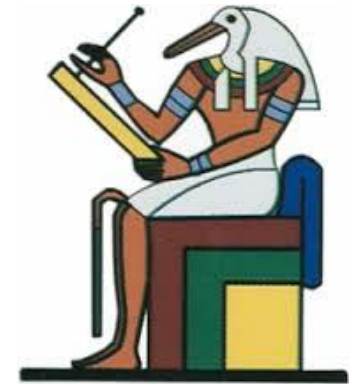




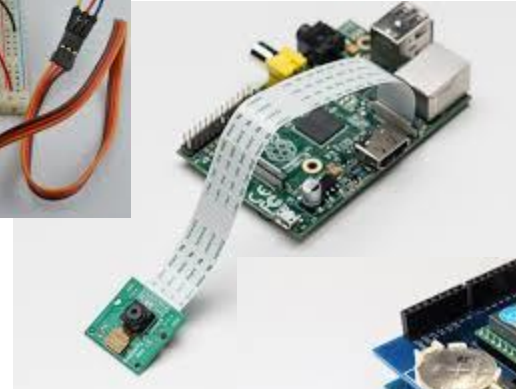
# Linux For Embedded Systems

## *For Arabs*

Cairo University  
Computer Eng. Dept.  
CMP445-Embedded Systems



Ahmed ElArabawy



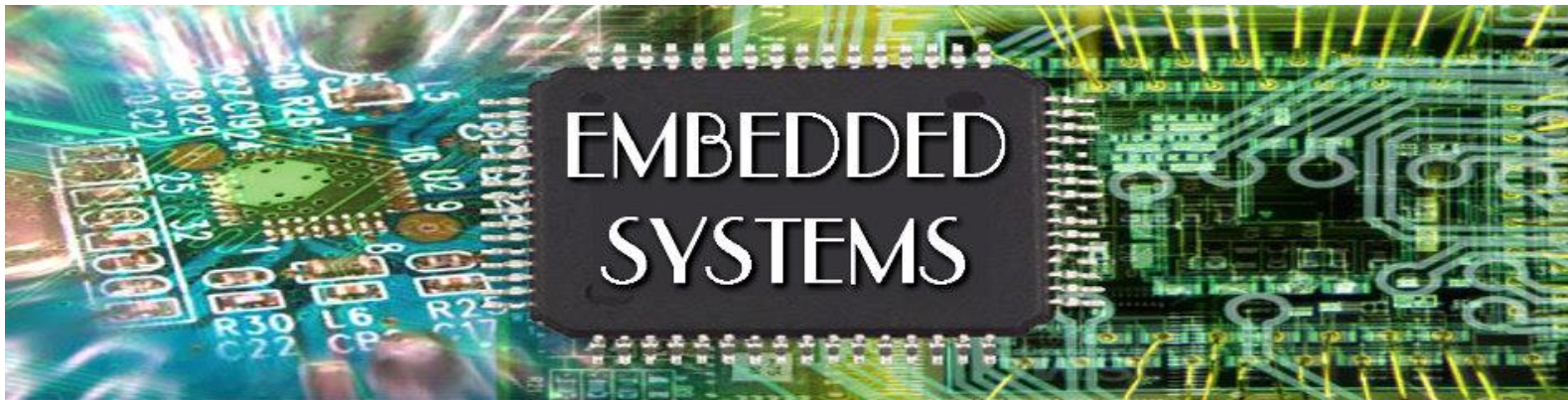
# Lecture 1: Course Overview

# The Lecturer

- Ahmed ElArabawy
- Education:
  - BSc Alexandria University (1992)
  - MSc Alexandria University (1994)
  - PhD SMU University, TX, USA (2001)
- Work
  - Faculty Staff @ Alexandria Univ.
  - Faculty Staff @ Cairo Univ.
  - Microsoft, SySDSoft (Egypt)
  - Ericsson, Broadcom, Solectek, WiLan Labs (USA)
- Embedded Systems Initiatives
  - Linux for Embedded Systems
    - <http://linux4embeddedsystems.com/>
    - <https://www.facebook.com/groups/linuxforEmbeddedSystems/>
  - Raspberry Pi for Arabs
    - <https://www.facebook.com/groups/linuxforEmbeddedSystems/>
- More Details
  - <https://www.linkedin.com/in/ahmedelarabawy>



# This Course



- This is an introductory hands-on course in the area of Embedded Systems
- We will be using the Raspberry Pi to learn about the basic aspects of Embedded Development
- We should come out from this course with a decent level of knowledge and hands on experience with embedded systems
- Although the course addresses embedded systems in general, we will be focusing on the use the Raspberry Pi Board throughout the course



# Why The Raspberry Pi ??

- The reason of selecting the Raspberry Pi for this Course:
  - The Raspberry Pi is a very capable board, and can demonstrate all the aspects of embedded systems that we will study in this course (**ARM Processor, Linux Support, ...** )
  - The Raspberry Pi is very rich in its interfaces (**USB, Ethernet, GPIO, I2C, SPI, UART, CSI, DSI, ....**)
  - The Raspberry Pi has strong support of different programming and scripting languages (**Bash, Python, Java, C/C++, ..**)
  - The Raspberry Pi comes with a huge community and tons of tutorials and projects on the Internet
  - The Raspberry Pi is less Expensive than other comparable board
  - The Raspberry Pi is more available in local market than other boards



# What About Other Platforms ?

- A lot of the materials in this course is useful for other embedded system boards
- It is advisable to focus now on the Pi to avoid distractions in the boards differences, and to have a common platform
- Later, you can apply the same course material on a lot of other platforms

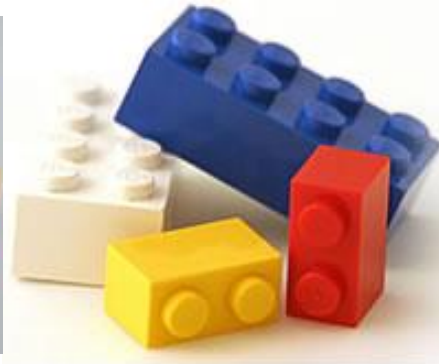
# Course Objectives



- The Internet is full of tutorials, guides, and videos for different projects on the Pi
- So this course will not try to add to this pile with more projects
- The Objective of this course is to perform a structures and organized study on Embedded Systems using the Pi and its associated capabilities
- Each lecture will cover one concept in Embedded Systems using the Pi
- I will be building mini-projects in the lecture to apply the concepts of the lecture
- Then I will be referring to some of the online projects that utilize the discussed topic



# Course Projects



- Most of the projects used in this course are simple projects that consider a single concept
  - Connecting to a specific sensor
  - Controlling a specific Motor
  - Interfacing to a specific Display
- In real world projects, the system will contain multiple of these aspects
- So consider the projects in this course as building blocks, for bigger projects
- You will be assigned to do more projects on your own





# Course Logistics



- It is not enough to watch the video lectures
- The Course Web Site includes much more resources
  - List of applicable Projects
  - Useful Links
  - More Reading Material
  - FAQ
  - Assignments
  - Quizzes and grading

# Course Project Code



- All code used in this course will be available on the course GitHub Repository  
<https://github.com/Linux4EmbeddedSystems>
- You will need to have your own GitHub account, so if you don't have one already, create one.... It is free  
<https://github.com/>
- You will need the GitHub account to deliver code and associated documentation for all assigned mini-projects

