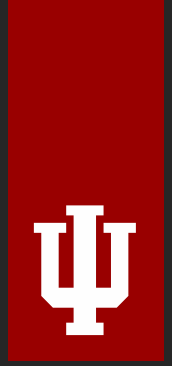


Engineering Cyber-Physical Systems

GPIO/LED

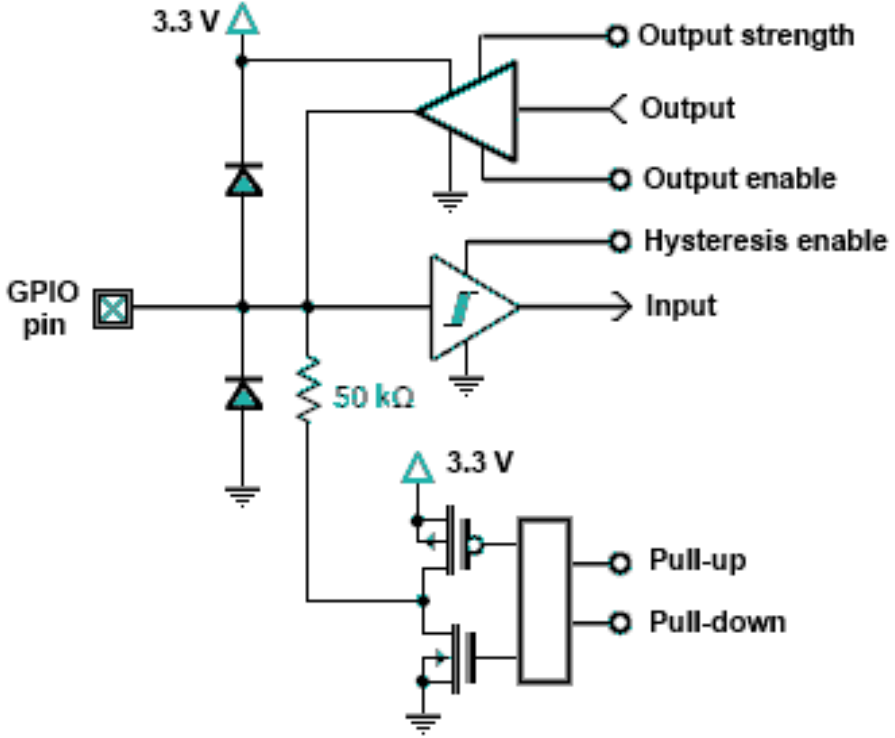
Bryce Himebaugh

Course Schedule

Weekly Focus	Reading	Monday	Wed	Lab
CPS Intro/UART		**1/10:** CPS Introduction	**1/12:** Pi Intro/UART Bus	**Project 0 Raspberry PI Setup**
I2C Bus		**1/17:** MLK Day	**1/19:** I2C Bus Overview	**Project 1 I2C Pressure/Temperature Sensor**
I2C and SPI Bus		**1/24:** Pressure Sensor	**1/26:** SPI Bus Overview	**Project 2 SPI Accelerometer**
SPI/Networking		**1/31:** Accelerometer	**2/2:** MQTT	**Project 3 MQTT Sensor Data Server**
Networking		**2/7:** GPIO/LED	**2/9:** Flask	**Project 4 Sensor LED Output**
Web Server		**2/14:** No Class	**2/16:** CPS Wrapup, Exam Review	**P5 Demultiplexer**
Evaluation		**2/21:** Exam 1	**2/23:** CE Intro/ Logic	**P6 ALU**

GPIO Structure

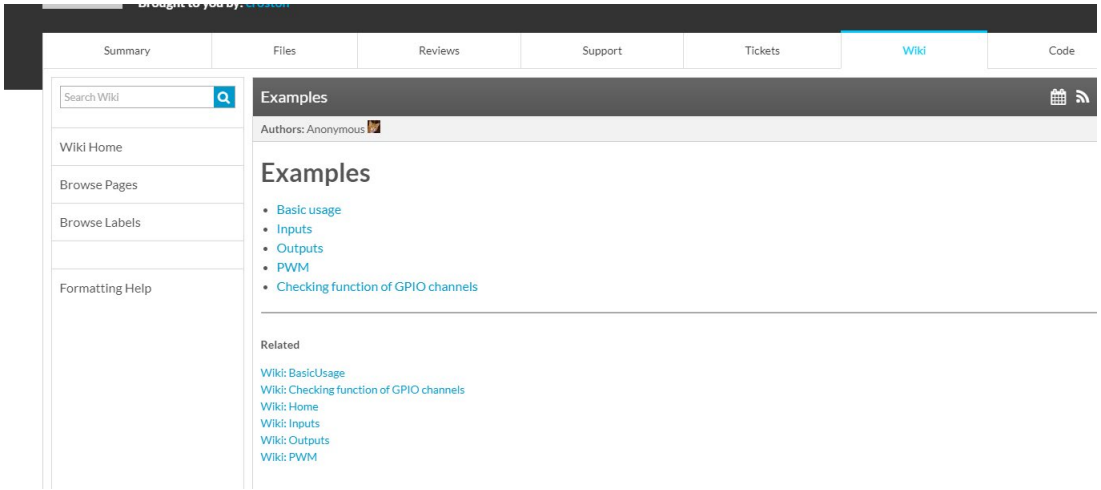
Equivalent Circuit for Raspberry Pi GPIO pins



