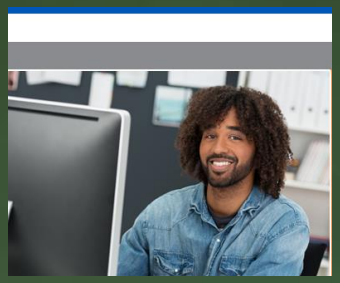
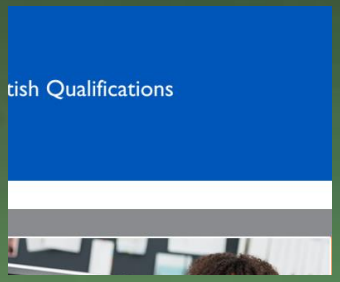
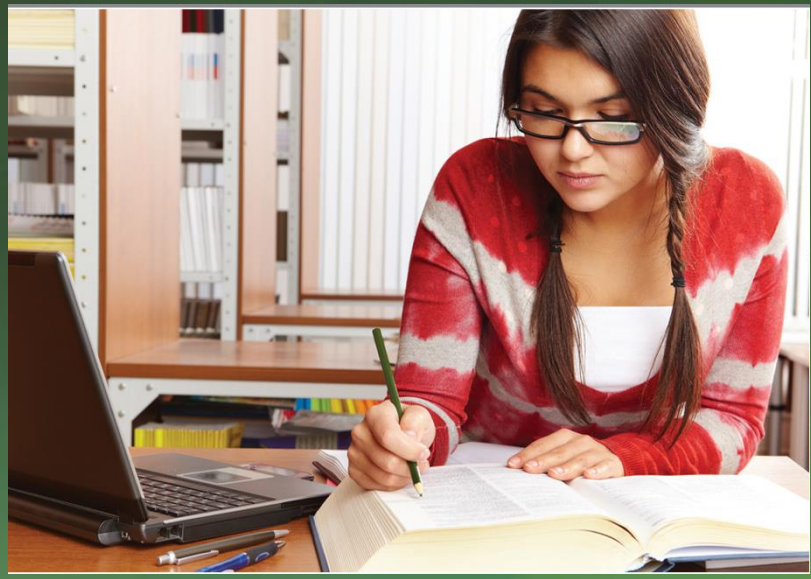
Awarding Great British Qualifications







Computer Systems

Topic 3:

Computer Hardware

Scope and Coverage

This topic will cover:

- Component Architecture:
  - CPU (re-cap)
  - Memory (Cache, RAM, ROM)
  - Backing storage (Internal & External HDD)
  - Power supplies and Cooling
  - Interfaces & Expansion (Networking, Graphics, Sound)
- Component Identification (PC lab)

Learning Outcomes

By the end of this topic students will be able to:

