Introduction to Robotics

Course 2

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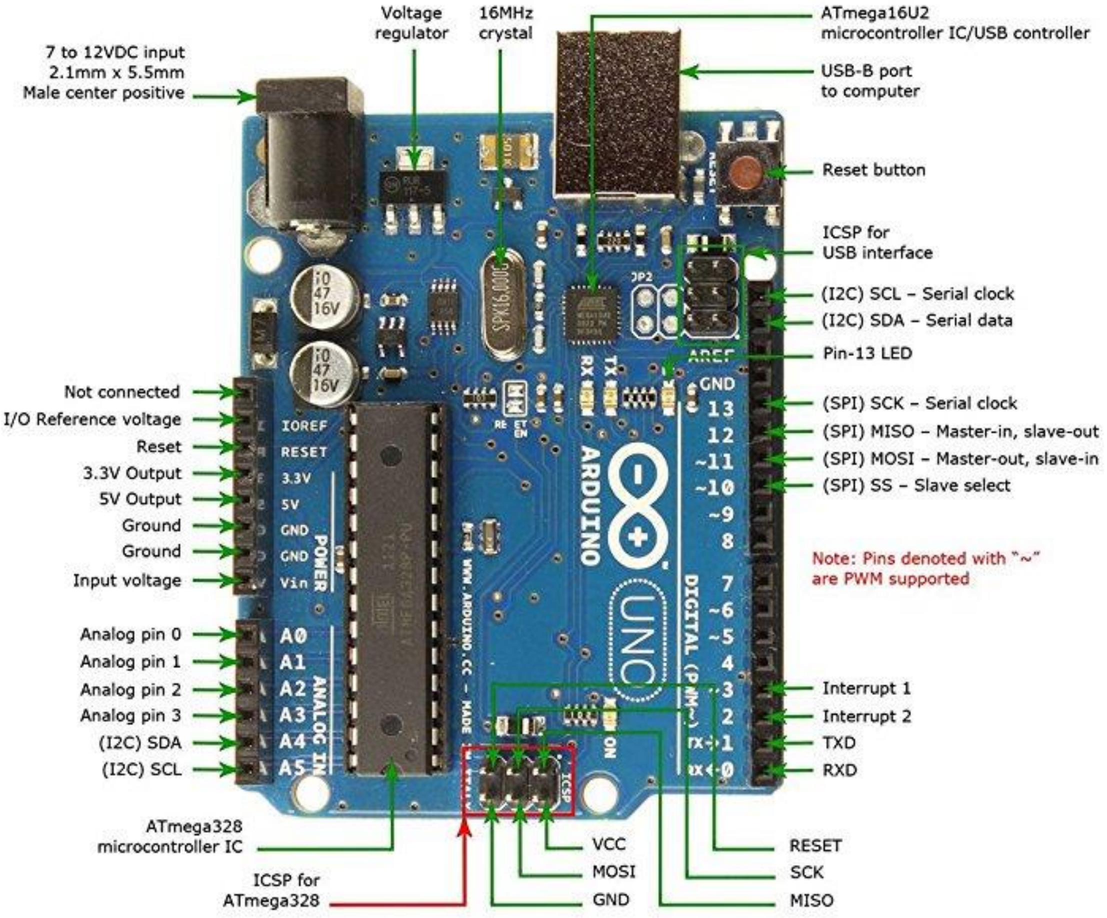
What we’ll do today

- Introduction to the Arduino Uno board
- What’s a microcontroller?
- Arduino Uno PINS
- Digital PINS
- Digital Input and Output
- Analog Input
- Analog Output
- PWM (Pulse-Width Modulation)
- Arduino IDE and environment
- Simple electronic components
- Thales tech challenge
- Homework
- Some books
- Some links

Arduino Uno board



Note: Pins denoted with "~" are PWM supported

Arduino Uno board

- Circuit board that have microcontroller chips on them. You’ll hear Arduino itself being called a microcontroller and that’s technically incorrect
- Uses the ATmega328 microcontroller
- Arduino’s designers basically took an off-the-shelf microcontroller, that requires a lot of setup and extra parts to get working and put all of them together in an easy to use way

But what’s a microcontroller?

