Introduction to Arduino and Raspberry Pi

Presented by SEAS Computing Facility  
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Materials Used in Presentation

- Raspberry Pi
- Raspberry Pi power supply
- Keyboard
- Mouse
- Monitor
- Monitor power supply
- HDMI–HDMI or HDMI–DVI cable
- Breadboard
- Ribbon cable and breakout board
- Two jumper cables
- LED
- 220 Ω resistor
- Arduino
- Arduino USB cable
Top 10 Arduino Projects
Components
Jumper Cables
Push Button

- All four pins are **connected** when pressed on.
- If off, the **left** and **right** are separated.
Light Emitting Diode

- A **diode** is a component that only allows flow of current in one direction.
- A **light emitting diode (LED)** emits light when current passes in the correct direction.
Circuit Basics

- Ohm’s Law: \( V = IR \)
  - \( V \): Voltage (volts)
  - \( I \): Current (amperes)
  - \( R \): Resistance (ohms)
- LEDs have a maximum current
- Ohm’s Law (rewritten): \( I = \frac{V}{R} \)
  - To keep current \( I \) low, resistance \( R \) must be high enough

### LED Absolute Maximum Rating

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Absolute Maximum Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Current</td>
<td>( I_F )</td>
<td>20</td>
<td>mA</td>
</tr>
<tr>
<td>Peak Forward Current</td>
<td>( I_{P} )</td>
<td>120</td>
<td>mA</td>
</tr>
<tr>
<td>Reverse Voltage</td>
<td>( V_R )</td>
<td>5</td>
<td>V</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>( P_d )</td>
<td>85</td>
<td>mW</td>
</tr>
<tr>
<td>Operation Temperature</td>
<td>( T_{op} )</td>
<td>-35°C – 80°C</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>( T_{stg} )</td>
<td>-40°C – 80°C</td>
<td></td>
</tr>
<tr>
<td>Lead Soldering Temp.</td>
<td>( T_{sol} )</td>
<td>Max. 200°C for 3sec Max.</td>
<td></td>
</tr>
</tbody>
</table>

*\( I_F \) Conditions: Pulse Width≤10μsec duty≤1/10
\( T_{sol} \) Conditions: 8mm from the base of the epoxy bulb

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**1st digit | 2nd digit | Multiplier | Tolerance**

- 0 | 0 | \( x1 \) | \( ±1\% \)
- 1 | 1 | \( x10 \) | \( ±2\% \)
- 2 | 2 | \( x100 \) | \( ±1\% \)
- 3 | 3 | \( x1K \) | \( ±2\% \)
- 4 | 4 | \( x10K \) | \( ±5\% \)
- 5 | 5 | \( x100K \) | \( ±10\% \)
- 6 | 6 | \( x1M \) | \( ±2\% \)
- 7 | 7 | | |
- 8 | 8 | \( x0.1 \) | \( ±5\% \)
- 9 | 9 | \( x0.01 \) | \( ±10\% \)
Raspberry Pi
What is a Raspberry Pi?

- Single-board computer
- Developed in the UK
- Several models
- Inexpensive ($5 for cheapest model, the Raspberry Pi Zero)
- Can be used with a computer monitor, keyboard, and mouse
What is Raspbian?

- Operating system optimized for the Raspberry Pi
- Based on the Linux kernel
- Can be used like a desktop computer or through the terminal
Raspberry Pi 3 Model B

Dimensions: 85.6mm x 56mm x 21mm

- 40 Pin Extended GPIO
- Broadcom BCM2837 64bit Quad Core CPU at 1.2GHz, 1GB RAM
- On Board Bluetooth 4.1 Wi-Fi
- MicroSD Card Slot
- DSI Display Port
- Micro USB Power Input. Upgraded switched power source that can handle up to 2.5 Amps
- 4 x USB 2 Ports
- 10/100 LAN Port
- 3.5mm 4-pole Composite Video and Audio Output Jack
- CSI Camera Port
- Full Size HDMI Video Output
Connecting to the Internet