GPIO Library Documentation

Documentation for the GPIO Library

1. https://sourceforge.net/p/raspberry-gpio-python/wiki/Examples/



Importing the Library

```
import RPi.GPIO as GPIO
```

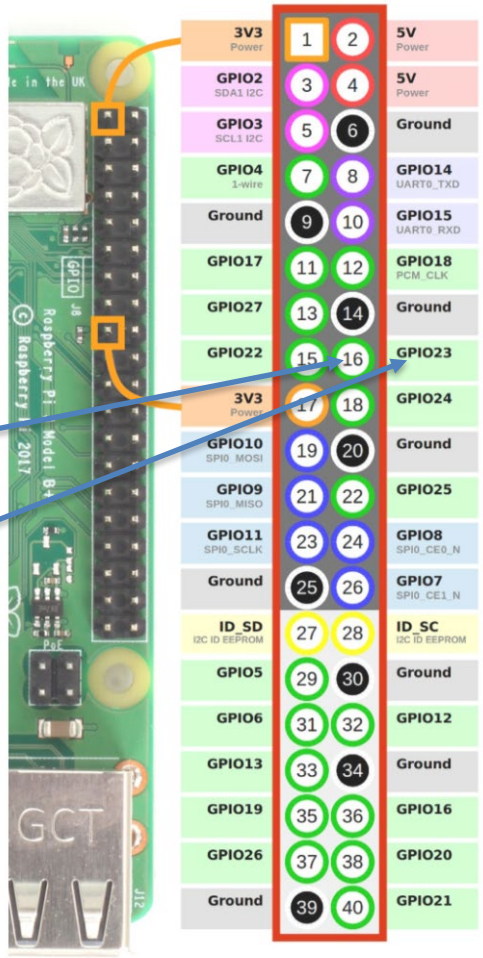
Pin Numbering

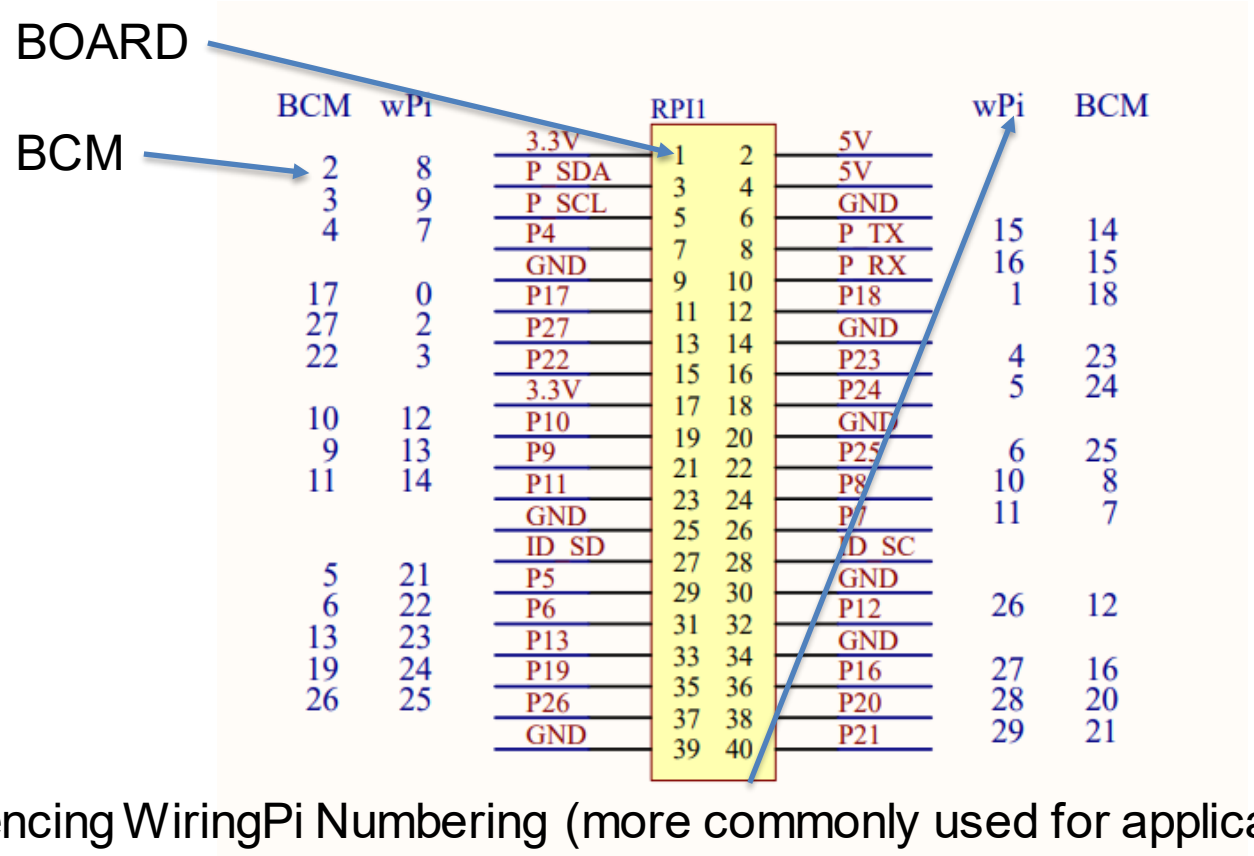
```
import RPi.GPIO as GPIO
