CS 1010

Detecting Heart Beats

Raspberry Pi with pulse sensor and A/D converter

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```
import numpy as np
Import matplotlib.pyplot as plt
Import PCF8591 as ADC
```

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Photo: Kartik Bulusu

Frequency of signals and measurements

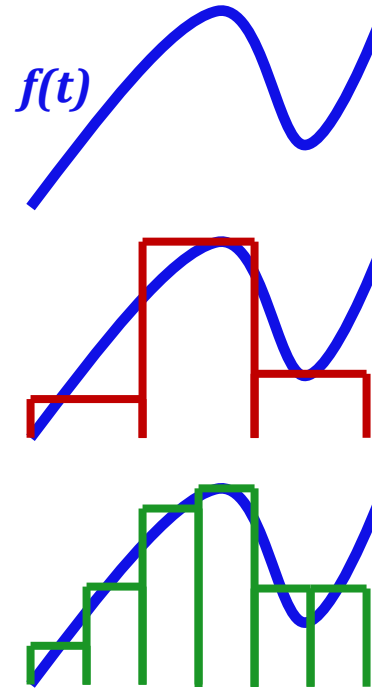**Frequency** is the number of occurrences of a repeating event per unit **time**.

f = 0.5 Hz
T = 2.0 s

f = 1.0 Hz
T = 1.0 s

f = 2.0 Hz
T = 0.5 s

Wikimedia Commons

The **sampling frequency** or **sampling rate, f_s,** is the average number of samples obtained in one second (*samples per second*), thus **f_s = 1/T**.

f(t)

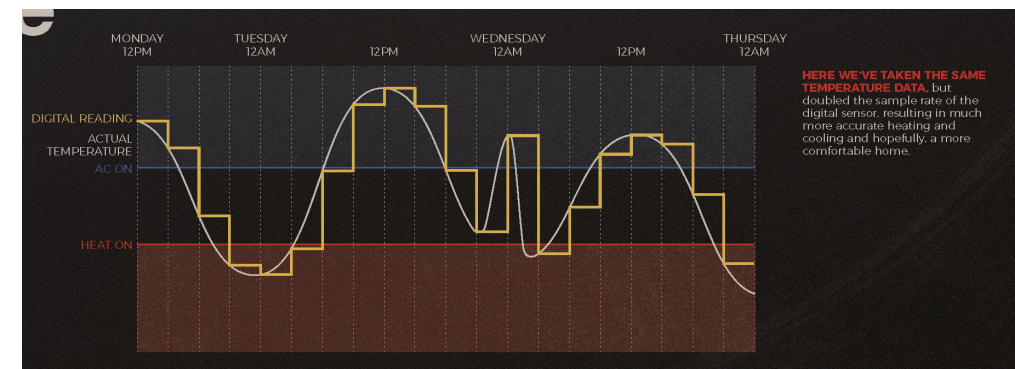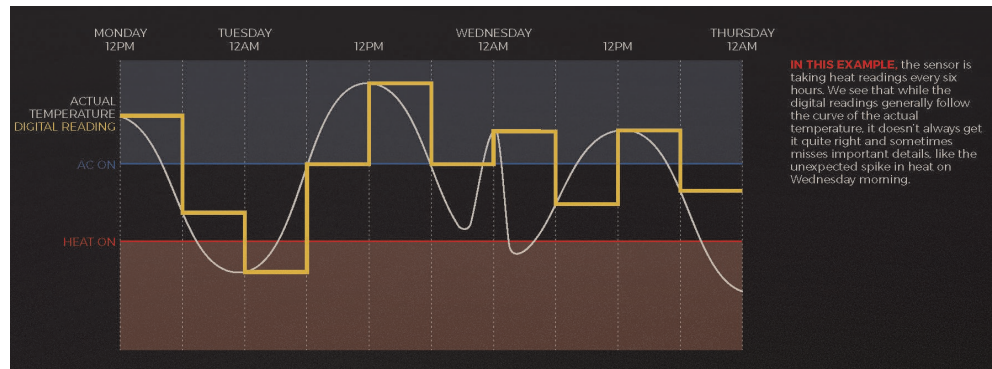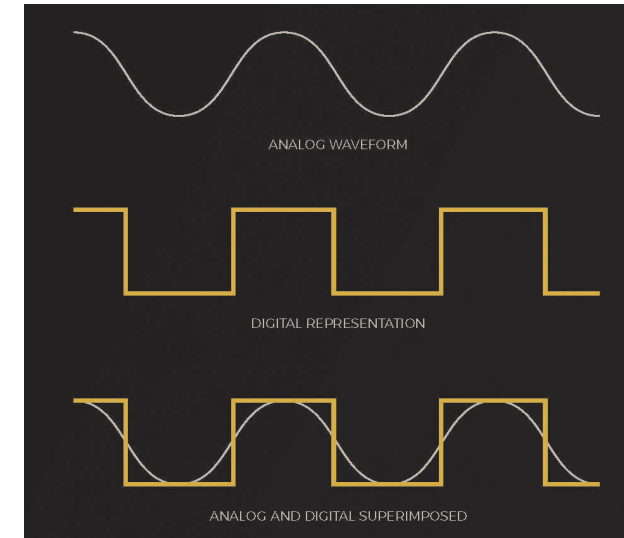The general range of hearing for young people is 20 Hz to 20000 Hz.

