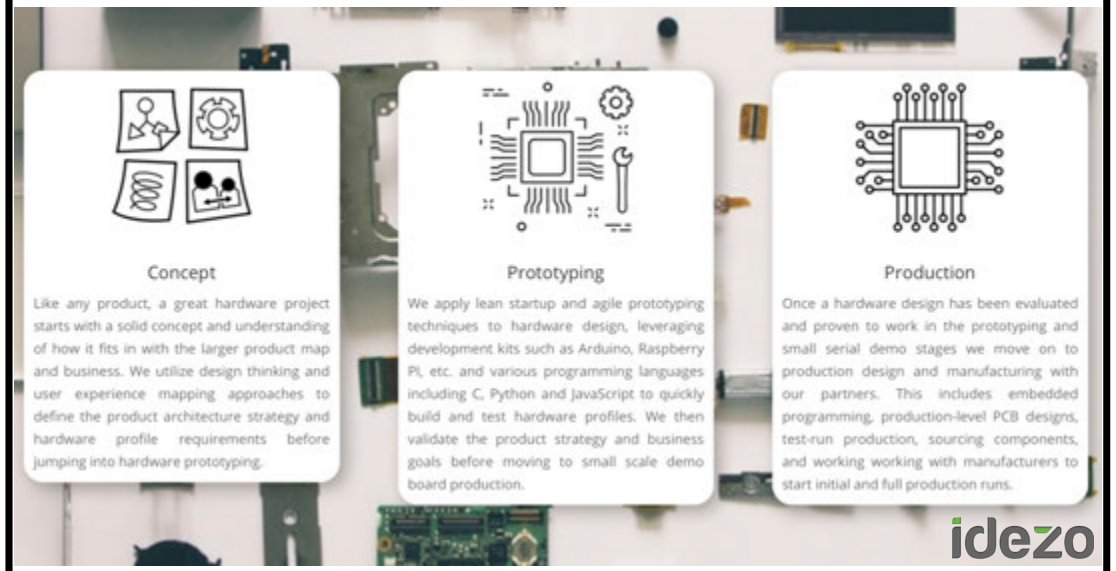
HANDS ON APPROACH TO

Data Science

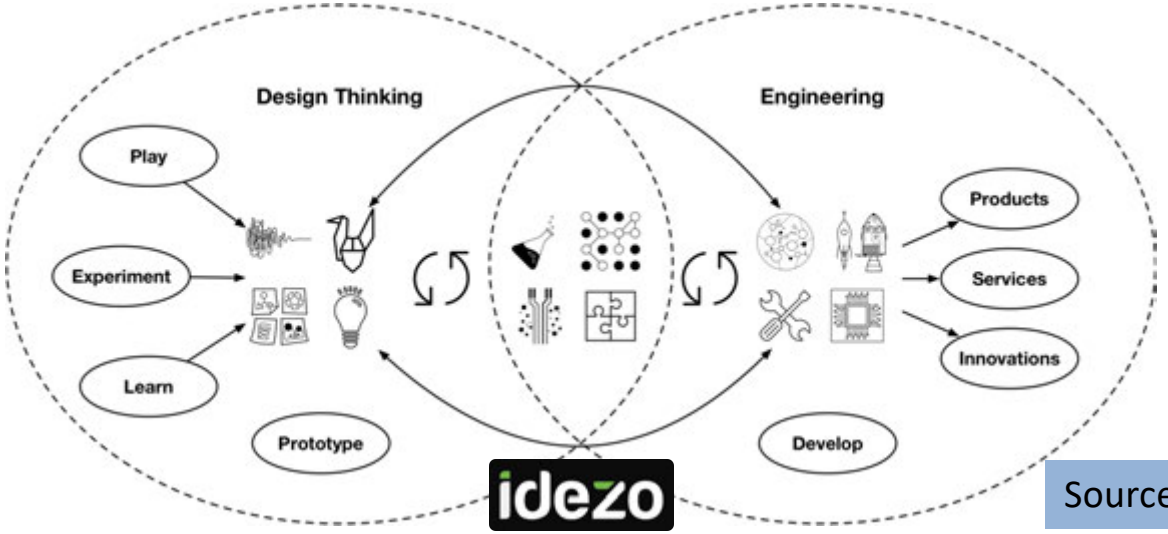
for (the)

IoT



Rob van der Willigen

HANDS ON APPROACH TO DATA SCIENCE for (the) IoT

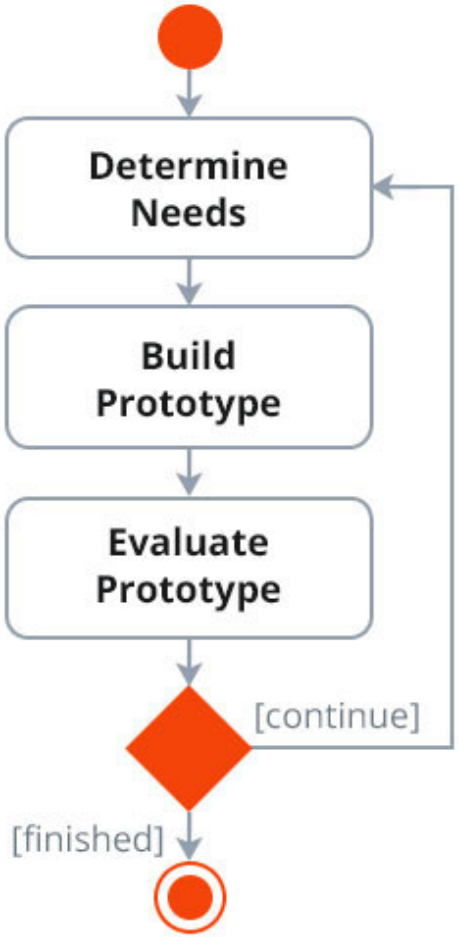


Source: https://idezo.ch

This Data Science Course was developed for keuzevak- program of the School of Communication, Media and Information Technology (CMI, at the Hogeschool Rotterdam **(Rotterdam University of Applied Sciences, RUAS)**.
If you find errors or omissions, please contact the author, Rob van der Willigen, at r.f.van.der.willigen@hr.nl. Materials of this course and code examples used will become available at:
https://github.com/robvdw/CMIDAT01K-DATA-SCIENCE-for-IOT

Rapid Prototyping

- You never get it right first time
- If at first you don"t succeed ...



Course Setup

Lesson 01:	**Discovering the IoT Data Science Domain**
Lesson 02:	**Defining project requirements**
	+ Cost calculation/estimate
Lesson 03	**Learn to write code**
Lesson 04-05:	**Autonomous project work**
Lesson 06-07:	**Demonstrating working IoT prototype**
Lesson 08:	**Wrap-up**

Week 09/10: FEEDBACK + GRADING

lesson three

HOGESCHOOL ROTTERDAM

HOGESCHOOL ROTTERDAM

LES: 03

Think like a programmer

Preview Les 04

Write your first line of code (Python)

How to Think about ALGORITHMS

HOGESCHOOL ROTTERDAM

HOGESCHOOL ROTTERDAM

Thinking like a computer scientist means more than being able to program a computer. It requires thinking at multiple levels of abstraction.

JEANNETTE M. WING (wing@cs.cmu.edu) is the President's Professor of Computer Science in and head of the Computer Science Department at Carnegie Mellon University, Pittsburgh, PA.

Computational Thinking

It represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use.

" Computational thinking
is a way of solving problems,
designing systems, and
understanding human behavior
that draws on concepts
fundamental to computer science."

COMMUNICATIONS OF THE ACM March 2006/Vol. 49, No. 3

Wat is an algorithm?

A tool for solving a well-defined (computational) problem by manipulating symbols

The word is derived from the name of the Persian mathematician al-Khwārizmī, who lived in the 9th century.

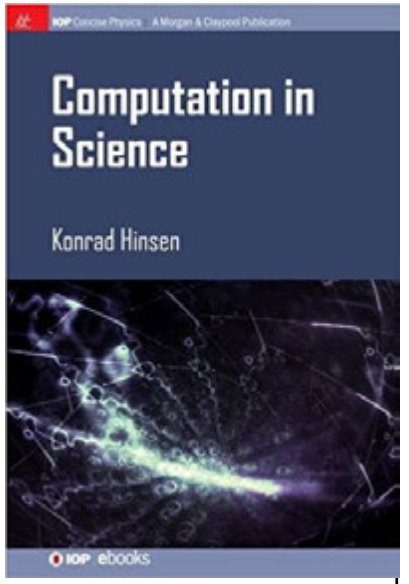
His book describing the 'Indian numbers', which today we call Arabic numerals, introduced our modern decimal notation and its rules for arithmetic into Europe.

The use of this system was called 'algorism' in the late middle ages and is transformed into today's 'algorithm'.

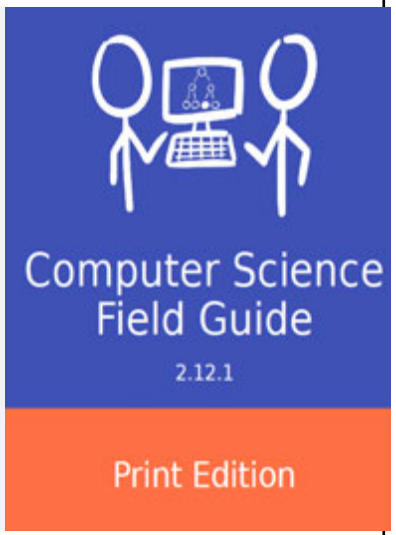
Crossley J.N., & Henry A.S. (1990)Thus spake al-Khwārizmī:
a translation of the text of Cambridge University Library Ms. Ii.vi.5 *Hist. Math.* 17(2) 103–31

Wat is computation?

$$\begin{array}{rrr} 1 & 7 & 3 \\ 0 & 5 & 1 \\ & 0 & \\ \hline & & 4 \end{array} \quad \rightarrow \quad \begin{array}{rrr} 1 & 7 & 3 \\ 0 & 5 & 1 \\ 1 & & \\ \hline & 2 & 4 \end{array} \quad \rightarrow \quad \begin{array}{rrr} 1 & 7 & 3 \\ 0 & 5 & 1 \\ & & \\ \hline 2 & 2 & 4 \end{array}$$



Computations are arithmetic operations or numerical calculations that we all do in everyday life: adding up, multiplying, dividing etc.



Wat is computation?

When thinking about computation,
it is important to know that
symbols & **meanings** are separate.

This is known as the distinction between
syntax and **semantics**.

NUMBERS vs SYMBOLS

Computations do not work on numbers alone,
but on **Symbols:**
a specific representation for numbers

.

NUMBERS vs SYMBOLS

Different representations lead to different methods for doing arithmetic.

NUMBERS vs SYMBOLS

Even though the decimal character string '42', the roman-numeral character string 'XLII', and the English language character string 'forty-two' refer to the same number, they cannot be manipulated in the same way.

SYNTAX vs SEMANTICS

Syntax defines **which** sequences of **symbols** a particular algorithm deals with:

'a sequence of any number of the digits 0 to 9'

0 … 9 (maths)
X=0:1:9 (matlab)

SYNTAX vs SEMANTICS

Semantics defines
how such sequences of **symbols** are **interpreted**,
such as "natural numbers"
2 3 4 but not 0.00123 or 89/234

Non-numerical computation

$$y + 2x = z \quad \rightarrow \quad x = \tfrac{1}{2}(z - y)$$

Once we get rid of the idea that computation is about numbers, we can easily identify other operations that qualify as computations.

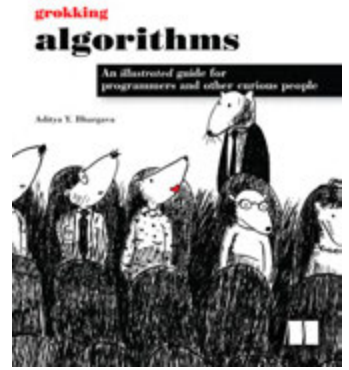
Wat is an algorithm?

No knowledge of *semantics* is needed to apply an algorithm for adding two natural numbers.

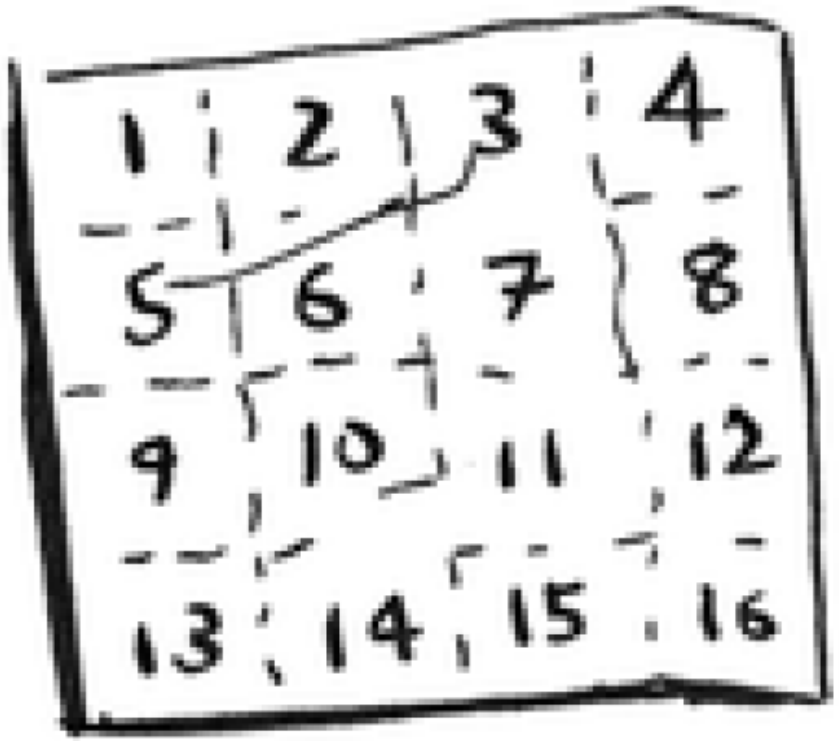
It is essential to understand what **an algorithm** does, and in particular which problems it is ment to solve.

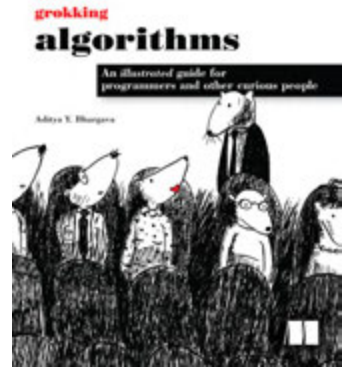
Algorithm

Step by step process or recipe describing *how to solve a problem* and/or *complete a task*, which will always give the correct result

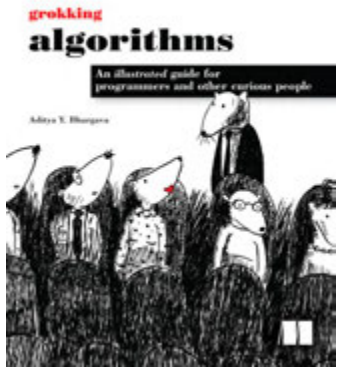


What algorithm will produce these sequence of numbers?



