Learning outcomes

- Review of DC motor and motor driver
- Learn how to control Motor using motor driver in our lab

DC motor

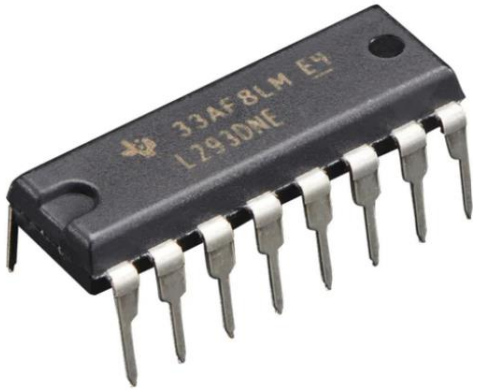
- DC motors are used in many applications, from toys to advanced robotics.
- They are ideal motors to use when continuous rotation is required, such as in the wheels of an electric vehicle. Typically, they have only two electrical terminals to which a voltage is applied. The speed of rotation and the direction of rota-tion can be controlled by varying this voltage.
- Most DC motors require more current than the RPi can supply, so we could use help of a motor driver and external power.

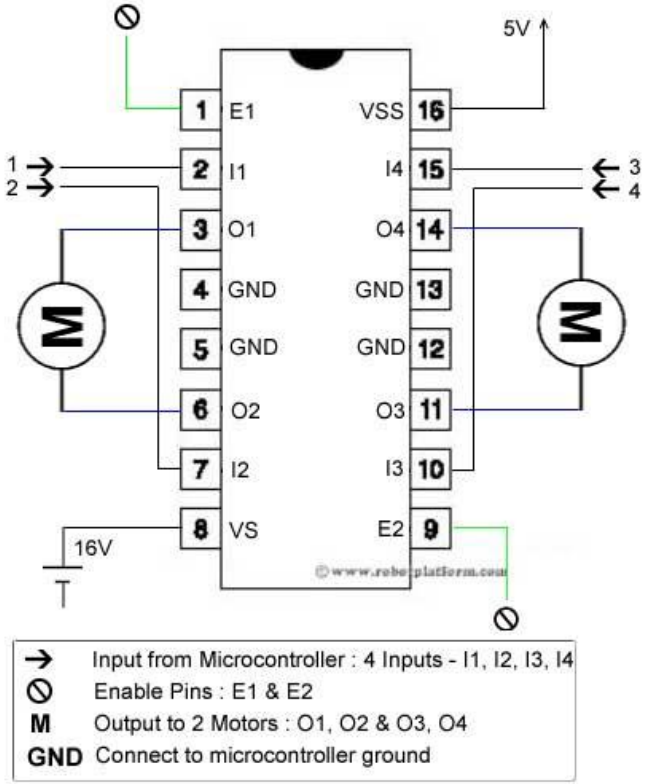
DC motor driver

- A **motor driver** transfer electrical energy from a source that could be of a given voltage, current at a certain frequency to an electrical output of desired voltage, current, frequency to the motor.
- It protects GPIO, it provides voltage and current higher than GPIO could produce, and it provides more control possibilities (like direction of the motor spinning).
- Usually, **we would need external power connected to driver.**

DC motor driver and diagram

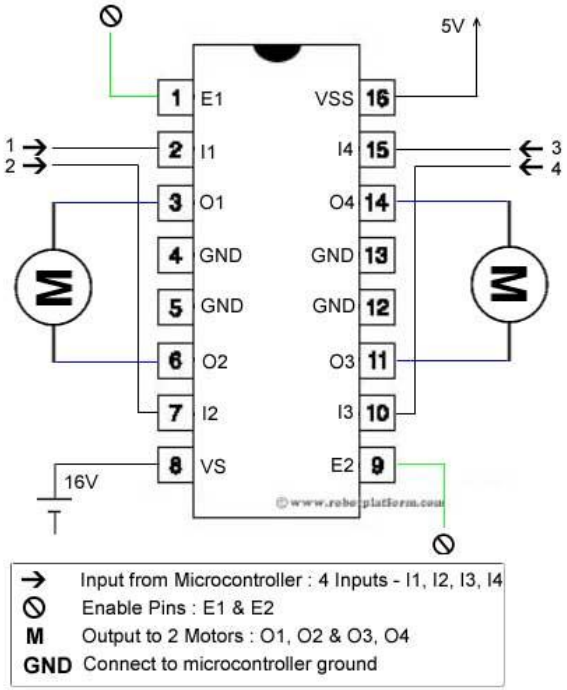
- A **motor driver or motor controller** is a microcontroller or processor we used to control a motor.
- We introduce **L293D** today (also because we have many of these).
- Right is the circuit diagram for L293D motor driver.





