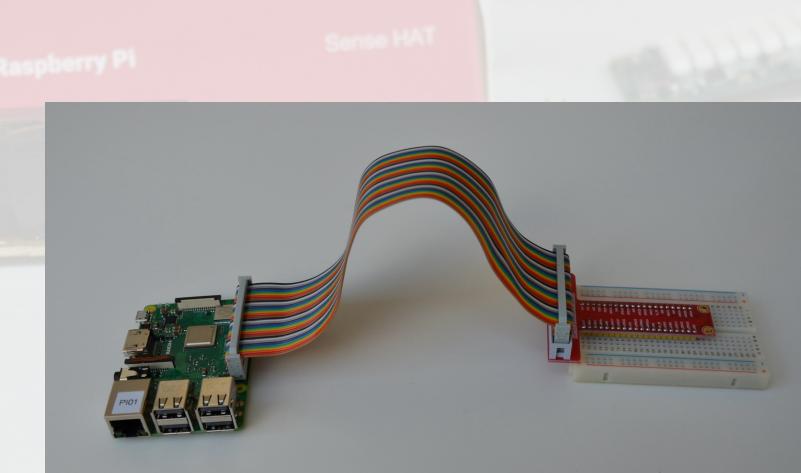


- Raspberry Pi OS (previously called Raspbian) is the recommended operating system for normal use.
- Raspberry Pi OS is a free operating system based on Debian, optimised for the Raspberry Pi hardware.
- The OS comes with over 35,000 packages: pre-compiled software bundled in a format for easy installation.



Components and sensors in your kits

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



Access to the RPi in the laboratory