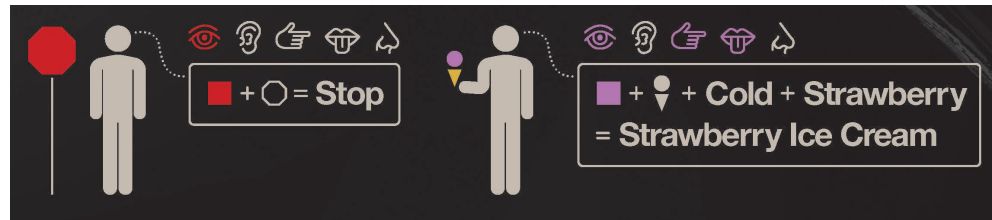Audio CD, most commonly used with MPEG-1 audio is sampled at 44100 Hz

HD DVD (High-Definition DVD) audio tracks are sampled at 98000 Hz

The approximately double-rate requirement is a consequence of the Nyquist theorem.

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From Analog to the Digital World

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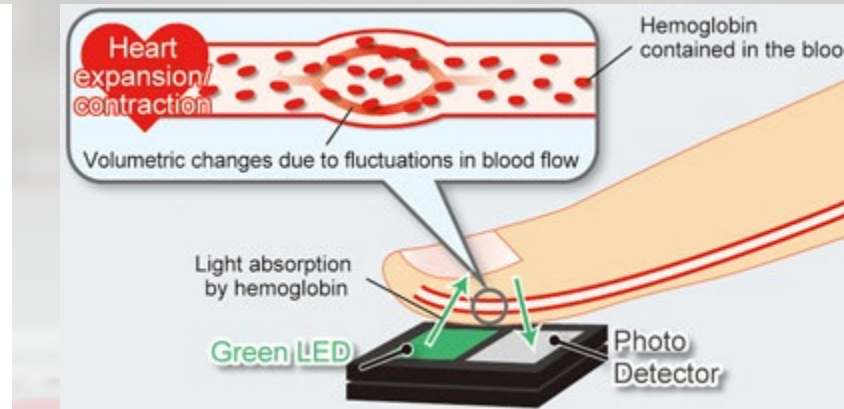& Applied Science
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Heart expansion/contraction

Hemoglobin contained in the blood

Volumetric changes due to fluctuations in blood flow

Light absorption by hemoglobin

Green LED

Photo Detector

Green light source which has a high absorption rate in hemoglobin and less susceptibility to ambient light

Hemoglobin