# Course Pre-requisites



- Good Understanding of Linux and its command Line Interface, if you need to refresh your knowledge on this topic, attending the course **C-102 Understanding Linux** in the public section of the website is highly recommended (I will be referring to specific lectures throughout the course when needed )
- Have access to a **Raspberry Pi** Board is needed (you will be provided with one)
- Other hardware accessories will be mentioned in each lecture
- This course will use different computer programming and scripting languages:
  - It will use some **Bash Scripts**, no previous advanced knowledge of Bash Scripts are needed
  - It will use some **Python Scripts**, so it will be useful to have some knowledge about Python, but it is not a must since python is very easy to learn as we go
  - Some parts of the course will be using **C Code**
  - Other parts will be using **Java Code**

# Communication Channels

## Course WebSite



- All Students will need to create an account in the course website  
<http://linux4embeddedsystems.com>
- Students will need also to create a GitHub Account  
<https://github.com/>
- Students need to send me the email (used in the course login) and their GitHub username by Midnight today
- I will enroll you in the course, and send you instructions by email
- Announcements from the lecturer will be put on the website, and sent by email
- The course website will contain,
  - Access to the lecture videos, note that the videos will be on **youtube**, so you can download them if you need to
  - Access to the lecture slides in pdf format
  - A list of required reading material. These are part of the course, and will be included in the midterm and final exams
  - A list of optional reading material. These are recommended for those who are interested in the topic, and they are not going to be part of the exam
  - Any course related announcements
  - Weekly assignments/mini-projects description
  - Quizzes and grades
  - Discussion forums

# Communication Channels

## Discussion Forum



- All student questions should be placed on the discussion forum in the course website
- Both the Lecturer and the course TAs will be monitoring the discussion forum to answer course related questions
- Other students are encouraged to respond to their colleague questions
- You can also post ideas, interesting articles, interesting embedded news on the discussion forum
- It is highly encouraged to keep the discussion forum active with students/TAs/Lecturer interaction

# Communication Channels

## Lecturer Availability



- It is highly recommended to use the discussion forum for student questions
- However, if you need to address the lecturer directly, you can communicate to him via email  
[aelarabawy.cmp445@gmail.com](mailto:aelarabawy.cmp445@gmail.com)
- Lecturer should be responding to your emails, or will ask you to post your question on the discussion forum (if the question does not require a private answer)
- The Lecturer will be available online for interactive communication with the students on a specified time on weekly basis (time will be specified via a course announcement)





# Student Groups

## Assigning Groups

- Some of the course assignments will be assigned on an individual basis
- However, most of the course assignments will be assigned on team/group basis
- Students will need to form teams/groups of 3-4 students per group
- Each group will need to pick a name to their group (must be a name related to embedded Systems)
- Each group will need to assign a group leader for their group
- Each group leader will need to send to the Lecturer and TAs the group name and team member names by midnight Monday



# Project Assignments

- Throughout the course there will be a lot of mini-projects assigned for students
- Projects will be assigned on group basis
- Sometimes all groups will have the same project, other times, each group will have their own project
- Each group will be handed over a hardware kit at the beginning of the course (A Raspberry Pi + Accessories)
- This hardware will remain with the students throughout the full term, and they will need to return it in a working condition at the end of the term
- The provided hardware will include most of the required material for the assigned projects, however, sometimes minor additions may be required by the students
- Project deliverable will be:
  - Showing the TA the project outcome
  - Commit the project code and associated documentation to the group leader GitHub Account
  - Send the lecturer an email to inform him of the readiness of the project



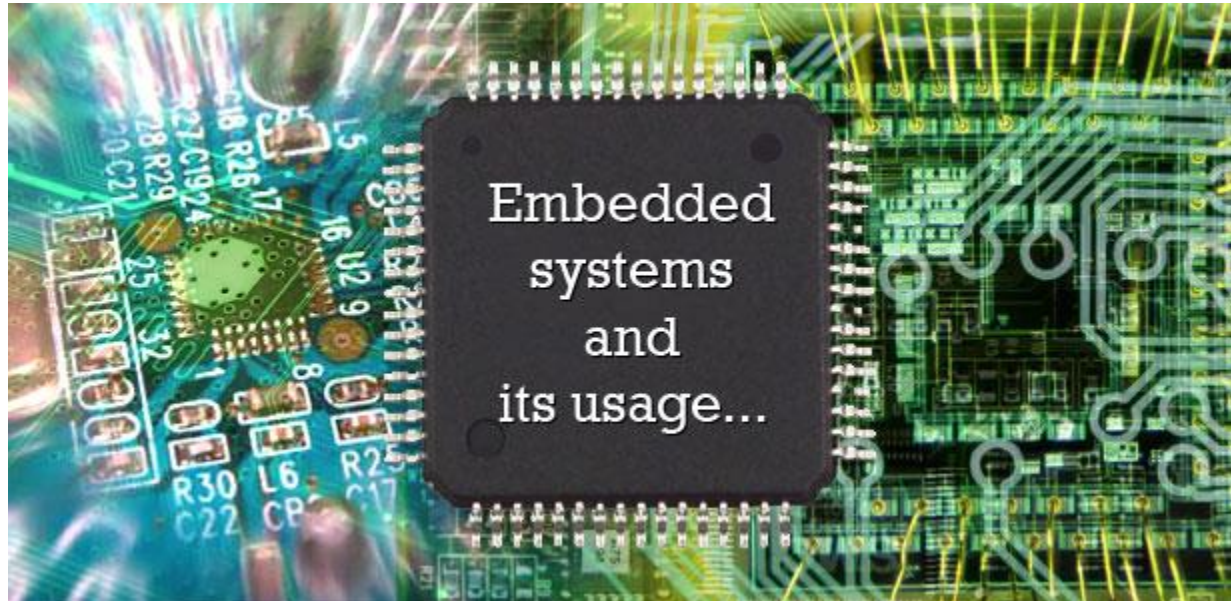
# Course Grading

- Course Grade will be based on the following:
  - Final exam: 70%
  - Midterm exam: 10%
  - Projects and Assignments: 20%
- All exams will be open book, open notes (all you can bring)
- Exams will cover:
  - Lecture material
  - Mandatory Reading material
  - Assignments and Projects