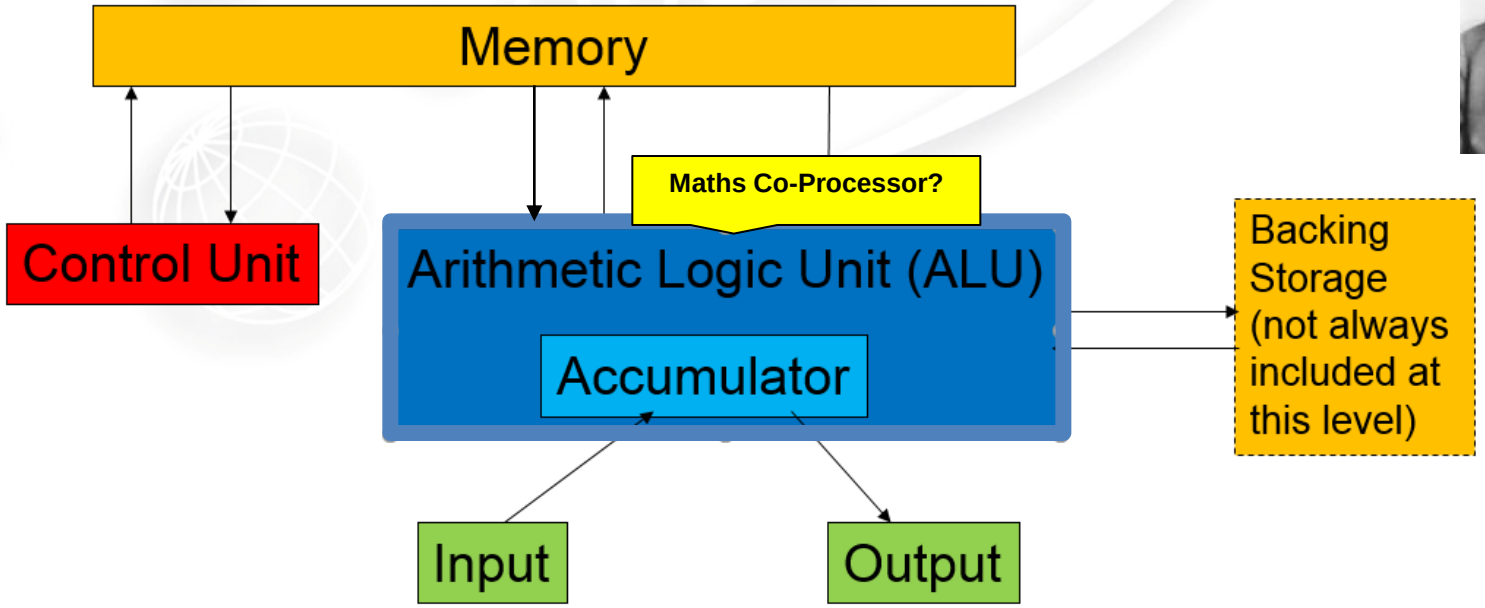
- Explain the hardware, software and peripheral components of a computer system.
- Build and configure a computer system to meet a design specification.

CPU Re-cap…

- In the last Lecture (#2) we looked at:
  - The Central Processing Unit (CPU)
  - The Von Neumann architecture
  - The Fetch-Decode-Execute cycle
- If the CPU is the ‘brain’, we now look at the ‘body’ of a typical computer – the hardware that comes together build a working computer

CPU Re-cap…

- Von Neumann Architecture



http://www.computinghistory.org.uk/det/3665/john-von-neumann/

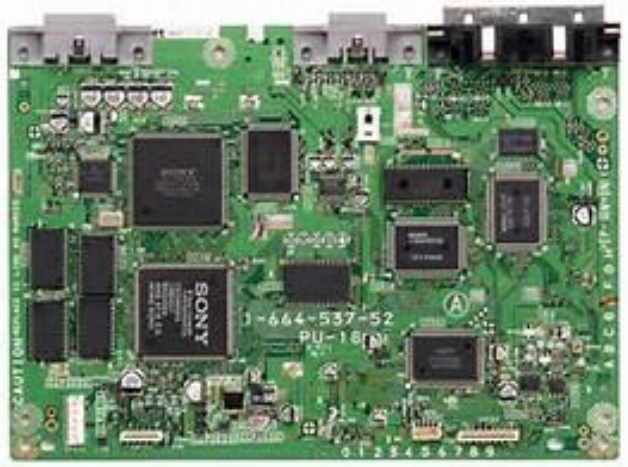
CPU Architectures

- Just as different human brains are ‘wired’ differently, so too can computer ‘brains’.
  - CPUs are based on different ‘architectures’.
  - The chosen CPU architecture will affect:
    - Physical CPU structure and layout
    - Logical CPU operations and sequencing of tasks
    - Overall performance of the computer
    - See…

https://www.cl.cam.ac.uk/teaching/1415/L25/4ModernProcessorArchitectures.pdf
https://www.intel.com/content/dam/www/public/us/en/documents/white-papers/ia-introduction-basics-paper.pdf