- An integrated circuit
- Basically a tiny computer
- Can run small, simple software programs
- Low power enough to be run on simple batteries for days
- Fast enough to process data efficiently

Arduino Uno PINS

- Power pins: **5v and 3.3v**. Make sure it doesn’t draw too many milliamps. For example, you can use LEDs and simple components, but cannot power a motor
- GND is the ground pin
- **0 and 1** (**RX** and **TX**) are used for serial communication. Can be used for digital read or write as well, but may cause problems so use them only if truly necessary. Can be used to send data from a Bluetooth module, GPS module, WIFI module etc
- **2 – 13** digital input and outputs
- **A0 – A5** analog input pins. Used to measure continuous voltage anywhere between 0v and 5v
- **Pins with ~** are used for PWM (pulse-width modulation), aka analog output (more on that soon)

Digital Pins

- Digital pins: 2 – 13
- Can and have to be configured for input or output
- **pinMode(pinNumber, INPUT)** configures the pin for input
- **pinMode(pinNumber, OUTPUT)** configures the pin for output
- When reading or writing to a digital pin, there are only two possible values a pin can take/be-set-to:
  - **LOW** = digital 0
  - **HIGH** = digital 1
  - Controlled with **digitalWrite(pinNumber, variable)**
  - Example: **digitalWrite(pinNumber, LOW)** or **digitalWrite(pinNumber, HIGH)**

Digital Input

- Digital Input:
  - Is set up with **pinMode**(**pinNumber**, INPUT)
  - Will report a HIGH if:
    - **a voltage greater than 3.0V is present at the pin (5V boards)**
    - a voltage greater than 2.0V volts is present at the pin (3.3V boards)
  - Will report LOW if:
    - **a voltage less than 1.5V is present at the pin (5V boards)**
    - a voltage less than 1.0V (approx) is present at the pin (3.3V boards)
  - Are said to be in a **high-impedance** state, meaning that input pins make extremely small demands on the circuit they are sampling, equivalent to a series of resistor of 100 Megohms in front of the pin. This makes them useful for reading a sensor
  - If you connect a switch and read the value of a input pin, you will see it will float between 0 and 1

Digital Output

- Digital Output:
  - Is set up with pinMode(pinNumber, OUTPUT)
  - When set to **HIGH** with digitalWrite, the pin is at:
    - **5V (5V boards)**
    - 3.3V (3.3V boards
  - When set to **LOW**, for both 5V and 3.3V boards, the pin is at **0V**.
  - Are said to be in a **low-impedance** state, meaning they can provide a substantial amount of current to other circuits. Atmega pins can source (provide current) or sink (absorb current) up to 40mA (milliamps). Loads greater than 40mA (e.g. motors) will require a transistor or other interface circuitry

Analog Input

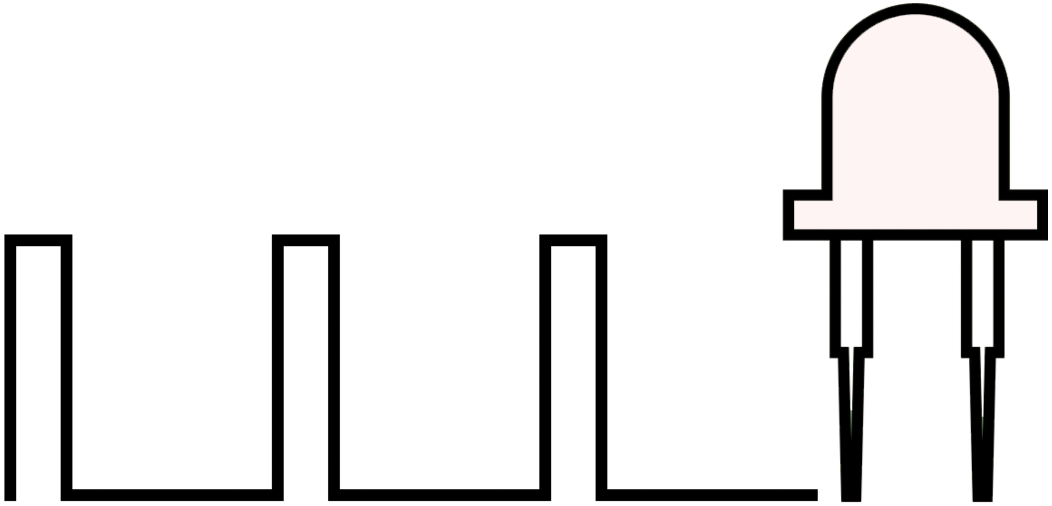
- Analog Input Pins: A0 – A5
- Read value with **analogRead(pinNumber)**
- Returned value is between **0…1023** (saved internally in a 10-bit number)