# Course Contents

# Course Contents



## Overview on Embedded Systems

# Course Contents



Overview on Embedded Systems OSs

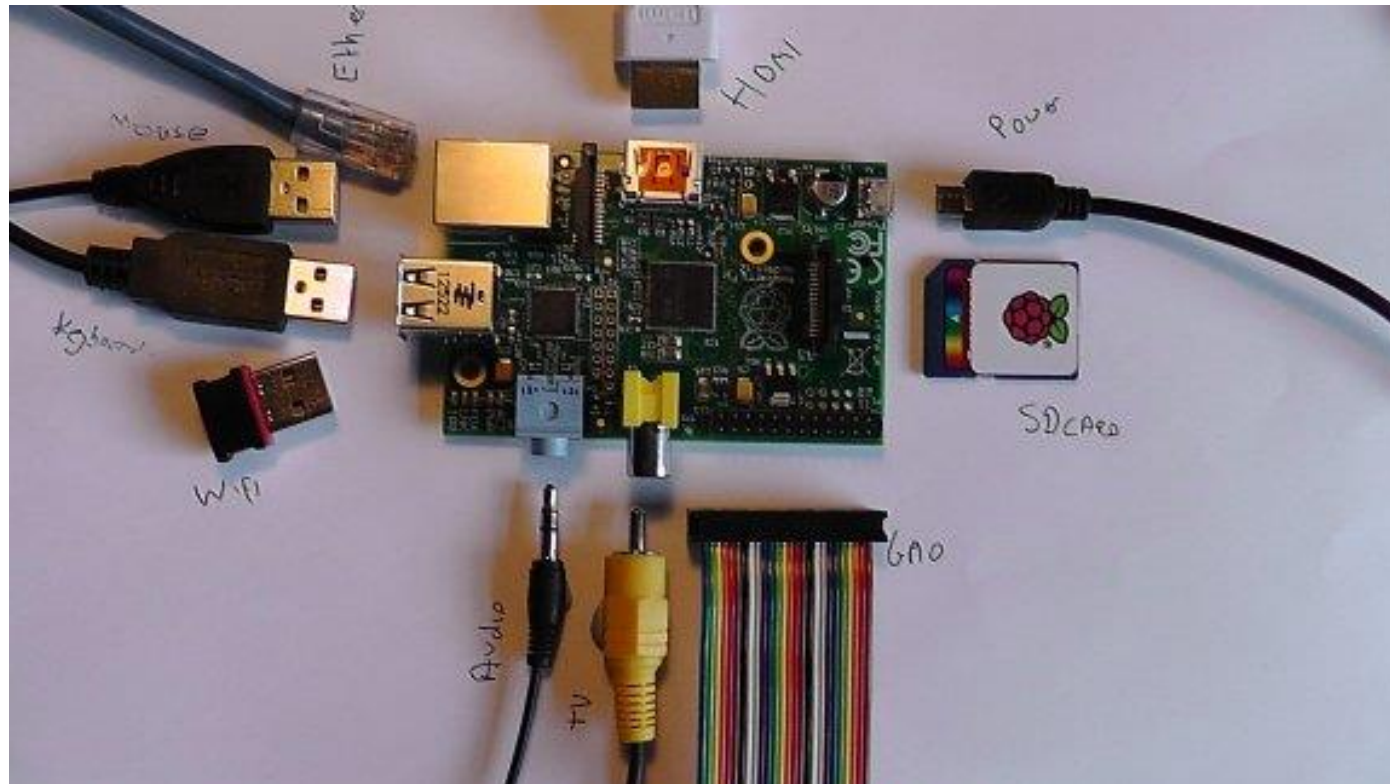
# Course Contents



# Unwrapping the Raspberry Pi

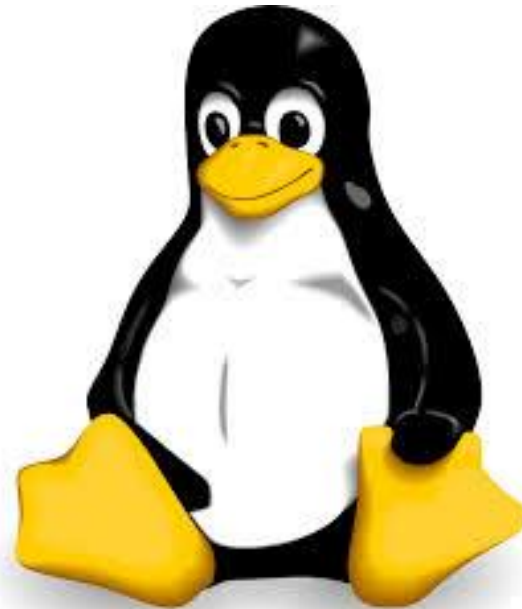
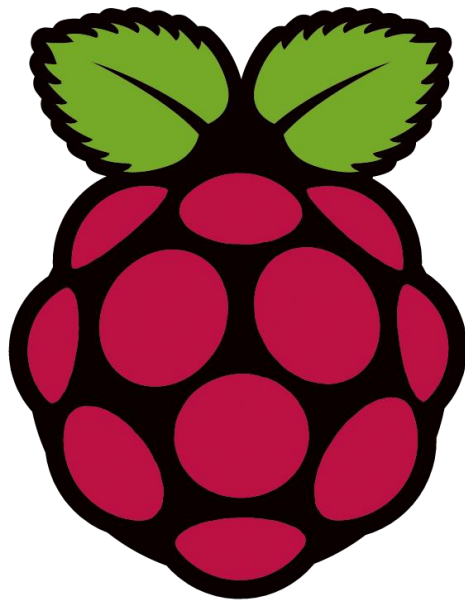