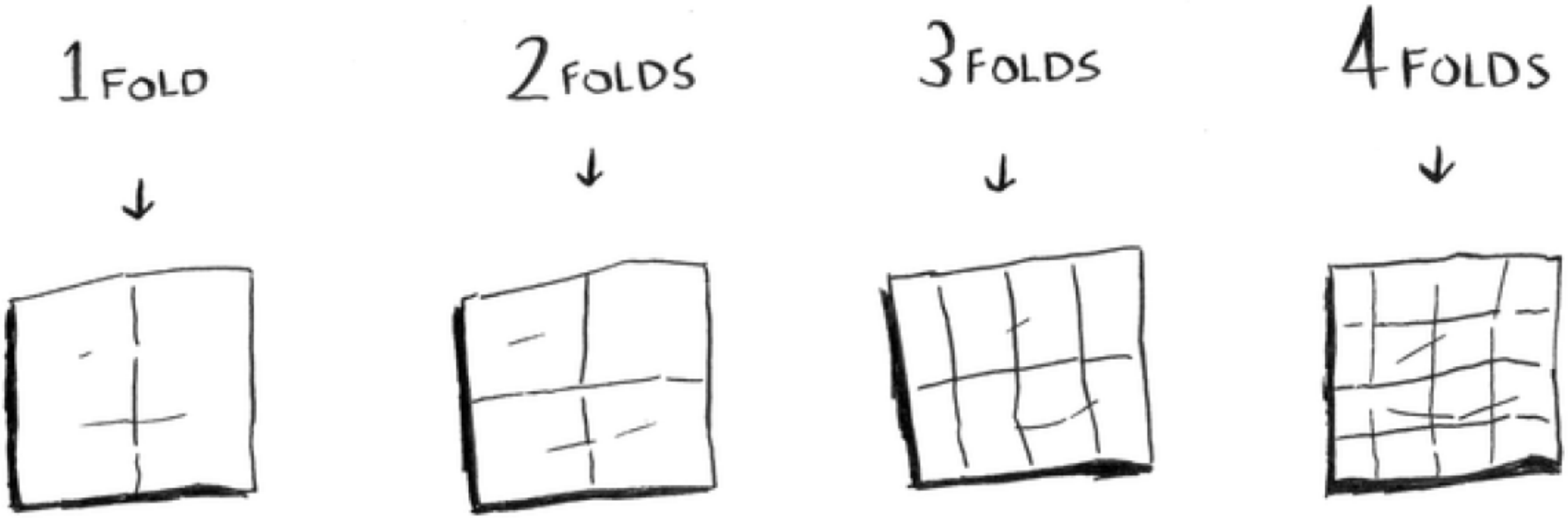


Algorithm 1:
Drawing a grid one box at a time



One way to do it is to draw 16 boxes, one at a time.
How many operations will it take, drawing one box at a time?

Algorithm 2:
Fold the paper again, and again, and again.



You can "draw" twice as many boxes with every fold,
so you can draw 16 boxes in 4 steps.

Algorithm 3:
The Fox, the Goose, and the Corn

PROBLEM: HOW TO CROSS THE RIVER?

A farmer with a fox, a goose, and a sack of corn needs to cross a river. The farmer has a rowboat, but there is room for only the farmer and one of his three items. Unfortunately, both the fox and the goose are hungry. The fox cannot be left alone with the goose, or the fox will eat the goose. Likewise, the goose cannot be left alone with the sack of corn, or the goose will eat the corn. How does the farmer get everything across the river?

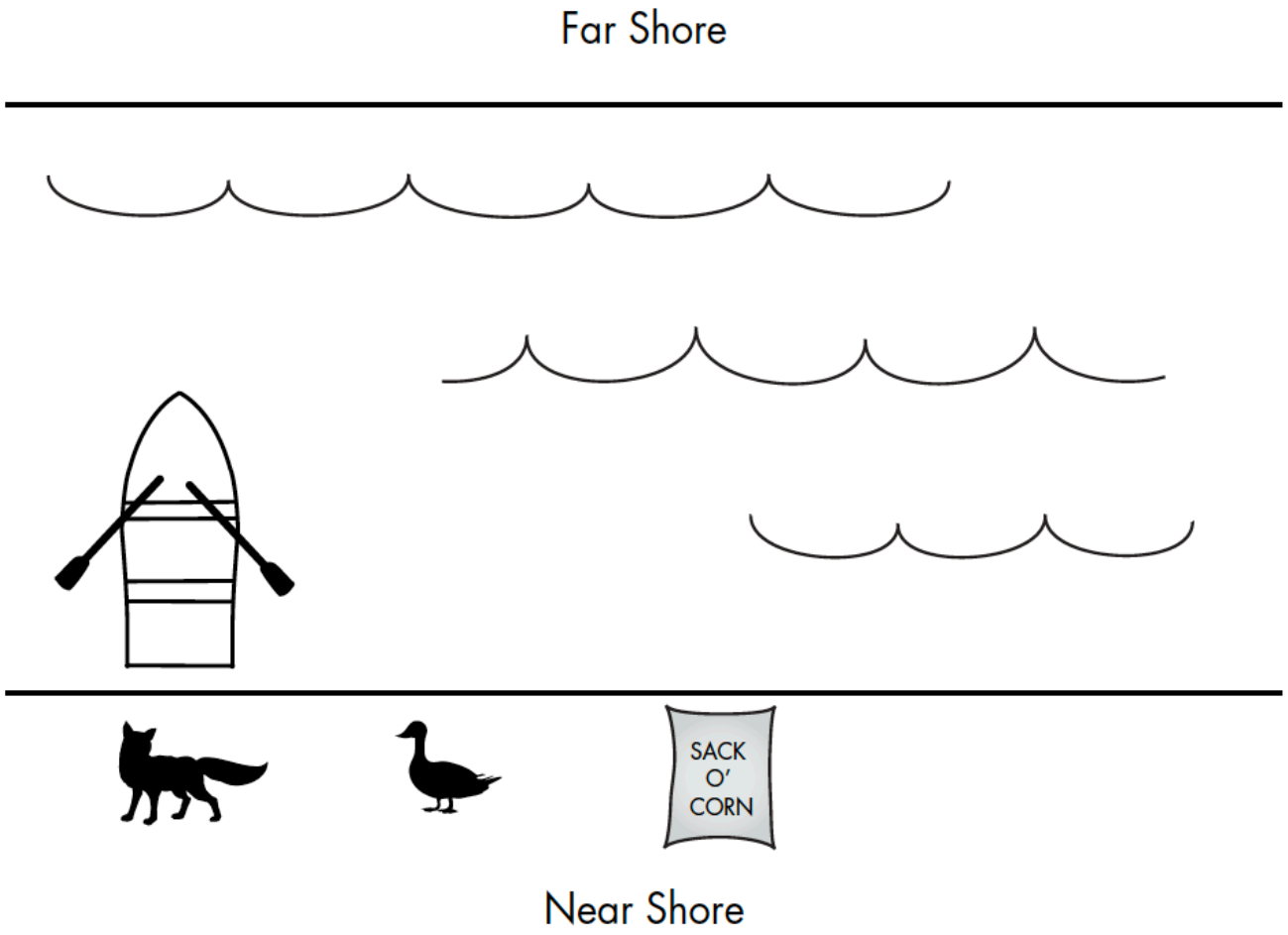
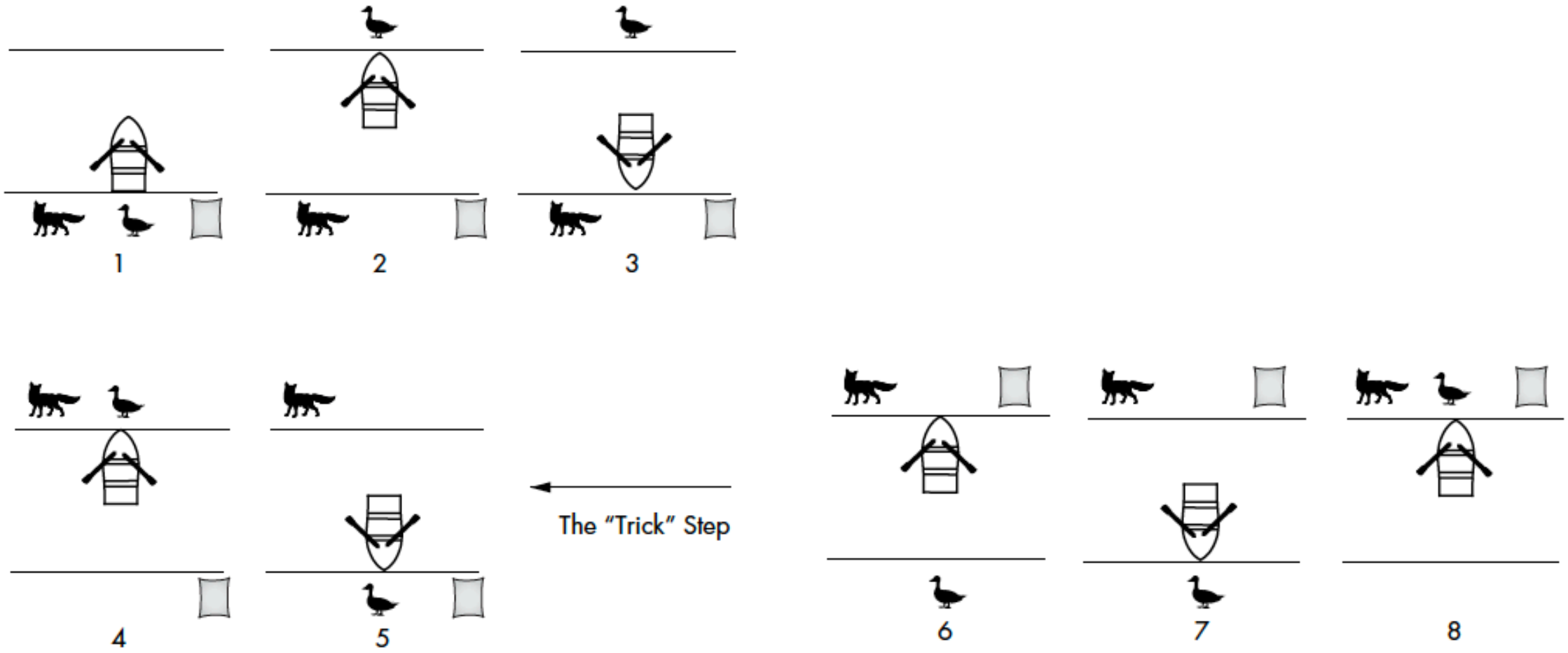


Figure 1-1: The fox, the goose, and the sack of corn. The boat can carry one item at a time. The fox cannot be left on the same shore as the goose, and the goose cannot be left on the same shore as the sack of corn.

Algorithm 3:
Step-by-step solution to the fox, goose, and corn problem

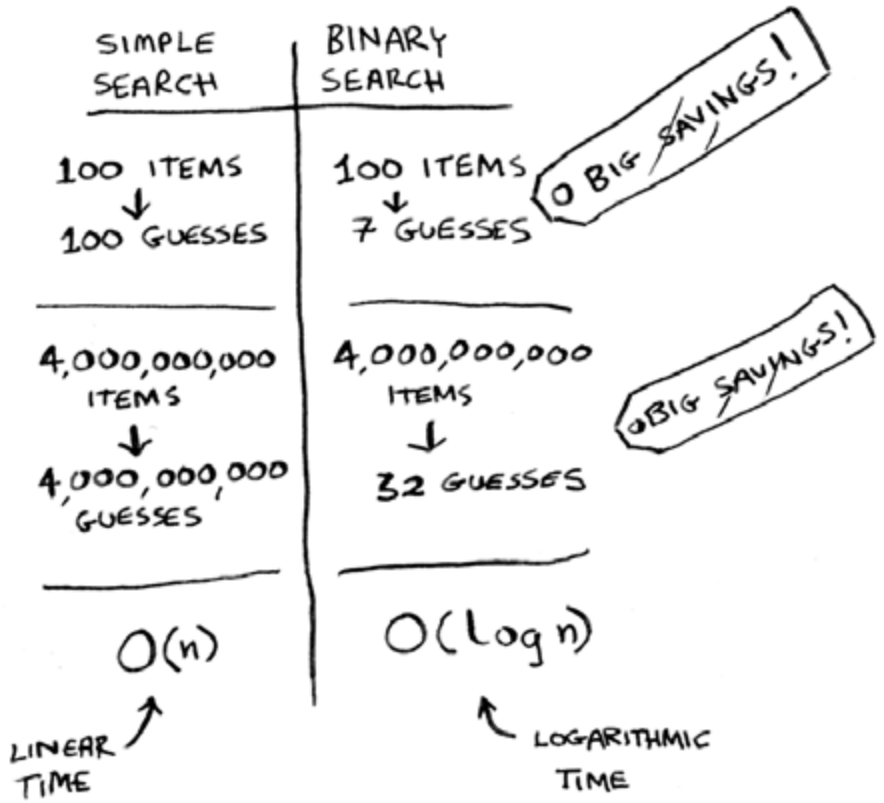


26

The running time vs linear time of an algorithm

Linear time problem:
Simple search of a list of 100 takes up 100 guesses

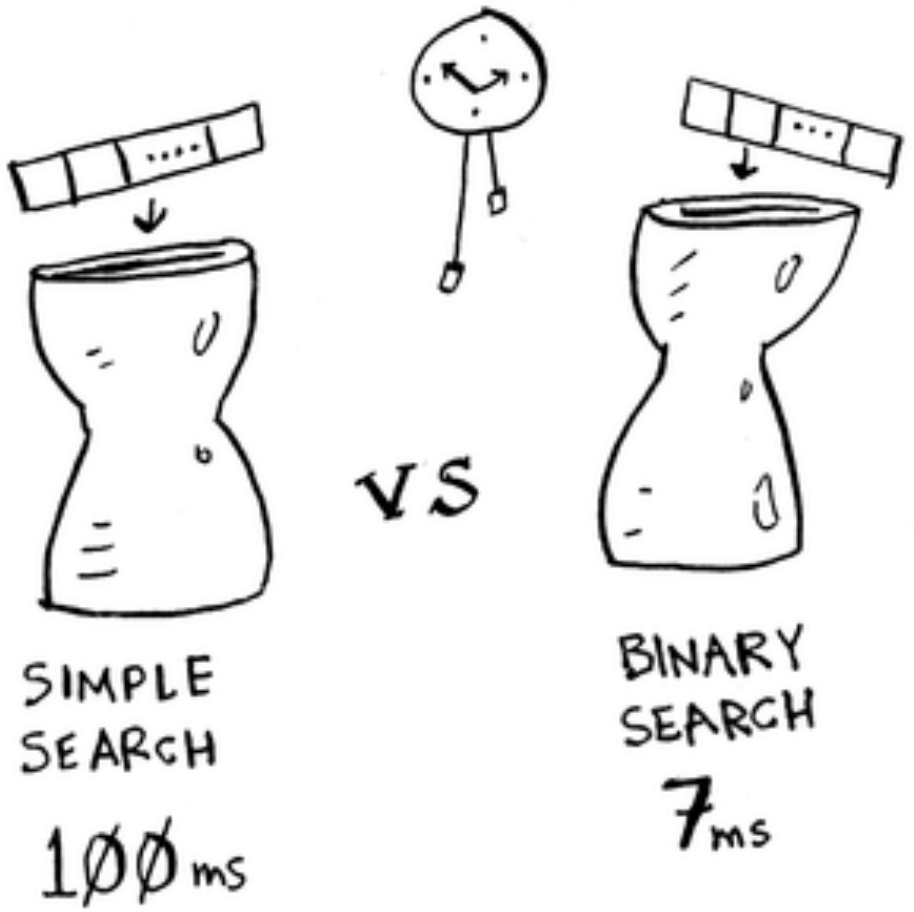
Running time problem:
Binary search of a list of 100 takes up 7 guesses



Big O notation

Big O
tells you how fast
an algorithm is.

