



Engineering Cyber-Physical Systems

# **GPIO/LED**

Bryce Himebaugh

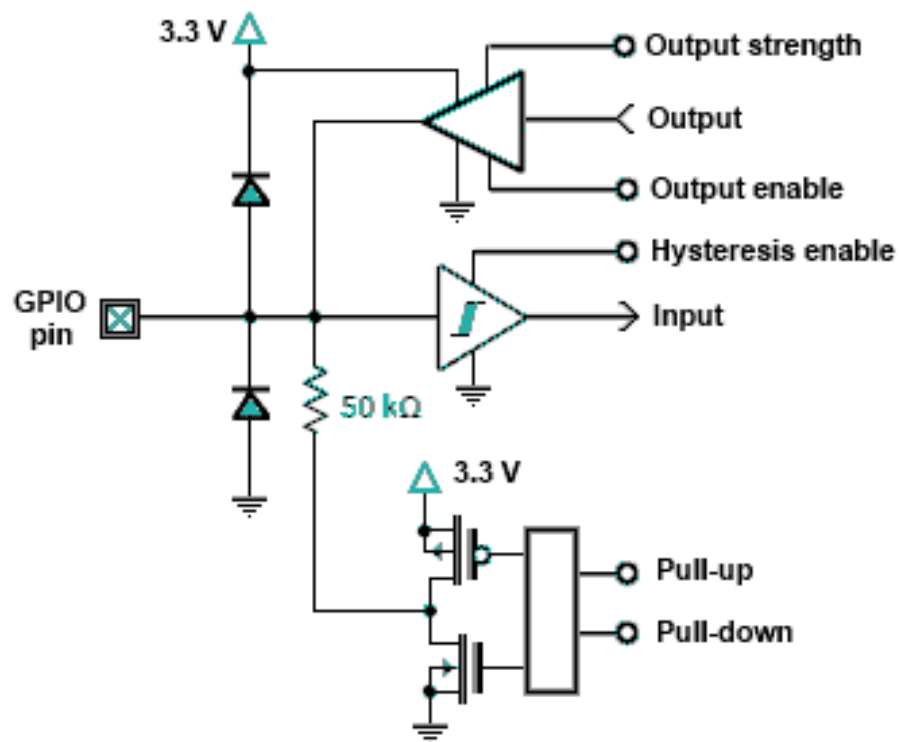
## Course Schedule

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



# GPIO Structure

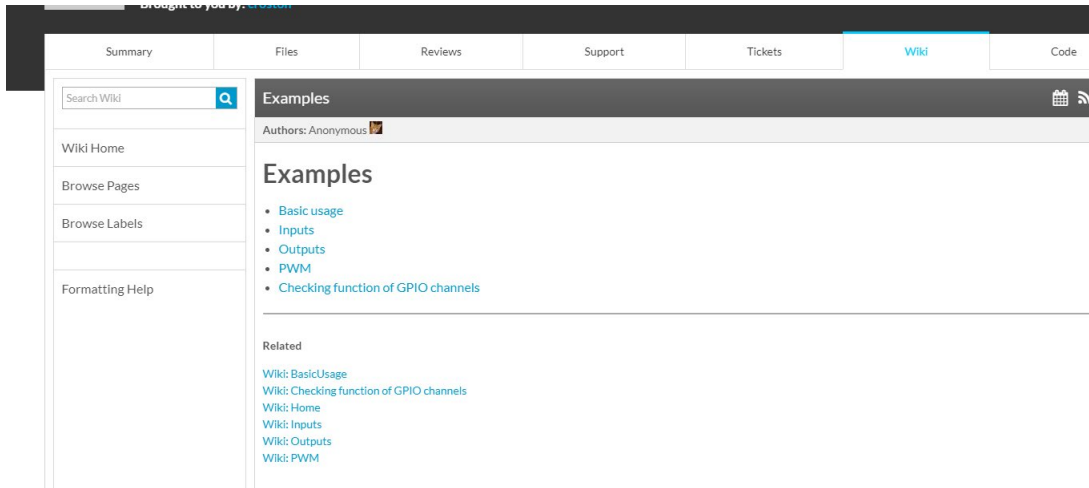
## Equivalent Circuit for Raspberry Pi GPIO pins



