Digital Electronics and Microprocessor Systems (ELEC211)

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Outline

- Introduction
- General purpose processor
- Examples
- Functional units of a processor
  - Input/output unit
  - Bus architecture
  - Central Processing Unit (CPU)
  - Memory and memory organization
- Data Formats and definitions

Computer as a processor

- A computer processes data to provide information
  - E.g. a computer in a supermarket which controls the check-out tills.
  - When the bar code of a bag of sugar is passed over the bar code reader the data it contains is processed by the computer.
  - The computer provides information such as price and description to show on the till display and to print on the receipt.

Computer versus human

- A human can perform the same functions as a computer
  - E.g. the human could read the number next to the bar code, look that number up in a table, read out the price and description to the customer and write them down on the receipt.
- The only difference is computers can do this much more quickly and they don't make mistakes when they get tired.

Instructions

- For a human to perform a task she/he needs instructions
  - E.g. to knit a jumper the instructions are the knitting pattern or to bake a cake the instructions are in the recipe.
- Computers also need instructions so that the data is processed into information correctly.

General purpose processor

A processor is a device that runs a set of instructions (program)

- Reads input data
  - Keyboard, mouse, camera, microphone
- Processes data
  - Registers, Control Unit, ALU
- Stores data
  - Memory, hard-drive
- Send output data to different peripherals
  - Screen, speakers

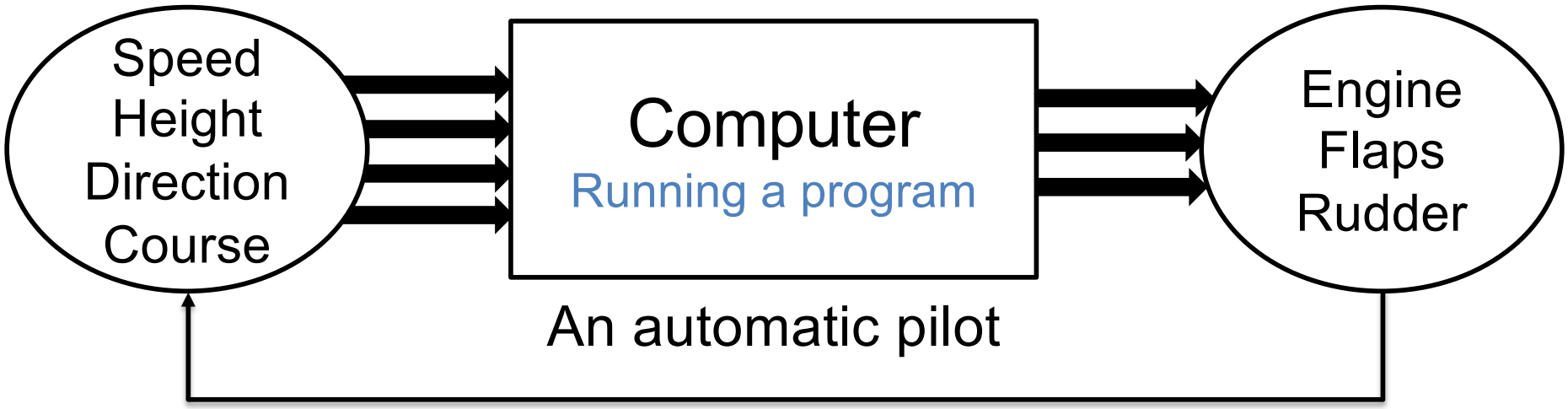
Example 1: video game

- Input data
  - Joystick movement, button presses
- Output data
  - Pictures from the screen, sounds from the speakers

A video game

Example 2: automatic pilot

- Input data
  - Aircraft speed, height, direction and course
- Output data
  - Signal to control the engines, flaps and rudder