DC motor driver

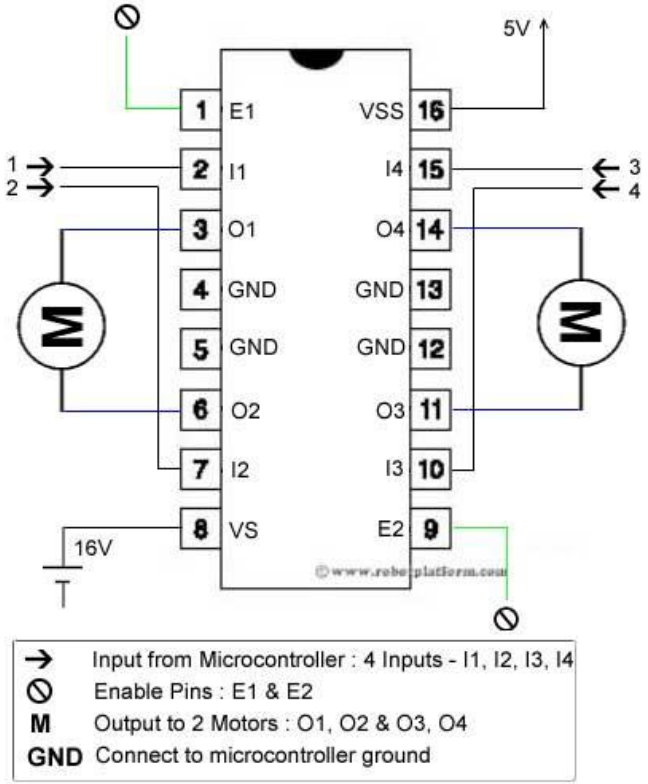
- We could control 2 motors with one driver.
- Below is the table of PIN signals and corresponding behavior.
- Use GPIO to control these pins.



Pin 1	Pin 2	Pin 7	Function
High	High	Low	Turn counter-clockwise (Reverse)
High	Low	High	Turn clockwise (Forward)
High	High	High	Stop
High	Low	Low	Stop
Low	X	X	Stop

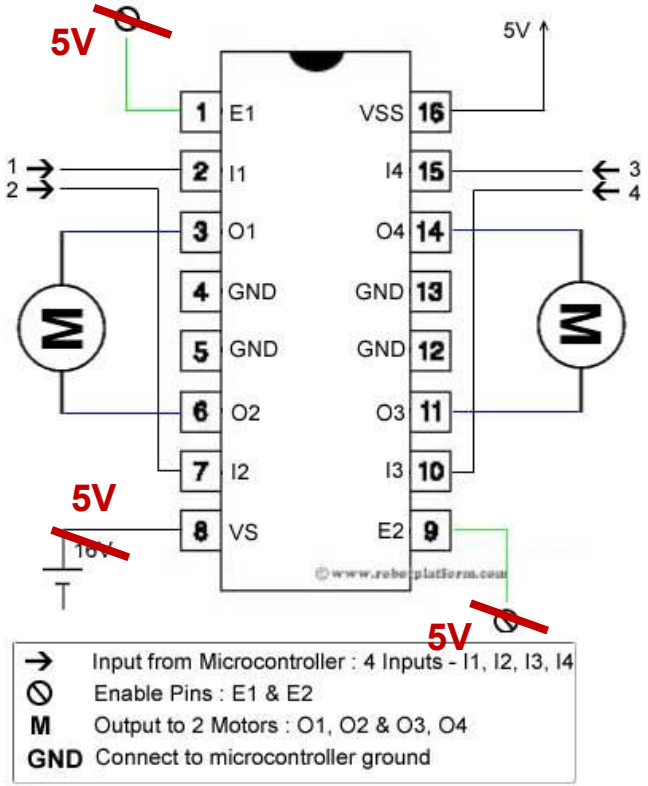
Motor and PWM

- PWM can be used to control the light level of LEDs, but it can also be used to control the speed of DC motors
- Typically, the frequency is in the kHz range for motor control. (I would say 5kHz to 20kHz is a safe range).
- Then we could just change the duty cycle to control its speed.



