4 Operating systems and computer architecture

Term	Definition
Operating system	The software running in the background of a computer system. It manages many of the basic functions
Interrupt	An interrupt is a signal sent from a device (or from some software) to the processor requesting its attention
Buffer	A buffer is a temporary memory area in a device
Computer architecture	How a computer system is designed
Buses	Buses move data around the computer and also send out control signals to synchronise the internal operations
Register	High-speed storage areas within the computer
Memory unit	Made up of addresses and contents
Control unit	Controls the operation of the memory, processor and input/output devices

Operating systems, interrupts and buffers

Operating systems

The basic operations/tasks carried out by an operating system include:

- human–computer interface (HCI)
- multi-tasking

- multiprogramming
- batch processing
- error handling/reporting
- load/run applications
- management of user accounts
- file utilities (such as save, copy, delete)
- processor management
- memory management
- real-time processing
- interrupt handling
- security (e.g. log on, passwords, username, etc.)
- input/output control.

Some household devices, such as ovens or washing machines, do not require an operating system. This is because they carry out simple, unchanging tasks which are initiated by the user pressing a button or selecting from a touch screen.

Interrupts and buffers

An interrupt is a signal sent from a device (or from some software) to the processor requesting its attention. The interrupt will cause the processor to temporarily stop what it is doing to service the interrupt. Examples include: paper jam in a printer, pressing <CTRL><ALT><BREAK> keys on a keyboard or software trying to divide by zero.

A buffer is a temporary memory area in a device. It is often used to compensate for the slower operating speed of peripherals when compared to a processor. Buffers allow a processor to carry on with other tasks whilst, for example, a print job is being carried out in the background. They are also used when streaming music or videos from the internet to

ensure that playback doesn't keep pausing waiting for the data transfer/download to take place.

Common errors

- Students often claim that a message or data (rather than a signal) is sent to a processor as a definition of an interrupt; such answers always lose marks.
- Many students think that it is only hardware that can send interrupts; in fact, software interrupts are far more common (these can either be faults in the software itself or errors found during running,

Examiner's tips

When writing essay-type questions, remember to pick out the main points; it is often a good idea to note down key points (in the margin or on one of the blank sheets) to ensure you don't miss any of these points in your final answer.

Computer architecture

Von Neumann architecture

This concept holds programs and data in memory. Data moves between the memory unit and the processor. A number of different diagrams exist to show the links and flow of data between the processor (control unit), memory unit and input/output devices.

Buses

Buses move data around the computer and also send out control signals to synchronise the internal operations. There are three different buses used:

- **Address bus:** this carries signals relating to addresses between the processor and memory; it is uni-directional.
- **Data bus:** this sends data between the processor, memory unit and the input/output devices; it is bi-directional.
- **Control bus:** this carries signals relating to control and coordination of all activities within the computer; it can be uni-directional or bi-directional due to internal connections.

Registers

These are high-speed storage areas within the computer; all data must be represented in a register before it can be processed. There are five different registers in this type of architecture:

- Memory Address Register (MAR)
- Memory Data Register (MDR)
- Arithmetic and Logic Unit (ALU)
- Program Counter (PC)
- Current Instruction Register (CIR).

Memory unit

This is made up of addresses and contents. Each address will uniquely identify every location within the memory map.

Control unit

This controls the operation of the memory, processor and input/output devices; the control unit reads instructions, interprets them and sends out signals along the control bus to synchronise all computer components.

Common errors

- Students often confuse the role of the MAR and MDR in, for example, the READ and WRITE operation from/to the memory unit.
- Many students suggest that the ALU can 'make decisions'; this is not the case – the ALU allows arithmetic and logical operations to be carried out and makes no decisions on what happens following these operations.

EXAMPLE:

3 a The location in a memory unit contains the address 1 1 0 1 1 0 0 0 and the contents 0 0 0 1 1 0 0 0.