```

Pin Numbering

GPIO Pin Numbering Scheme

1. Used in the GPIO.setmode() Method
   - GPIO.BOARD follows Header Numbering
   - GPIO.BCM follows the Broadcom Chip Numbering

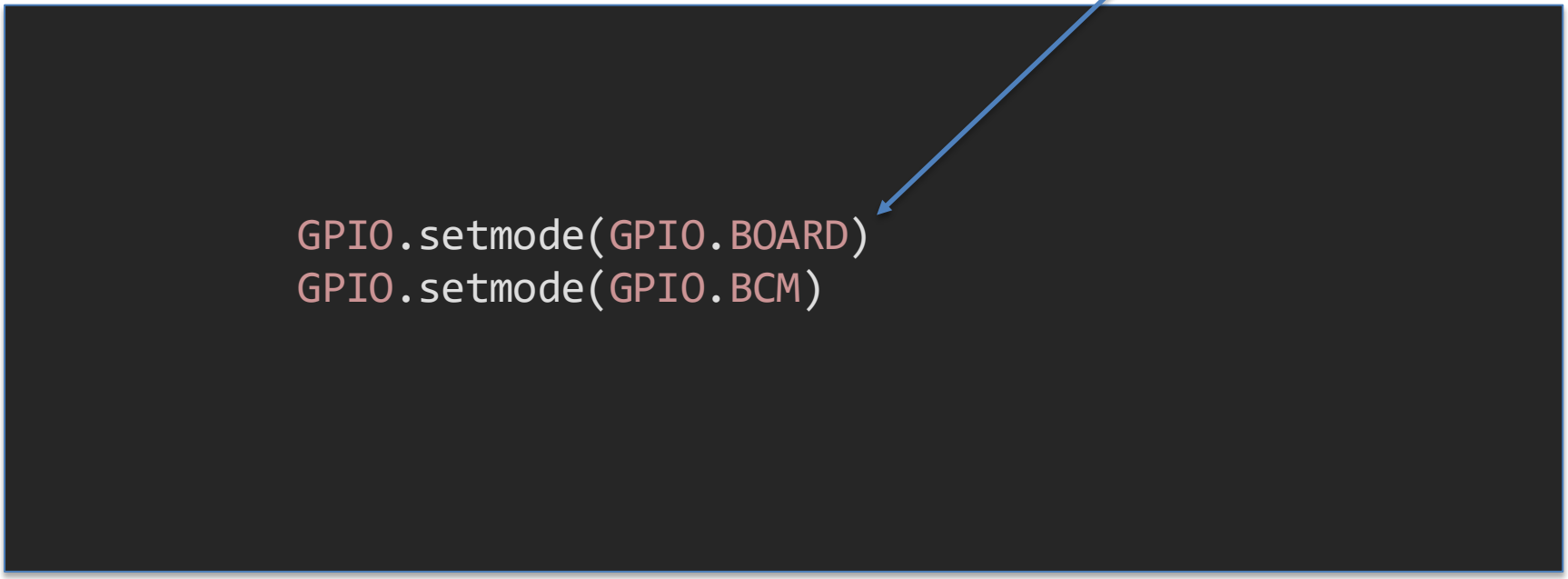




Referencing WiringPi Numbering (more commonly used for applications written in C)