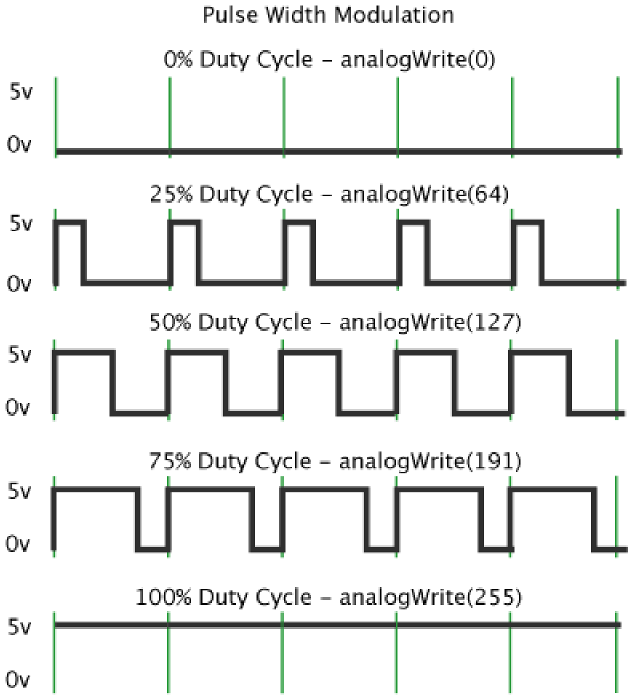
Analog Output (PWM)

- Can be used on pins with **~ (3, 5, 6, 9, 10, 11)**
- Is used with the **analogWrite(pinNumber, value)** function
- The function receives values between **0..255**
- When using a value from analogRead to analogWrite, be sure to map the values to the same interval with the **map** function
- int **outputValue = map(readValue, 0, 1023, 0, 255)**
- **analogWrite(pinNumber, outputValue)**

PWM (pulse-width modulation)