Meet the Motherboard

- Like a human brain, the CPU needs to physically reside somewhere - the ‘motherboard’…



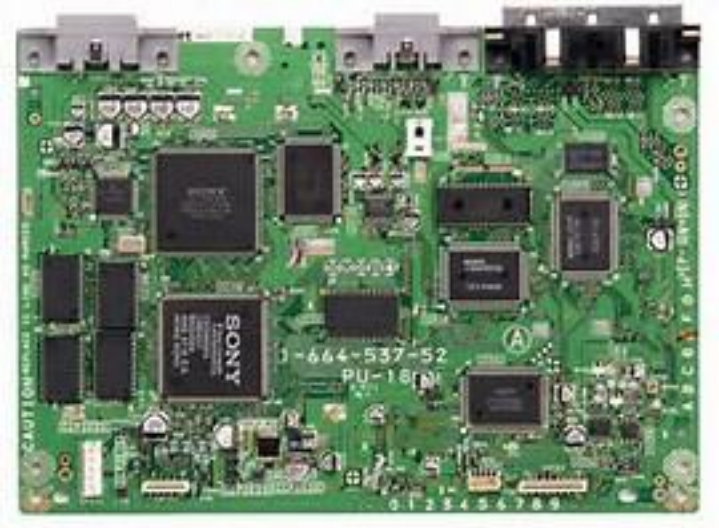
Mount the Motherboard

Related Concepts…

- ZIF (Zero Insertion Force)
- ZIF Socket
- Surface Mount Packaging
- BGA socket
- DIP socket
- And others…

Beyond the CPU…

- The CPU needs a lot of assistance
- Lots of other components on the motherboard
- Just look at them all on this motherboard…



Never Forget…

- It is necessary to store (and recall) program instructions and data - both whilst they are in use and over longer periods.
- Several broad classifications of memory:

1. Primary Storage: To be accessed ‘right here, right now’ by CPU
2. Secondary Storage: To be accessed ‘as and when needed’ by CPU
3. Archived Storage: To be accessed (or not) at some unknown time

Thanks for the Memory

- Also called ‘main memory’
- Implemented as ‘solid state’ (electronic) random access memory (RAM)
- RAM is fast, small with low power consumption, but relatively expensive (cost per bit) and volatile (data is lost when switched off)
- Like a CPU, it is build as an IC (integrated circuit)

Thanks for the Memory

- Two basic RAM technologies:
- Static RAM (**SRAM**) – uses a flip-flop circuit and remembers as long as it has power but costs more
- Dynamic RAM (**DRAM**) – uses a capacitor to hold charge, which leaks out so needs refreshing but costs less
- Most PC systems (and games consoles etc) use dynamic RAM because of cost.

http://computer.howstuffworks.com/ram.htm

Thanks for the Memory

- Modern computers have multiple Gigabytes (GB) of RAM in a small number of chips mounted on a circuit board package called a ‘dual in-line memory module’ (DIMM) which mount in slots on the motherboard.
- There is also ‘single in-line memory module’ (SIMM)

ROM stands Firm

- ROM: Read Only Memory
- Also known as ‘firmware’
- A variation on the previous main memory
- The data or program instructions are built into the chips when they are made and cannot be changed
- Non-volatile – will retain data when power removed
- Used for code that does not change, such as PC BIOS

http://computer.howstuffworks.com/rom.htm

ROM Variations

- **PROM** – Programmable ROM – made as a “blank” which can then be programmed once or “burned” (after which it can not be changed).
- **EPROM** – Erasable PROM – made blank, programmed like PROM but can be erased (blanked) usually using UV light.

ROM Variations

- **EEPROM** – Electrically Erasable PROM – usually read only, but can be erased and re-written. This is very slow compared with normal RAM and there is a limit to the number of cycles (changes) that can be made before the unit fails. It is useful for configuration settings which do not change very often.