Pin Numbering

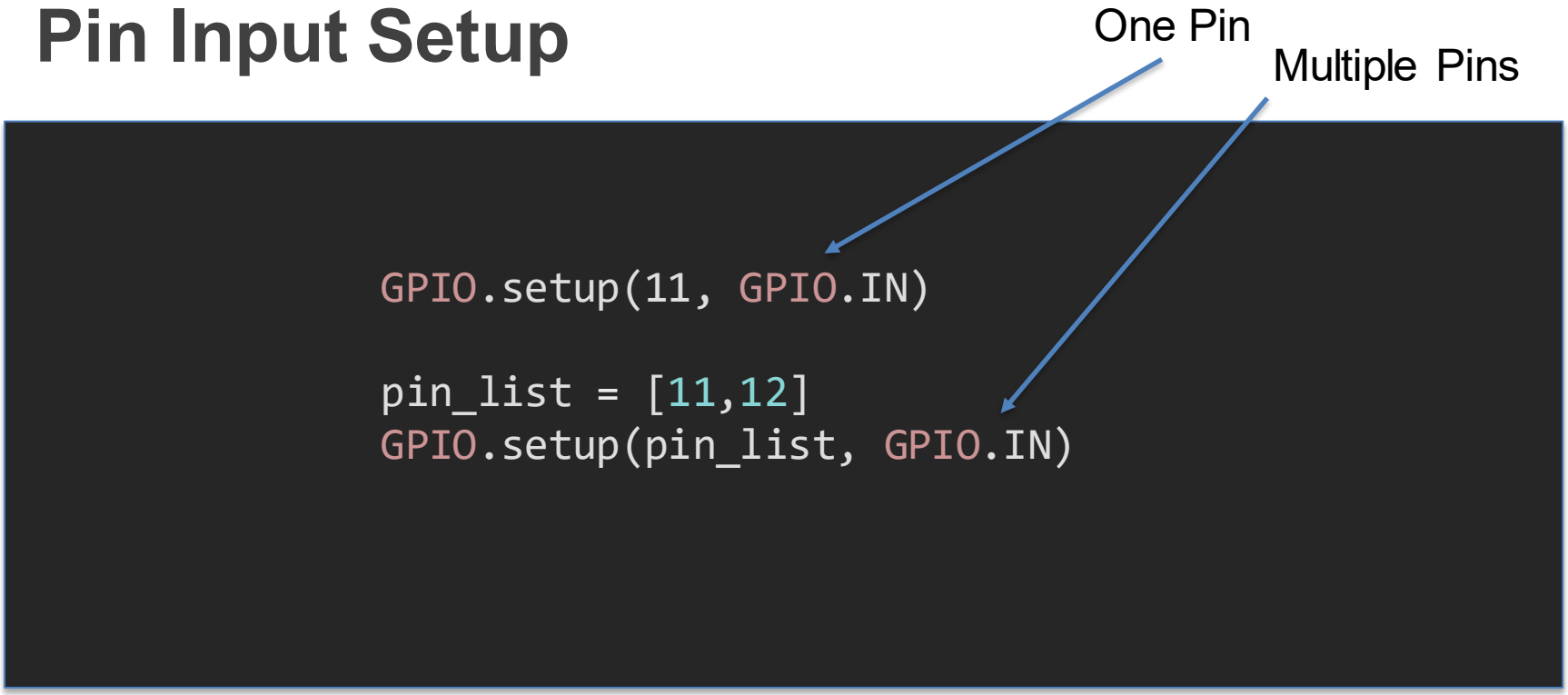
One or the other …



```
GPIO.setmode(GPIO.BOARD)
GPIO.setmode(GPIO.BCM)
```