# **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
```



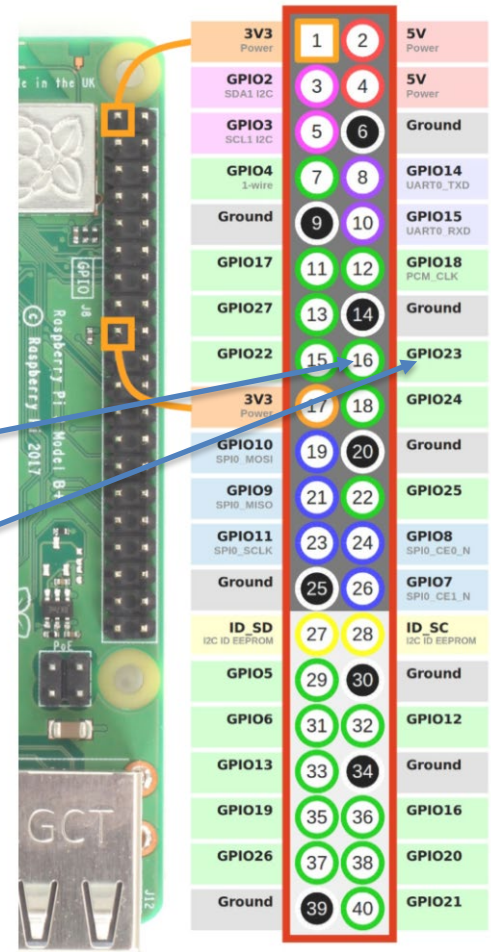


# Pin Numbering

# GPIO Pin Numbering Scheme

## 1. Used in the GPIO.setmode() Method

- GPIO.BOARD follows Header Numbering
- GPIO.BCM follows the Broadcom Chip Numbering



BOARD

BCM

BCM	wPi		RPi1		wPi	BCM
		3.3V	1	2		
2	8	P SDA	3	4		
3	9	P_SCL	5	6		
4	7	P4	7	8		
		GND	9	10	15	14
17	0	P17	11	12	16	15
27	2	P27	13	14	1	18
22	3	P22	15	16		
		3.3V	17	18	4	23
10	12	P10	19	20	5	24
9	13	P9	21	22		
11	14	P11	23	24	6	25
		GND	25	26	10	8
		ID_SD	27	28	11	7
5	21	P5	29	30		
6	22	P6	31	32	26	12
13	23	P13	33	34		
19	24	P19	35	36	27	16
26	25	P26	37	38	28	20
		GND	39	40	29	21

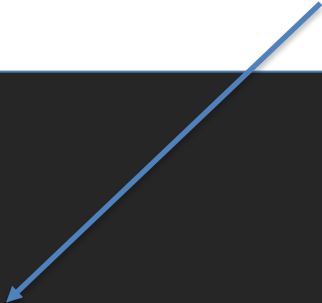
Referencing WiringPi Numbering (more commonly used for applications written in C)



# Pin Numbering

One or the other ...

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





# Input

# Pin Input Setup

One Pin

Multiple Pins

```
GPIO.setup(11, GPIO.IN)
```

```
pin_list = [11,12]
```

```
GPIO.setup(pin_list, GPIO.IN)
```



# Pin Input Read

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





**Output**



# Pin Output Setup

One Pin

Multiple Pins