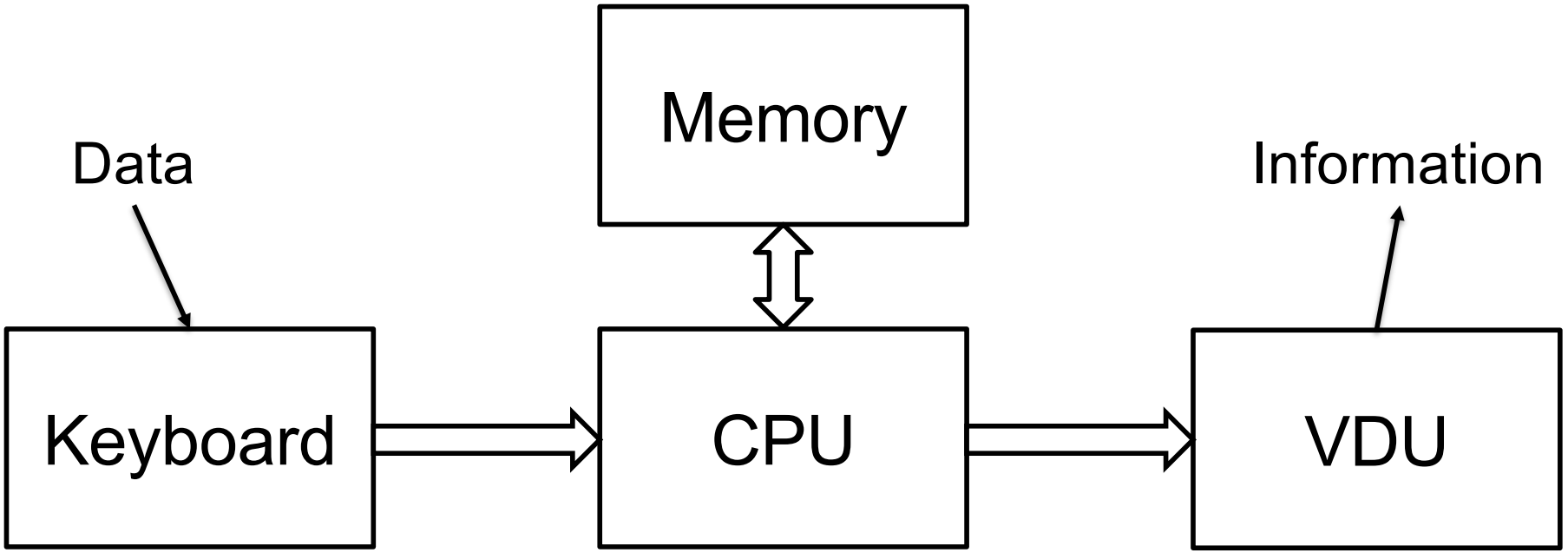


A simple computer

- So a simple computer needs to be able to receive data, process it and return information back.
- In addition the computer must be able to store instructions.
- A keyboard can receive data into the computer.
- A CPU (central processing unit) can process it.
- A VDU (visual display unit) can return the information to the user.
- And computer memory can store instructions

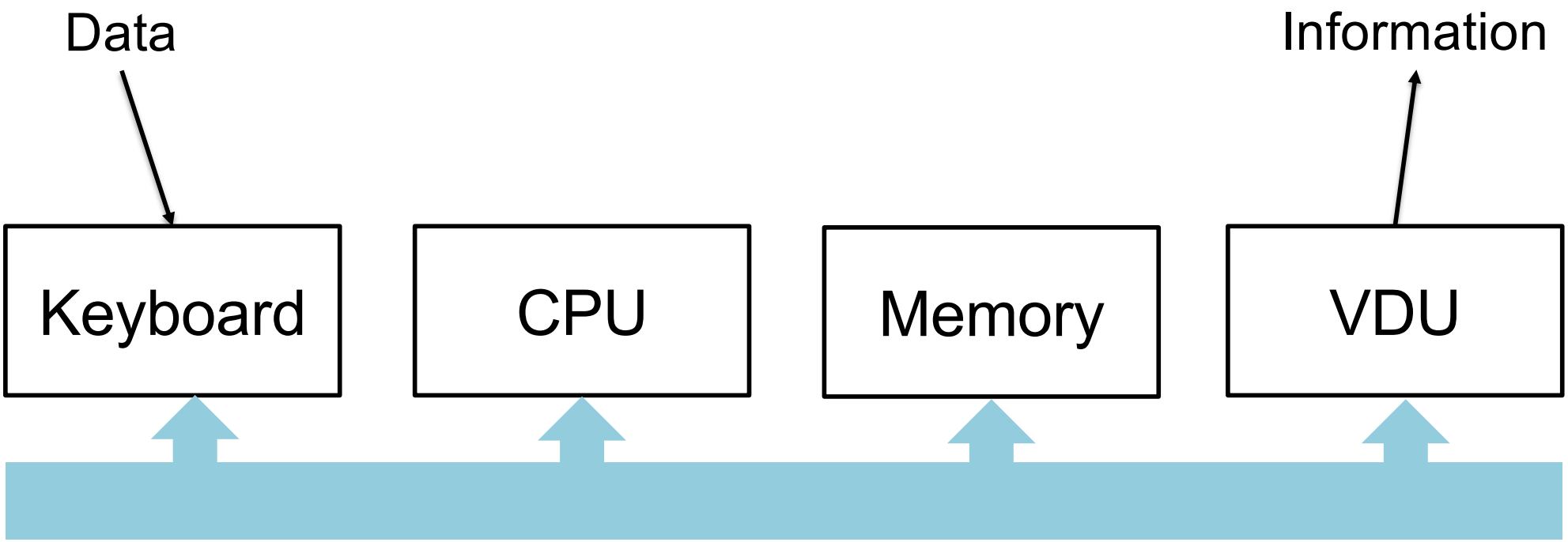
A simple computer architecture

- A simple computer layout or ‘architecture’ could be as shown below. Data and information pass between the blocks as electrical signals.