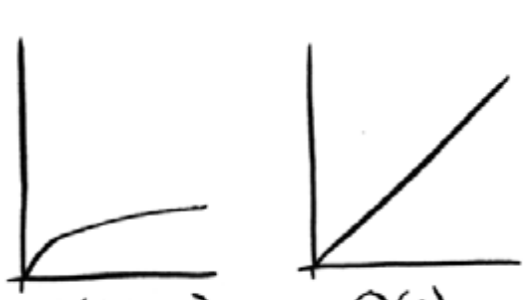
	SIMPLE SEARCH	BINARY SEARCH
100 ELEMENTS	100 ms	7 ms
10,000 ELEMENTS	10 seconds	14 ms
1,000,000,000 ELEMENTS	11 days	32 ms



Big O notation

Run Times

FAST



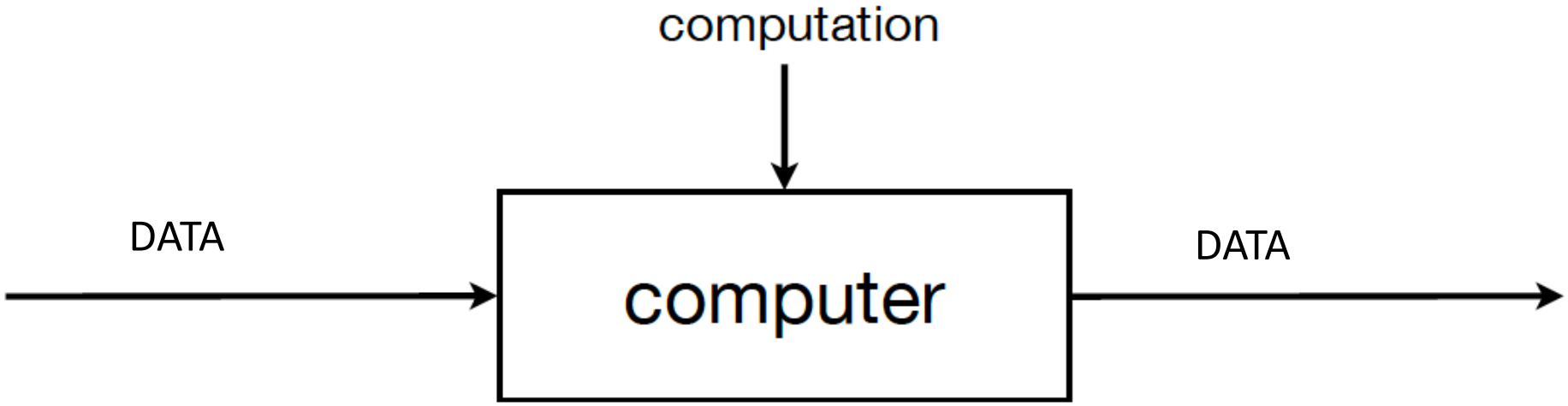
# OF BOXES	O(Log n)	O(n)	O(n Log n)	O(n²)	O(n!)
16	0.4 sec	1.6 sec	6.4 sec	25.6 sec	6630 years
256	0.8 sec	25.6 sec	3.4 min	1.8 hrs	8.6×10^{505} years
1024	1.0 sec	1.7 min	17 min	1.2 days	5.4×10^{2638} years

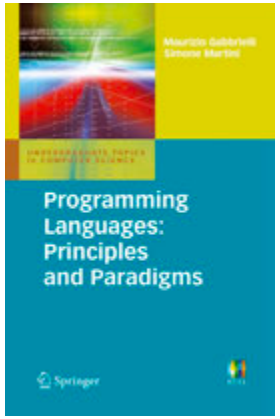
SLOW

Programming languages

HOGESCHOOL ROTTERDAM

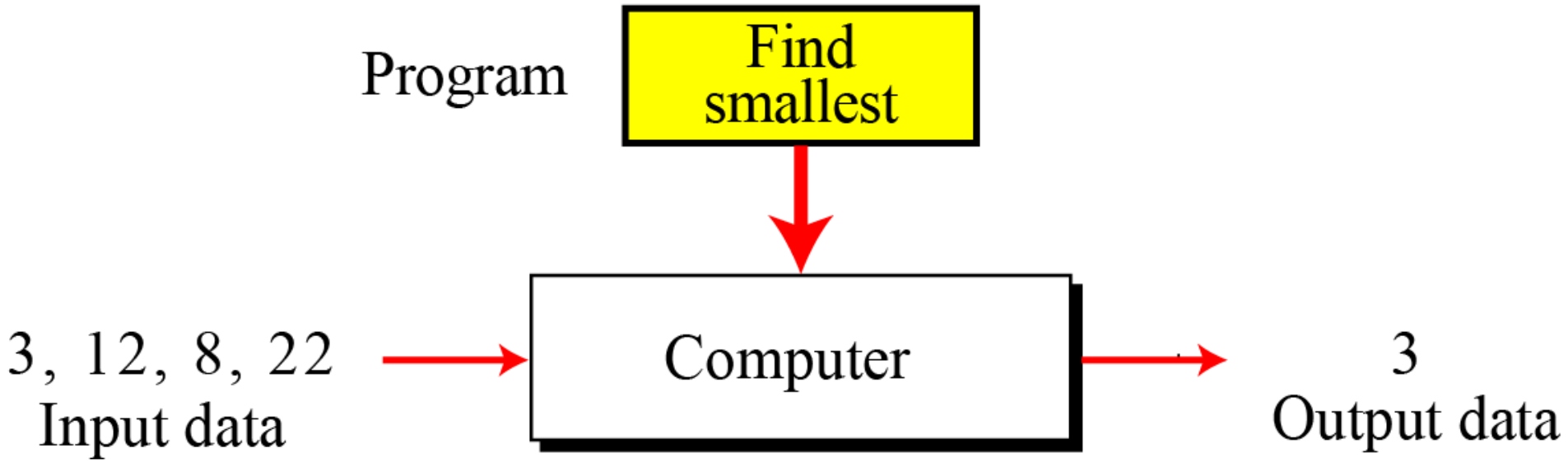
What is a Computer?





A computer is a programmable machine that receives input, stores and manipulates data, and provides output in a useful format.

Computers act as a Computational Data Processor



Modern computer acts as a *black box* that accepts input data, processes the data, and creates output data.

Software

Computersoftware, of gewoon software,
maakt deel uit van een computersysteem dat bestaat uit gegevens of computerinstructies,
in tegenstelling tot de fysieke hardware waaruit het systeem is opgebouwd.

https://www.codeguild.nl/software-engineering-development-ontwikkeling-wikipedia-begrippenlijst-terminologieen/wat-is-software/

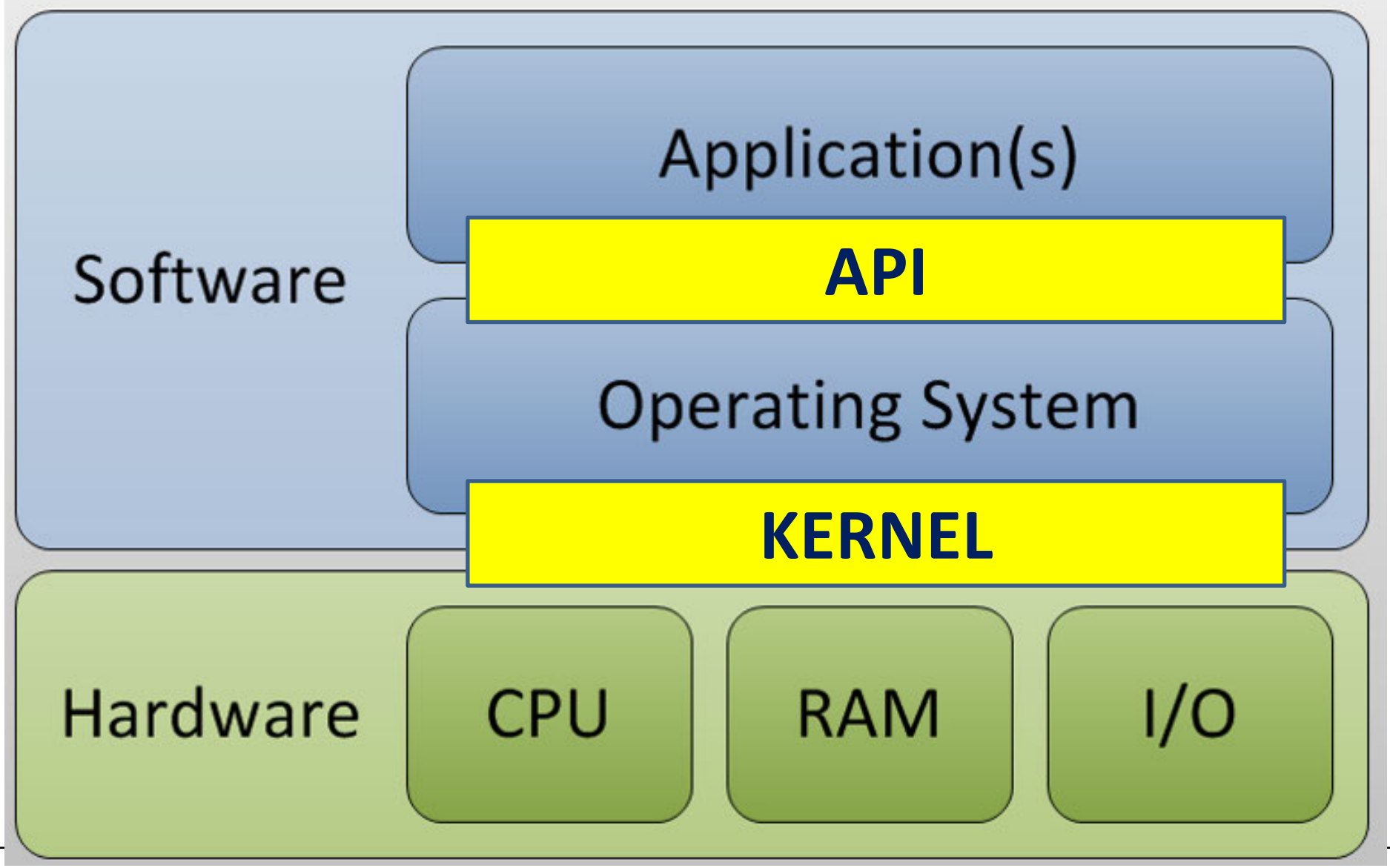
In computerwetenschap en softwareontwikkeling is computersoftware alle informatie die wordt verwerkt door computersystemen, programma's en gegevens.

Software

Software is a generic term, which is used to describe a group of computer programs & procedures which perform some task on a computer (system).

It is an ordered sequence of instructions given for changing the state of the computer hardware, in a certain predefined manner.

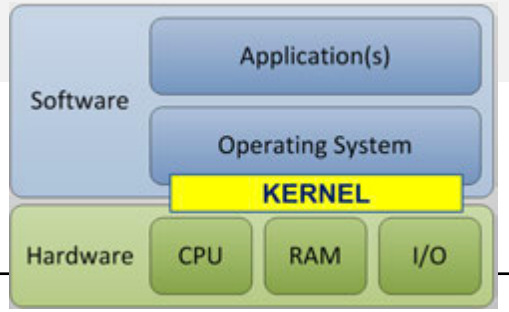
Software vs Hardware



Application software:
Perfoms User Tasks

Application software is a computer software which is designed to help the user in performing single or multiple related tasks.

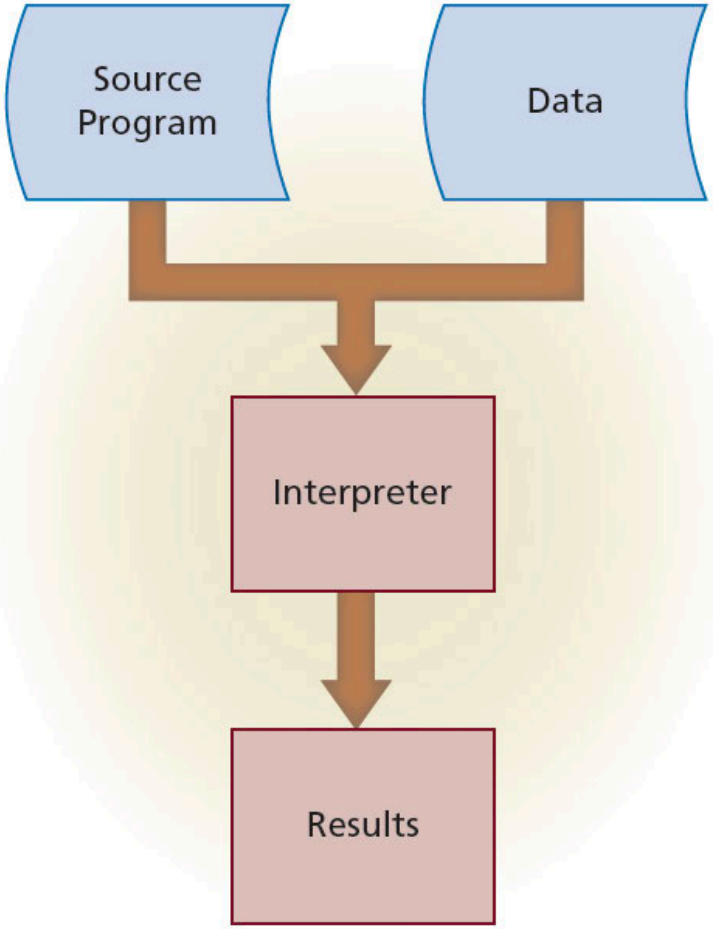
In other words, application software is actually a subclass of computer software,
which employs the capabilities of a computer directly to a task that the user wishes it to perform.