- A technique for getting analog results with digital means

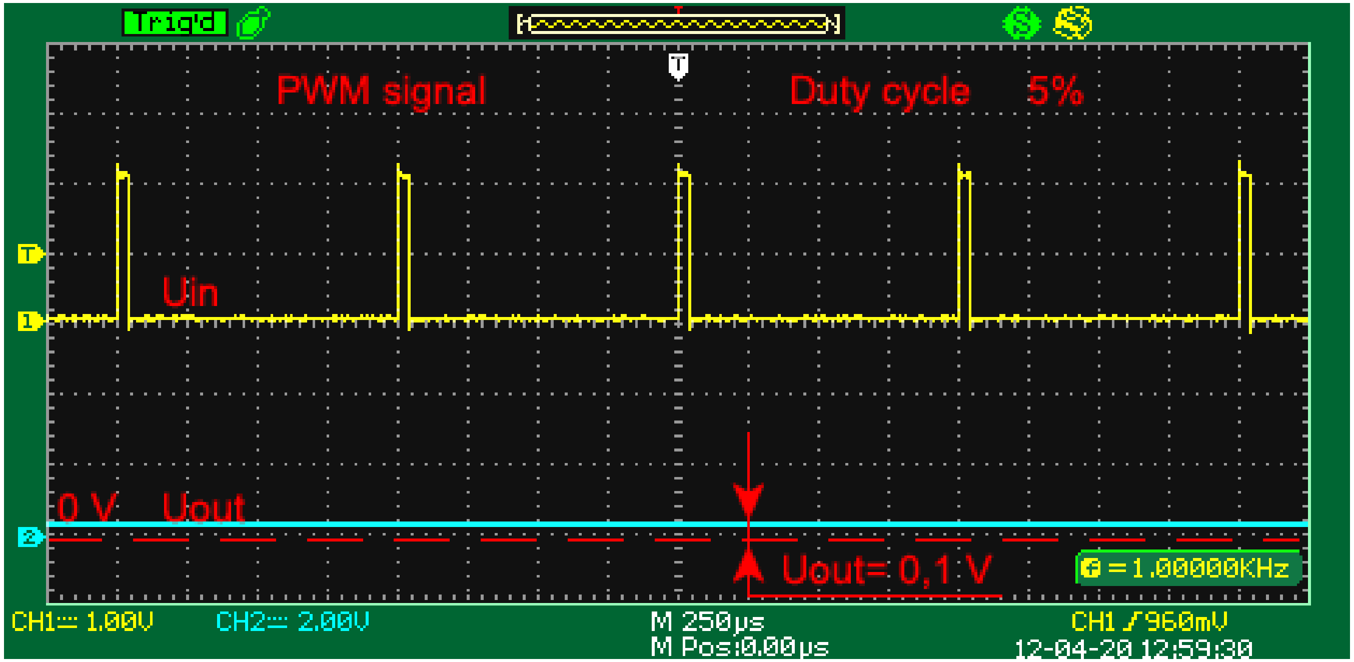


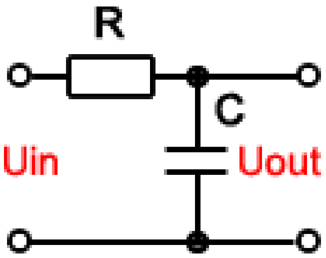

Pulse Width Modulation
0% Duty Cycle – analogWrite(0)
5v
0v
25% Duty Cycle – analogWrite(64)
5v
0v
50% Duty Cycle – analogWrite(127)
5v
0v
75% Duty Cycle – analogWrite(191)
5v
0v
100% Duty Cycle – analogWrite(255)
5v
0v

*gif works if you open the .ppt. It is possible to do so in the browser.

Pulse-width Modulation

- In practice, we use a RC low pass filter to convert the square wave into a continuous analog voltage (bottom line)





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Arduino IDE

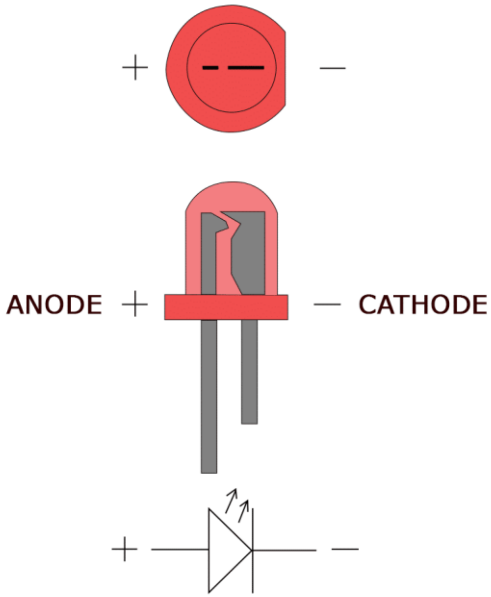
- Most of the work you do with Arduino will be with the software.
- Download it from https://www.arduino.cc/en/main/software (should've done that already)
- Make sure you connect to the right type of board from tools -> boards -> Arduino / Genuino Uno
- Make sure you are connected through the right port from tools -> ports -> COM<n> (Arduino / Genuino Uno) ----- most common problem! Always check for this when you have upload errors!
- Lots of built in examples can be found on File -> Examples
- All the examples contain information on how to set up the hardware