# Course Contents



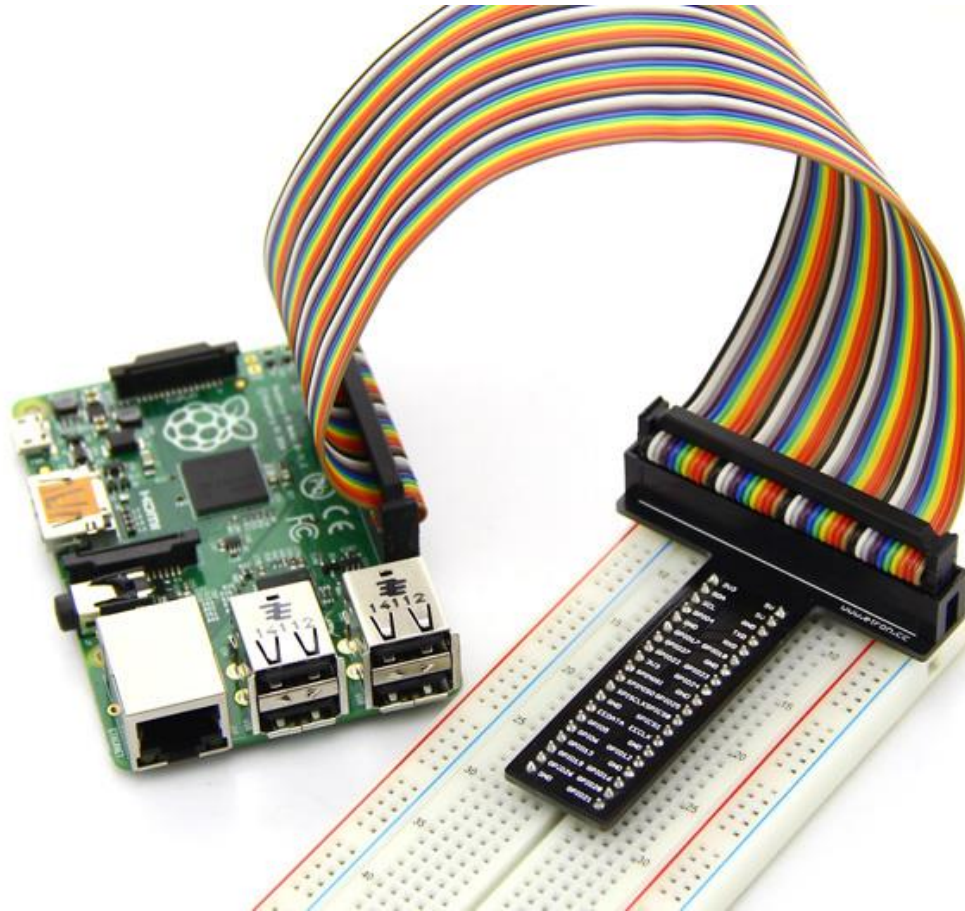
## Preparing the Raspberry Pi

# Course Contents



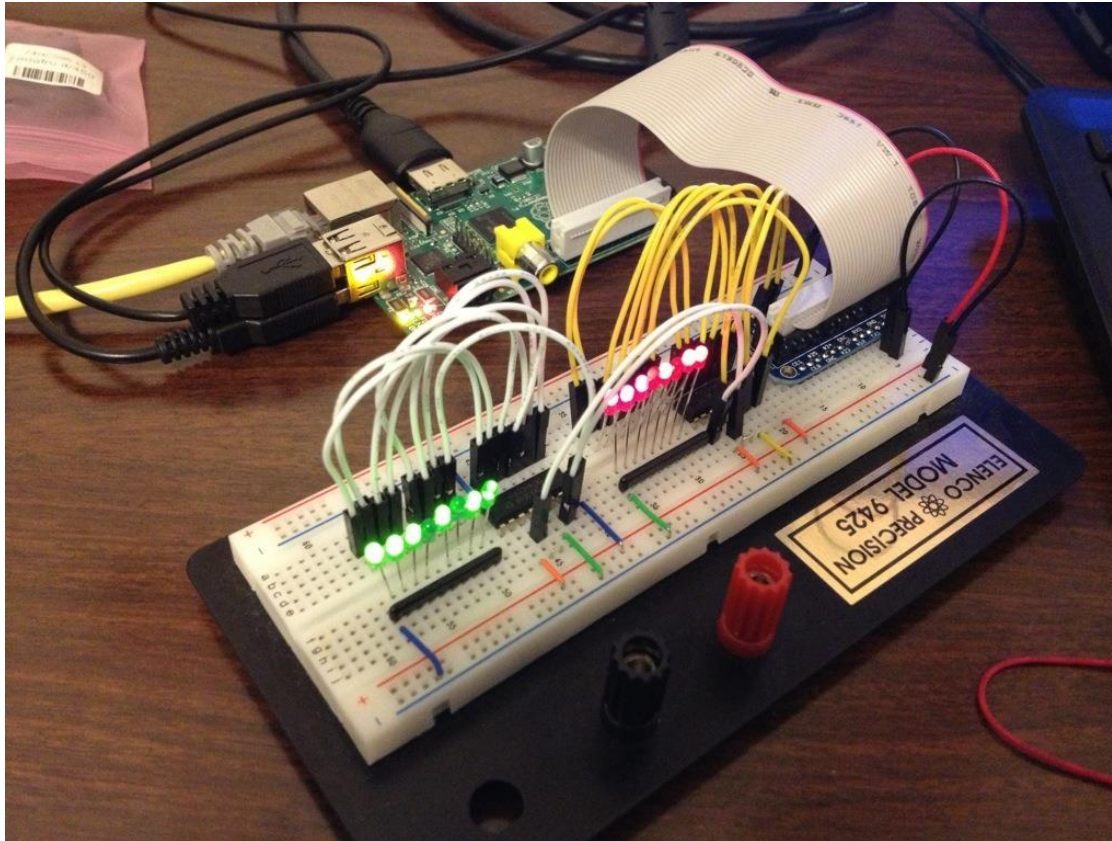
The Pi as a Linux Box

# Course Contents



The Pi Control Arm

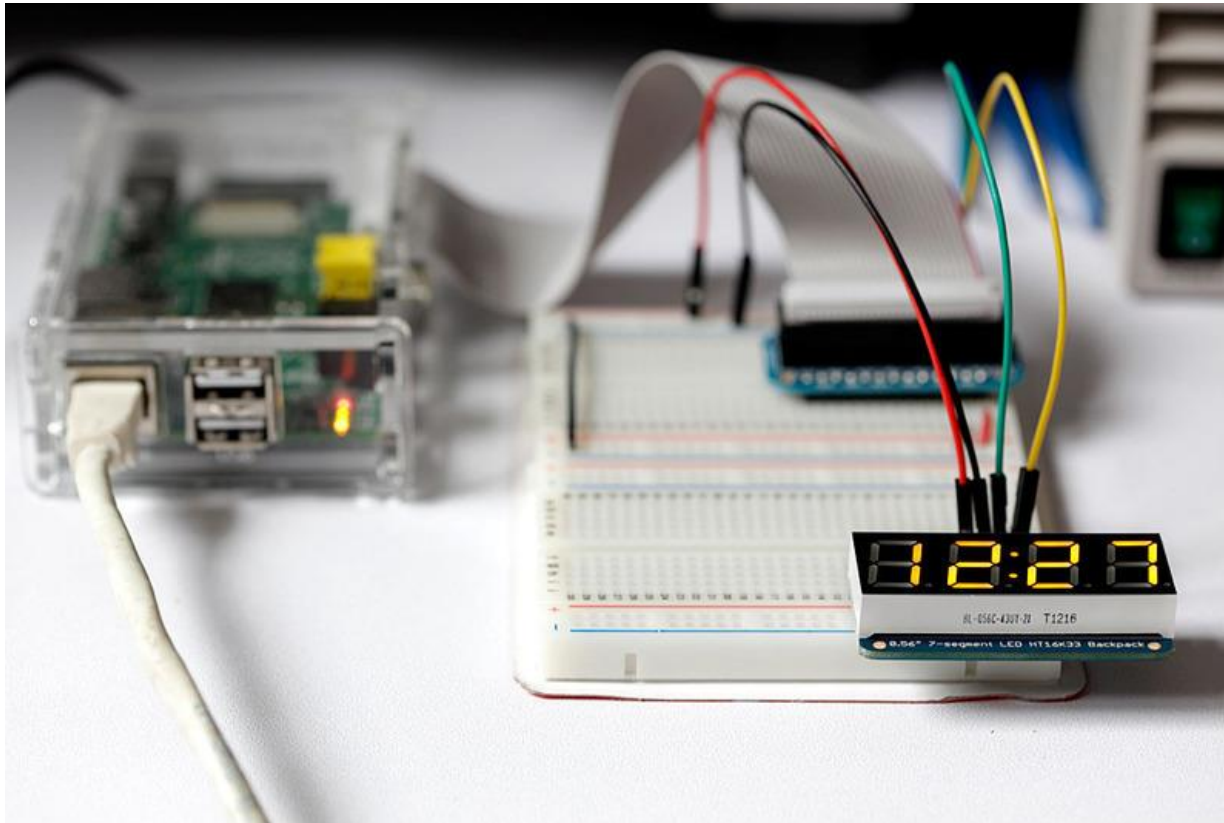
# Course Contents



## Accessing the Pi GPIO

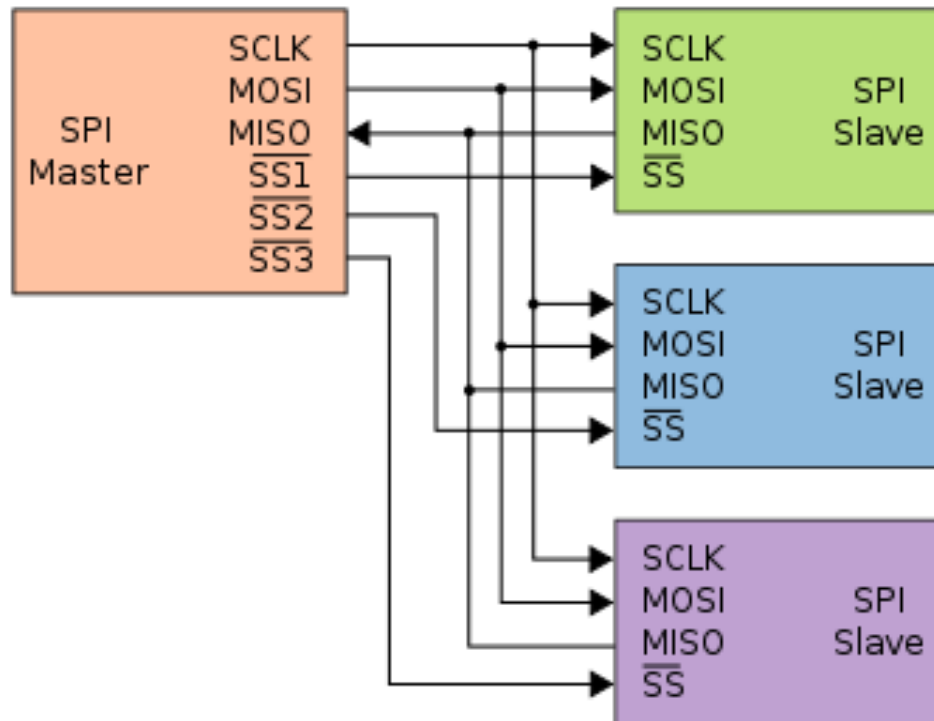


