CLASSROOM CHALLENGE

RASPBERRY PI ARCHITECTURE

In this lesson you will learn about the Raspberry Pi as a computer platform. You will be able to connect peripheral devices to it and understand how it functions.

RESOURCES NEEDED FOR THIS ACTIVITY

- Raspberry Pi

TASK 1 – IDENTIFYING COMPONENTS ON THE RASPBERRY PI (10 minutes)

Use the interactive drag and drop activity to locate all of the interfaces and components on the board.

TASK 2 – INVESTIGATING THE "SYSTEM ON CHIP" (30 minutes)

Read the information below:

The Broadcom "System on chip" BCM2835 (SoC)

The Raspberry Pi does not have a separate **CPU (Central Processing Unit)**, **RAM (Random Access Memory)** or **GPU (Graphics Processing Unit)**. Instead they are all squeezed into one component called a **System on Chip or SoC unit**. This is essentially the entire computer on one chip.

The Raspberry Pi uses an **ARM1176JZF-S 700MHz CPU** which is also installed in a wide variety of mobile phones, hand held games consoles and eReaders. This CPU is **single core**, however it does have a **co-processor** to perform **floating point calculations**. Many calculations required by a program involve whole numbers (integers). These are easier for the CPU to handle. Integer calculations produce accurate results. Floating point or real numbers have a fractional part e.g. 1.5. They are more demanding for the CPU to process.

The **Model B Raspberry Pi** has **512MB SDRAM (Synchronous Dynamic RAM)**. This is working memory that is used to store programs that are currently being run in the CPU.

The ARM CPU has **32KB of Level 1 cache memory for instructions** and **32KB for data**. It also has **128KB of Level 2 cache memory**. Cache memory is important in improving the performance of the system because it stores recently used program lines copied from RAM ready to be used again if needed. Most processors have **levels** of cache. **Level 1** is the smallest size but is closest to the CPU core. **Level 2** is larger but is situated slightly further away from the CPU core. The CPU is based on **32 bit architecture** and has **32 bit registers**. It also uses a 32 bit words. A word is a complete piece of information that the CPU can execute. The **Arithmetic Logic Unit** is the part of the CPU where instructions are executed.

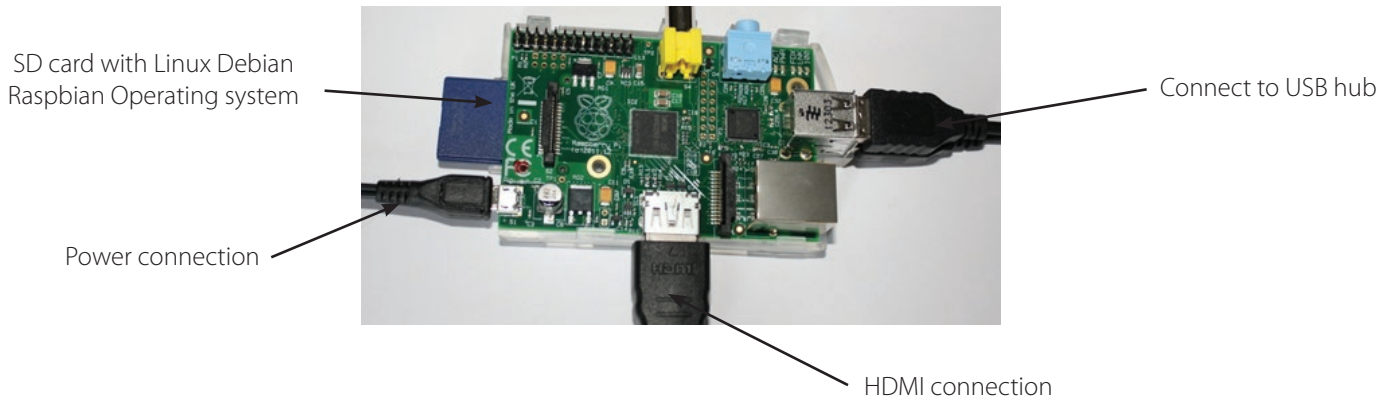
Below are a series of questions about the Raspberry Pi. Work in a team and write down your answers. When you have finished, swap your answers with those of another group. Your teacher will discuss the correct answers with you so that you can mark your partner group's work. Don't forget to give them some feedback on how well they did and give them some tips to improve.