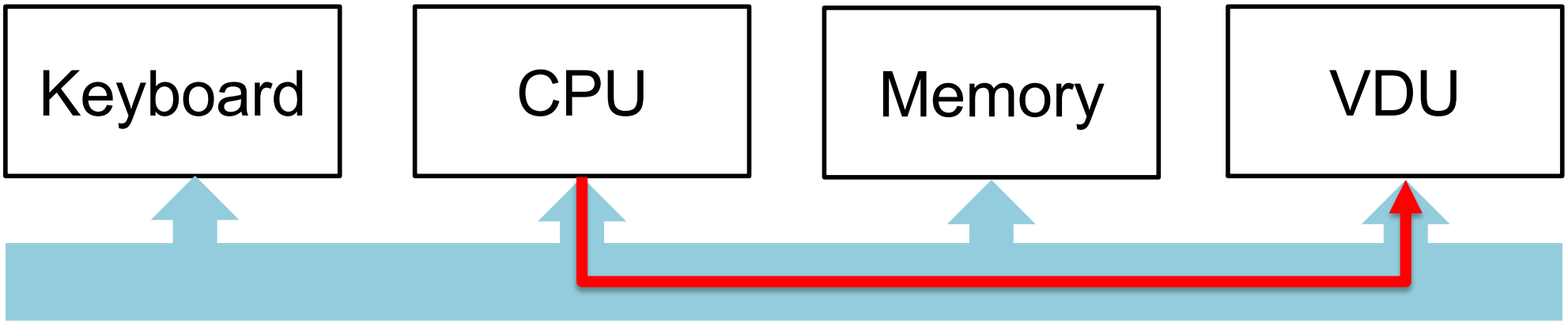
The Bus Architecture

- The bus architecture can be extended over any number of devices. All devices have only one connection onto the ‘bus’.



The Bus Architecture

- A bus is a collection of electrical connections - normally 8, 16, 32 or 64 individual wires.
- 32 bits of data and information can pass along a 32 bit bus at the same time
  - E.g. the codes of 4 ASCII characters could go from CPU to VDU.

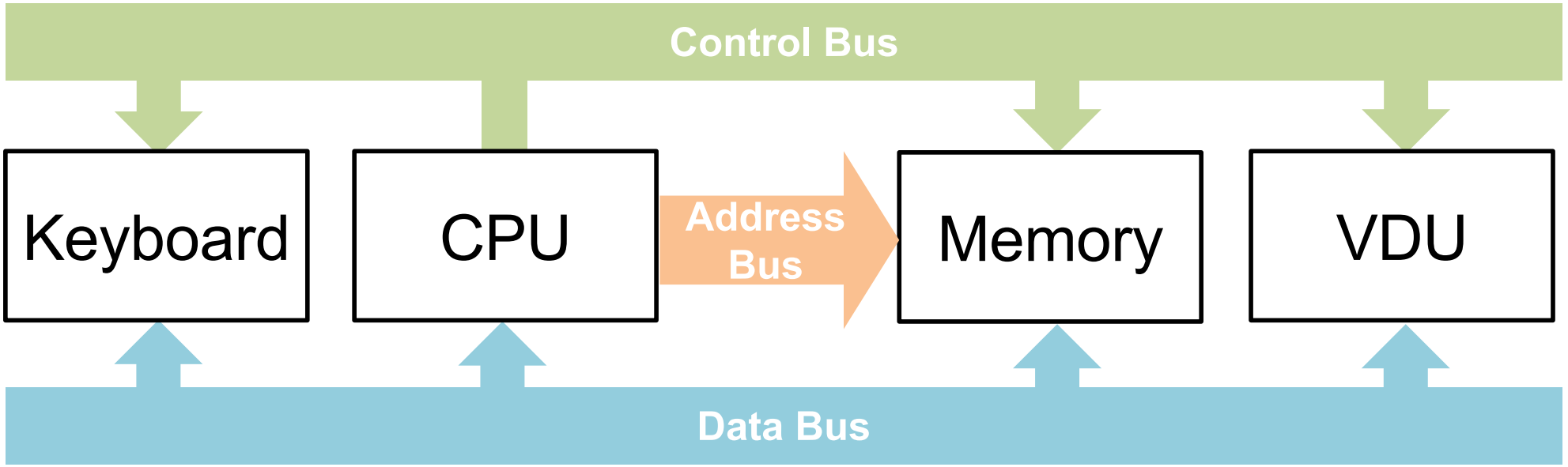


Controlling the Bus

- It is important that signals do not collide on the bus - only one device at a time can send data.
- The CPU controls all movements on the bus using special wires to activate devices and to synchronise the sending and receiving devices.
- These special connections are known as the control bus and they are completely independent of the bus along which data is passed.
- To avoid confusion this is called the data bus.