# Course Contents



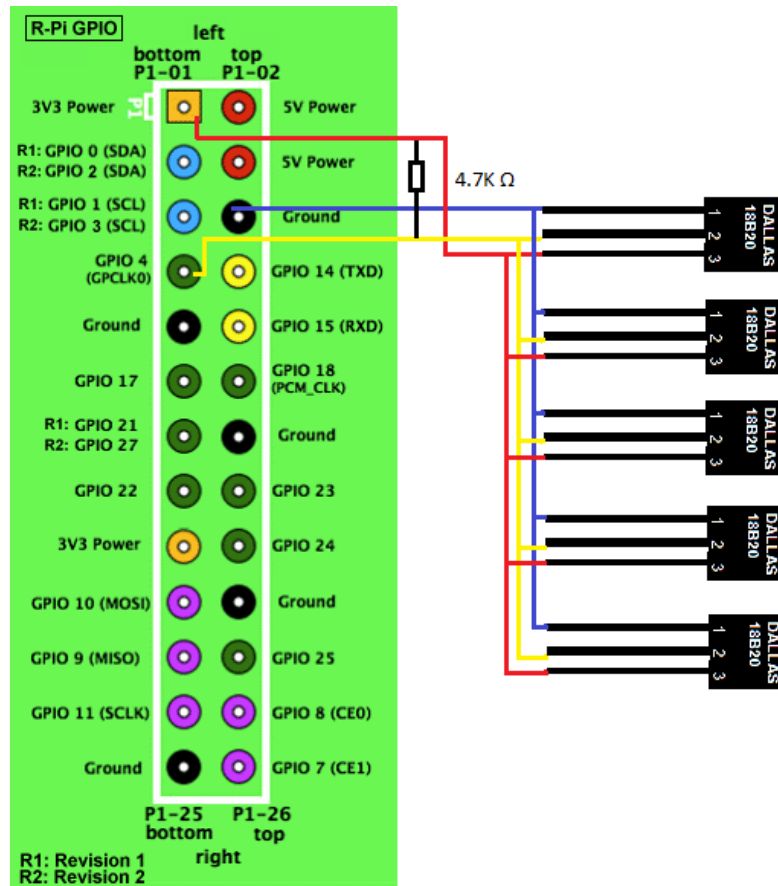
The I<sup>2</sup>C Interface

# Course Contents



## The SPI Interface

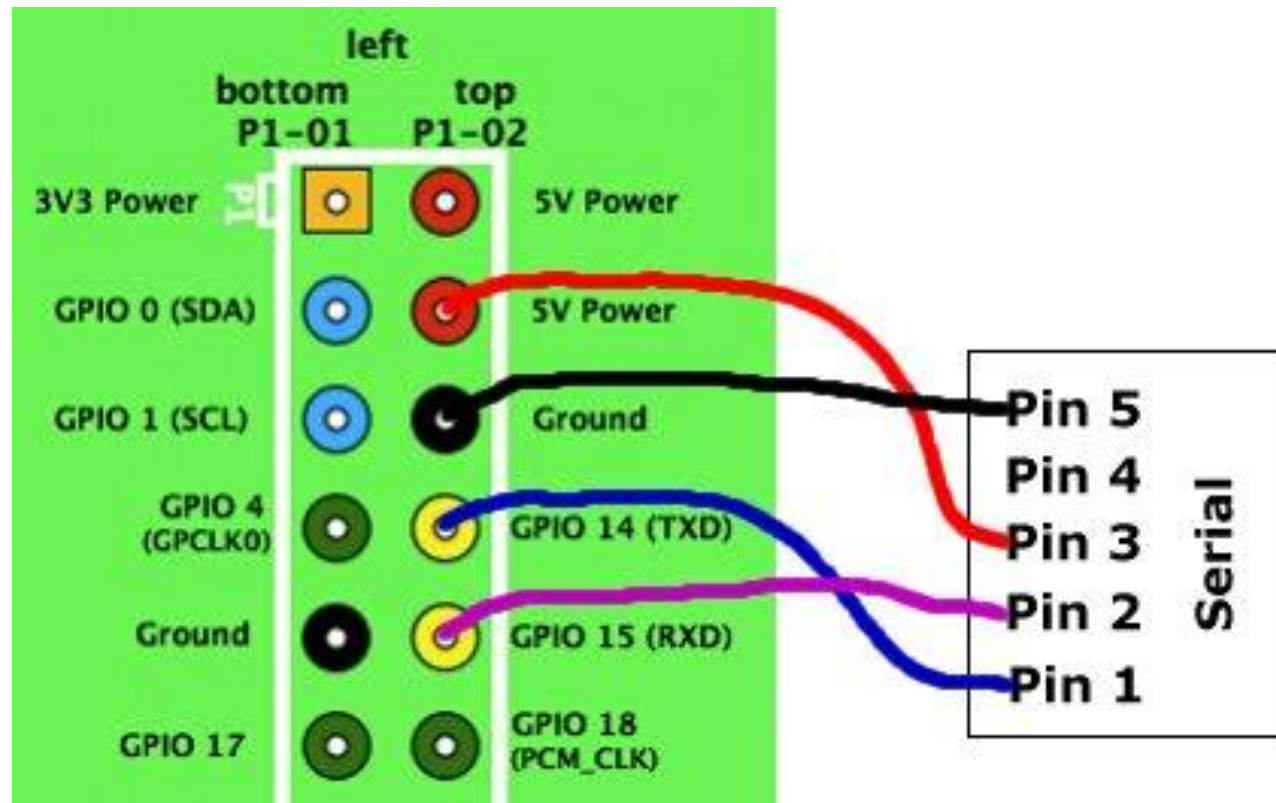
# Course Contents



## The 1-Wire Interface

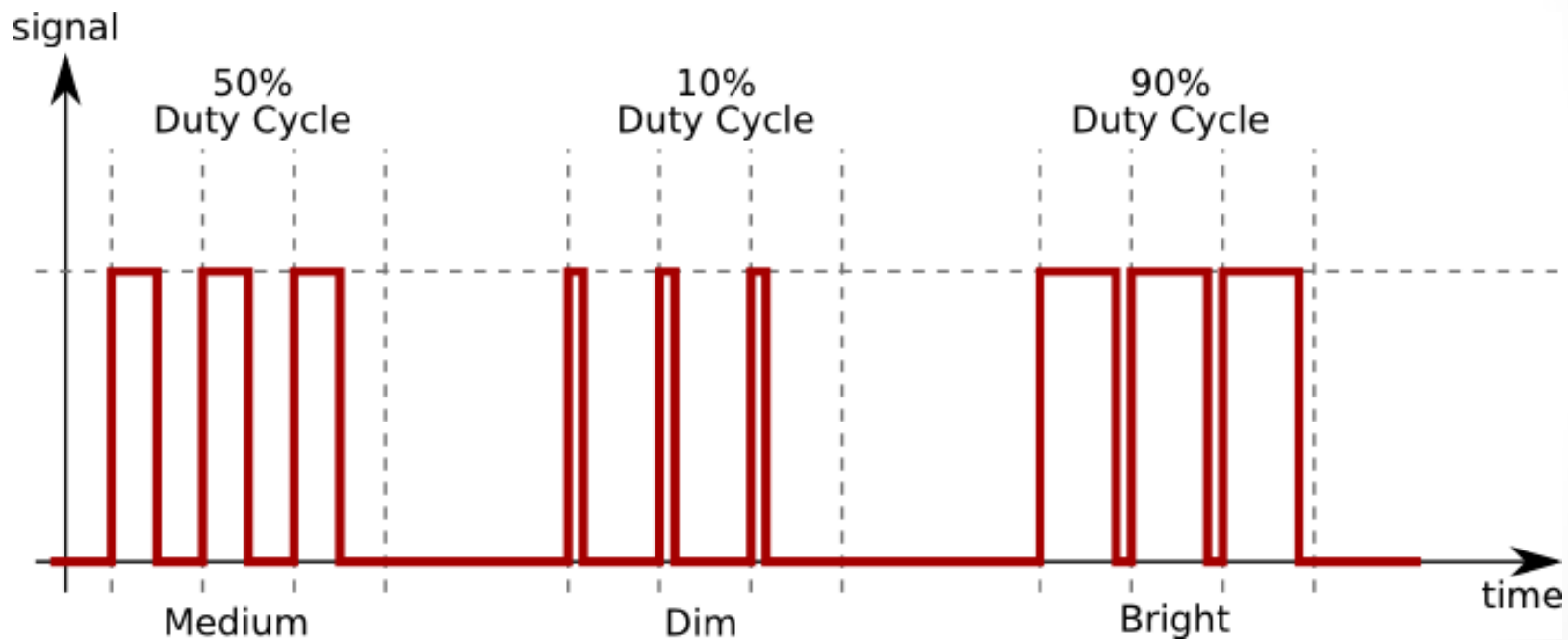