Blood Vessel (Artery)

Green LED

Photodetector

Pulse Sensor
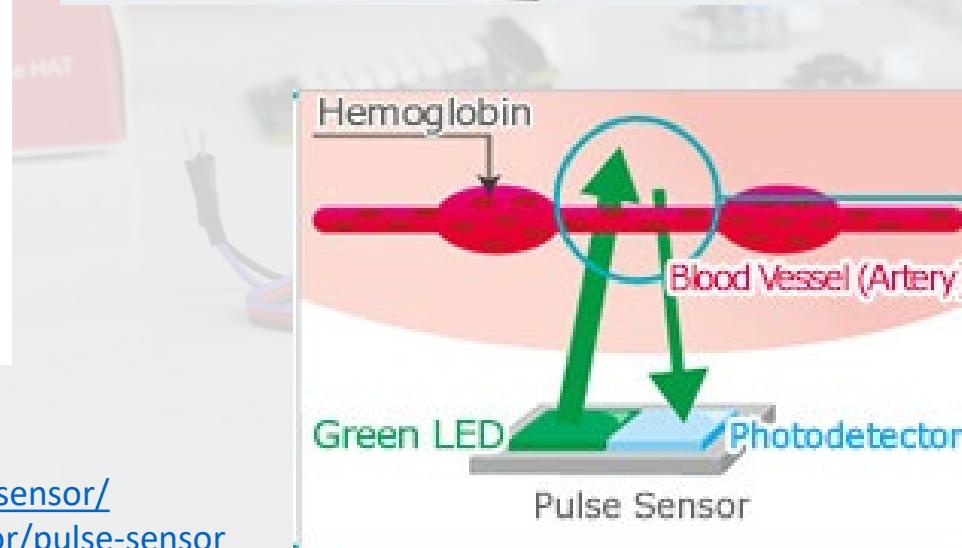
The amount of light absorbed will vary based on changes in blood vessel volume, resulting in a waveform as shown below.

Signal (V)

Pulse Wave

Time(sec)

Sources:
https://pulsesensor.com/
https://www.electroschematics.com/heart-rate-sensor/
https://www.rohm.com/electronics-basics/sensor/pulse-sensor
https://www.rohm.com/sensor-shield-support/heart-rate-sensor

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Photo: Kartik Bulusu

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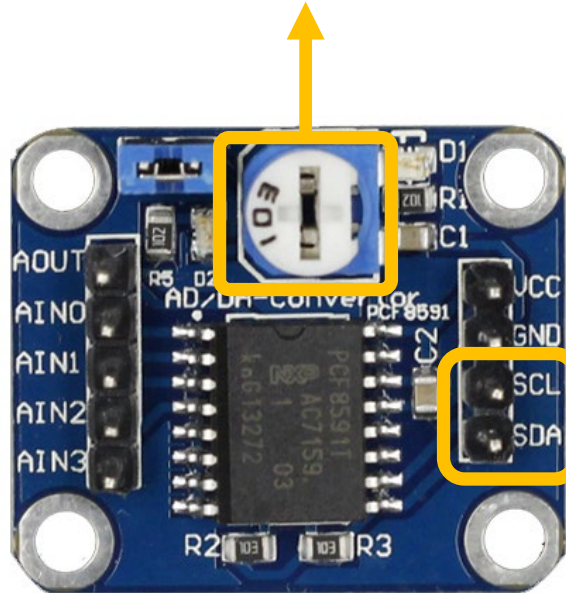CSCi 1010   Computer Science Orientation

Introducing the PCF8591 8-bit A/D and D/A converter

Potentiometer –
- To regulate the input voltage supply
- To adjust the quality of the analog input signal by changing the "gain".