QUESTIONS

1. How many **cores** does the Raspberry Pi's CPU have and what speed does it operate at?
2. What features does the ARM1176 processor have that improve its performance?
3. The Broadcom SoC is installed in a large range of mobile devices. Explain what the advantages are of having a System on a Chip rather than separate CPU, GPU and RAM components.
4. Explain using step-by-step instructions how the CPU executes a simple program such as adding two whole (integer) numbers together. You should refer to RAM, cache, registers and the Arithmetic Logic Unit your explanation. You may also be able to name the roles of some of the registers.

TASK 3 – INPUT AND OUTPUT (30 minutes)

The Raspberry Pi can interface with a very wide range of peripheral devices. The board has two USB ports but if you connect one of these to a **powered** hub, it is possible to connect more devices. However, as the Raspberry Pi is a new computer, it may not be compatible with all devices that you connect to it.



Additionally, the supply voltage required by the Raspberry Pi is 5v DC. The more peripherals that are connected that are drawing power directly from it i.e. that do not have their own power supply, reduce that voltage. If the Raspberry Pi's voltage drops below 4.75v, the system may become unstable. Hardware system designers need to think carefully about how optimum power can be supplied: too much will damage delicate circuits; too little will cause the system to malfunction or not work at all.

The operating system must also support the attached peripheral. Drivers are small programs that allow the operating system to communicate with the peripheral hardware. The most commonly installed operating system is Debian Linux Raspbian.

ESSENTIAL PERIPHERALS

- Display (HDMI or composite video)
  - HDMI (High Definition Multimedia Interface) supports high-quality digital video and audio through a single cable.
  - Composite video allows the Raspberry Pi to be connected to a TV that does not support HDMI. This is an analogue standard that does not produce as high quality output as HDMI.
  - It is also possible to connect a computer monitor with a DVI (Digital Visual Interface) connection to HDMI using a converter. Both of these standards are digital.
  - Touchscreens and smaller LCD displays will be supported via the DSI (Display Serial Interface) header connection.
- USB keyboard and mouse

OTHER PERIPHERALS

- Network adapters
  - USB Wireless 802.11g or n USB adapter to allow a WiFi connection to an existing network.
  - Wired Ethernet 802.3 at 10 and 100Mbps via the on board RJ45 connection.
  - USB Bluetooth adapter.
- Cameras
  - These will be supported by the CSI (Camera Serial Interface)
  - A number of USB cameras are supported.
- USB Printers
- USB Sound card
- Speakers or headphones
  - Connect via 3.5mm audio socket.
- Interface board
  - This allows the Raspberry Pi to connect to a wide range of sensors and actuators such as motors , buzzers and LEDs. It also protects it from the higher voltage circuits needed to power electric motors. An example of an interface board is the **Piface** - http://pi.cs.man.ac.uk/interface.htm.

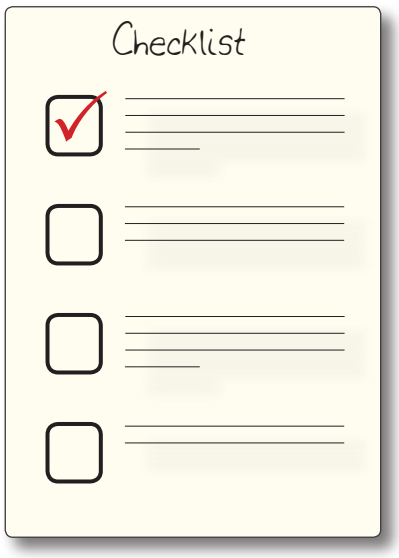
The Raspberry Pi is a small, compact computer system. It could be used as the basis for many different devices. In the following activities, you are going to design a mini games console based on the Raspberry Pi. Below are some activities for you to complete. Write the answers or type them in using a computer. When all groups have finished, you will work through your answers in a group with your teacher.

5. Think about which peripherals could be used for building a **mini-games console** using a Raspberry Pi. Put together a "bundle" of peripheral devices by researching real products online. Record the details in a table with the following layout:

Peripheral name	Input or output	Connection type	Purpose (why it is needed)	Example product

6. What is a driver and why is it necessary?

7. Work in a group and discuss what should be included in a handy checklist that could be used to identify issues with peripherals not working correctly.



ADDITIONAL ACTIVITY

8. It is important that your mini-games console looks good and protects all of the hardware components. Draw an original design for your mini-games console that will protect the devices and look attractive. Label your diagram carefully to explain your ideas.