```
GPIO.setup(channel, GPIO.OUT)
```

```
pin_list = [11,12]  
GPIO.setup(pin_list, GPIO.OUT)
```



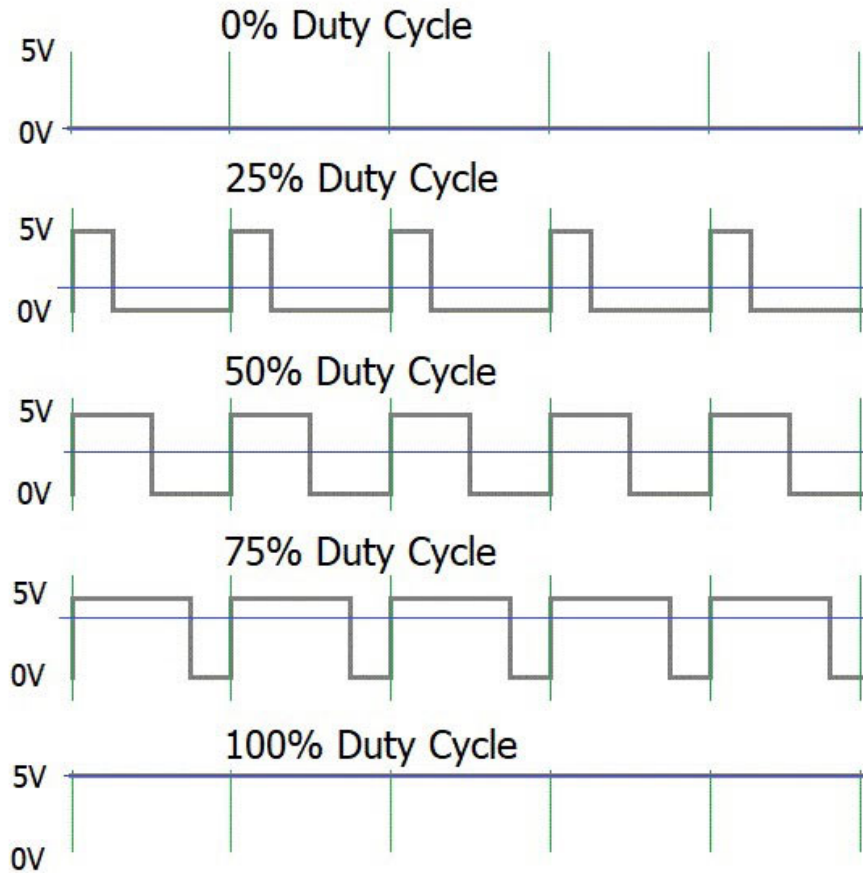
# Pin Output Write

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





**PWM**



# Pin Output Setup

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



# Start/Stop PWM

0 >= duty cycle >= 100

```
pwm_out.start(50)
```

```
pwm_out.stop()
```



# 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)

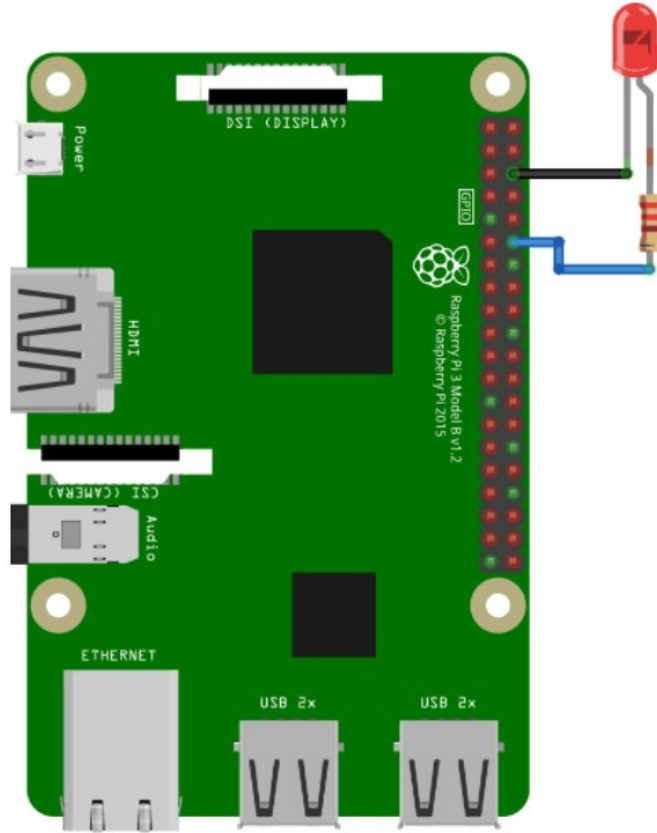
while (dc >= 0):
    pwm_out.ChangeDutyCycle(dc)
    dc = int(input("Enter an integer duty cycle between 0 and 100, -1 to exit: "))
pwm_out.stop()
```