Input

Pin Input Setup

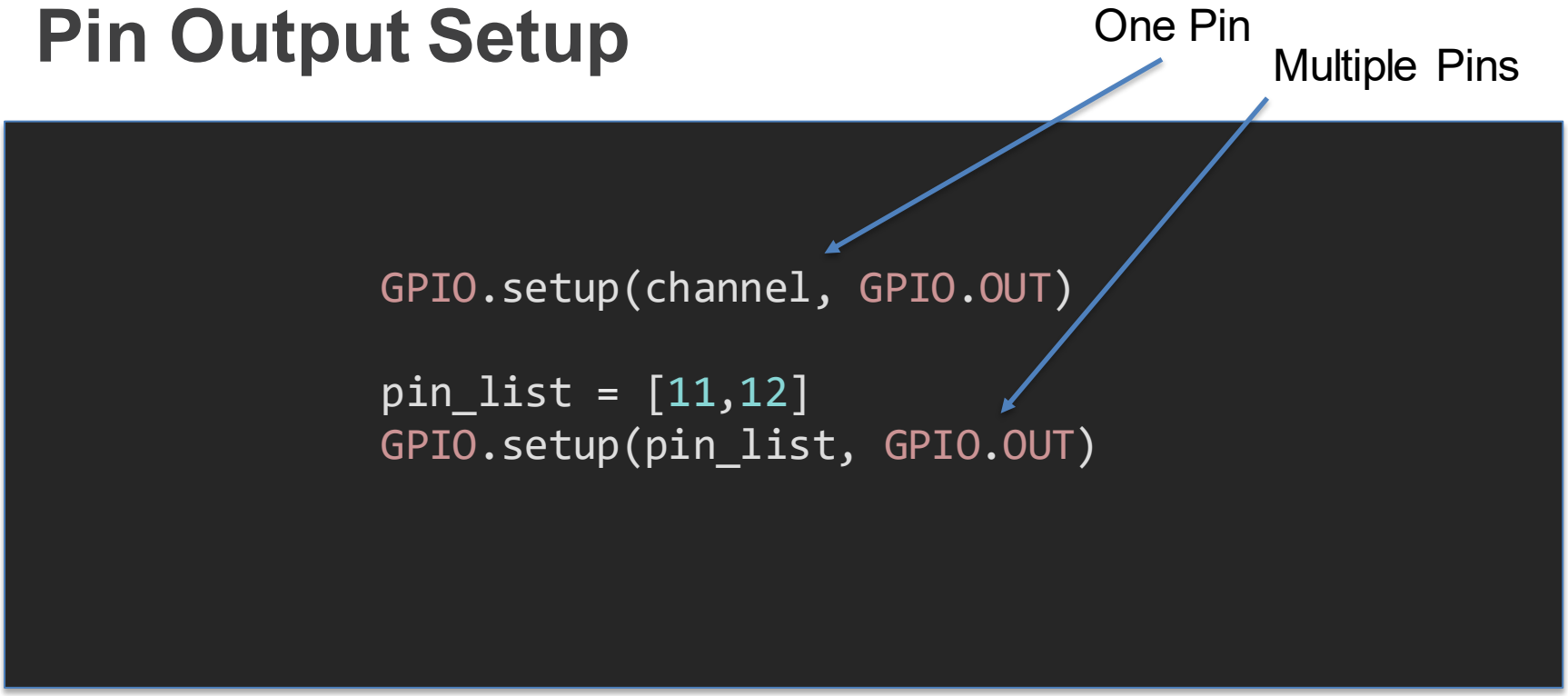


Pin Input Read

```
pin_state = GPIO.input(11)
if pin_state == 1:
    print("Pin High")
else:
    print("Pin Low")
```

Output

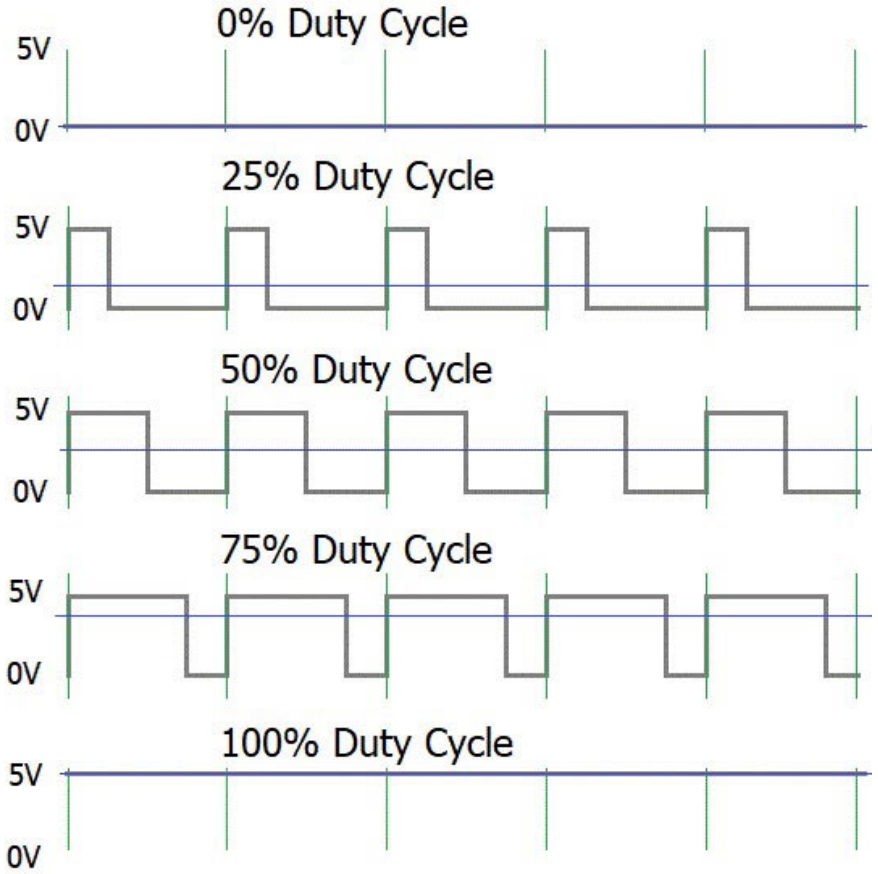
Pin Output Setup



Pin Output Write

```
# State can be 0 / GPIO.LOW / False or 1 / GPIO.HIGH / True.
GPIO.output(11, 1)
```

