NAME DATE STARTED TARGET END DATE

GCE A LEVEL — COMPUTER SCIENCE UNIT 4 QUESTION PACK

1500U40-1 · 2015 spec Unit 4 Topic 2 · A2 unit, first sat 2017, 100 marks, 2h paper

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COMPUTER SCIENCE — UNIT 4 · Operating Systems — Interrupts, Scheduling, Processes & Buffering

Topic 4.2 — OS responsibilities: process states, interrupt handling, priorities and buffering

Naming and describing the three basic states of a process (ready/running/blocked), how interrupts are generated and prioritised, where interrupt-checking fits into the fetch-decode-execute cycle, and why buffering (single and double) is needed when fast and slow devices co-operate.

2015 specification · current

Estimated time for entire question pack: ~1 h 14 min

Derived from the Unit 4 pace of ~1.5 min/mark, padded for written-prose answers (49 marks over 6 questions).

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive topic question pack**, not a single mock paper. It contains every question from the WJEC A2 Unit 4 papers (Summer 2017 – Summer 2024, COVID gap) that maps onto Topic 4.2 of the 2015 specification.

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working. A calculator is allowed where useful.

For Examiner's use only

Q	Source	Max	Mark
1	S17 Q7	13	
2	S19 Q1	10	
3	S22 Q2	4	

Q	Source	Max	Mark
4	S23 Q8	6	
5	S24 Q3	4	
6	S24 Q5	12	
Total		**49**	

Operating Systems — Interrupts, Scheduling, Processes & Buffering — what the spec asks

WJEC GCE A Level Computer Science (from 2015) · Unit 4: Computer Architecture, Data, Communication & Applications · Topic 4.2.

Process states

- Ready: process is waiting for the scheduler to give it CPU time.
- Running: currently using the CPU.
- Blocked / waiting: held up waiting for I/O or another event.
- Transitions: ready→running (scheduled), running→blocked (I/O), blocked→ready (event signalled).

Why we need interrupts

- Allow asynchronous events (key press, completed I/O, hardware fault) to be serviced.
- Avoid CPU wasting cycles polling slow devices.
- Provide an entry point for the OS to make scheduling decisions.
- Support multi-tasking and real-time response.

Interrupt handling

- Save current process state (PC, registers) onto a stack.
- CPU jumps to an Interrupt Service Routine (ISR) chosen via an interrupt vector.
- After the ISR finishes, state is restored and the original process resumes.
- Interrupts of higher priority can pre-empt lower-priority handlers.

Priorities

- Hardware errors / power failure get the highest priority — act immediately.
- Real-time / time-critical I/O next (sensor, network packet, audio buffer).
- Software-generated interrupts (system calls) at lower priority.
- Same-priority interrupts are typically queued in arrival order.

Where interrupts fit in the cycle

- After every fetch–decode–execute cycle the CPU checks the interrupt flag.
- If set, the current process is suspended and the ISR runs.
- Only the highest-priority pending interrupt is handled at any one time.
- Once cleared, the CPU resumes the interrupted process exactly where it left off.

Buffering

- Buffer = temporary memory region between a fast producer and a slow consumer (or vice versa).
- Single buffer: one region; producer waits while the consumer drains.
- Double buffering: two buffers swap roles — producer fills one while consumer empties the other.
- Essential in printing, audio/video streaming, 3-D printing, network IO.

Crib sheet »

Operating Systems — Interrupts, Scheduling, Processes & Buffering in one page

Quick-reference notes — revisit before each question.

Process states

Ready — in run queue.
Running — on the CPU.
Blocked — waiting for I/O.
Transitions driven by scheduler & events.

Interrupt cycle

1. Save state (PC, regs).
2. Look up ISR in vector table.
3. Run ISR.
4. Restore state.
5. Resume original process.

Priorities

HW fault / power > real-time IO > clock tick > software syscall > user.
Higher pri pre-empts lower; same pri queues.

Buffer

Temp memory between fast & slow.
Single buffer: one region.
Double buffer: producer fills B_1 while consumer empties B_2, then swap.
Smooths throughput, hides latency.