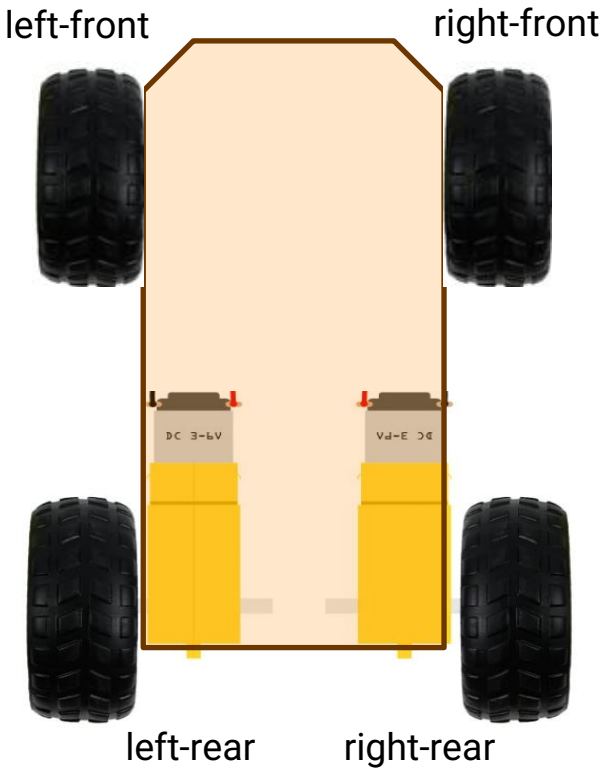
Motor in our lab

- In our lab, we don't have enough power source to drive the motor driver in its full functionality.
- In such case, we could just use 5V connected to pin 8.
- But because power voltage is not high enough, we need consistent power connecting to our Enable Pins.
  - Directly connect E1 and E2 to the 5V power supply (or 3.3V if you don't need large torque)
  - We can not use E1 and E2 to control motor driver anymore. Instead, use I1/I2 and I3/I4 to turn the motor on or off.



Motor to drive car

- A very popular way (but not the only way) to control a motor driving car is as shown on the right.
  - You could choose front-wheel drive or rear-wheel drive. Our example is choosing rear-wheel drive (which means we connect motor to the rear tires).
  - To move forward on straight line, both motors need to run with same speed clockwise (counter-clockwise if we wish to move backward).
  - To turn left when moving, left motor should spin slower than the right motor. Same logic for turning right.
  - To make a left U-turn , left motor should stop and right motor should spin. Same logic for right U-turn.

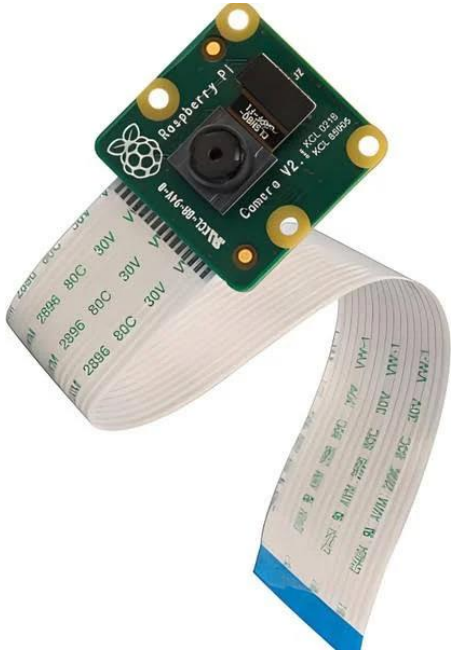


Learning outcomes

- Using Raspberry Pi Camera V2 Module to take photos and videos
- Send an email from Raspberry Pi using python program
- Create and manipulate file from Terminal or using Python