# Course Contents



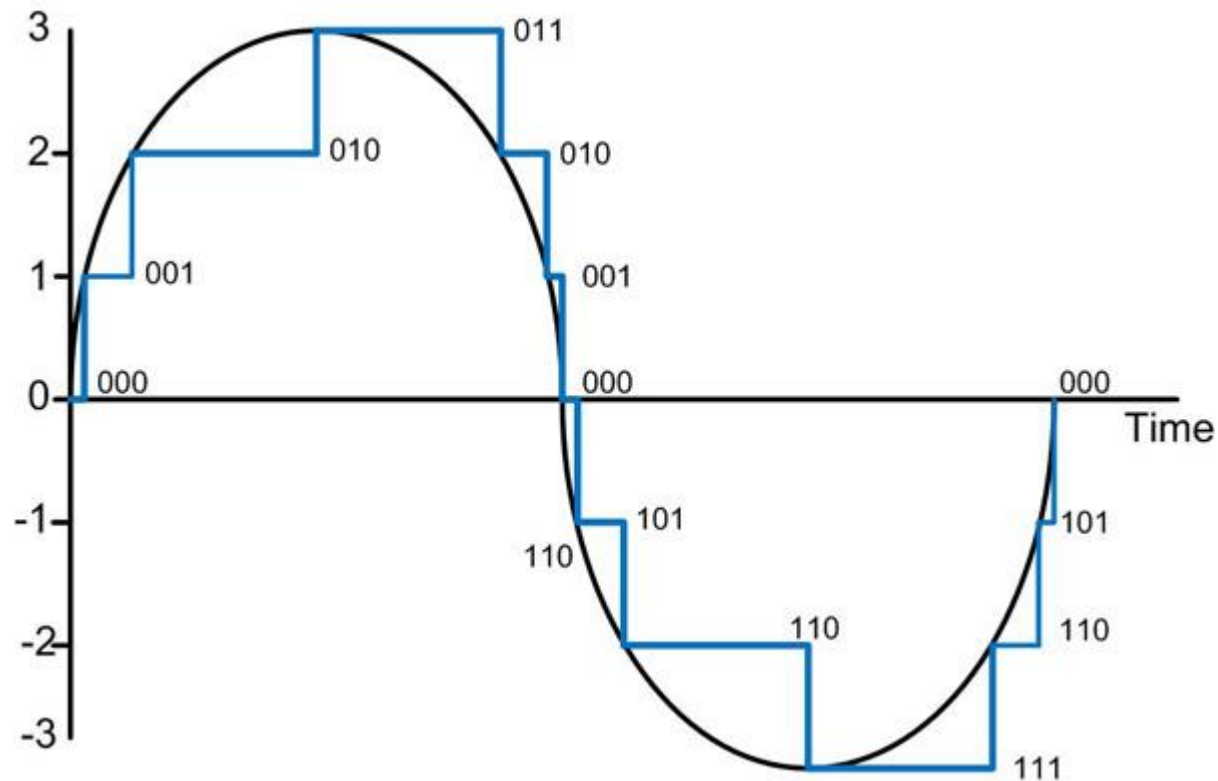
## The UART Interface

# Course Contents



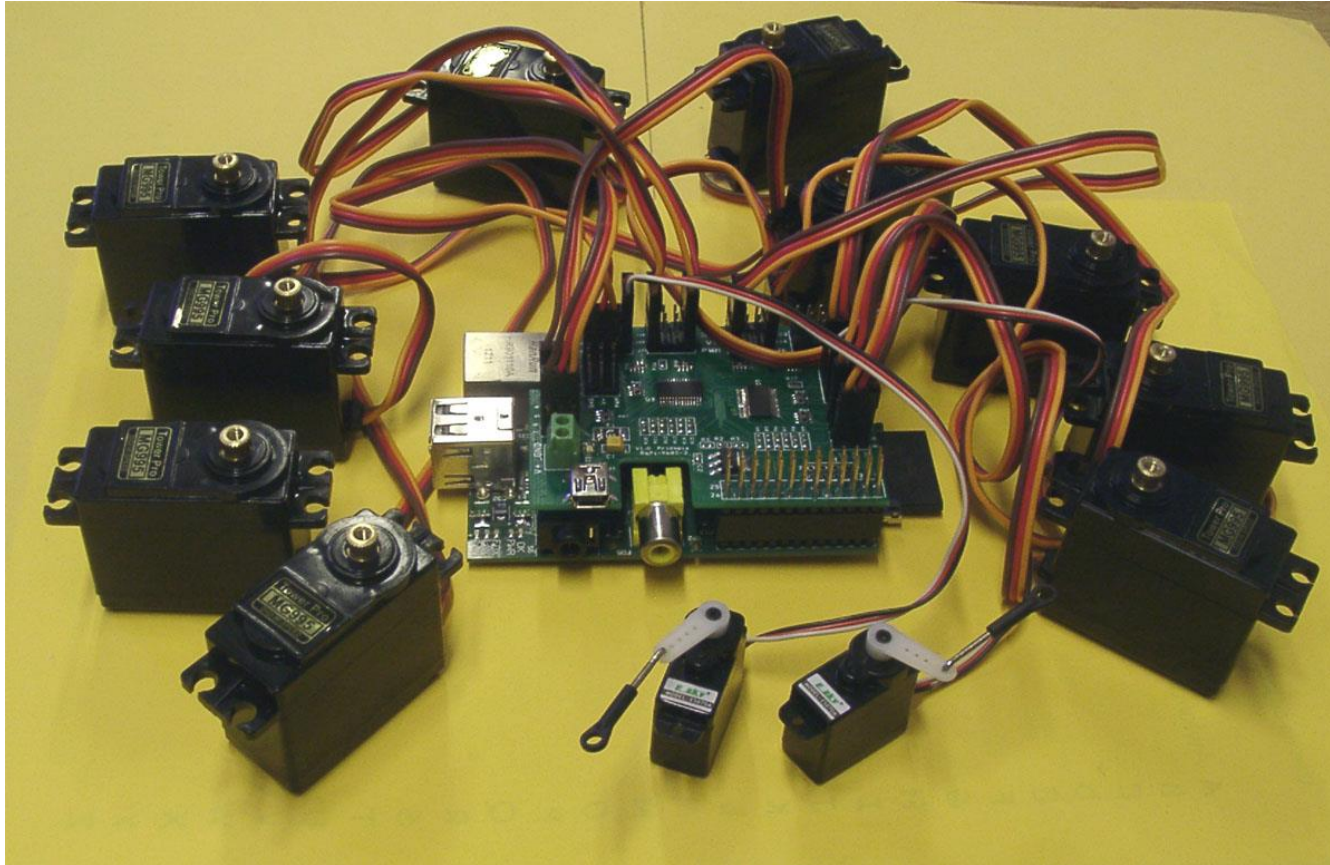
Using PWM Control

# Course Contents



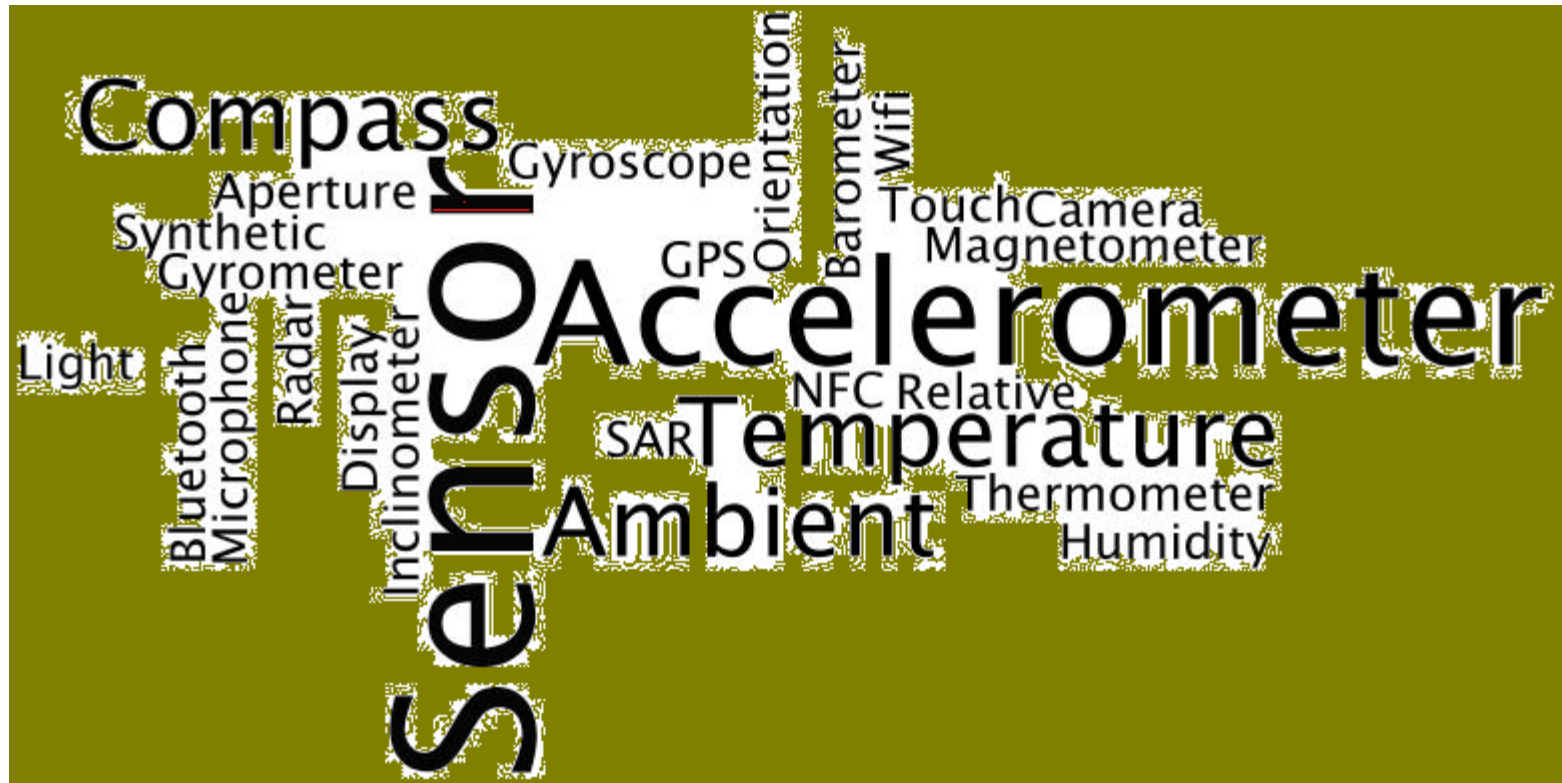
## Handling Analog Signals

# Course Contents



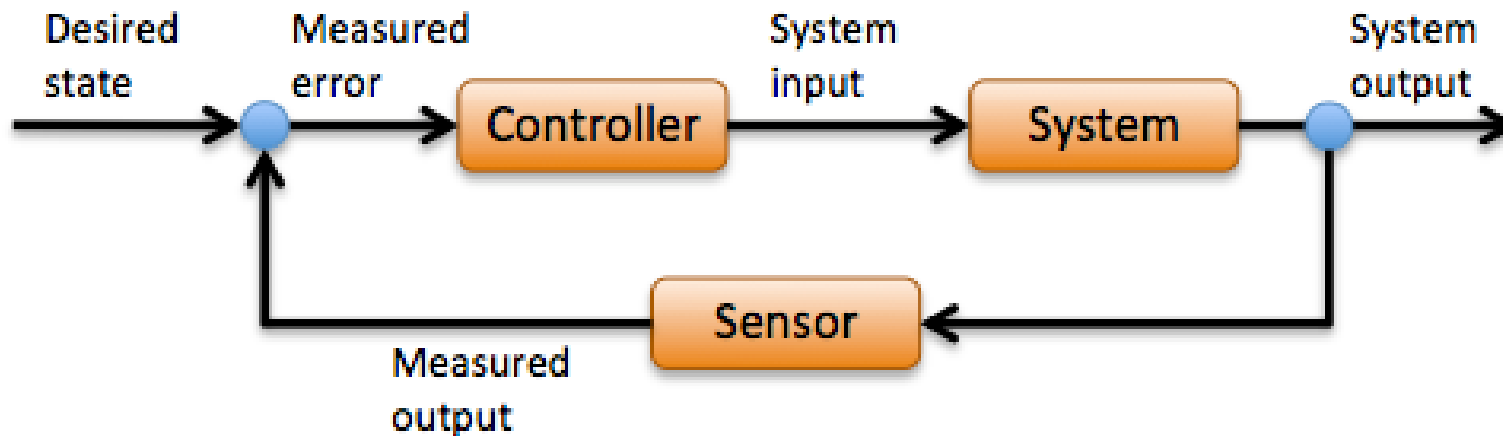