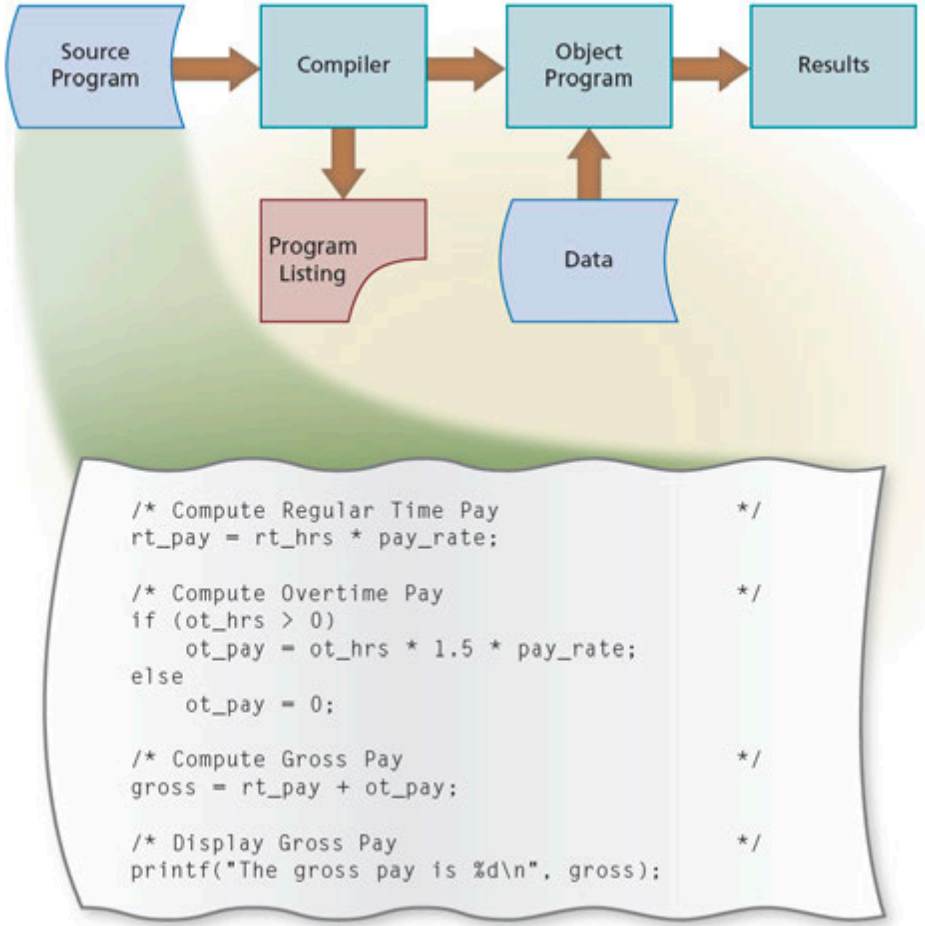
Types of programming languages

https://www.youtube.com/watch?v=fbZ4ZhzCeR4

Script(ing) languages
Do NOT need to be Compiled



High-level Program languag
need to be Compiled



Mark-up vs Programing Languages

Markup languages

Markup languages are used to control the presentation and structure of the content

Programming languages

Programming languages are used to create instructions for a machine to execute & automate tasks

Mark-up vs Programing Languages

HOGESCHOOL ROTTERDAM

Markup Languages

HTML
CSS
XML

HTML defines content

CSS defines presentation

JavaScript defines behaviour

Programming languages

C
C++
C#
Java

Scripting languages

JavaScript
Php
Perl
VBScript

High-level Program languages need to be Compiled

Compile is the process of creating (compilation) an executable program from code written in a compiled programming language.

Compiling allows the computer to run software without the need of the source-code itself on your computers.

Is Platform/Operating System [OS] dependent:
Desktop: Mac OS / Windows / UNIX / Linux
Mobile: iOS / Android / Chromium / Tizen

Script(ing) languages
Do NOT need to be Compiled

A script or scripting language is a computer language with a series of commands within a file that is capable of being executed without being compiled.

Examples are Perl, PHP, Python & JavaScript.

Interpreted vs Compiled Languages

An interpreted programming language does **not** need to be compiled before its programs are executed.

Instead, another program, called an interpreter, reads the program and executes it on the fly.

Often called scripting languages Perl, PhP & Python

Interpreted vs Compiled Languages

A compiled program generally performs faster (higher Big O) for the end user, because its machine code can be highly optimized during the compilation process.

In contrast, interpreted languages can offer unique benefits to the programmer. One example is a REPL, which allows the programmer to interact with the program while it is being written.

API v.s. SDK v.s. IDE

Application Programming Interface (API)

A library of functions and methods.

You don't need to know how it works, but you have to know how to call them.

Software Development Kit (SDK)

Many tools are included in SDK. Different platform, different SDK.

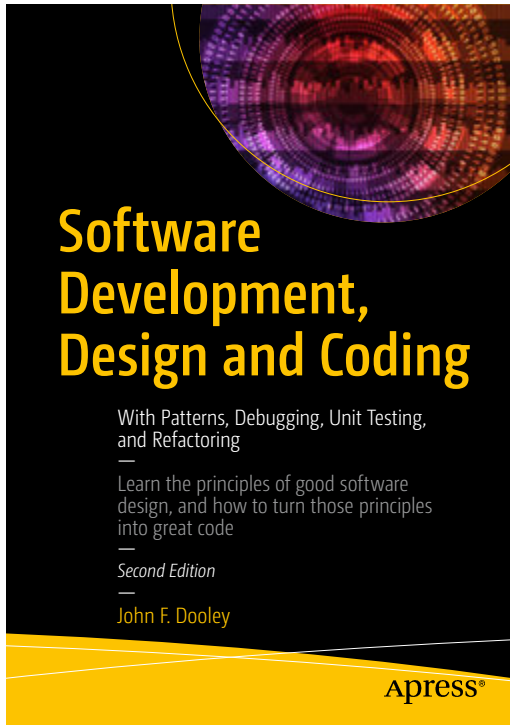
Integrated Development Environment (IDE)

Usually includes code editor, debugger, compiler.

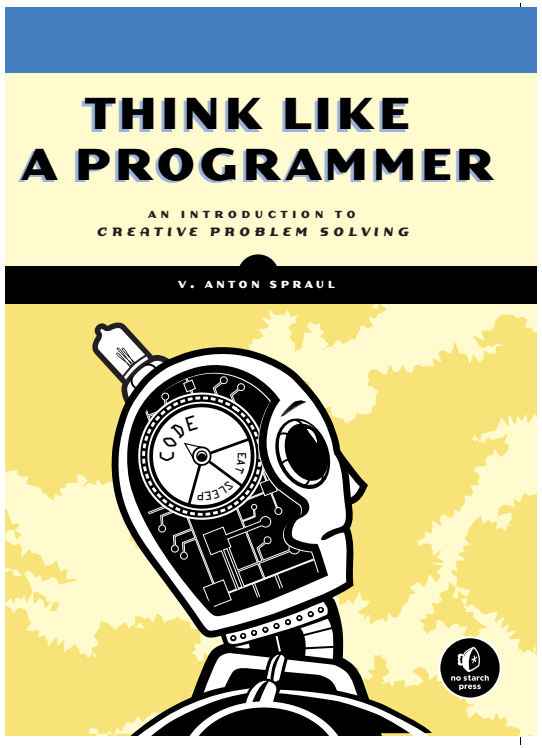
How to start Coding

HOGESCHOOL ROTTERDAM

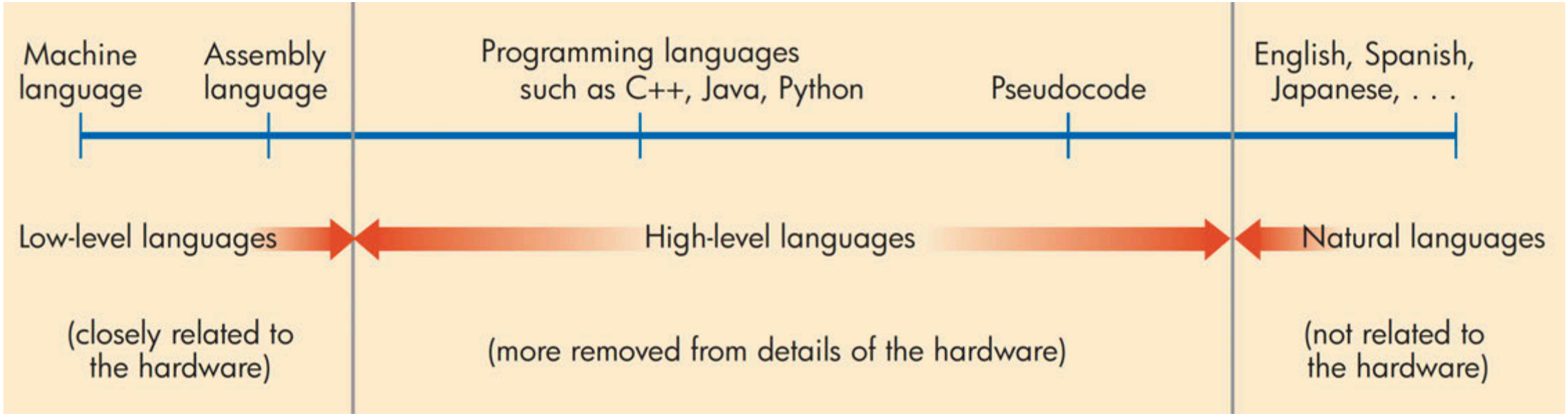
Coding


Software Development, Design and Coding
With Patterns, Debugging, Unit Testing, and Refactoring
Learn the principles of good software design, and how to turn those principles into great code
Second Edition
John F. Dooley
Apress®


GET CODING!
Learn HTML, CSS & JavaScript & build a website, app & game
Supported by Young Rewired State the expert community of coders


THINK LIKE A PROGRAMMER
AN INTRODUCTION TO CREATIVE PROBLEM SOLVING
V. ANTON SPRAUL
CODE
EAT
SLEEP
no starch press

Coding-paradigma's



Coding-paradigma's

	Scripting	Compiled
Feature	Can run without compilation	Need to compile to machine code before running
Examples	Python, Perl, PHP, Ruby, Javascript	C/C++, Fortran, Pascal, Java
Advantage	Easy to understand and extend Portable	Optimized and run faster, Source code protected
Running and Debugging model	Use an interpreter to understand and run the code on-the-fly	Codes are compiled to executables using compiler

Coding: a definition

Anyone interested in developing software, such as a source-code, game, or online service, must start by learning a programming language & decide which (source-code) Editor/Debugger to use.

https://www.computerhope.com/issues/ch000675.htm

Command Line Terminal (interface)

What Is the Command Line?

The command-line interface, sometimes referred to as the CLI,

is a tool into which you can type text commands to perform specific tasks—in contrast to the mouse's pointing and clicking on menus and buttons.

Since you can directly control the computer by typing, many tasks can be performed more quickly, and some tasks can be automated with special commands that loop through and perform the same action on many files—saving you, potentially, loads of time in the process.

Script(ing) languages
Do NOT need to be Compiled

A script or scripting language is a computer language with a series of commands within a file that is capable of being executed without being compiled.

Examples are Perl, PHP, Python & JavaScript.

Interpreted vs Compiled Languages

An interpreted programming language does **not** need to be compiled before its programs are executed.

Instead, another program, called an interpreter, reads the program and executes it on the fly.

Often called scripting languages Perl, PhP & Python

Interpreted vs Compiled Languages

A compiled program generally performs faster (higher Big O) for the end user, because its machine code can be highly optimized during the compilation process.

In contrast, interpreted languages can offer unique benefits to the programmer. One example is a REPL, which allows the programmer to interact with the program while it is being written.

API v.s. SDK v.s. IDE

Application Programming Interface (API)

A library of functions and methods.

You don't need to know how it works, but you have to know how to call them.

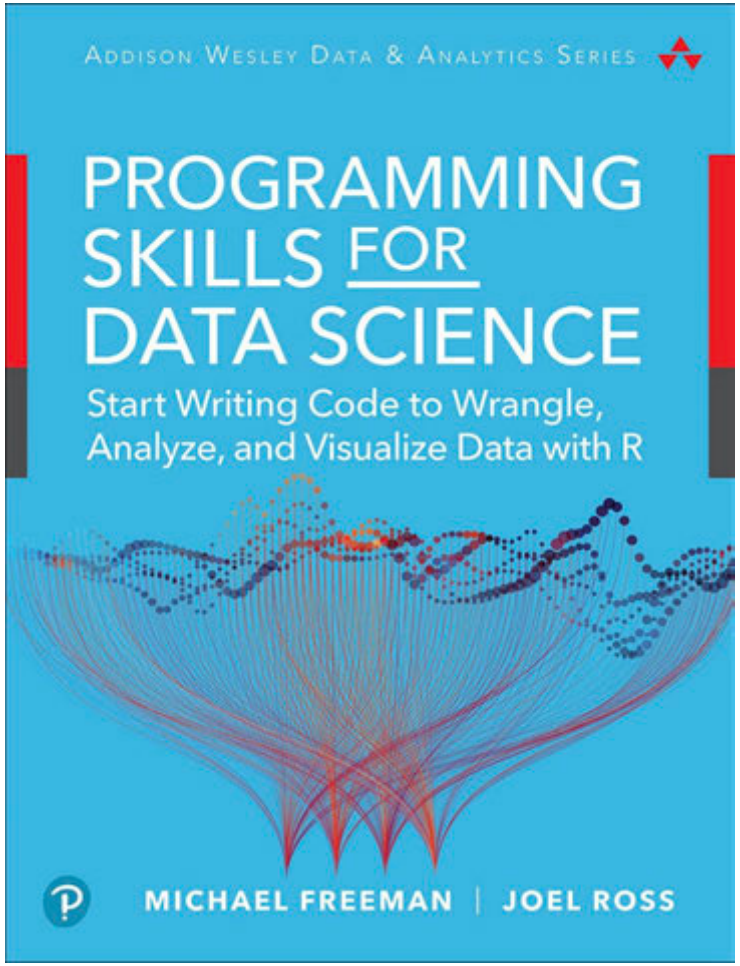
Software Development Kit (SDK)

Many tools are included in SDK. Different platform, different SDK.

Integrated Development Environment (IDE)

Usually includes code editor, debugger, compiler.

Setting Up Your Computer



Command Line Terminal (interface)

What Is the Command Line?

The command-line interface, sometimes referred to as the CLI,

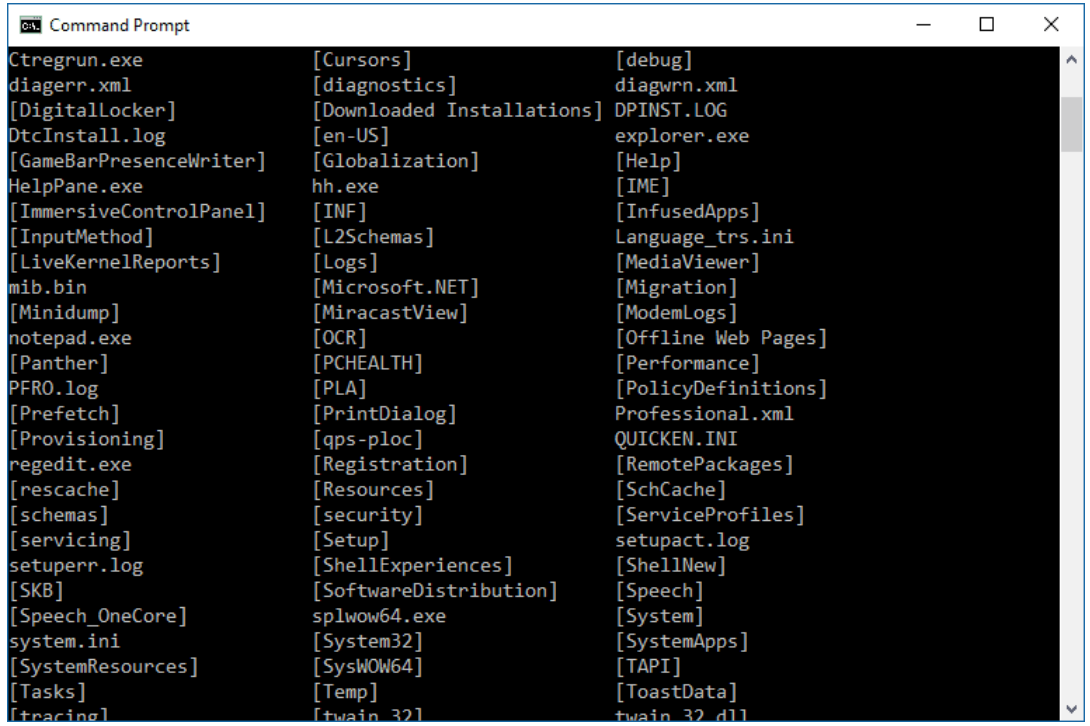
is a tool into which you can type text commands to perform specific tasks—in contrast to the mouse's pointing and clicking on menus and buttons.