SYMBOL	PIN	DESCRIPTION
AIN0	1	analog inputs (A/D converter)
AIN1	2	
AIN2	3	
AIN3	4	
A0	5	hardware address
A1	6	
A2	7	
V_{SS}	8	negative supply voltage
SDA	9	I^{2}C-bus data input/output
SCL	10	I^{2}C-bus clock input
OSC	11	oscillator input/output
EXT	12	external/internal switch for oscillator input
AGND	13	analog ground
V_{REF}	14	voltage reference input
AOUT	15	analog output (D/A converter)
V_{DD}	16	positive supply voltage

I^{2}C (**Inter-Integrated Circuit**, *eye-squared-C*), alternatively known as **I2C** or **IIC**, is a synchronous, multi-master, multi-slave, packet switched, single-ended, serial communication bus invented in 1982 by Philips Semiconductors.
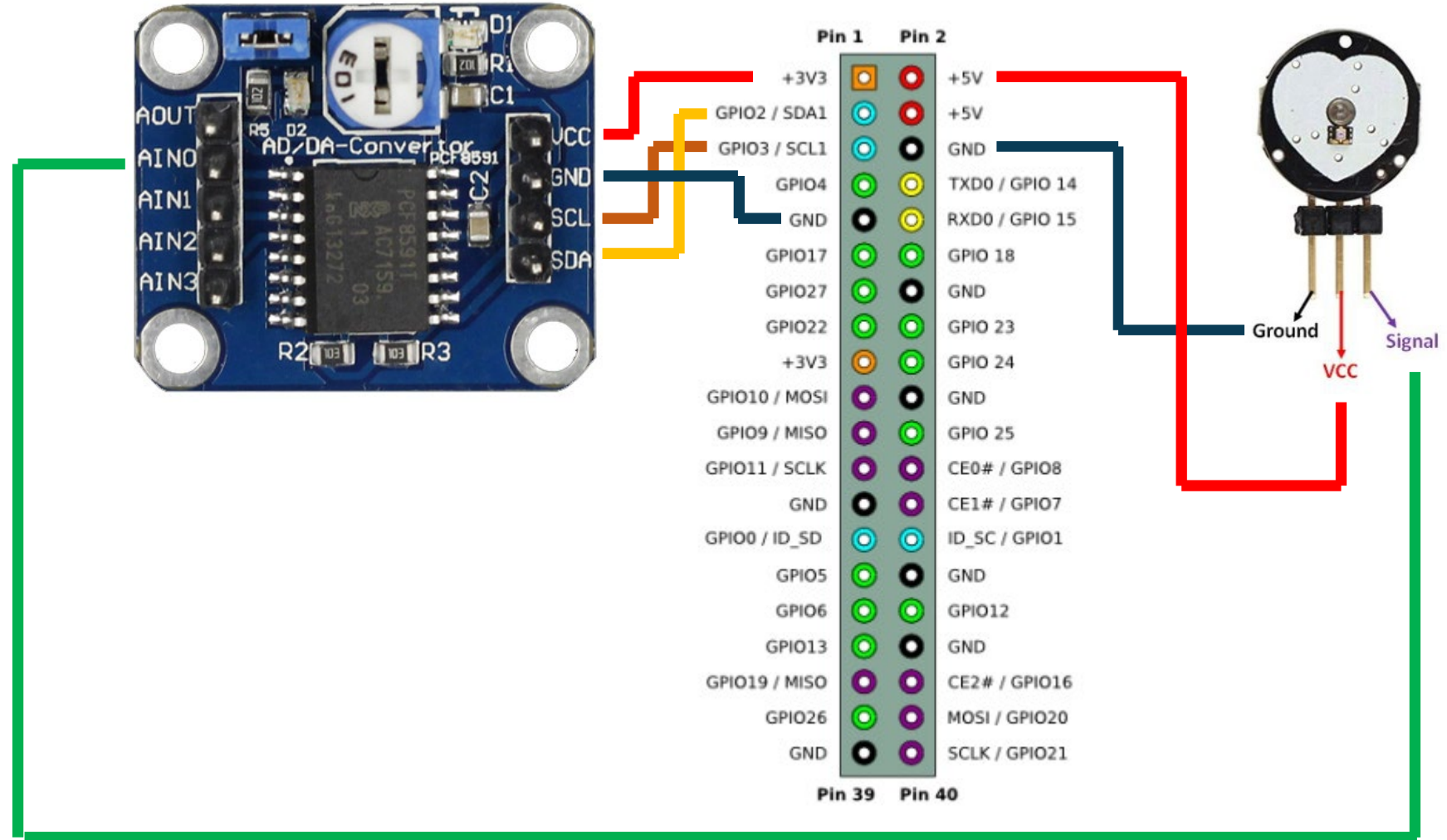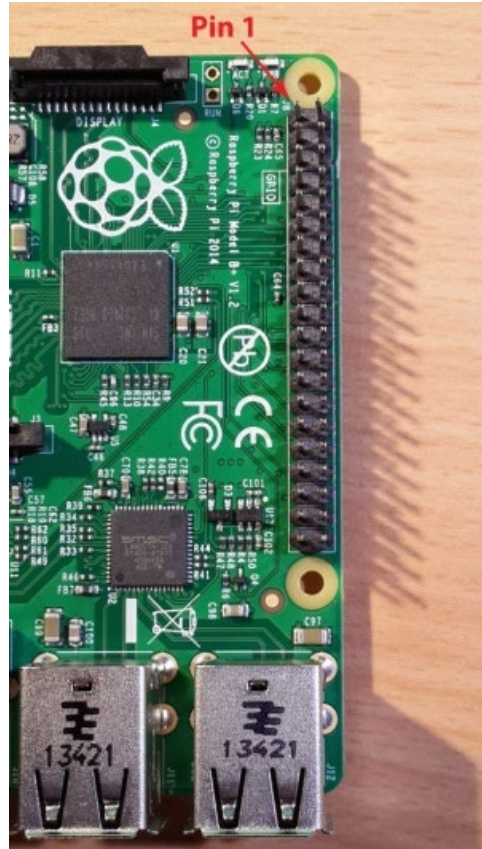
It is widely used for attaching lower-speed peripheral ICs to processors and microcontrollers in short-distance, intra-board communication.

Sources:
https://en.wikipedia.org/wiki/I%C2%B2C
http://wiki.sunfounder.cc/index.php?title=PCF8591_8-bit_A/D_and_D/A_converter_Module

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Pulse sensor + A/D converter

Pin 1

AOUT
AIN0
AIN1
AIN2
AIN3

AD/DA-Converter
PCF8591

VCC
GND
SCL
SDA

Pin 1		Pin 2
+3V3		+5V
GPIO2 / SDA1		+5V
GPIO3 / SCL1		GND
GPIO4		TXD0 / GPIO 14
GND		RXD0 / GPIO 15
GPIO17		GPIO 18
GPIO27		GND
GPIO22		GPIO 23
+3V3		GPIO 24
GPIO10 / MOSI		GND
GPIO9 / MISO		GPIO 25