A Third Bus

- In addition to the data bus and control bus there is a third bus called the address bus. The address bus is used by the CPU to determine which location in memory is sending or receiving data.



What is in memory?

- Memory is used to store the instructions which the CPU uses to process the data.
- Memory can also be used to store data in the form of numbers or characters.
- All computer memories work in binary so that instructions and data must be coded in binary
  - E.g. characters can be coded in ASCII
- Instructions are coded in ‘machine code’.

What is computer memory?

- Computer memory is a very big sequential logic circuit made up of thousands or millions of simple logic gates, such as a D type latch, which can remember a 0 or a 1, that is one bit of data. Groups of these gates are collected together in a memory ‘location’.
- There are typically 8 bits of data in one location.
- Each memory location has a unique memory address
  - E.g. 512 ROM Street, L’pool, L16 3PC

Memory organization

- Taking the ARM7TDMI microprocessor as an example at each memory location it has 8 bits of data - 8 bits is known as a byte.
- The ARM is a 32 bit processor and addresses are 32 bits long from 0x00000000 to 0xFFFFFFFF.
- That means there can be up to 4,294,967,296 (or 2^{32}) different memory locations all with a unique memory address.
- In practice not all addresses are used for memory.

Memory storage capacity

- The size of memory can be expressed using two different systems and these are often confused.
  - Kilobytes (kB), megabytes (MB) and gigabytes (GB)
    - Refers to multiples of 1000 like other SI units
    - Typically used for HDD and DVDs.
  - Kibibytes (KiB or KB), mebibytes (MiB) and gibibytes (GiB)
    - Refers to multiples of 1024 (= 2^{10})
    - Typically used for semiconductor memory storage, capacity and sizes of computer files / software.

Some definitions

- A byte is equal to 8 bits.
- A kibibyte is equal to 1024 bytes ($1024 = 2^{10}$).
- A mebibyte (MiB) is equal to 1024 kibibytes or 1048576 bytes ($1048576 = 2^{20}$).
- A gibibyte (GiB) is equal to 1024 mebibytes or 1073741824 bytes ($1073741824 = 2^{30}$).
- A 32 bit processor could be directly connected to 4 GiB of memory using a 32 bit address bus if every memory address had memory connected.

Some definitions

Decimal term	Abbreviation	Value	Binary term	Abbreviation	Value
kilobyte	kB	10^3	kibibyte	KiB	2^{10}
megabyte	MB	10^6	mebibyte	MiB	2^{20}
gigabyte	GB	10^9	gibibyte	GiB	2^{30}
terabyte	TB	10^{12}	tebibyte	TiB	2^{40}
petabyte	PB	10^{15}	pebibyte	PiB	2^{50}
exabyte	EB	10^{18}	exbibyte	EiB	2^{60}
zettabyte	ZB	10^{21}	zebibyte	ZiB	2^{70}
yottabyte	YB	10^{24}	yobibyte	YiB	2^{80}

Question

Poll locked. Responses not accepted.

How many kibibytes are there in a gibibyte?

32768

1048576

1024

2^{30}

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Some more definitions

- Another term which is commonly used is a ‘word’.
- The ‘word’ depends upon the processor used and for a 32 bit processor like the ARM a word is equal to 32 bits or 4 bytes.
- Similarly a ‘half word’ is 16 bits or 2 bytes.
- Another way to say this is that the ‘word length’ is 32.

Question

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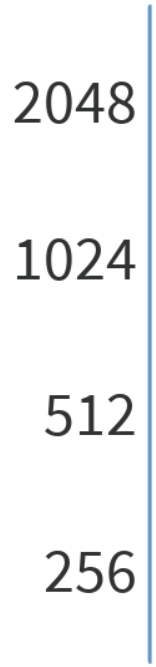
For the ARM processor, how many words are there in a kibibyte?



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Question

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How many bits are there in a kibibyte?

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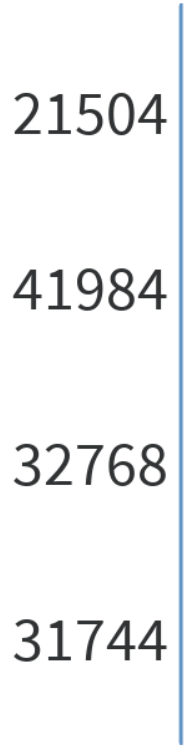
Question

Poll locked. Responses not accepted.

How many bytes are there in 31 kibibytes?



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Summary

- General purpose processor
- A simple computer architecture
- Functional units of a processor
- Data formats and definitions

Next class?

Tomorrow at 2 p.m. in the
Building 502,
Lecture Theatre 2
(502-LT2)