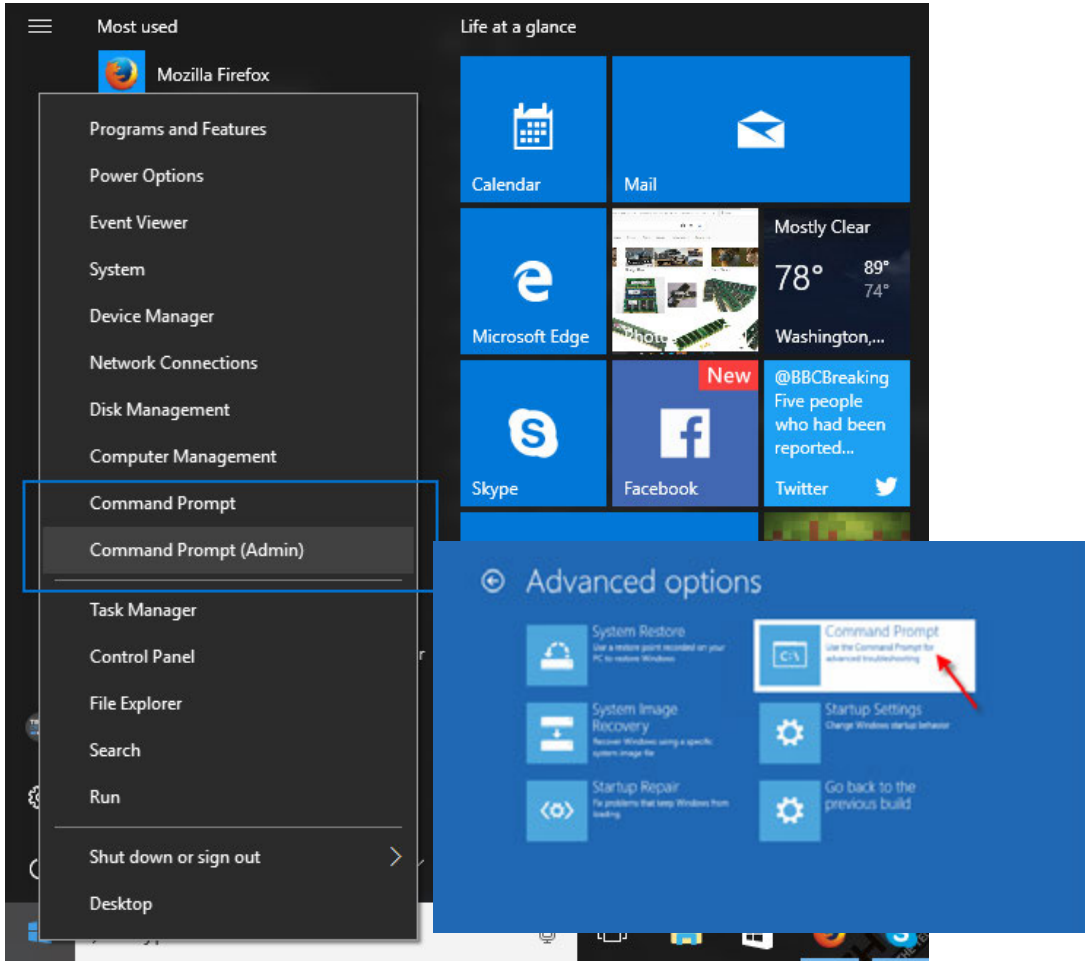
Since you can directly control the computer by typing, many tasks can be performed more quickly, and some tasks can be automated with special commands that loop through and perform the same action on many files—saving you, potentially, loads of time in the process.

Command Line Terminal (windows)

List of Command Prompt Commands

Complete list of CMD commands for Windows





The Command Prompt in Windows provides access to over 280 commands! These commands are used to do certain operating system tasks from a command line interface instead of the graphical Windows interface we use most of the time.

Note: It's important to know that the commands in Windows 10, 8, 7, Vista, and XP are called *CMD commands* or *Command Prompt commands*, and the commands in Windows 98/95 and MS-DOS are called *DOS commands*.

https://www.lifewire.com/command-prompt-tricks-and-hacks-2618104

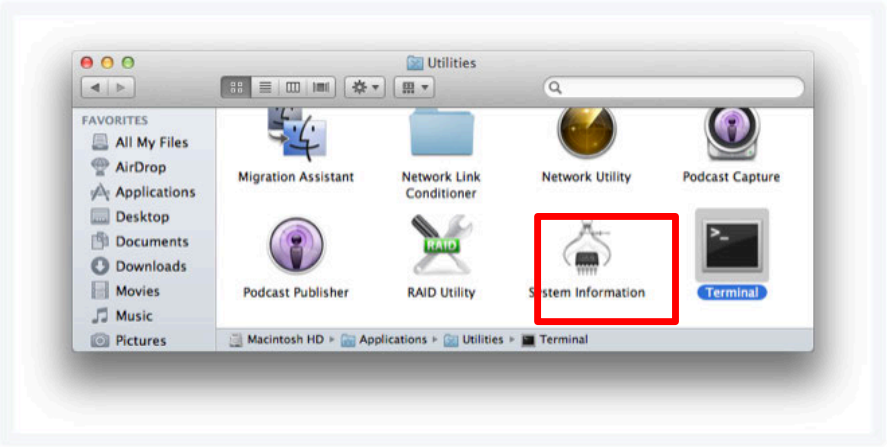
Command Line Terminal MacOS

Introduction to the Mac OS X Command Line

How to open the command line.

Before you can use it, you need to be able to find it.

So what we need to do is open the terminal. On OS X, open your Applications folder, then open the Utilities folder. Open the Terminal application. You may want to add this to your dock. I like to launch terminal by using Spotlight search in OS X, searching for "terminal".



http://blog.teamtreehouse.com/introduction-to-the-mac-os-x-command-line

Anatomy of the Console

First let's clarify a few terms.

Console: This is the system as a whole. This is both the command line as well as the output from previous commands.

Command Line: This is the actual line in a console where you type your command.

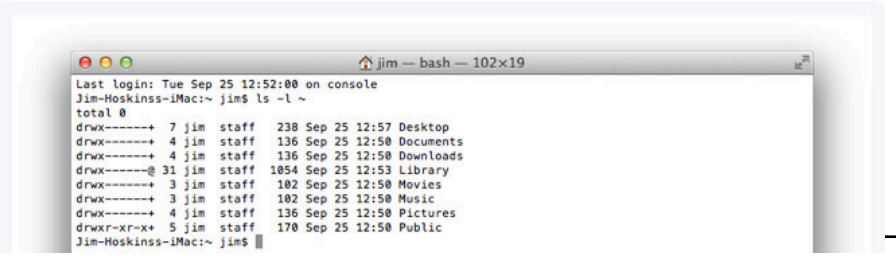
Prompt: This is the beginning of the command line. It usually provides some contextual information like who you are, where you are and other useful info. It typically ends in a **$** . After the prompt is where you will be typing commands.

Terminal: This is the actual interface to the console. The program we use to interact with the console is actually a "terminal emulator", providing us the experience of typing into an old school terminal from the convenience of our modern graphical operating system.

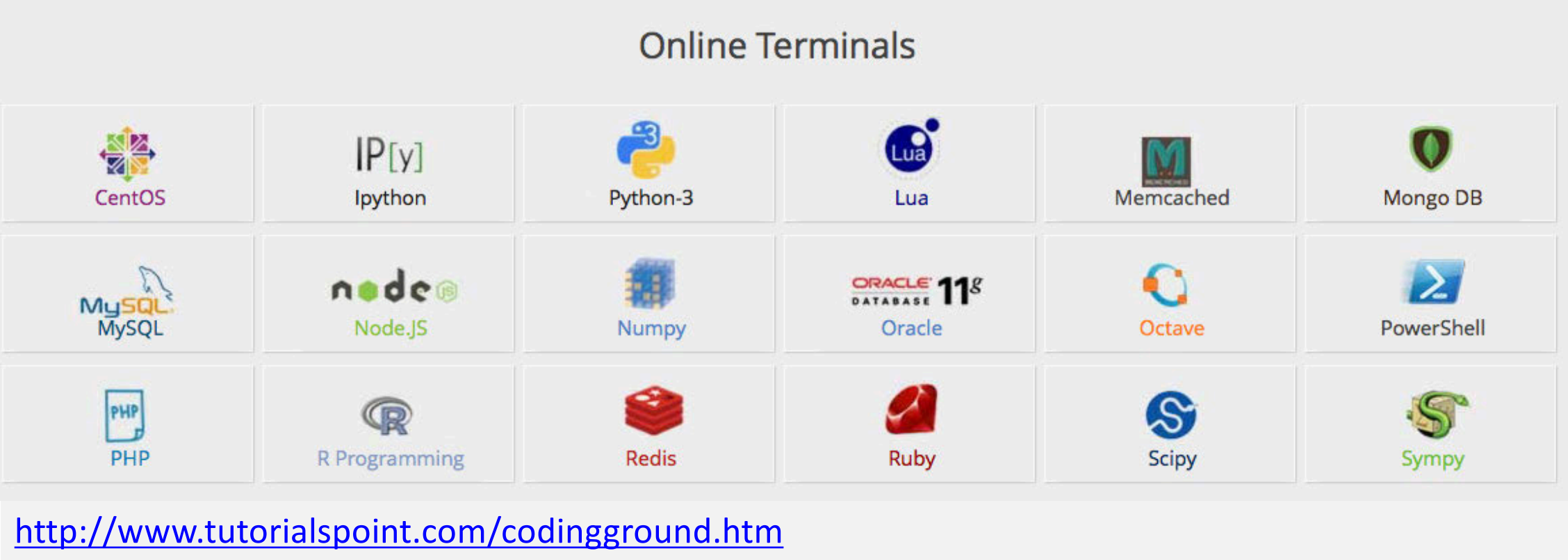
Running a Command.

Nearly all commands follow a common pattern with 3 main parts. The program, the options, and the arguments. Let's see an example.

```
$ ls -l ~
```



Command Line Terminal



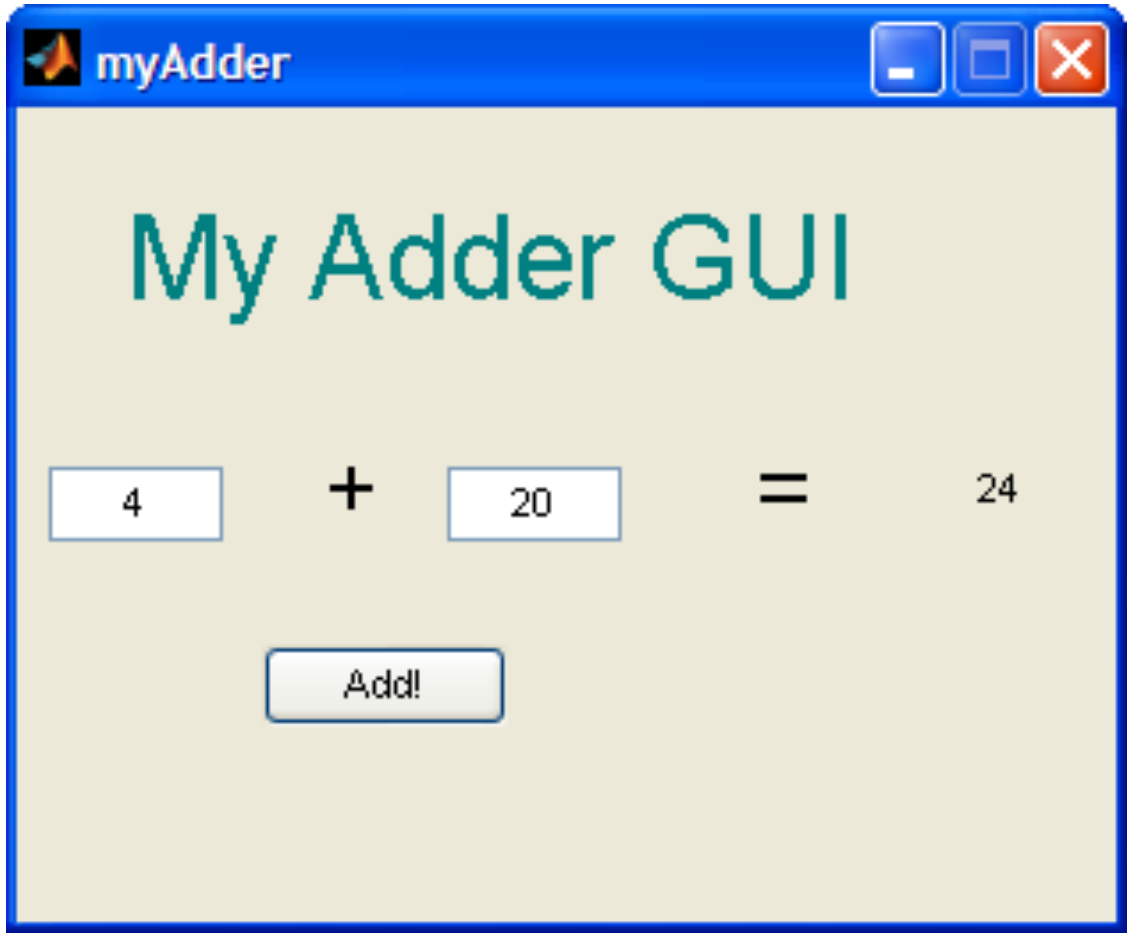
http://www.tutorialspoint.com/codingground.htm

What is (source) Program Software: Integrated Development Environment (IDE)?

IDEs are designed to encompass
all programming tasks in one application.