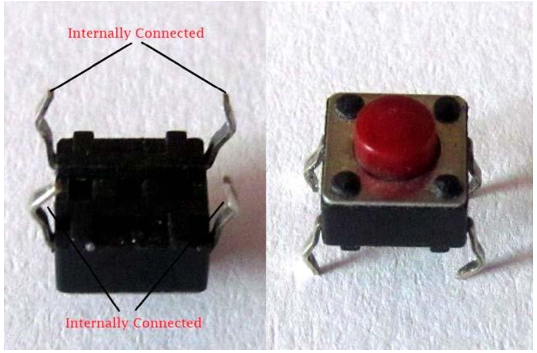
Arduino program

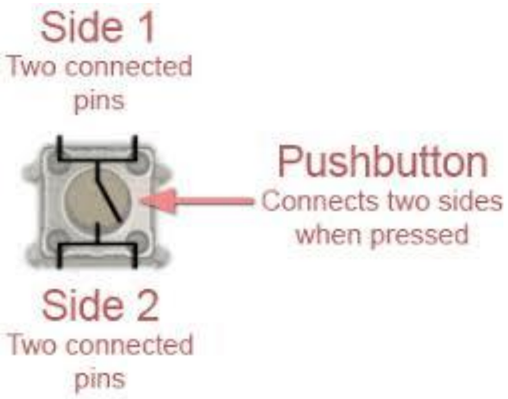
- Has 2 main functions: **setup()** and **loop()**
- **setup()** is only run once when the boards boots up
- **loop()** is run contiuosly
- **Serial.begin(9600)** initializes the communication at 9600 bps, a fairly common bitrate.
- **Serial.println()** values can be seen in the SerialMonitor

Simple electronic components

- LED Push button Resistor







Resistors are electrical components used to limit current in a circuit. They are passive components, meaning they only consume power (and can't generate it). The resistor's resistance limits the flow of electrons through a circuit.

Simple electronic components

- Breadboard

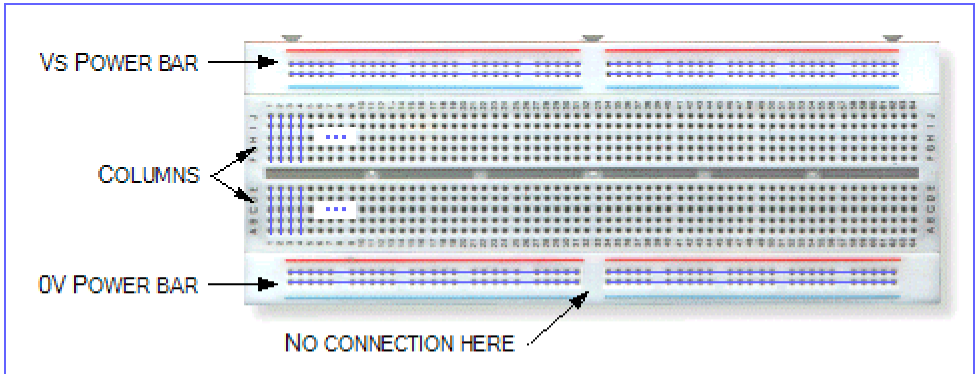
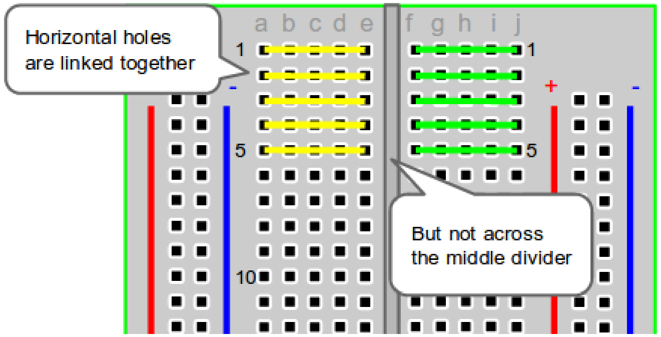
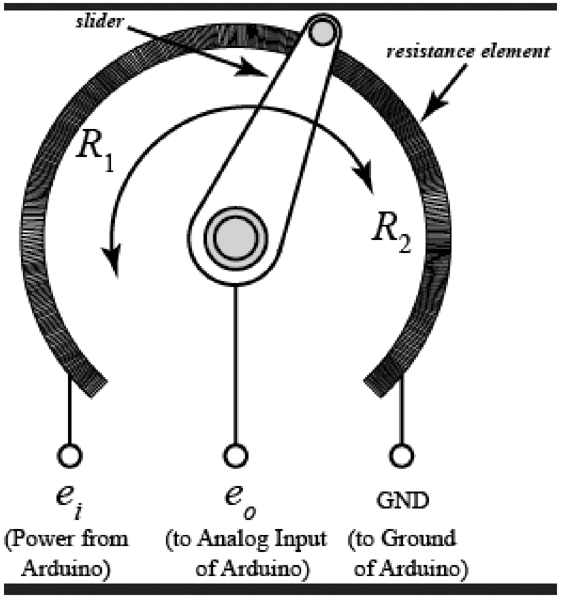