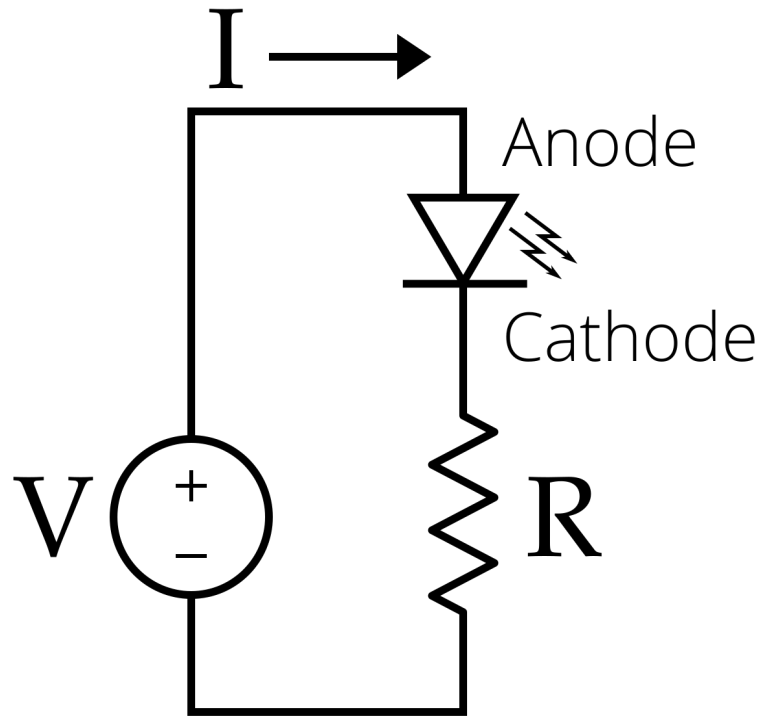






**LED**





# Standard LED

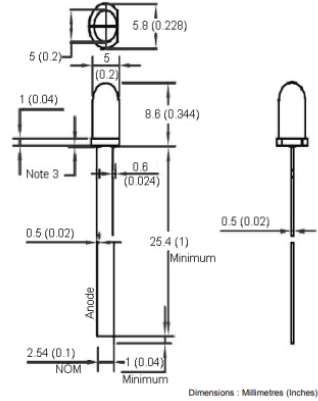
## Red Emitting Colour



### Features:

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

### Package Dimensions:



### Specification Table

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

### Notes:

1. Tolerance is  $\pm 0.25$  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

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# Standard LED

## Red Emitting Colour



### Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$

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 $T_a = 25^\circ\text{C}$

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

#### 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 ( $\lambda_d$ ) is derived from the CIE chromaticity diagram and represents the single wavelength which defines the colour of the device

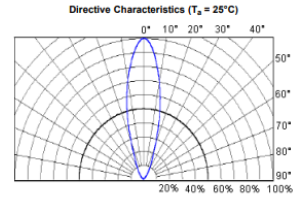
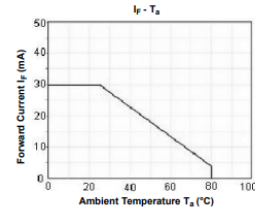
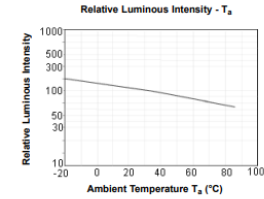
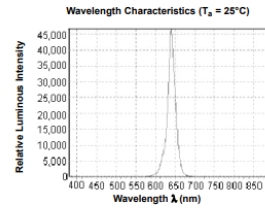
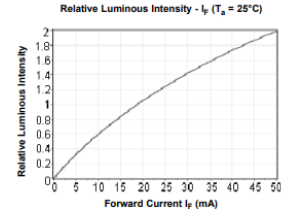
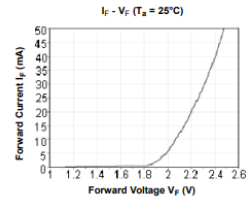


# Standard LED

## Red Emitting Colour



### Typical Characteristics



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