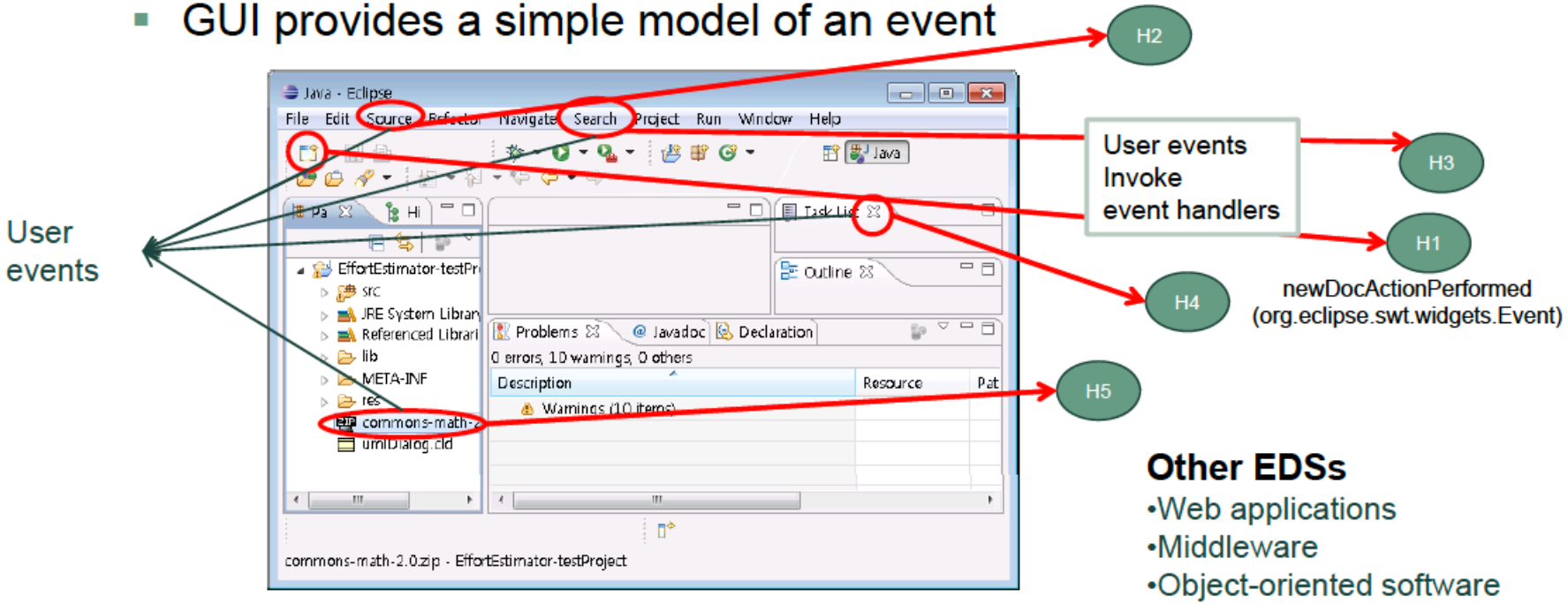
IDE is a software application that provides comprehensive facilities or graphical user interface [GUI] to programmers for software development in addition to CLI (command line interfacing).
An IDE normally consists of a source code editor, build automation tools and a debugger. Most modern IDEs have intelligent code completion.

Graphical User Interface (GUI)



Graphical User Interface (GUI)

- GUI provides a simple model of an event



Other EDSs

- Web applications
- Middleware
- Object-oriented software
- Multi-agent based systems

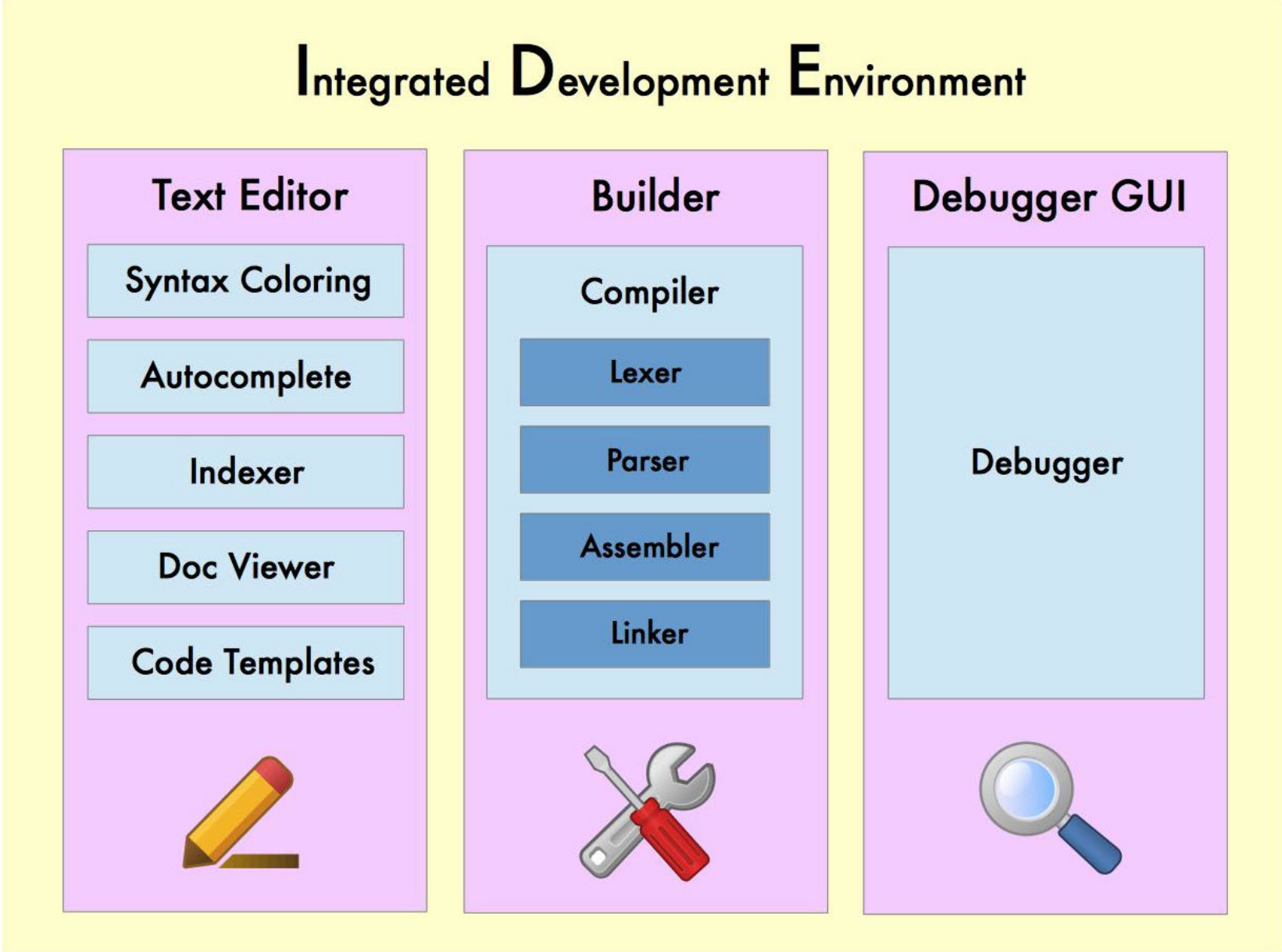
GUI is a type of user interface item that allows people to interact with programs in more ways than typing.
GUI software is an Event-driven Software(EDS)

CLI vs GUI

Topic	Command line (CLI)	GUI
Ease	Due to a higher degree of memorization and familiarity needed for operation and navigation, new users find operating a command line interface more difficult than a GUI.	Because a GUI is much more visually intuitive, users typically pick up on how to use a GUI faster than a command line interface.
Control	Users have a good bit of control over both the file and operating systems in a command line interface. However, for new or novice users, it is not as user friendly as a GUI.	A GUI offers a lot of access to files, software features, and the operating system as a whole. Being more user friendly than a command line, especially for new or novice users, a GUI is utilized by more users.
Multitasking	Although many command line environments are capable of multitasking, they do not offer the same ease and ability to view multiple things at once on one screen.	GUI users have windows that enable a user to view, control, manipulate, and toggle through multiple programs and folders at same time.
Speed	Command line users only need to utilize a keyboard to navigate the interface, often resulting in faster performance.	While newer technology is making a GUI faster and more efficient than ever before, using both a mouse and keyboard to navigate and control the GUI is still a bit slower than a command line interface.
Resources	A computer that is only using the command line takes a lot less of the computer's system resources than a GUI.	A GUI requires more system resources because of the elements that require loading, such as icons and fonts. Video, mouse, and other drivers need to be loaded, taking up additional system resources.
Scripting	A command line interface mostly requires users to already know scripting commands and syntax, making it difficult for new or novice users to create scripts.	Creating scripts using a GUI has beco much easier with the help of programming software, which allows users to write the scripts without having to know all the commands and syntax. Programming software provides guides and tips for how to code specific functions, as well as preview options to see if and how the script will work.
Remote access	When accessing another computer or device over a network, a user can manipulate the device or its files with a command line interface. However, you must know the commands to do so and is not as easy for new or novice users.	Remotely access another computer or server is possible in a GUI and easy to navigate with little experience. IT professionals typically use a GUI for remote access, including the management of servers and user computers.
Diversity	After you've learned how to navigate and use a command line, it's not going to change as much as a new GUI. Although new commands may be introduced, the original commands almost always remain the same.	Each GUI has a different design and structure when it comes to performing different tasks. Even different iterations of the same GUI, such as Windows, can have hundreds of different changes between each version.
Strain	A command line interface is often very basic and can be more of a strain on a user's vision. Carpal Tunnel Syndrome can also be a bit of a risk when using a command line interface because users are only using a keyboard. There is little need to change hand positions and strain to the wrists or even fingers can occur.	The use of shortcut keys and more frequent movement of hand positions, due to switching between a keyboard and a mouse, strain may be reduced. Visual strain can still be a risk, but a GUI has more colors and is more visually appealing, leading to a potential reduction in visual strain.

https://www.computerhope.com/issues/ch000619.htm

IDE


Integrated Development Environment
Text Editor
Syntax Coloring
Autocomplete
Indexer
Doc Viewer
Code Templates
Builder
Compiler
Lexer
Parser
Assembler
Linker
Debugger GUI
Debugger

What is (source-code) Program Software: Integrated Development Environment (IDE)?

Code editor: This feature is a text editor designed for writing and editing source code.

Source code editors are distinguished from text editors because they enhance or simplify the writing and editing of code.

Compiler/Interpreter: This tool transforms source code written in a human readable/writable language into a form executable by a computer.

Debugger: This tool is used during testing to help debug application programs.

Build automation tools: These tools automate common developer tasks.

Source-Code Editor

A source code editor is a text editor program designed specifically for editing source code of computer programs by programmers.

It may be a Standalone Application or it may be built into an Integrated Development Environment (IDE) or Web Browser.

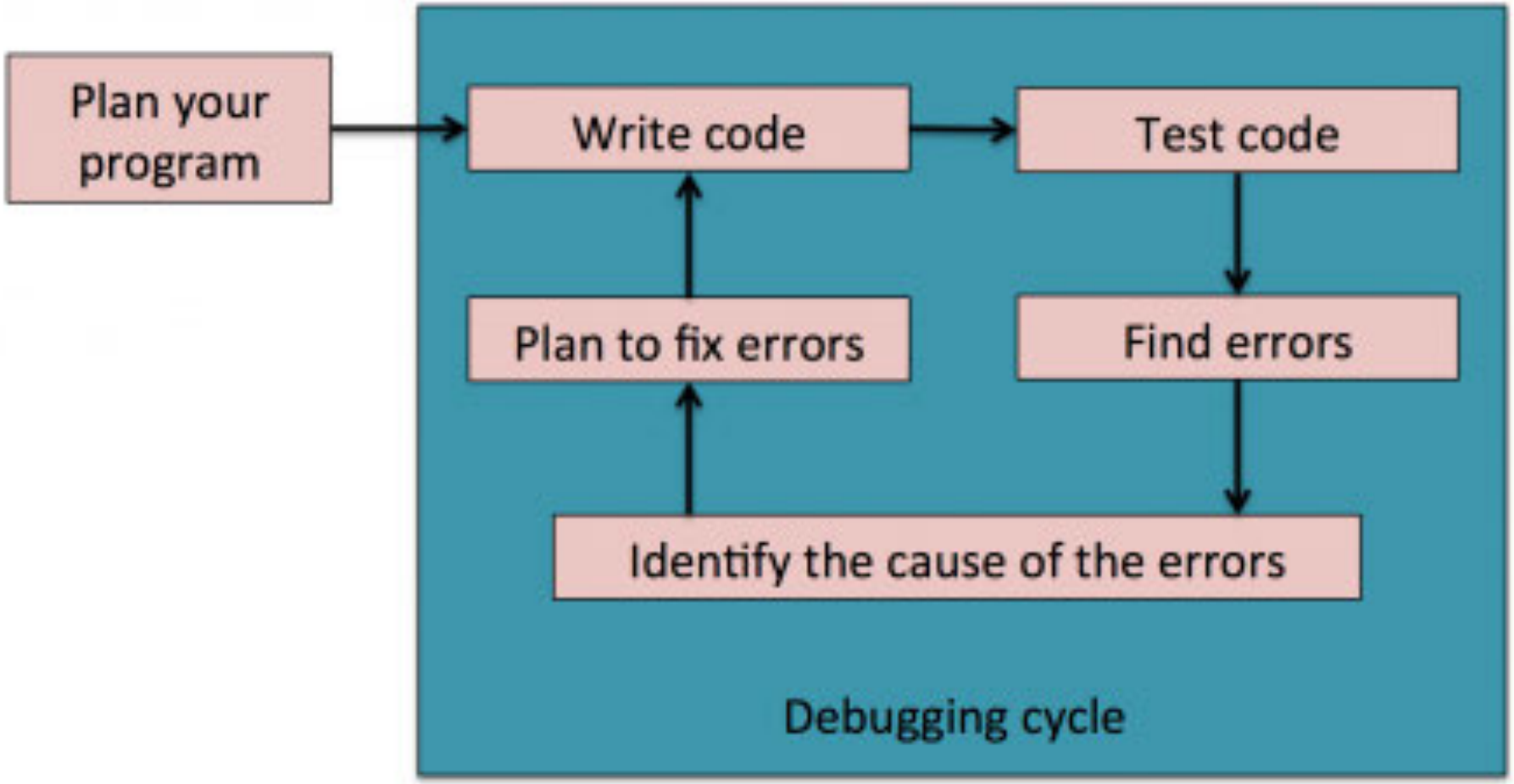
Source code editors are the most fundamental programming tool, as the fundamental job of programmers is to write and edit source code.

Debugging

Debugging is a process of analyzing a computer program source-code and removing its logical or syntactical errors.

Software which assists this process is a debugger.

Using a debugger, a software developer can step through a program's code and analyze its variable values, searching for errors.

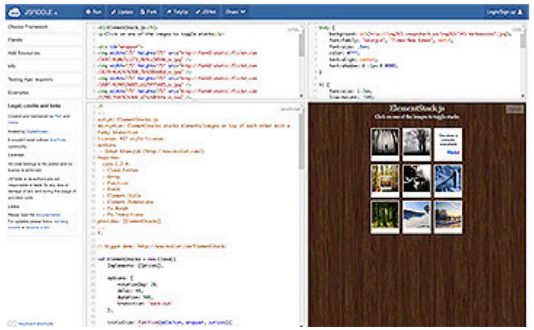

Plan your program
Write code
Test code
Plan to fix errors
Find errors
Identify the cause of the errors
Debugging cycle

Source-Code Play-Grounds

https://www.sitepoint.com/7-code-playgrounds/

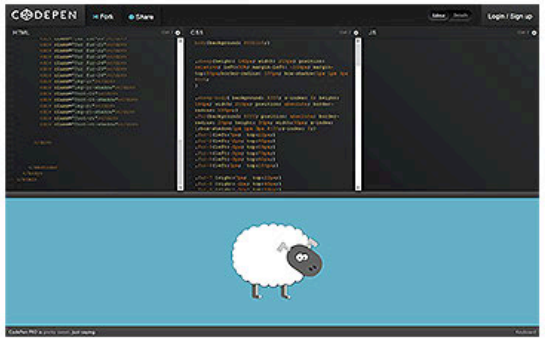
JSFiddle

JSFiddle was one of the earliest code playgrounds and a major influence for all which followed. Despite the name, it can be used for any combination of HTML, CSS and JavaScript testing. It's looking a little basic today, but still offers advanced functionality such as Ajax simulation.