- **Flash Memory** – a variation of EEPROM that can be changed more easily and quickly – has a much higher cycle limit (currently about 1 million cycles) – used in cameras, PDAs, MP3 players and USB flash drives (memory sticks) etc.

Secondary Storage – Hard Disks

- Also called ***backing store*** - *n*ormally implemented as a hard-disk drive (HDD)
- Non-volatile, low cost per bit, high power consumption, many times slower than RAM
- Originally developed by IBM for mainframes - been massive advances in data storage density and overall capacity – even in laptops and desktops

http://computer.howstuffworks.com/hard-disk1.htm

Secondary Storage – Hard Disks

- HDD capacity now multi-terabytes (TB)
- Multiple ‘platters’ are held in a stack, coated with a magnetic material, and divided into sectors, tracks and clusters
- These partitioned platter surfaces can be magnetised in two ways – giving binary storage
- A read/write head hovers over the spinning disk surfaces and through electro-magnetism can detect (read) the values or record (write)new data

http://www.ntfs.com/hard-disk-basics.htm

Secondary Storage – Solid State Disks

- SSD capacity multi-terabytes (TB)
- Uses interconnected flash-memory chips, not magnetic media, to store data.
- No moving parts, SSDs can deliver improved reliability.
- Significant increase in the performance of a computer equipped with an SSD.
- SSDs consume far less power than traditional hard drives.

https://computer.howstuffworks.com/solid-state-drive.htm

Secondary Storage – Optical Disks

- Originally based on **Compact Disk** (CD) technology from the music industry – have variations like CD-R
- Then came **Digital Versatile Disk** (DVD) from the movie industry - due to higher data compression and thus storage capacity
- Now we have **Blu-ray** disks
- Hard disks (HDD) use spots of *magnetism* to store data
- Optical disks use spots of *light* – as reflective disk surface stamped with **"*pits*"** and **"*lands*"- ** giving a binary storage system - read by bouncing a laser off the surface and detecting changes in reflection from pits and lands

http://electronics.howstuffworks.com/cd.htm
http://electronics.howstuffworks.com/dvd.htm
http://electronics.howstuffworks.com/blu-ray.htm

Secondary Storage – Flash

- Use flash **RAM technology** as secondary storage
- Common examples include **USB memory stick** and **camera data cards**
- Should be regarded as temporary storage as they are less reliable long term than hard disk or optical storage
- Subject to physical damage

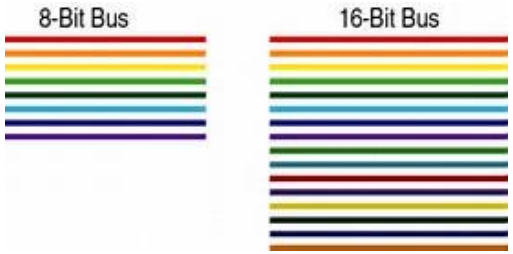
Archived Storage

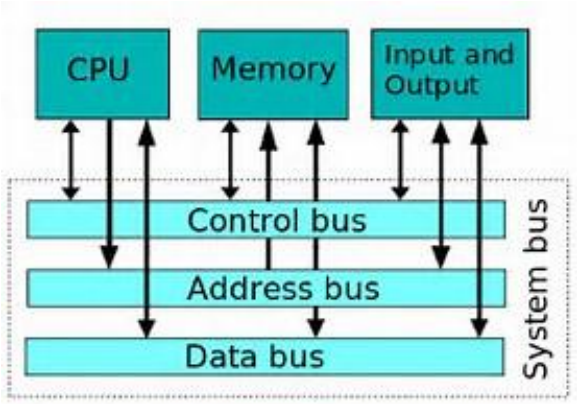
- Sometimes you have data that you don't need right now or may never need again – but for some reason, it needs to be retained
- Over time, that volume of data will get very large which means the storage solution needs to be cheap and scalable
- You could therefore use:
  - Magnetic tape
  - DVD
  - Cloud-based storage