- **Wired Connection**: The SEASCF Raspberry Pis can instantly connect to the GW network from the SEH Studio Labs using an ethernet cable. This is the easiest and fastest option.
- **GWiressless**: Raspberry Pis cannot connect to GWiressless.
- **eduroam**: Raspberry Pis can be connected to eduroam by modifying two configuration files and running commands.
  - Instructions: [seascf.seas.gwu.edu/eduroam-connection](seascf.seas.gwu.edu/eduroam-connection)
    - It may be necessary to run `/etc/init.d/networking stop` before running `/etc/init.d/networking start`
Keyboard Check

Open the web browser and type # and “ in the address bar

If the symbols do not appear as expected, follow these steps:

1. Click the Raspberry Pi icon in the upper-left corner, click Preferences, and click Raspberry Pi Configuration
2. Click Localisation, Click Set Keyboard, choose United States as country, select English (US) for variant, and click OK
Creating a Basic Python Program

1. Open Terminal
2. Type `nano helloworld.py` and press ENTER to open a new file in the nano text editor
3. Type `print("Hello, World!")`
4. Use CTRL + O and ENTER to save
5. Exit with CTRL + X
6. Type `python helloworld.py` and press ENTER to run the program
7. Hello, World! should appear
Connecting to a Breadboard
Connecting to a Breadboard
Connecting to a Breadboard
Building the LED Circuit

- Two jumper cables
- LED
- 220 Ω resistor
Building the LED Circuit

- Add a resistor to the breadboard
- Connect a wire from the red power rail to one end of a resistor
Building the LED Circuit

- Connect the anode (long end) of the LED to the resistor
Building the LED Circuit

- Connect a wire from the cathode (short end) of the LED to the blue ground rail of the breadboard
- The LED should glow!
Blinking an LED

1. Connect the cable from the resistor to pin 21 of the breakout board
2. Open Terminal
3. Type `nano blinky.py` and press ENTER to open a new file in the nano text editor
4. Type the code
5. Use CTRL + O and ENTER to save
6. Exit with CTRL + X
7. Type `python helloworld.py` and press ENTER to run the program

Code:
```python
import RPi.GPIO as GPIO
import time
GPIO.setmode(GPIO.BCM)
GPIO.setup(21, GPIO.OUT)
for i in range(0,100):
    GPIO.output(21, i % 2)
    time.sleep(0.25)
GPIO.cleanup(21)
```
Arduino
What is an Arduino?

- Single-board microcontroller
- Originated in Italy
- Many variations from different makers
- Cannot be directly connected to a monitor, keyboard, mouse, etc.
- Does not normally have an operating system
Arduino Uno

- Power In: Barrel Jack, USB
- Ground Power In
- Analog In
- Digital In/Out (PWM 3, 5, 6, 9, 10, 11)
- RX/TX
- ARef
- Reset
- Power Out (3.3v and 5v)
- Reset
Running a Basic Arduino Program

1. Open the Arduino Desktop IDE (install required)
   a. There is also an Arduino Web IDE (account required)
2. Connect the Arduino to the computer using a USB cable
3. Open example sketch from **File > Examples > 01.Basics > Blink**
4. Select the board type from **Tools > Board**
5. Select the port with the Arduino from **Tools > Port**
6. Click the upload button
7. The built-in LED near pin 13 should start to blink

Programs will stay on the Arduino until overridden by another program.

Programs start whenever the Arduino is powered on or reset.
Running a Basic Arduino Program

Code:

// the setup function runs once when you press reset or power the board
void setup() {
   // initialize digital pin LED_BUILTIN as an output.
   pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
   digitalWrite(LED_BUILTIN, HIGH);  // turn the LED on (HIGH is the voltage level)
   delay(1000);                      // wait for a second
   digitalWrite(LED_BUILTIN, LOW);   // turn the LED off by making the voltage LOW
   delay(1000);                      // wait for a second
}
Useful Arduino Functions