Figure 1: How the holes in a breadboard are connected electrically


Horizontal holes are linked together
a b c d e
f g h i j
1
5
10
+
-
But not across the middle divider

Potentiometer



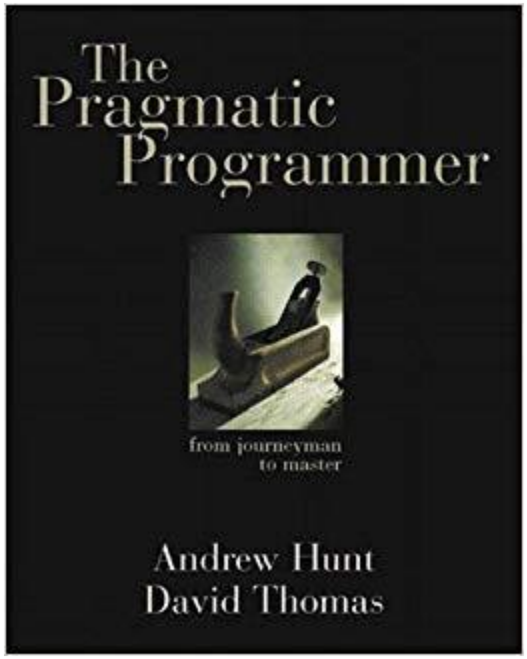
A potentiometer is a simple knob that provides a variable resistance, which we can read into the Arduino board as an analog value.

Homework

- Create a github account and repository with a “Lab homeworks” folder.
- You must add **2** readme files:
  - one in the repository, with some basic info (“repository for the Introduction to Robotics course” etc)
  - One in the folder (“Laboratory homeworks:”) which you will edit after each added homework.
- In this folder you will upload all your lab homeworks
- (You’ll have to add 3 more folders in time, but more on that later)
- This homework will be verified at the next lab and will be graded as well

Some books

- The pragmatic programmer



The Pragmatic Programmer

from journeyman to master

Andrew Hunt
David Thomas

The bible of programming.
Read this and you’ll be a better programmer than most of your colleagues.

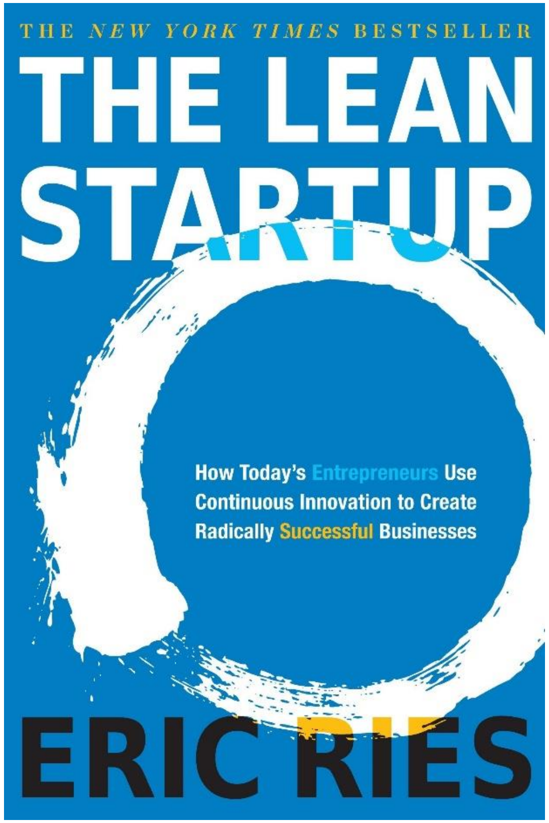
Read this and you’ll use good practices better than some of the managers you’ll encounter.

Read this and you’ll be years ahead of the learning curve for your mean level.

Its techniques are applicable in other fields as well, not only programming.