Interconnection – Buses

- The interconnection between parts of a computer is called a **bus** (for obvious reasons)
- There are three buses in a computer system…

1. **Data** Bus
2. **Address** Bus
3. **Control** Bus





There is also power distribution, but this is not called a bus

Expansion Slots

- From the very first IBM PC, the facility to add extra devices via plug-in expansion cards/slots has provided a high degree of flexibility
- Many devices that used to be provided on expansion cards are now usually built into the core motherboard
- Sound, network interface, graphics etc
- But expansion slots are still important for new technologies and upgrades

https://computer.howstuffworks.com/pc.htm#pt2

Expansion Slots

Computer expansion slots

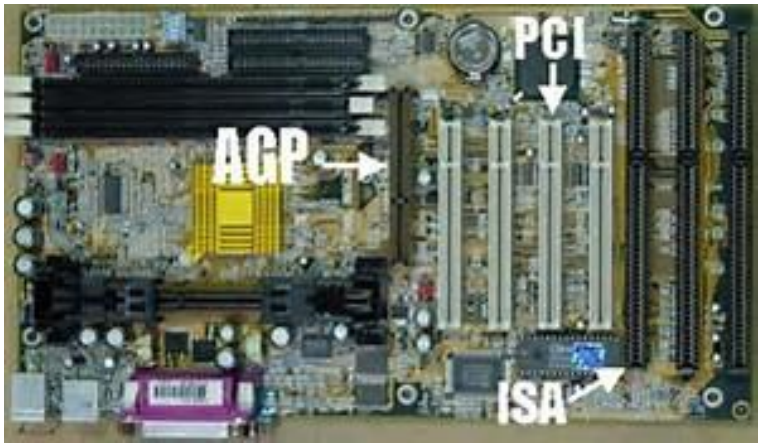
- **AGP** - Video card
- **AMR** - Modem, Sound card
- **CNR** - Modem, Network card, Sound card
- **EISA** - SCSI, Network card, Video card
- **ISA** - Network card, Sound card, Video card
- **PCI** - Network card, SCSI, Sound card, Video card
- **PCI Express** - Video card, Modem, Sound Card, Network Card
- **VESA** - Video card

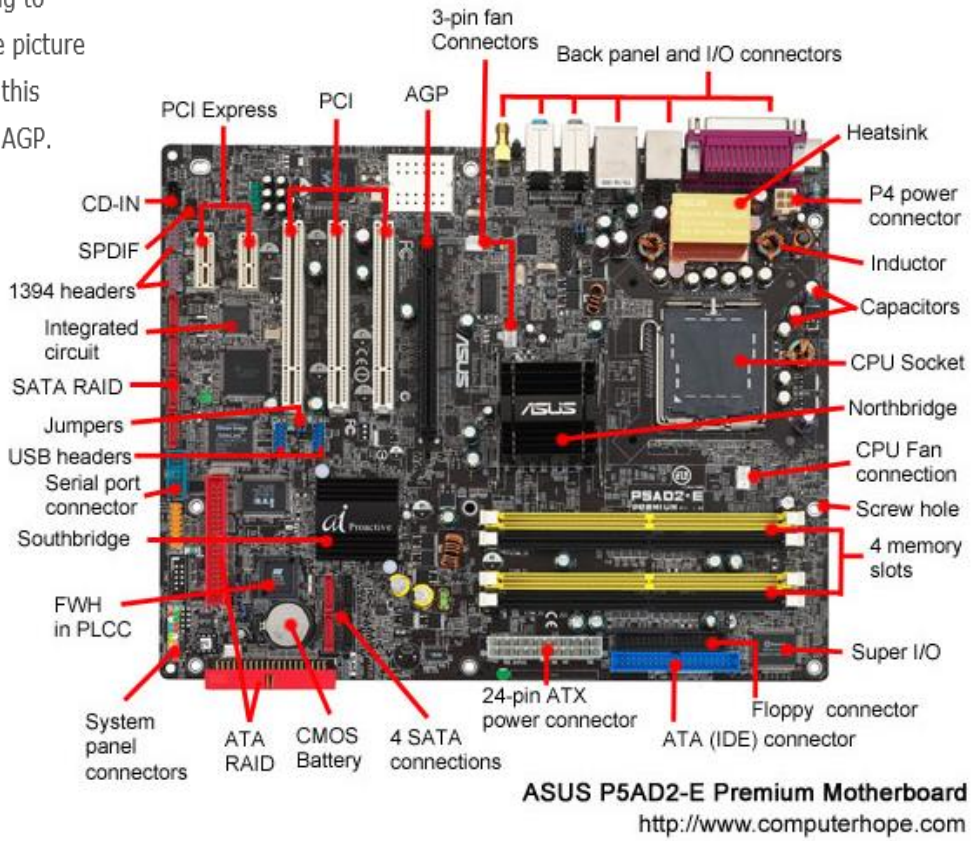
https://www.computerhope.com/jargon/e/expaslot.htm