Describe a READ operation on location 1 1 0 1 1 0 0 0 indicating the role of the MAR, MDR and buses.

b If the value 1 1 1 0 1 1 1 0 is to be stored in location 1 1 1 1 0 1 1 1, describe the WRITE operation indicating the role of the MAR, MDR and buses.

Student answer

3 a MAR will contain 1 1 0 1 1 0 0 0

MDR will contain 0 0 0 1 1 0 0 0

A read signal is sent to the computer memory along the control bus.

b MAR will contain 1 1 1 1 0 1 1 1

MDR will contain 1 1 1 0 1 1 1 0

A write signal is sent to the computer memory along the control bus.

Examiner's comments

Whilst the student has answered the question correctly in both parts, it is often a good idea to show a memory map to aid in the description.

Address	Contents
1101 1000	0001 1000
↓	↓
1111 0111	1110 1110

This will help greatly in the description of the READ and WRITE operation. The location contains the address and contents; it is important to distinguish between location and address.

Examiner's tips

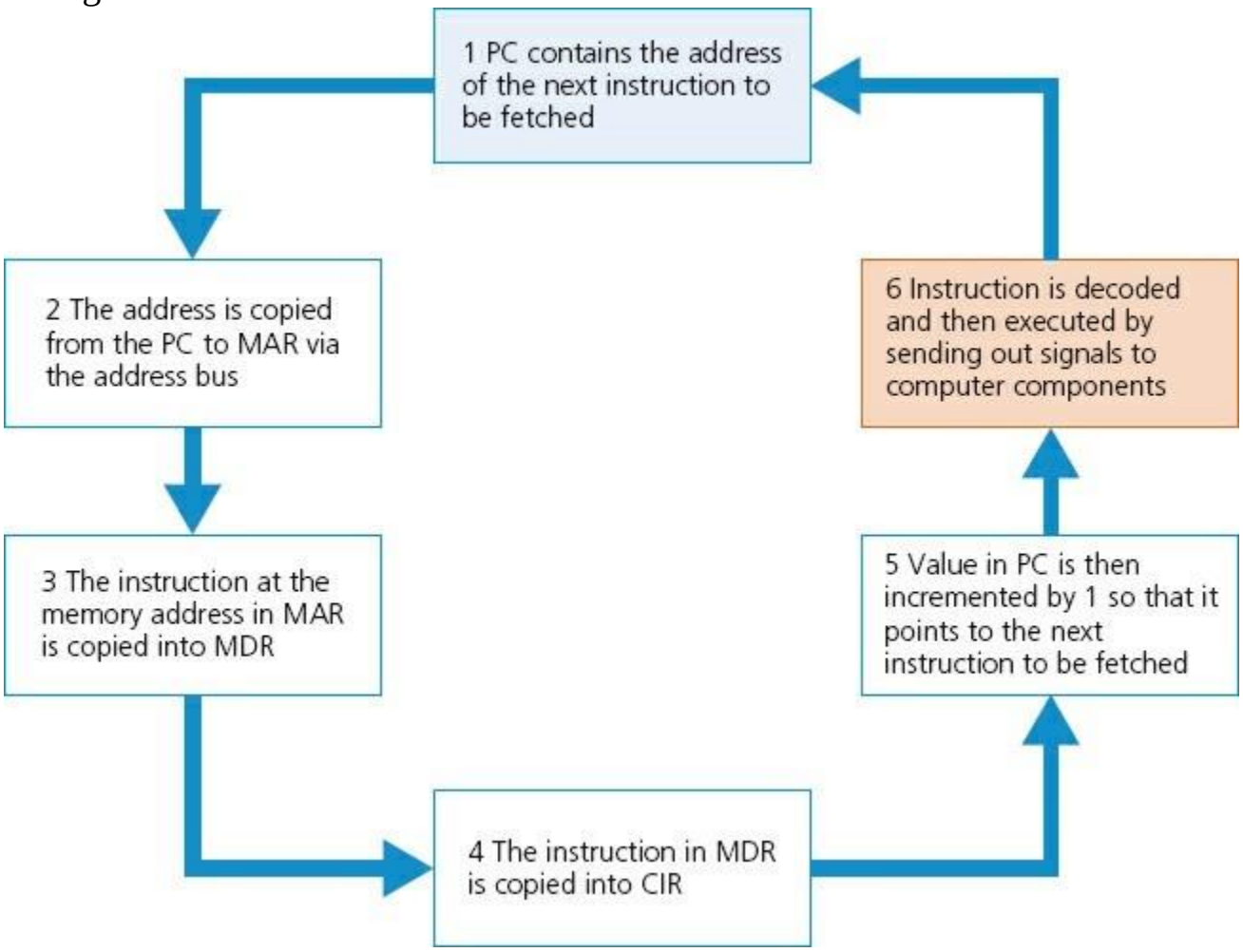
A basic understanding of how to draw a diagram linking together all the components in the von Neumann computer architecture is very useful in questions of this type. The two diagrams shown in the Student's Book are fairly simple to understand, but other diagrams exist which prove to be more useful to some students.