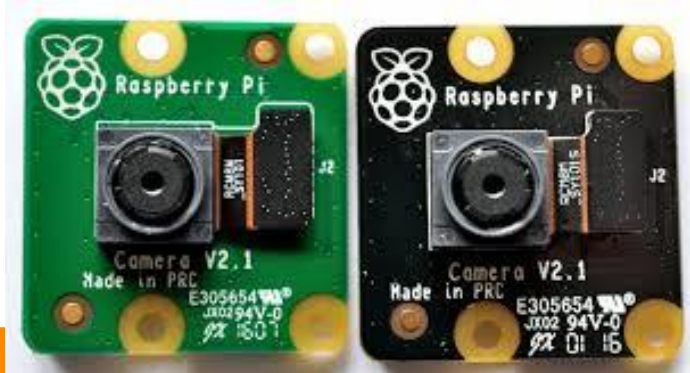
Raspberry Pi Camera V2 Module

- Raspberry Pi provides a camera module which could easily extract photos and videos.
- With camera, you are able to create much more smart and impressive applications (like home security system).



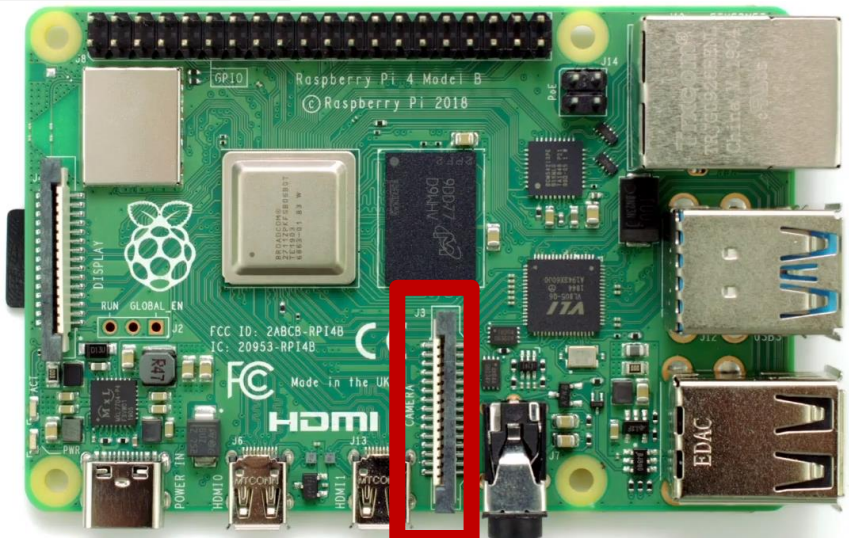
Work with the Pi Camera

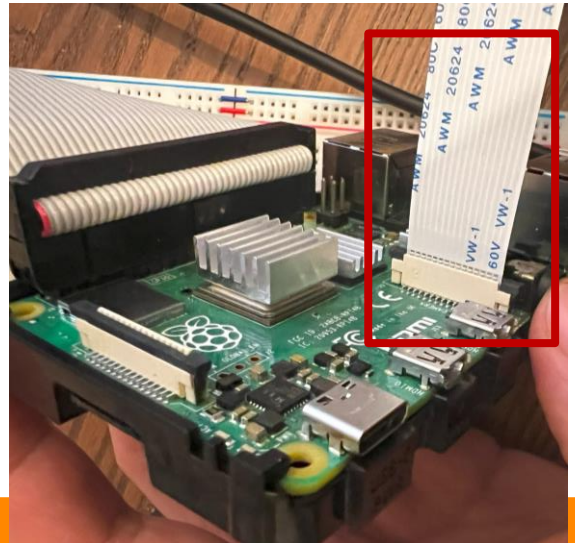
- There are 2 available types of Pi camera:
  - The standard camera, which is mounted on a green PC board is for general use – It gives nice quality images/videos when the light of the room is good enough.
  - The NoIR camera (black) which means no infrared is mounted on the black PC board – it works great in low light environments so you can use it in a completely dark room or at night.
    - However, the images will not look as good as the standard one in daylight.