Expansion Slots

Many of the above expansion card slots are obsolete. You're most likely only going to encounter AGP, PCI, and PCI Express when working with computers today. In the picture below is an example of what expansion slots may look like on a motherboard. In this picture, there are three different types of expansion slots: PCI Express, PCI, and AGP.

https://www.computerhope.com/jargon/e/expaslot.htm





Buses – Peripheral Connections

- There have been a number of different ways of connecting peripherals to PCs
  - Originally **parallel port** and **RS232 serial port**
  - Now commonly **Universal Serial Bus (USB)**
    - Many generations: USB 1.x, USB 2.0, USB 3.0 etc.
  - Less commonly **Firewire**
    - An Apple trademark - properly known as **IEEE 1394**

http://computer.howstuffworks.com/usb.htm

Power Supply (PSU)

- All PCs need power
- Usually comes from:
  - Mains electricity
  - Battery (laptops etc.)

- Modern power supplies will detect input voltage
- Better supplies have modular cable systems, allowing you to just use the cables you need
- Heed health & safety warnings!

Cooling

- Computers use a lot of power - ends up as heat!
- Heat is very bad for computers – causing processors and other components to fail
- It is usual to have a number of fans:
  - Case fan
  - Processor fan
  - Graphics processor fan
  - PSU fan

- In general, larger fans move more air, so they can run slower, which makes them quieter

Graphics Cards

- Produce the image that you see on the screen
- One major manufacturer of graphics processors is **Nvidia** (https://www.nvidia.com/en-gb/)
- Most motherboards now have a graphics chip set built in, which is fine for office use but will struggle with games
- Hence the popularity of specialised games consoles – optimised for graphics processing

Sound Cards

- The original IBM PC could only beep
- Sound cards were common additions
- Creative Labs (https://uk.creative.com/) have been at the forefront of sound card technology for many years
- Now, sound is built in to the vast majority of motherboards
- Not always very good quality
- OK for MS-Windows sound effects but not very good for music - better speakers may improve things more than changing the sound card

Network Interface Card (NIC)

- The vast majority of computers are now networked
- Most PCs will have at least one network interface build into the motherboard
- Usually Ethernet running at 100Mbps or gigabit Ethernet at 1000Mbps
- May also have a wireless Ethernet (Wi-Fi, 802.11 a/b/g/n) interface for connecting to wireless access points
- Can still get separate network interface cards, allowing upgrade of older systems or the installation of multiple cards for building firewalls, bridges and routers

References

- http://computer.howstuffworks.com/computer-hardware-channel.htm
- https://www.computerhope.com/
- http://www.learning-about-computers.com/

Awarding Great British Qualifications

Topic 3 – Computer Hardware

Any Questions?