Fetch–execute cycle

Fetch: the next instruction is *fetched* from the memory address currently stored in the Program Counter (PC) and is then stored in the Current Instruction Register (CIR); the PC is then incremented so that the next instruction can be processed.

Execute: the decoded instruction is then passed as a set of control signals to the appropriate components of the computer system.

In diagrammatic form:



EXAMPLE 2:

5 Describe three of the registers used in the fetch–execute cycle including their function.

Student answer

Program counter (PC) – this is used to keep track of the address of the next instruction to be fetched.

Memory address register (MAR) – this stores the address of the instruction to be processed.

Memory data register – this stores the instruction to be processed.

Current instruction register – this temporarily stores the instruction currently being processed.

Examiner's comments

All that is required is a brief description of the function of each register. Just naming the registers would not be enough for more than half the marks in a question of this type.
Only three registers were needed.

Examiner's tips

It is a good idea to learn the rudimentary diagram showing the von Neumann computer and

also to try to apply the fetch–execute cycle to your diagram; this will greatly help in questions involving computer architecture and how instructions are processed.

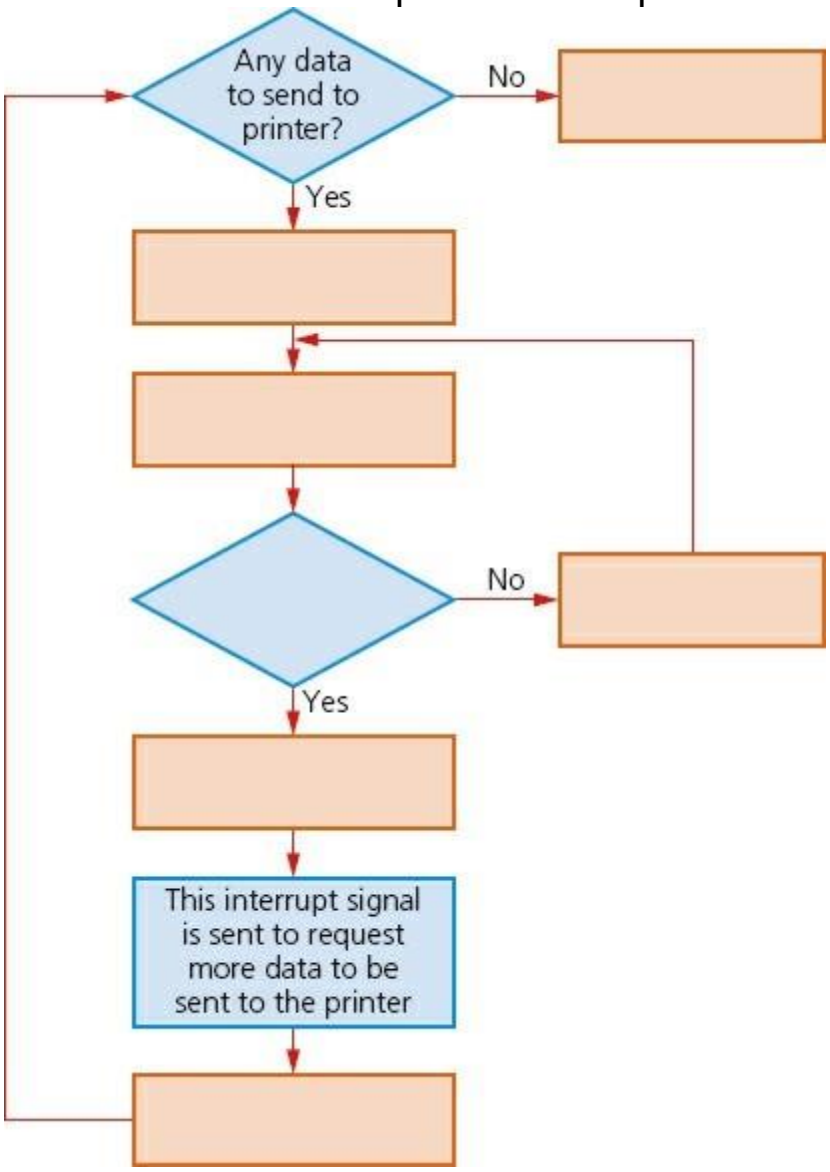
PRACTICE:

1 **a** What is meant by the two terms:

(i) buffer
(ii) interrupt?

[4 marks]

b Look at the flowchart which shows what happens when a document is sent to a printer and is printed out.



Seven statements are missing from the flowchart.

By writing the statement numbers ONLY, complete the flowchart, using the statements from the following list.

[7 marks]

Statement number	Statement
1	contents of the buffer are emptied to the printer and data from the document printed
2	current processor task is suspended whilst the interrupt is being serviced
3	data from the document to be printed is sent to the buffer from the computer memory
4	has all the data been sent to the printer?
5	processor continues with its tasks
6	processor is able to carry out other tasks while the buffer is being emptied
7	when all the data is printed, the buffer becomes empty; an interrupt signal is then sent to the processor

2 **a** A student made the following statements. Explain the statements.

(i) 'Windows is an example of a single-user multi-tasking operating system.'

(ii) 'Many operating systems support error handling.'

[4 marks]

b Name **three** other features of an operating system.

[3 marks]

3 **a** Name and explain the function of the three main buses used in a typical computer system.

[6 marks]

b Look at this memory map.

(i) The contents at address 1 0 0 0 0 0 1 1 are to be read. What values would be stored in the MAR and MDR?

(ii) If the value 1 1 1 0 0 1 1 1 is to be written at memory location 1 1 1 1 1 1 1 0, what values would be stored in the MAR and MDR?

(iii) Complete the memory map showing the value from part (ii) after the WRITE function has been done.

[5 marks]

Address	Contents
1000 0000	1000 1000
1000 0001	0111 0110
1000 0010	1100 1111
1000 0011	0101 0110
1000 0100	1111 1110
↓	↓
1111 1100	
1111 1101	
1111 1110	
1111 1111	

4 a (i) Describe the function of the ALU.

(ii) Describe the function of the Control Unit.

[4 marks]

b The following table shows the stages in the fetch–execute cycle. They are not written in the correct order. Place the numbers 1 to

6 in the right-hand column to show each stage in its correct order.

The first one has been done for you.

[5 marks]

Stage	Order
address is copied from PC to MAR; this is done using the address bus	
contents at memory location contained in MAR are copied temporarily into MDR	
contents of MDR are copied and placed in CIR	
instruction is finally decoded and then executed by sending out signals (via the control bus) to various components of the computer system	
program counter (PC) contains address of memory location of next instruction to be fetched	1
value in PC is incremented by 1 so that it now points to the next instruction to be fetched	