## Motor Control Using the Pi

# Course Contents



## Using Sensors

# Course Contents



## Closing the Loop



# Course Contents



LED Displays

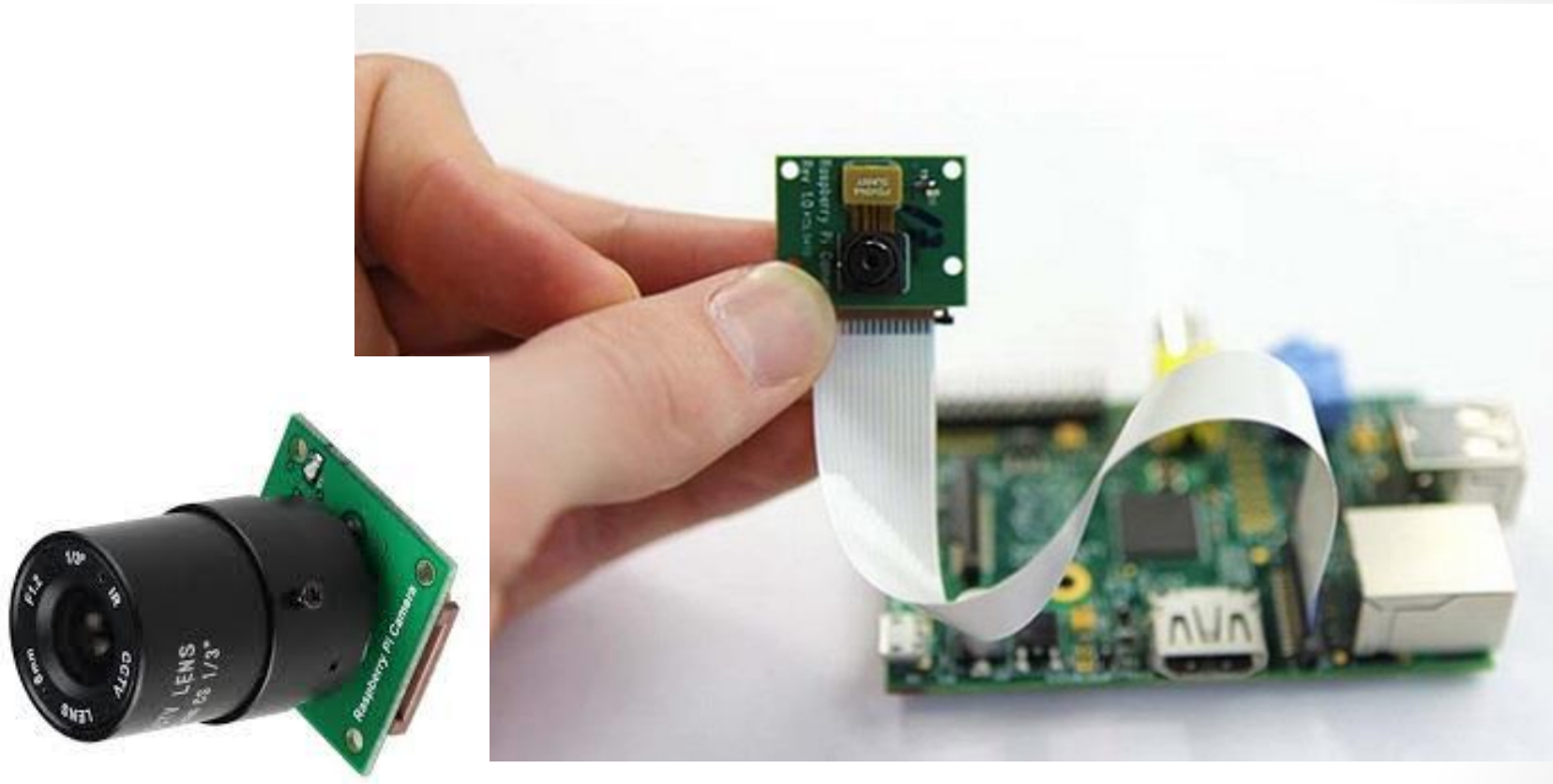


# Course Contents



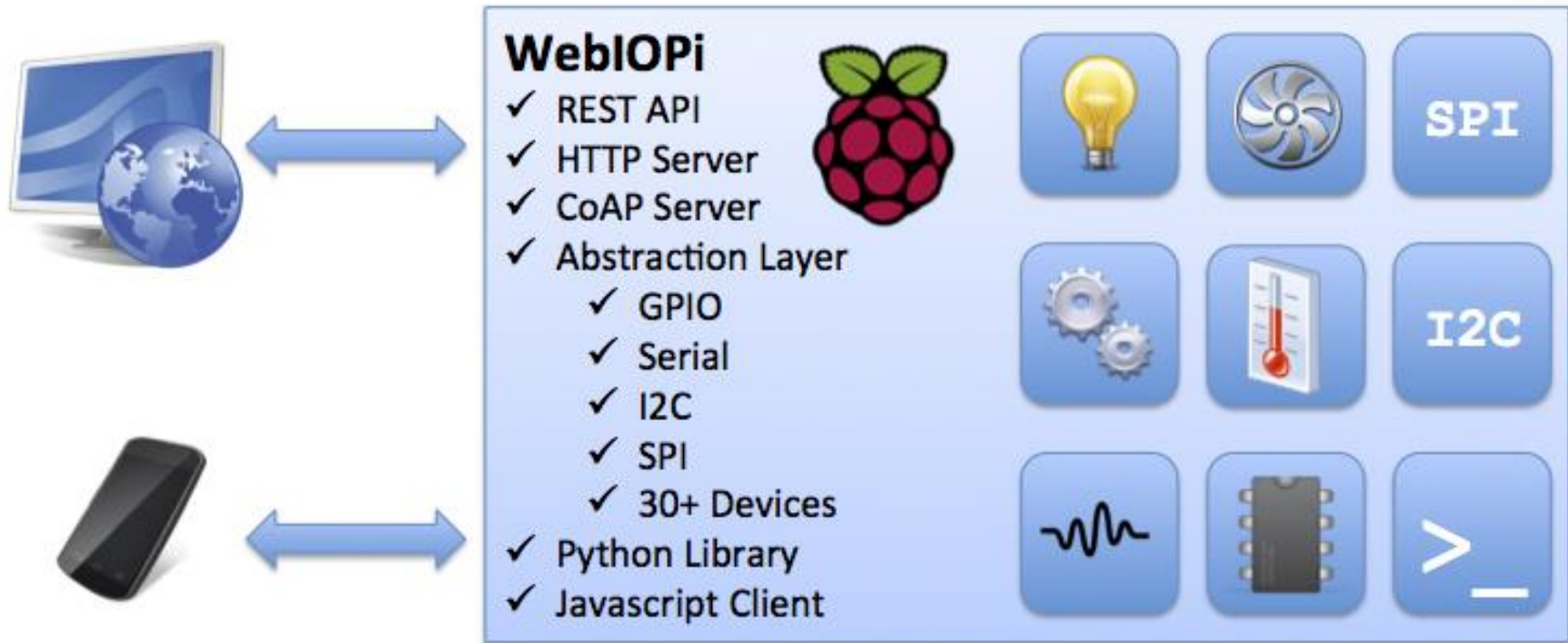
## LCD and Touch Screens

# Course Contents



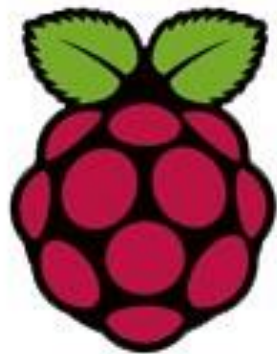
## Interfacing to Cameras

# Course Contents



## The Pi and the Web

# Course Contents



**OpenCV**

Using OpenCV with the Pi

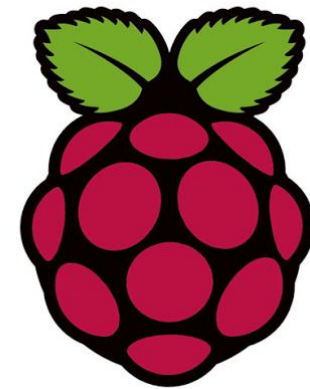
# Course Contents



Using FFMPEG With The Pi



# Course Contents



Using Matlab with the Pi







# Linux4

## Embedded Systems

<http://Linux4EmbeddedSystems.com>