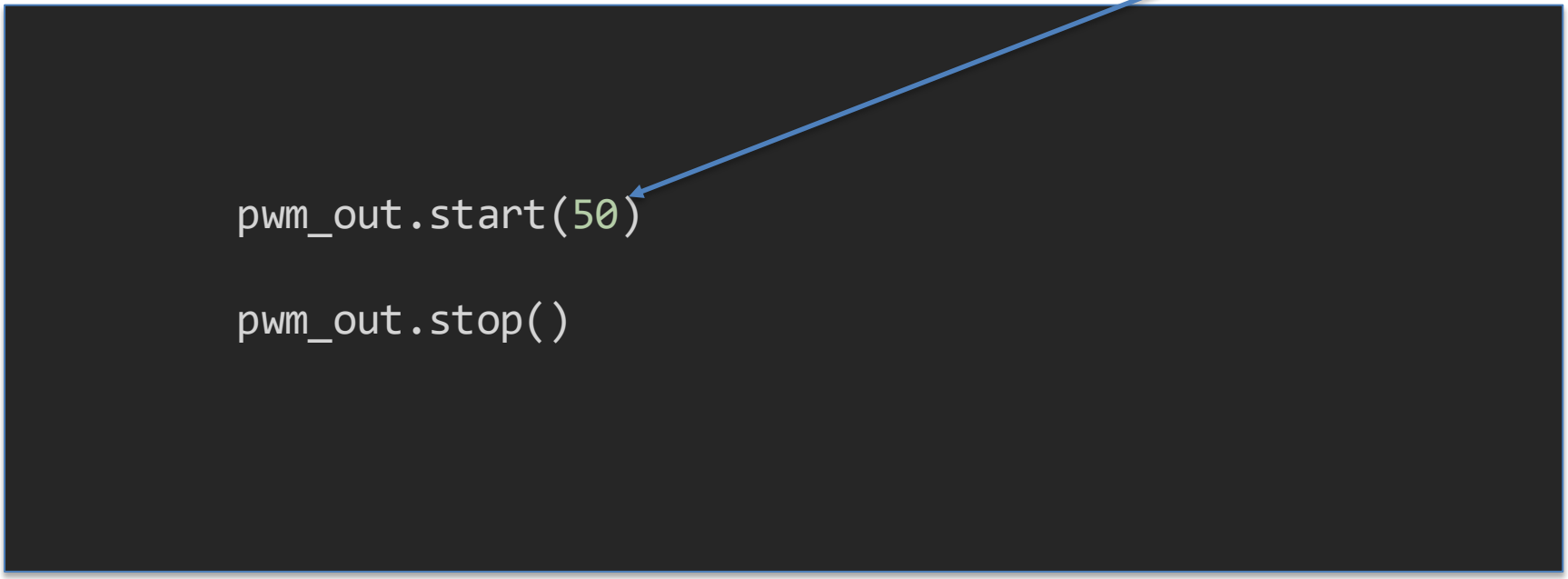
PWM


0% Duty Cycle
5V
0V
25% Duty Cycle
5V
0V
50% Duty Cycle
5V
0V
75% Duty Cycle
5V
0V
100% Duty Cycle
5V
0V

Pin Output Setup

```
frequency_hz = 100
pwm_out = GPIO.PWM(12, frequency_hz)
```