Examples of interrupts

Hardware: keyboard press, mouse click, disk done.
Software: syscall, divide-by-zero, page fault.
Timer tick: pre-emptive scheduling.

Where interrupts fit

Checked at end of each fetch-execute cycle.
If pending, current process suspended.
OS picks highest-priority ready handler.

7. *(a)* When scheduling, name and describe the **three** basic states of a process. [6]

(b) Interrupts cause the operating system to respond to system events. Give **two** examples of common interrupts. [2]

(c) Describe a single buffer and a double buffer. Explain the role of a single buffer and a double buffer. Explain why double buffering is usually preferred. [5]

8. Cryptography uses asymmetric or symmetric encryption methods.

Symmetric encryption methods use a single key which encrypts and decrypts data. Asymmetric encryption methods use a public key for encryption and a private key for data decryption.

(a) Describe the advantages of asymmetric encryption and the advantages of symmetric encryption. [4]

(b) The Boolean operation XOR is often used in cryptography.

In the 8 bit ASCII character set, the characters OK! are represented by the following binary numbers.

$O = 01001111_2$
$K = 01001011_2$
$! = 00100001_2$

Use XOR to encrypt the string OK! with the 8 bit binary key 11110011_2 [3]

(c) Describe **two** deficiencies of the key used in question 8*(b)*. [2]

9. A company with a large office building operates a “Bring Your Own Device to Work” (BYOD) scheme allowing employees to use personal devices (e.g. tablet or laptop) on the company’s network.

(a) Describe the hardware necessary to connect a device to the company’s network wirelessly and provide an Internet connection. [3]

(b) Identify and describe **two** network applications that could be used by an employee with a connected device. [4]

Answer **all** *questions.*

1. *(a)* (i) Define the term **buffering** in a computer system. [2]

(ii) Explain why buffering may be required. [2]

(iii) Discuss the benefits of double buffering over single buffering. [2]

(b) (i) Explain what is meant by the term **interrupt** in a computer system. [2]

(ii) Describe **two** instances where an interrupt would be generated, and the resulting action which would be taken by the computer. [4]

2. A plumber when undertaking a **job** will record the job number and description. She also records the items used for the job. Each **item used** can be found in a **stock list** (that includes stock codes and unit prices). A job may take more than one day, and the date and number of hours worked on each of the days are recorded in a **work session** table.

(a) Produce an entity-relationship diagram for the record system described above. [3]

(b) Design a database in third normal form to store the information required for the record system. [6]

3. A university runs a variety of degree courses. Each course consists of a number of modules, with each module studied for one year of the course. Students study several modules at the same time.

Two tables in the database, with example records, are shown below:

COURSE

CourseID	CourseTitle	Degree	YearsDuration
386	Environmental Science	BSc	3
427	Mechanical Engineering	MSc	4
781	Modern Languages	BA	3
925	Modern Languages	MA	1

MODULE

ModuleID	CourseID	ModuleTitle	YearStudied	StudentsEnrolled
1022	386	Freshwater Biology	2	42
2782	781	Russian, level 1	1	19
2988	781	Portuguese, level 2	2	27
3519	427	Hydraulic Systems	3	38

Answer **all** questions.

1. A file manager program provides an interface to a computer's file system.

(a) Describe how files may be organised and managed using a file manager program. [3]

(b) Files may be organised using a hashing algorithm. Explain the purpose of a hashing algorithm. [3]

2. Interrupts are often generated in a computer system.

(a) Identify a situation in which a high-priority interrupt may be generated. [1]

(b) Describe the procedure for dealing with an interrupt with a higher priority than the interrupt that is currently being processed. [3]

3. An assembly language program is required to check a four digit numeric code against a code stored in location Y.

If the code is entered correctly then the program should output 1. If the code entered is incorrect the program should output 2 and should allow the user to re-enter a code.

The assembly language used by the processor has an instruction set which includes the following commands:

Assembly Language Command	**Description**
INP	Input numeric value to the accumulator
OUT X	Output a numeric value X
STA X	Copy contents of accumulator to memory location X
LDA X	Load accumulator with contents of memory location X
HLT	End
SUB Y	Subtract the numeric value in location Y from the accumulator, leaving the result in the accumulator
JZE LABEL	Jump to LABEL if the contents of the accumulator are equal to zero
JMP LABEL	Jump unconditionally to LABEL

Using the instruction set, write a program to check the code entered. [6]

7. The owner of a shop requires a program to store stock records. Each stock item has a three-digit identification code in the range 000 to 999. The number of different stock items held by the shop is currently 95.