Plug Camera to Raspberry Pi

- To recap, we will put the wire to the Raspberry Pi's camera port.
- Pull out the plastic gear a bit from the port (not completely), then plug wire to the port.
- The blue side of wire should be facing the USB ports.
- When it is fully plugged in, you could push back the black stuff to stuck the wire.





Take a Photo From the Terminal

- We are going to use **rpicam** applications from Terminal to start working on camera.
- In the recent version of Raspberry Pi OS, the **rpicam** apps are already installed.
- We could start the preview window of our camera for 5 seconds with command:
  rpicam-hello
- We can change how long it will last by change –t option values:
  rpicam-hello -t 1000 will open the window for 1 second (1000 milliseconds)
- Now let's take a photo after 5 seconds using rpicam-still command, we also need option –o with file name to take image as file: **rpicam-still -o test1.jpg**
- There are many options we could use, below command:
  rpicam-still -o test2.jpg --width 1920 -height 1080 -shutter 20000 -t 2000
  waits for 2 seconds, then takes photo with size of 1920x1080, exposure time of 20ms

Take Video From the Terminal

- We use **rpicam-vid** command to take video:

```
rpicam-vid -t 5000 -o video1.h264
```

- take videos of 5 seconds and stores it in the file **video1.h264**.
- **--width**, **--height** options also work for **rpicam-vid**.

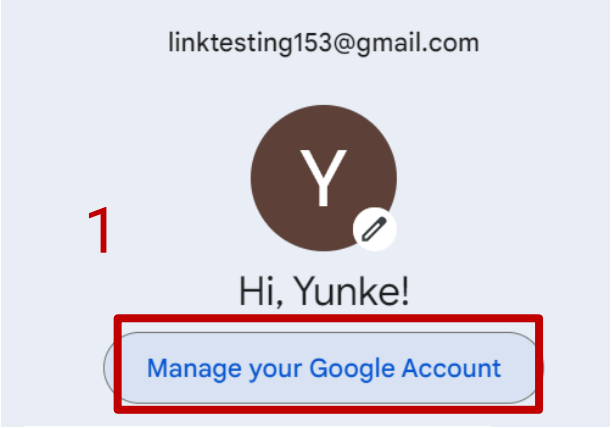
Take Photo or Video with Python

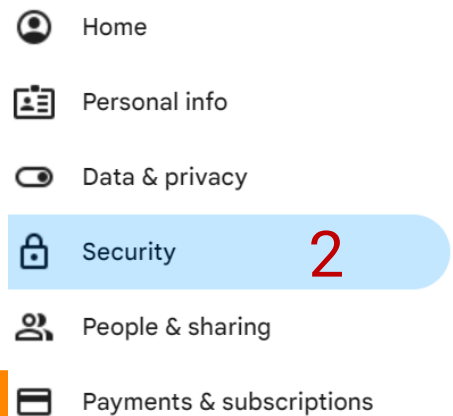
- Picamera2 is a Python library that gives convenient access to the camera system of Raspberry Pi.
- Check the camera1.py (take photo) and camera2.py(take video) and test the functionality.
- Picamera2 is much more powerful than what we show in the sample code. Visit the official documentation: https://datasheets.raspberrypi.com/camera/picamera2-manual.pdf for more information.

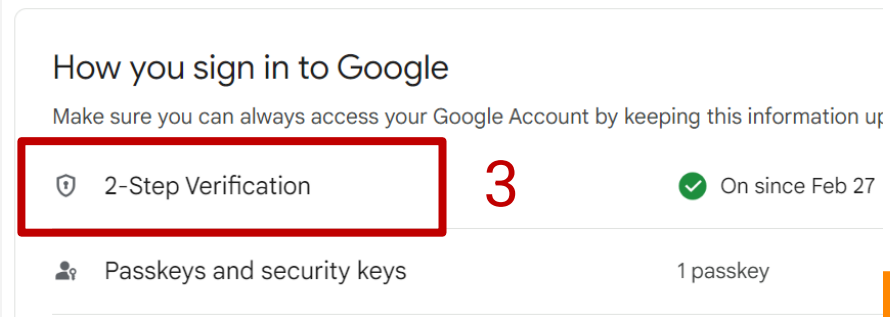
Create Gmail account for Raspberry Pi usage

Creating a new Gmail account won't be an issue, but we need to change some settings to bypass the security checking.