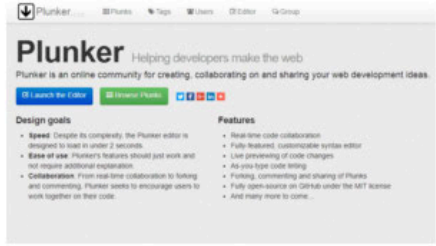
CodePen

The prize for the best-looking feature-packed playground goes to CodePen. The service highlights popular demonstrations ("Pens") and Projects, which is an online Integrated Development Environment you can use to build and deploy web projects, a feature only added in March 2017. It offers advanced functionality such as sharing and embedding of Pens, adding external JS and CSS libraries, popular preprocessors, and tons more. The PRO service provides cross-browser testing, pair-programming and teaching options starting from just $9 per month.



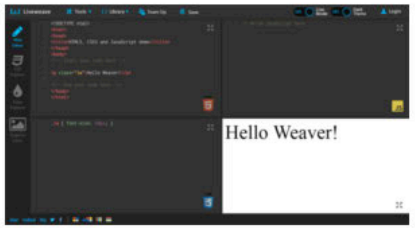
Plunker

Plunker lets you add multiple files, including community generated templates, to kick-start your project. Just like CodePen, with Plunker you can create working demos, also in collaboration with other devs, and share your work. Plunker's source code is free and lives on its GitHub repository.



Liveweave

Liveweave is one more online HTML5, CSS3 & JavaScript editor with live preview capabilities. It offers code-hinting for HTML5, CSS3, JavaScript and jQuery and lets you download your project as a zip file.



You can also add external libraries such as jQuery, AndgularJS, Bootstrap etc. quite easily in your workspace. Furthermore, Liveweave offers a ruler to help you code responsive designs and a "Team Up" feature which has the same features as JSFiddle's collaborative editing.

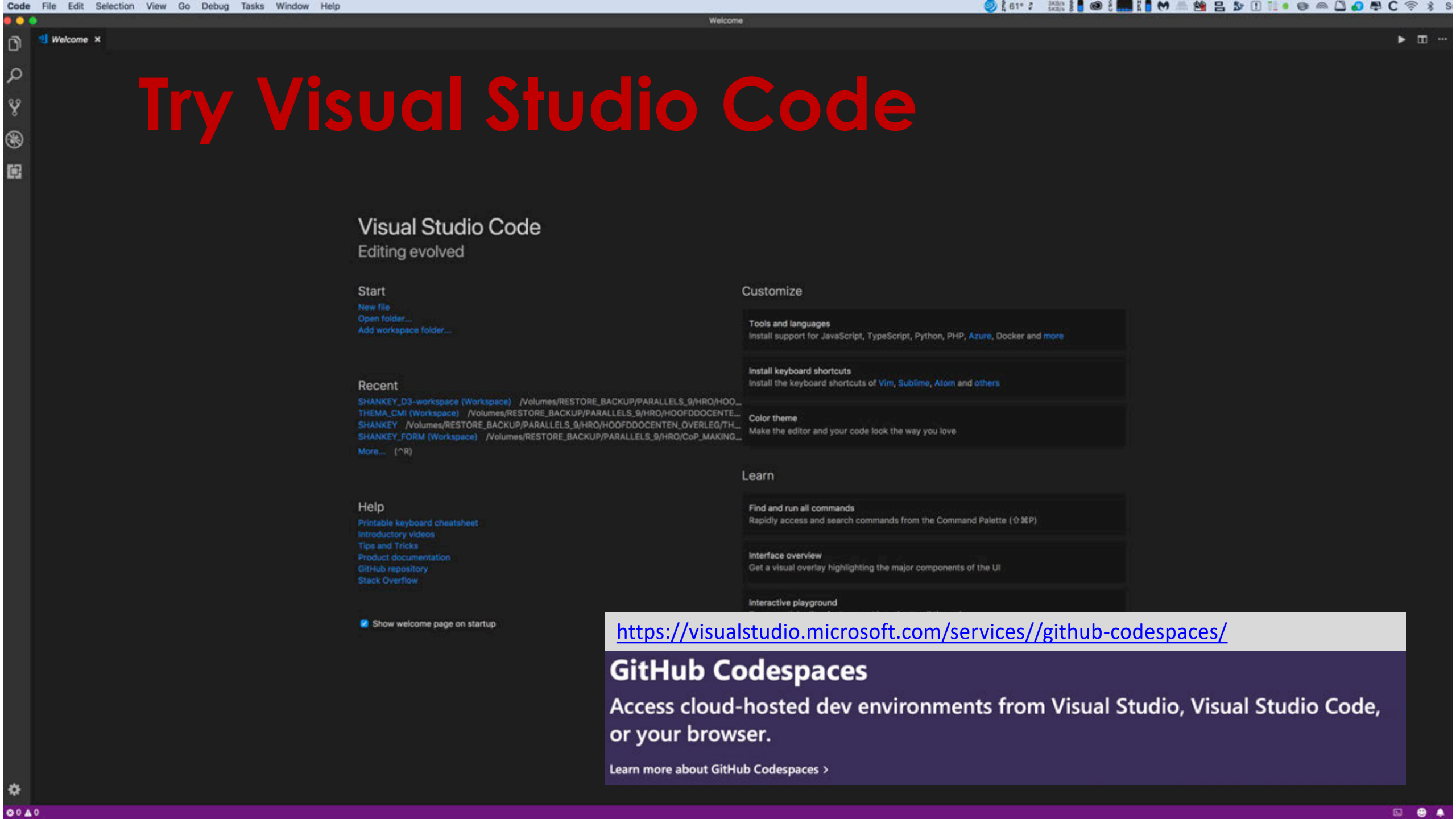
https://en.wikipedia.org/wiki/Comparison_of_online_source_code_playgrounds

Things you should Do

HOGESCHOOL ROTTERDAM

To Do's

Try Visual Studio Code



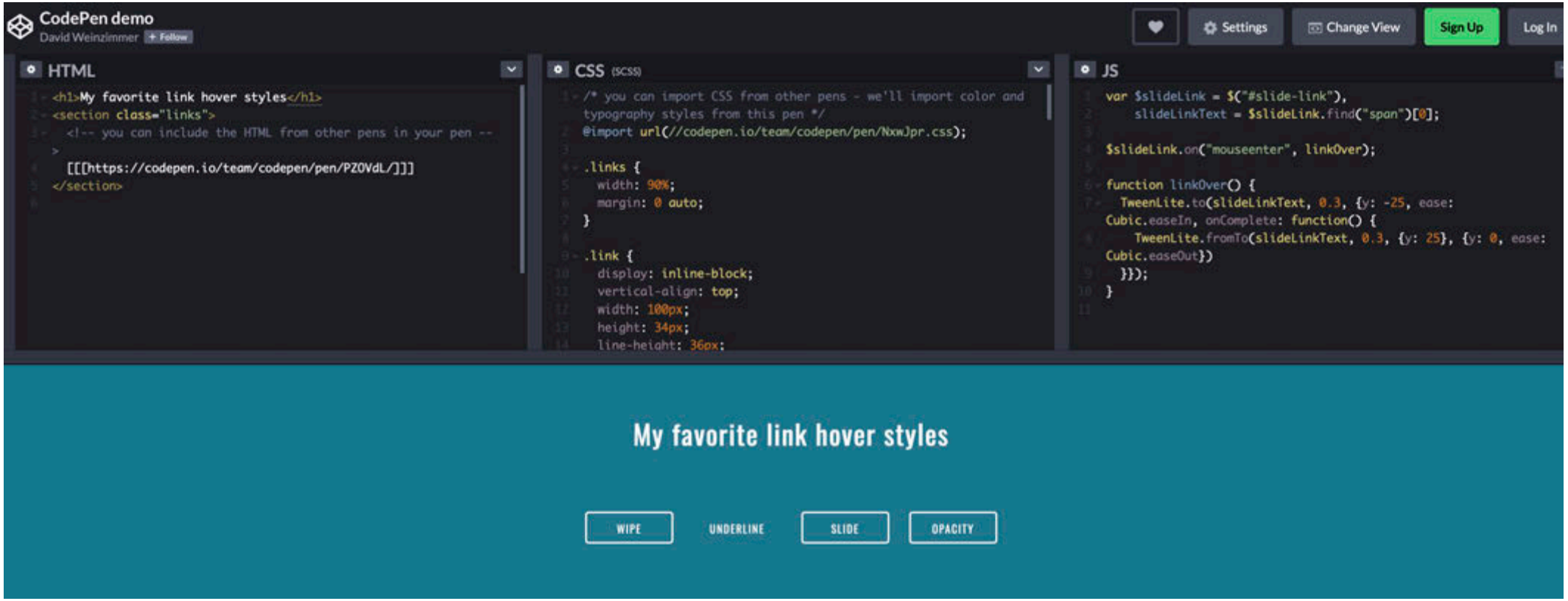
https://visualstudio.microsoft.com/services//github-codespaces/

GitHub Codespaces

Access cloud-hosted dev environments from Visual Studio, Visual Studio Code, or your browser.

Learn more about GitHub Codespaces ›

Try CODEPEN.IO



https://codepen.io/dweinz/pen/GdMbPz

Watch: "How to think like a programmer"

https://www.youtube.com/watch?v=azcrPFhaY9k

DIY Blinking an LED on the Raspberry Pi

https://embeddedcode.wordpress.com/2017/01/18/blinking-an-led-on-the-raspberry-pi/

Do it yourself (DIY) : Make a LED blinking

Raspberry Pi, Power Supply,

microSD Card with Raspbian Installed and Setup,

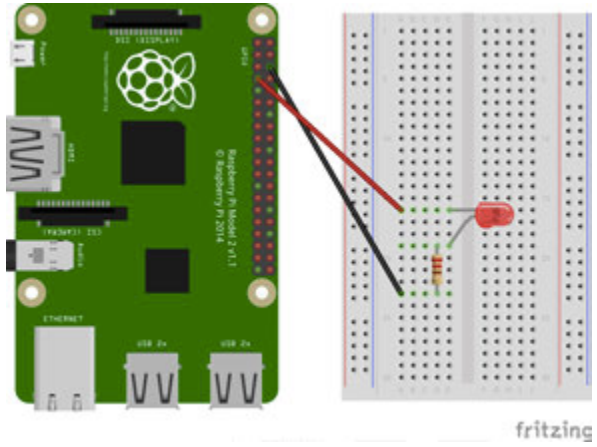
Internet connectivity (Optional),

Bread board,

connecting wires,

an LED 5mm of preferred colour

and a resistor of 220Ohms



LEARNING OBJECTIVES

In this Rapid prototyping experiment,
You will learn the essentials of Raspberry Pi GPIO control by toggling an LED at predefined intervals of time.

KEY WORDS, CONCEPTS, & PRACTICES

+ LED
+ Resistor
+ GPIO
+ Rapid Prototyping
+ Coding (Python)

Reminder lesson 01

1st STEP Managing Data Science for IoT Projects

➔➔➔Getting started with GitHub🡐🡐🡐

A Computational Thinking culture has an intellectual dimension, engaging with a set of creative concepts and practices. It has a physical dimension, encouraging interactions with others through the placement of desks, chairs, and computers. Most importantly, it has an affective dimension, cultivating a sense of confidence and fearlessness.

LEARNING OBJECTIVES

Students will:

+ be introduced to the concept of computational Thinking, in the context of GitHub
+ be able to imagine possibilities for their own GitHub-based computational thinking
+ become familiar with resources that support their computational thinking
+ prepare for creating GitHub projects by establishing a GitHub account, exploring GitHub, creating design journals

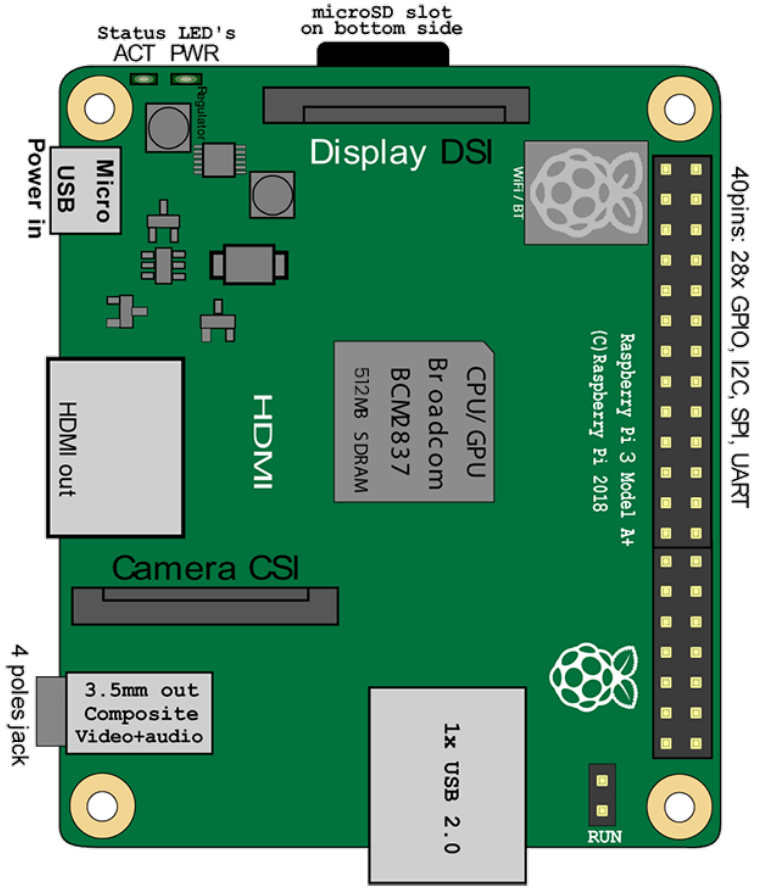
KEY WORDS, CONCEPTS, & PRACTICES

+ GitHub
+ Computational Thinking

Preview
lesson four

HOGESCHOOL ROTTERDAM

Raspberry Py 3A+

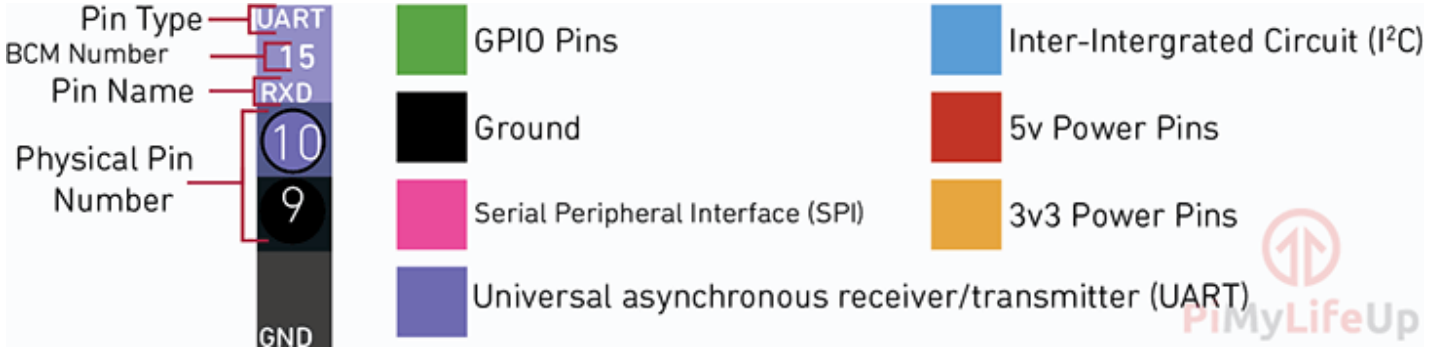


Here we have included some schematics of the Raspberry Pi 3 A Plus hardware.
These schematics show the general positioning of all the vital circuitry on the board.
The Raspberry Pi 3 A+ is a cut down version of the Pi 3B. As you can tell by its diagram, it features a single USB 2.0 Port. It's only means of network connectivity is the inbuilt Wi-Fi.