GPIO11 / SCLK		CE0# / GPIO8
GND		CE1# / GPIO7
GPIO0 / ID_SD		ID_SC / GPIO1
GPIO5		GND
GPIO6		GPIO12
GPIO13		GND
GPIO19 / MISO		CE2# / GPIO16
GPIO26		MOSI / GPIO20
GND		SCLK / GPIO21
Pin 39		Pin 40

Ground

Signal

VCC

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Goal of the lab segment

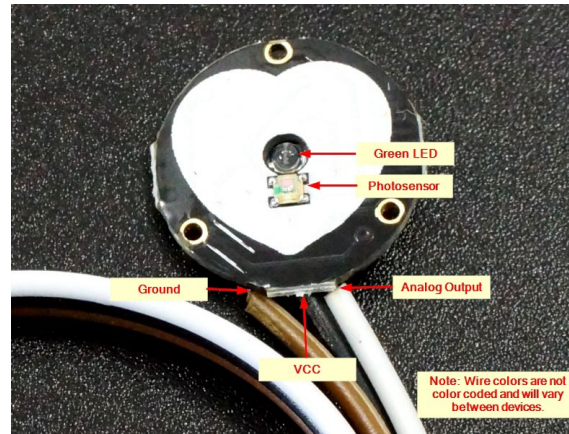## Co-work
- Observe, ask and try in groups

Make
- Build-a-hack
- Pulse sensors, A/D converter and Raspberry Pi 3B+

Analyze data using Python

Green LED
Photosensor
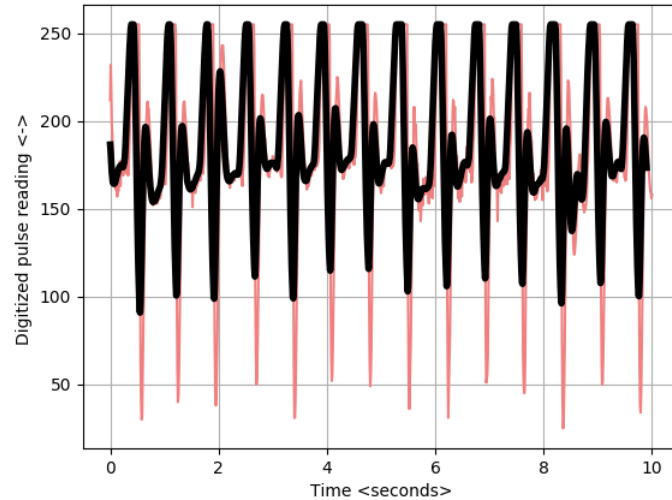Ground
VCC
Analog Output
Note: Wire colors are not color coded and will vary between devices.

Record your pulse at your wrist

1
2
3
4