A programmer considers two different methods of storing the stock records:

- A direct access file with 100 storage locations. The location for each item is calculated using the hash function: identificationCode MOD 100.
- A sequential access file with 1000 storage locations. The stock record is stored at the location corresponding to its identification code, so product 715 will be stored at location 715.

Explain the advantages and disadvantages of these two methods. [6]

8. Describe the three basic states of a process in a multi-tasking computer. [6]

9. Improved worker safety is a benefit of automation.

(a) Describe **two** *other* benefits and **two** drawbacks of automating a manufacturing process. [4]

(b) Explain, giving an example of each type of system, the main purpose of:

- a safety related control system
- a safety critical control system.

[4]

Answer **all** questions.

1. Describe the role of three of the main components of a contemporary Central Processing Unit (CPU). [6]

2. AJ Jewellers uses a direct access file with a separate overflow area to store stock records. Each record has a key field made up from a four-digit code followed by the year number, for example: 137524, 701924.

It is proposed to use the hashing algorithm: key field MOD 1000

(a) Calculate the location of the stock records for each of the two example key fields. [2]

(b) Explain why this hashing algorithm is unsuitable. [3]

(c) Give an example of a more suitable hashing algorithm for the file. [1]

3. AJ Jewellers has invested in a 3D printing system to produce objects in precious metals. The system includes CAD software and a double buffering printer interface.

Explain why the 3D printing system uses double buffering. [4]

4. (a) The maximum increase in speed due to parallel processing can be calculated as:

$$\frac{1}{S + \frac{P}{N}}$$

where P = parallel fraction, N = number of processors and
S = serial fraction. (S = 1 – P)

(i) Calculate the maximum increase in speed due to parallel processing using 2 processors and the increase in speed of doing the same task using 20 processors, where the parallel fraction P is equal to:

- 0.5 for 2 and 20 processors
- 0.9 for 2 and 20 processors [2]

(ii) Explain the limiting factor of parallel processing indicated by your calculations. [4]

(b) Explain **two** other limiting factors to parallelisation in parallel processing. [4]

5. An interrupt is a signal that is sent to the processor to request immediate attention. The operating system will have interrupt service routines designed to process each interrupt.

(a) Identify **two** events which could generate an interrupt. [2]

(b) Priorities are used when more than one device raises an interrupt. Describe how priorities are used when handling interrupts. [4]

(c) Describe the process carried out when an interrupt affects the execution of the fetch-decode-execute cycle of a running program. [6]

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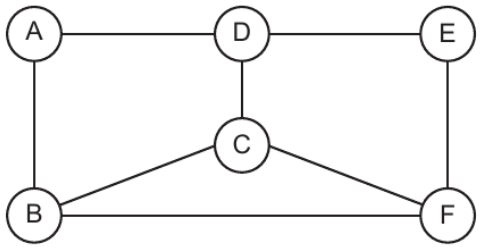
6. A series of nodes are connected in a network, as shown:



For this network a node-to-node transmission speed of 1 Mbps would produce a routing cost = 1. The costs for routing data packets between nodes are given in the table.

Network links	Transmission speed (Kbps)	Routing cost
A–B	250	4
A–D	(i)	20
B–C	100	10
B–F	80	(ii)
C–D	250	4
C–F	500	(iii)
D–E	100	10
E–F	250	4

(a) State the values that should be in cells (i), (ii) and (iii) of the table. [3]

(b) Packets are transmitted using the route that has the lowest total cost. State the route that packets would take from node A to node F. [1]

END OF QUESTION PACK

6 questions · 49 marks · ~1 h 14 min
Source: WJEC A2 Computer Science Unit 4 (1500U40-1), Summer 2017–2024, COVID gap
Curated for WJEC Computer Science 2015 spec A2 Unit 4 — Topic 2 (4.2)