1. First, click Manage your Google Account button for the account we just created.
2. Go to the security tab on the left.
3. Turn on the 2-Step Verification

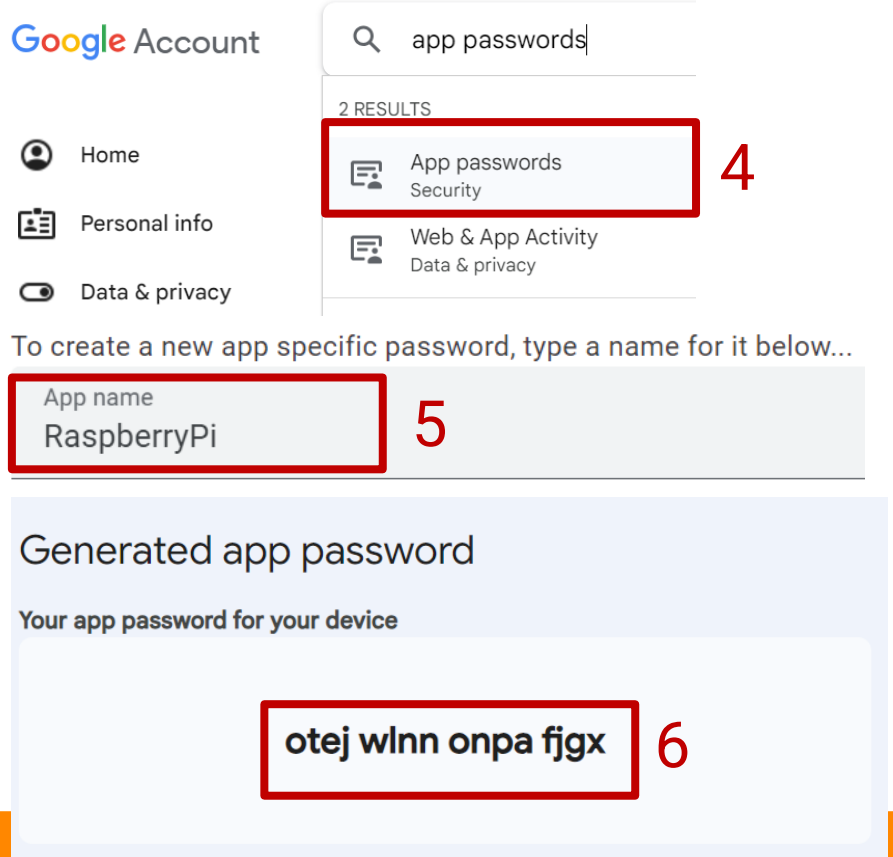






Create Gmail account for Raspberry Pi usage

4. Search for App passwords from the search bar.
5. Create a new app password, choose any name you like.
6. In the end, record down the passcode, that would be the password you should use in Python program of Raspberry Pi.



Install yagmail with Terminal

- Yagmail module is used to sending email from our Python program.
- Open the terminal on Raspberry Pi, and install the yagmail package with the command below:

```
sudo pip3 install yagmail --break-system-package
```

- Now after installation, in Terminal, type **`python`** to enter the python script mode, and type **`import yagmail`**.
  - If installation succussed, you won't receive any error message.

Create a hidden password file

- It might not be a wise idea to directly put password in your python program.
- A better idea would be putting the password in a separate file (better if it is hidden).
- We have learned how to create file in Linux. Here we will create a file starts with **dot**(`.`)and save the password in it. File starts with **dot**(`.`) would be considered as hidden file -- you would not be able to see it by normal ways. But python program could visit it.
  - **`touch`** command would be able to create a file: **`touch .email_pwd`**
  - The normal **`ls`** command can not see the file, but we could add **`-la`** option to see files including hidden ones: **`ls -la`**
  - **`nano`** command could edit the file using the terminal nano editor even file is hidden: **`nano .email_pwd`**

Sending email with Raspberry Pi

- Now testing if you could send email to from Raspberry Pi to your daily use email address.
  - mail1.py sends a simply email from email account you newly created
  - mail2.py creates a new file and send it as attachment in the email