2X Beats Per 30 Seconds
Date 6/2/2020 Time 8:30 am Pulse 66
1   2   3...
30 seconds

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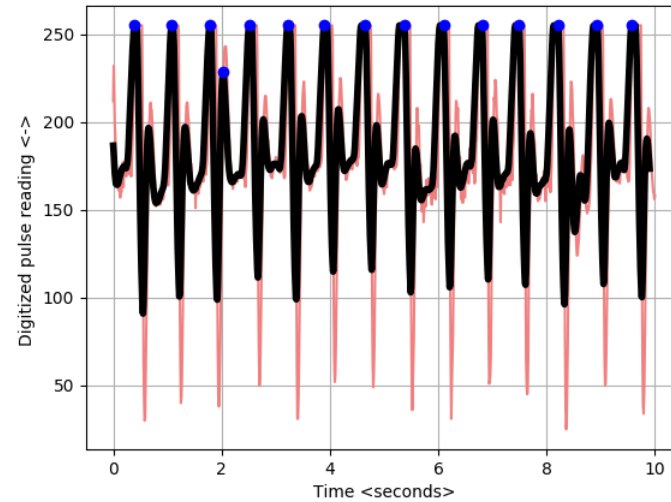CSCi 1010   Computer Science Orientation
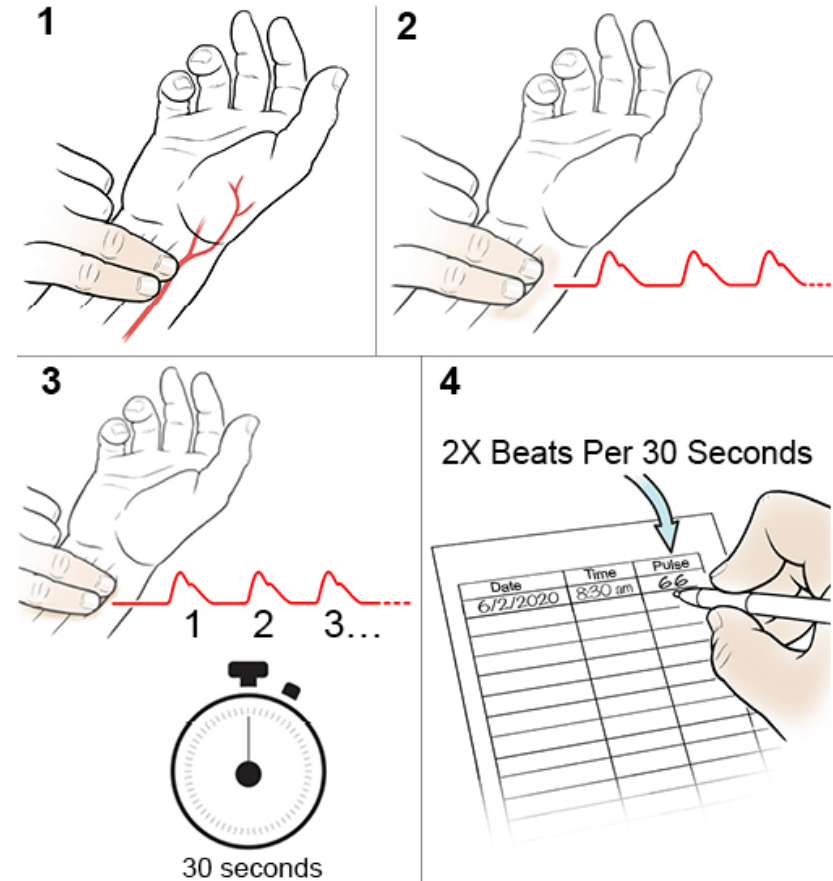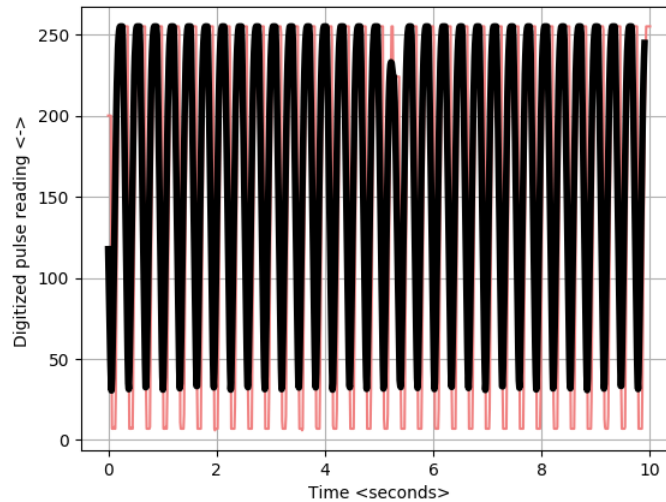
Recorded pulse signal

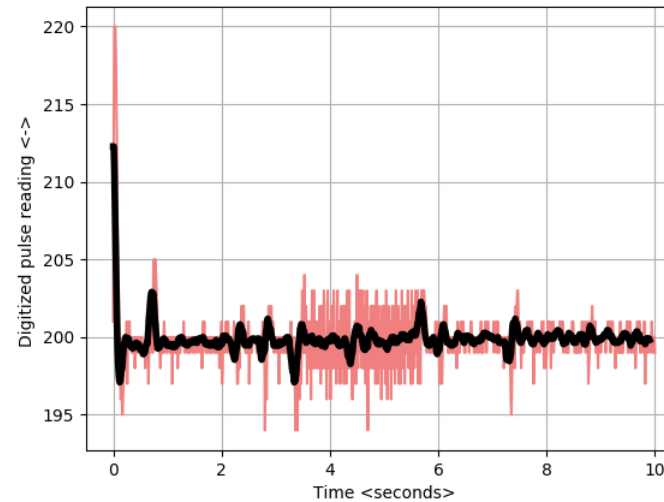# Pulse signal peaks detected by the Raspberry Pi 3B+ system

Signals generated by the heart rate measurements system after adjusting the potentiometer settings

Pulse signal with high gain setting

Pulse signal with low gain setting

Typical pulse signal with optimal gain setting

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