Some books

- The lean startup


THE NEW YORK TIMES BESTSELLER
THE LEAN STARTUP
How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses
ERIC RIES

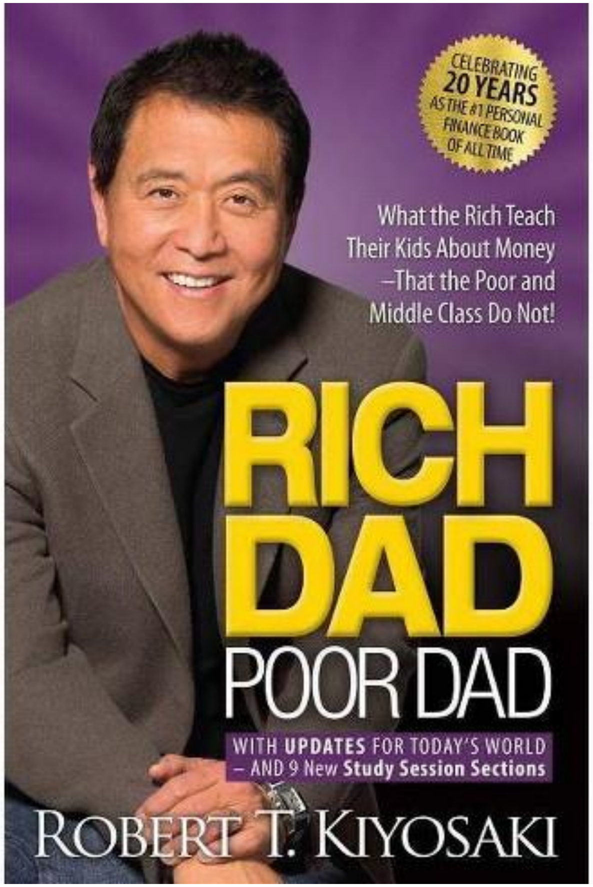
A must for anyone who wants to be part of a startup.

Useful for absolutely anyone who will work in an organization. It will help you develop the entrepreneurial mindset.

It's THE book that shaped silicon valley. Most things that work there originated from here

Some books

- Rich dad, Poor dad


CELEBRATING
20 YEARS
AS THE #1 PERSONAL FINANCE BOOK OF ALL TIME
What the Rich Teach Their Kids About Money –That the Poor and Middle Class Do Not!
RICH DAD
POOR DAD
WITH UPDATES FOR TODAY'S WORLD – AND 9 New Study Session Sections
ROBERT T. KIYOSAKI

The #1 book on personal finances.

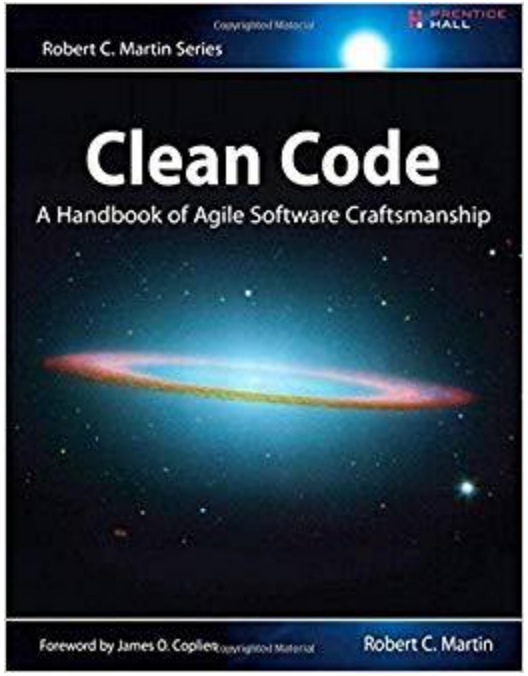
Contains controversial statements about money – some might seem harsh and with some you might not agree.

Will make you think less like an follower and more like an investor.

Excellent book on getting out of “the rat race”

Some books

- Clean code



Somewhat more technical, but excellent book on coding practices.

Reading this and The pragmatic programmer will put you way ahead most programmers, even the ones with experience.

Attendance check

- So I won’t forget...

And remember

Some links

- Arduino: www.arduino.cc
- https://www.arduino.cc/reference/en/language/variables/constants/constants/
- Github tutorial: https://guides.github.com/activities/hello-world/ (more complex than needed now, but useful to learn it)