- `pinMode(pin, mode)` - Sets the pin to be INPUT or OUTPUT
- `digitalRead(pin)` - Returns HIGH or LOW depending on the voltage of the specified pin
- `analogRead(pin)` - Returns a value from 0 to 1023 representing the voltage of the specified pin between 0 and 5 V
- `analogWrite(pin, value)` - Writes a value between 0 and 255 to the pin
- `digitalWrite(pin, value)` - Writes HIGH or LOW to the pin
- `Serial.begin(speed)` - Configures the serial output for the specified speed (9600 is typical)
- `Serial.write(val)` - Writes a value or string to the Serial monitor
More Components
Raspberry Pi Camera Module V2

- 1080p HD video at 30 frames/second
- 720p HD video at 60 frames/second
- 8 Megapixels for still photos (3280 x 2464)
- Fixed Focus Lens
- Connected to Raspberry Pi with 15-pin ribbon cable

https://www.amazon.com/Raspberry-Pi-Camera-Module-Megapixel/dp/B01ER2SKFS
PIR Motion Sensor Detector Module

- PIR: Passive Infrared
  - Senses infrared radiation from objects
- Range is adjustable up to 7 meters
- Viewing area is approximately a 120° cone

PIR Motion Sensor Detector Module

- Time Delay Adjust
  - Clockwise increases delay
- Sensitivity Adjust
  - Clockwise decreases range
- Pins
  - Power: Should be between 5 and 20 V input
  - Ground: Should be connected to ground
  - Output: Will be 3.3 V if activated, 0 if not

Diagram from Henry’s Bench
Sense HAT for Raspberry Pi

- Includes:
  - 8 x 8 RGB LED matrix
  - Five-button joystick
  - Gyroscope
  - Accelerometer
  - Magnetometer
  - Thermometer
  - Barometric pressure
  - Humidity
- Has been used on the International Space Station
Sense HAT Basics

Install the Sense HAT package

- `sudo apt-get install sense-hat`
- Ensure that you **unplug** your Pi
- Attach your Sense HAT
Setting up the code and sending text to the HAT

- Create a Python file: `nano helloWorld.py`
- Create Sense HAT object:
  ```python
  from sense_hat import SenseHat
  sense = SenseHat()
  ```
- Have text scroll across the Sense HAT
  ```python
  sense.show_message("Hello world")
  ```
Piezo Buzzer

- Piezoelectric buzzers use the piezoelectric effect to convert electrical to mechanical energy
- Connect one pin to ground and the other to a digital output

**Code:**
```c
int buzzerPin = 8;

void setup() {
    pinMode(buzzerPin, OUTPUT);
}

void loop() {
    tone(buzzerPin, 3000); // Play 3000 Hz tone
    delay(1000); // Continue playing for 1 second
    noTone(buzzerPin); // Turn off buzzer
}
```
Motor

- Motor draws more current than digital output can supply
- Transistor can be used as a switch to enable power to motor
- Switch wires on motor to change direction

Code:

```cpp
int motorPin = 3;

void setup() {
  pinMode(motorPin, OUTPUT);
}

void loop() {
  analogWrite(motorPin, 255);  // Run motor at max speed
}
```
Other Sensors

- Ultrasonic Sensor
- Water Sensor
- Sound Sensor
Further Information
## Raspberry Pi vs. Arduino

### Raspberry Pi
- Allows graphical user interface
- Can be directly connected to Internet
- More powerful and more memory
- Can be used with more programming languages

### Arduino
- Low power consumption
- Can directly read analog inputs
- Requires less hardware (monitor, mouse, etc.) to get started
- No operating system needs to be installed
Link to These Slides

seascf.seas.gwu.edu/workshops
Activity Options

- Button-activated LEDs
- Sense HAT Pong Game (Raspberry Pi only)
- Camera Module (Raspberry Pi only)
- Motion-Activated Camera (Raspberry Pi only)
- Clap-Activated Fan
- Flood Alarm
- Motion Detector
Link to These Slides
seascf.seas.gwu.edu/workshops

Link to Survey
go.gwu.edu/421survey