Start/Stop PWM



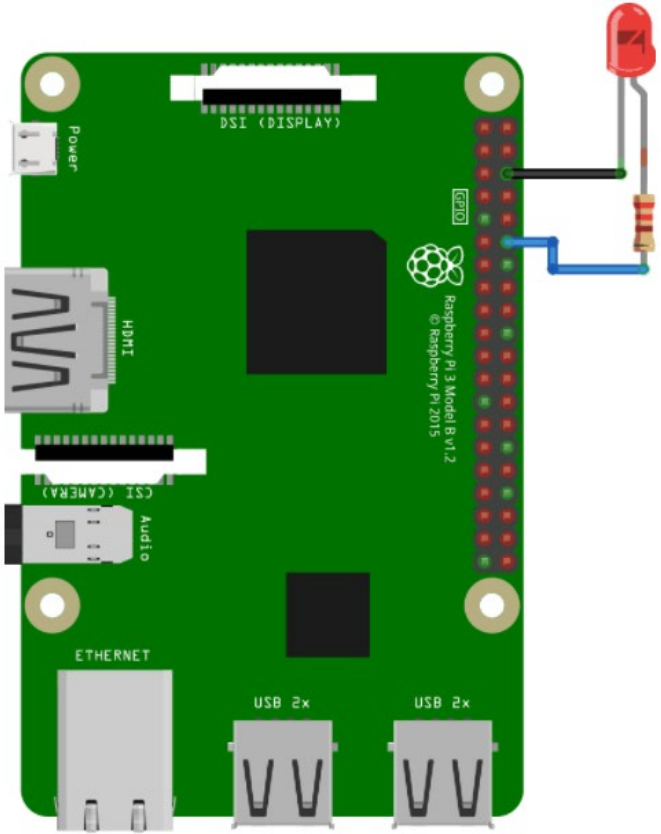
Changing Duty Cycle

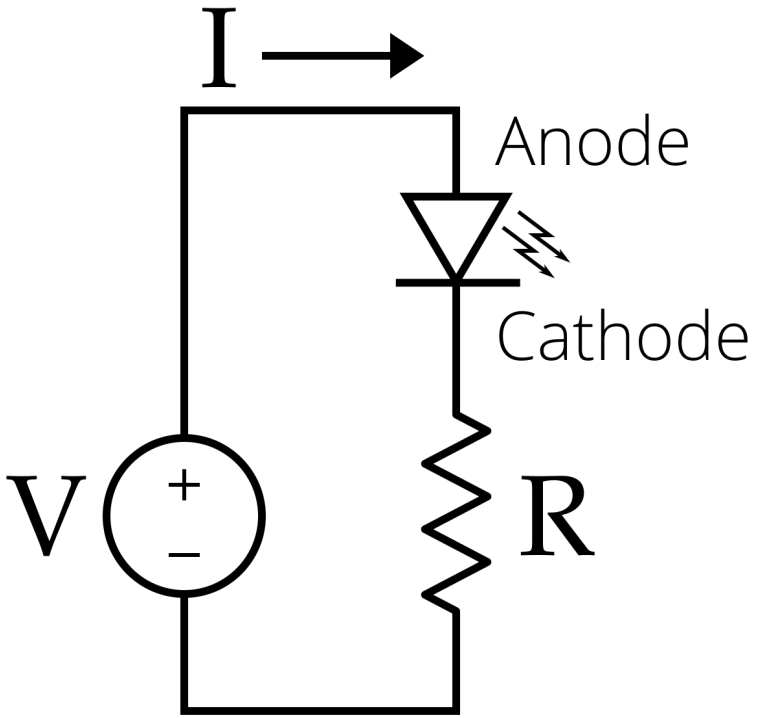
```
pwm_out.ChangeDutyCycle(90)
```

Example

```
#!/usr/bin/env python3

import RPi.GPIO as GPIO

GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)

GPIO.setup(12,GPIO.OUT)
pwm_out = GPIO.PWM(12,100)

dc = int(input("Enter an integer duty cycle between 0 and 100, -1 to exit: "))
pwm_out.start(dc)

while (dc >= 0):
    pwm_out.ChangeDutyCycle(dc)
    dc = int(input("Enter an integer duty cycle between 0 and 100, -1 to exit: "))
pwm_out.stop()
```

LED


DSI (DISPLAY)
Power
HDMI
CSI (CAMERA)
Audio
ETHERNET
USB 2x
USB 2x
GPIO
Raspberry Pi 3 Model B v1.2
© Raspberry Pi 2015


I
Anode
Cathode
V
+
–
R

Standard LED

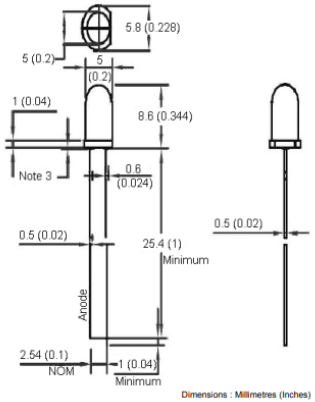
Red Emitting Colour

multicomp

Features:

- High intensity
- Standard T-1 3/4 diameter package
- General purpose leads
- Reliable and rugged

Package Dimensions:



Dimensions : Millimetres (Inches)

Specification Table

Chip Material	Lens Colour	Source Colour	Part Number
AlGaAs	Diffused	Red	MV5754A

Notes:

1. Tolerance is ±0.25 mm (0.01") unless otherwise noted
2. Protruded resin under flange is 1 mm (0.04") maximum
3. Lead spacing is measured where the leads emerge from the package

www.element14.com
www.farnell.com
www.newark.com

multicomp

Standard LED

Red Emitting Colour

multicomp

Absolute Maximum Ratings at T_a = 25°C

Parameter	Maximum	Unit
Power Dissipation	80	mW
Peak Forward Current (1/10 Duty Cycle, 0.1 ms Pulse Width)	100	mA
Continuous Forward Current	20	
Derating Linear From 50°C	0.4	mA / °C
Reverse Voltage	5	V
Operating Temperature Range	-25°C to +80°C	
Storage Temperature Range	-40°C to +100°C	
Lead Soldering Temperature (4 mm (0.157) Inches from Body)	260°C for 5 s	

Electrical Optical Characteristics at T_a = 25°C

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Test Condition
Luminous Intensity	I_v		40		mcd	I_f = 20 mA (Note 1)
Viewing Angle	$2\theta_{1/2}$		25		Deg	(Note 2)
Peak Emission Wavelength	λp		640		nm	I_f = 20 mA
Dominant Wavelength	λd		635		nm	I_f = 20 mA (Note 3)
Spectral Line Half-Width	$\Delta\lambda$		25		nm	I_f = 20 mA
Forward Voltage	V_f		2	2.5	V	I_f = 20 mA
Reverse Current	I_R	-	-	100	µA	V_R = 5 V

Notes:

1. Luminous intensity is measured with a light sensor and filter combination that approximates the CIE eye-response curve
2. $\theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity
3. The dominant wavelength (λd) is derived from the CIE chromaticity diagram and represents the single wavelength which defines the colour of the device

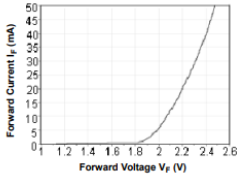
Standard LED

Red Emitting Colour

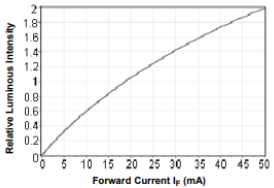
multicomp

Typical Characteristics

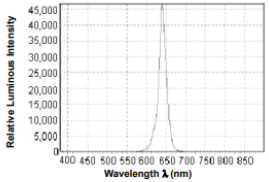
I_F - V_F (T_a = 25°C)



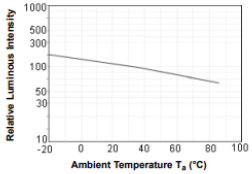
Relative Luminous Intensity - I_F (T_a = 25°C)



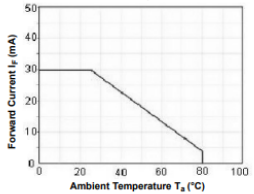
Wavelength Characteristics (T_a = 25°C)



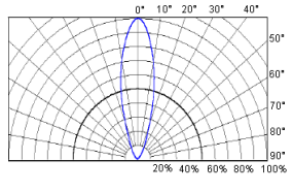
Relative Luminous Intensity - T_a

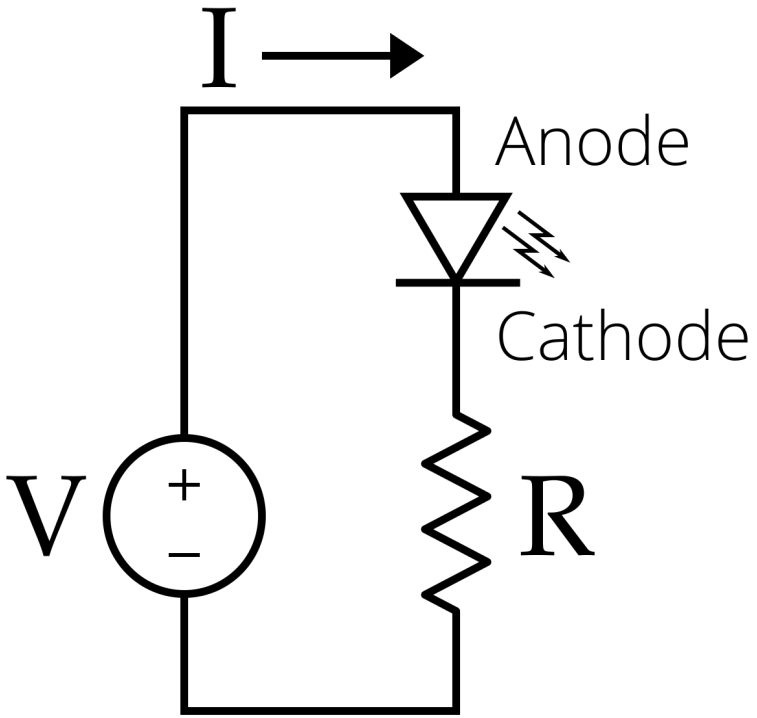


I_F - T_a



Directive Characteristics (T_a = 25°C)




I
Anode
Cathode
V
+
–
R