CPU: 1.4 GHz quad core ARM Cortex-A53
GPU: 250MHz Broadcom VideoCore IV
RAM: 512mb (Shared with GPU)
Storage: Micro SD
USB 2.0 Ports: 1
USB 3.0 Ports: 0
Networking: 802.11b/g/n/ac dual band 2.4/5 GHz wireless, Bluetooth 4.2 LS BLE
Video Input: 15-pin MIPI camera interface (CSI) connector
Video Ouputs: HDMI 1.3, MIPI display interface, DSI
Audio Inputs: Audio over I2S
Audio Outputs: 3.5mm phone jack, Digital Audio via HDMI
Low-Level peripherals: 17 x GPIO, +3.3v, +5v, ground, Plus the following that can be used as GPIO: UART, I2C Bus, SPI bus with two chip select, I2S audio
Power Source: 5v via MicroUSB or GPIO header
Size: 65.00mm x 56.50mm x 17mm
Weight: 23 g (0.81 oz)

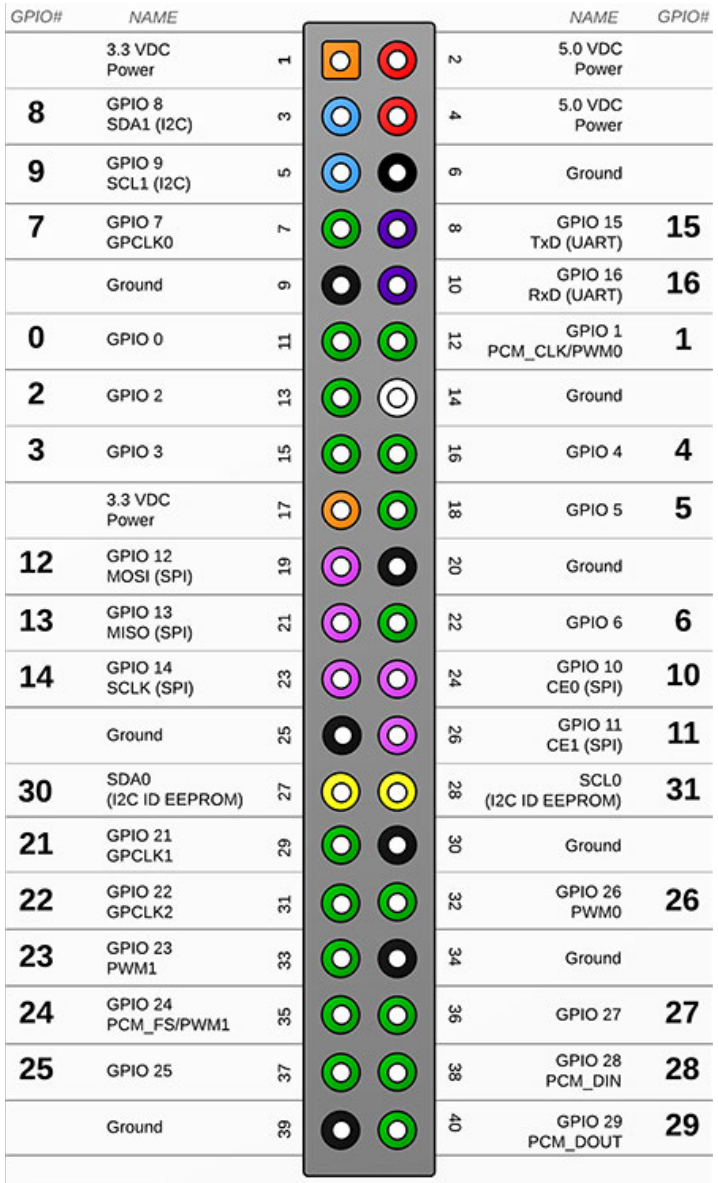
GPIO (general-purpose input/output)

connecting to the outside world



https://pimylifeup.com/raspberry-pi-3-a-plus/

GPIO pins groups on the Raspberry 3



GPIO#	NAME			NAME	GPIO#
	3.3 VDC Power	1	2	5.0 VDC Power	
8	GPIO 8 SDA1 (I2C)	3	4	5.0 VDC Power	
9	GPIO 9 SCL1 (I2C)	5	6	Ground	
7	GPIO 7 GPCLK0	7	8	GPIO 15 TxD (UART)	15
	Ground	9	10	GPIO 16 RxD (UART)	16
0	GPIO 0	11	12	GPIO 1 PCM_CLK/PWM0	1
2	GPIO 2	13	14	Ground	
3	GPIO 3	15	16	GPIO 4	4
	3.3 VDC Power	17	18	GPIO 5	5
12	GPIO 12 MOSI (SPI)	19	20	Ground	
13	GPIO 13 MISO (SPI)	21	22	GPIO 6	6
14	GPIO 14 SCLK (SPI)	23	24	GPIO 10 CE0 (SPI)	10
	Ground	25	26	GPIO 11 CE1 (SPI)	11
30	SDA0 (I2C ID EEPROM)	27	28	SCL0 (I2C ID EEPROM)	31
21	GPIO 21 GPCLK1	29	30	Ground	
22	GPIO 22 GPCLK2	31	32	GPIO 26 PWM0	26
23	GPIO 23 PWM1	33	34	Ground	
24	GPIO 24 PCM_FS/PWM1	35	36	GPIO 27	27
25	GPIO 25	37	38	GPIO 28 PCM_DIN	28
	Ground	39	40	GPIO 29 PCM_DOUT	29

https://pi4j.com/1.1/pins/model-3b-rev1.html

•**Power:** Pins that are labeled 5.0v supply 5 volts of power and those labeled 3V3 supply 3.3 volts of power. There are two 5V pins and two 3V3 pins.
•**GND:** These are the ground pins. There are eight ground pins.

•**Input/Outputpins**: These are the pins labeled with the # sign, for example, #17, #27, #22, etc. These pins can be used for input or output.

•**I2C:** I2C is a serial protocol for a two-wire interface to connect low-speed devices like microcontrollers, EEPROMs, A/D and D/A converters, I/O interfaces, and other similar peripherals in embedded systems. These pins are labeled **SDA** and **SCL**.

•**UART:** The **Universal Asynchronous Receiver/Transmitter** allows your Raspberry Pi to be connected to serial peripherals. The UART pins are labeled **TXD**and **RXD**.

•**SPI:** The **Serial Peripheral Interface** is a synchronous serial communication interface specification used for short distance communication, primarily in embedded systems. The SPI pins are labeled **MOSI**, **MISO**, **SCLK**, **CE0**, and **CE1**.

•**ID EEPROM:Electrically Erasable Programmable Read-Only Memory** is a user-modifiable read-only memory that can be erased and written to repeatedly through the application of higher than normal electrical voltage. The two EEPROM pins on the Raspberry Pi (**EED** and **EEC**) are also secondary I2C ports that primarily facilitate the identification of Pi Plates (e.g., Raspberry Pi Shields/Add-On Boards) that are directly attached to the Raspberry Pi.

GPIO general purpose IO

Voorgedefinieerde pennen

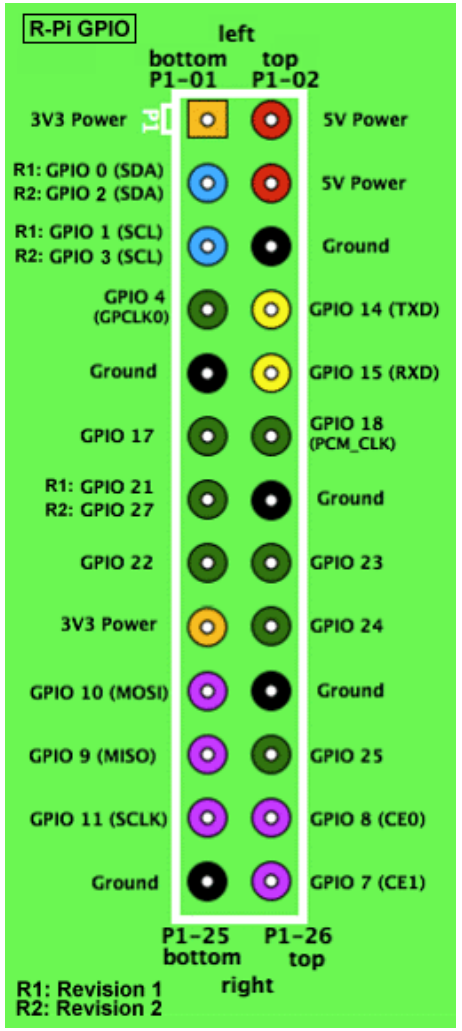
- 0V, 3.3V, 5V, Transmit, Receive
- I2C, 1-Wire

Vrijbeschikbare pennen

- GPIO 4, 17, 18, 8, 7

Naamgeving

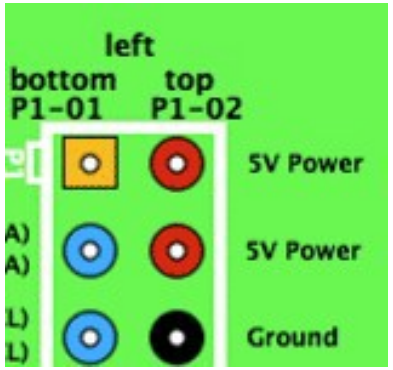
- Pinnummer van connector P1
- Broadcom documentatie van de SoC (System on Chip)



GPIO

Voordat je iets aansluit

- input maximaal 3.3V
  - let met name op de 5V van pin 2 en 4
- output maximaal 16 mA
  - LED over 330 Ω weerstand mag
  - motortje heeft een buffer nodig (ULN2003)
- totale output maximaal 50 mA



Programmeren

Schrijven (led laten knipperen)

- Eerst: GPIO pennetje definieren als output
- Dan: herhaaldelijk schrijven

Pennetje 26 = GPIO 7

Lezen (schakelaar uitlezen)

- Eerst: GPIO pennetje definieren als input
- Dan: herhaaldelijk lezen

Pennetje 24 = GPIO 8

Programmeren (bash)

- bash is de Linux command line interpreter
- als root in directory /sys/class/gpio werken
- GPIO 7 voor uitvoer

```
echo "7" >/sys/class/gpio/export
echo "out" >/sys/class/gpio/gpio7/direction
```

- led aan (1), led uit (0)

```
echo   "1"      > /sys/class/gpio/gpio7/value
echo   "0"      > /sys/class/gpio/gpio7/value
```

Programmeren (bash)

Knipperen

```
while sleep 0.5
do echo "1" > /sys/class/gpio/gpio7/value  sleep  0.5
   echo "0" > /sys/class/gpio/gpio7/value  done
```

GPIO 8 voor invoer

```
echo "8" > /sys/class/gpio/export
echo "in" > /sys/class/gpio/gpio8/direction
```

eenmalig lezen

```
cat /sys/class/gpio/gpio8/value
```

Programmeren (bash)

herhaald lezen

```
while sleep 0.1
do cat /sys/class/gpio/gpio8/value
done
```

opruimen

```
echo   "7"        >  /sys/class/gpio/unexport
echo   "8"        >  /sys/class/gpio/unexport
```

Programmeren (python)

Pi in Raspberry Pi staat voor Python

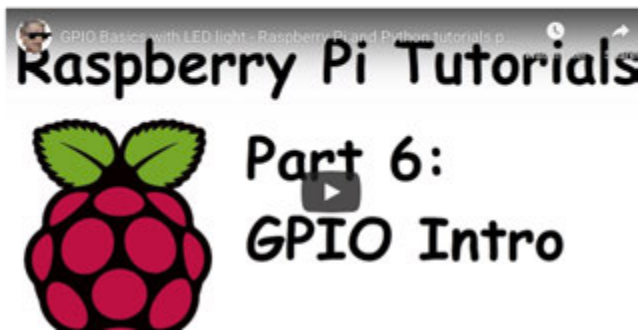
Standaard modules en bibliotheken

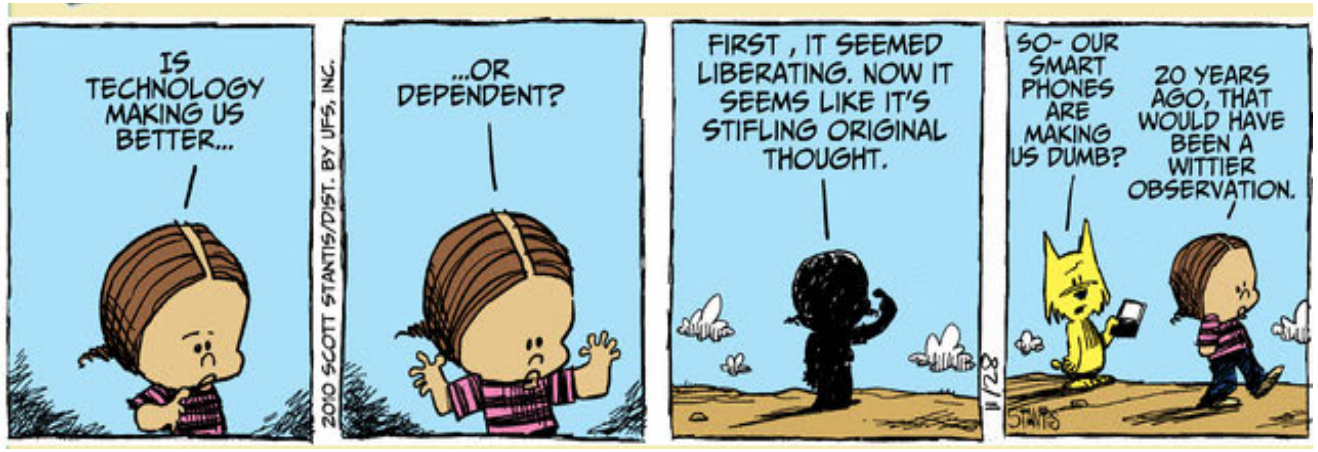
- keuze in naamgeving pennetjes / meer functies
- https://pythonprogramming.net/gpio-raspberry-pi-tutorials/

RPi.GPIO

- standaard onderdeel van Raspbian
- https://pypi.org/project/RPi.GPI

GPIO (General Purpose Input Output) Pins - Raspberry Pi tutorial





This lesson was developed by:
Rob van der Willigen
CMD, Hogeschool Rotterdam
NOV 2019

http://creativecommons.org/licenses/by-nc-sa/3.0/

This lesson is licensed under a Creative Commons Attribution-Share-Alike license. You can change it, transmit it, show it to other people. Just always give credit to RFvdW.

Creative Commons License Types

	Can someone use it commercially?	Can someone create new versions of it?
Attribution	👍	👍
Share Alike	👍	Yup, AND they must license the new work under a Share Alike license.
No Derivatives	👍	👎
Non-Commercial	👎	Yup, AND the new work must be non-commercial, but it can be under any non-commercial license.
Non-Commercial Share Alike	👎	Yup, AND they must license the new work under a Non-Commercial Share Alike license.
Non-Commercial No Derivatives	👎	👎

SOURCE
http://www.masternewmedia.org/how-to-publish-a-book-under-a-creative-commons-license/

http://creativecommons.org/licenses/

http://empoweringthenatives.edublogs.org/2012/03/15/creative-commons-licenses/

HOGESCHOOL ROTTERDAM