

**Comments** 180 students sat this exam paper. The average mark awarded was 55.6%.

A large majority of candidates chose to answer questions 2 and 3 (in addition to the compulsory question 1). The small number of candidates choosing to answer question 4 split roughly equally between also answering question 2 or question 3. The average marks for each question were similar and consistent with the overall average.

One major reason that marks were lost was an absence of an answer to some part or parts of a question.

Another major reason for loss of marks was an answer that was either partial (only part of the question was being addressed) or imprecise. This particularly affected the compulsory question which contains many "bookwork" style questions. To take just one example, part e) of question 1 asked: "Why is the size of the time-slice in pre-emptive scheduling algorithms chosen to be significantly higher than the time taken for a context switch?" Many candidates stated that the time taken for a context switch is wasted time, but hardly any explained precisely why this is so. It has to do with what the time-slice and a context switch are, and it needs to be explained so that the examiner can be sure that the candidate understands what is going on. It does not require much extra writing to get this across. For example: "Pre-emptive scheduling gives a default fixed amount of time (the time-slice) to a process that is selected to run. When that time is up, the scheduler reconsiders the decision and normally selects a different process to run. In order for the new process to run, a context switch must be performed so that the new process's state is available, instead of the old process's state. This entails transfer of data to-and-from disk by the CPU. The time taken to do this is potentially long and in some sense 'wasted', even though it is necessary for proper operation of the system." Failure to provide this explanation lost one of the two marks available for this part. Similar failings lost marks elsewhere in the paper.

Most candidates coped well with the straightforward problem-solving parts of the non-compulsory questions. The more difficult problem-solving parts were properly dealt with by fewer candidates, as might be expected. Answers to question 4 part c), d) and e) were generally disappointing, suggesting that candidates had in general avoided revision for the file manager part of the operating system.

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## Feedback – COMP25111

### Section A

#### 1. Operating Systems

##### 5 Short Questions RN

#### **General Feedback Comments**

The following general comments are suggested to make your reflection and feedback more readable/succinct and viable for a more general succinct meditation on what you could do to enhance your learning and may be adapt your revision methodology.

First, it is important to reflect on the last lecture RN presented to the cohort; at the end of that lecture a comprehensive set of steps and guidance was presented for revision that students have advised me that they utilise. This was derived from methods students have utilised to revise over the years. The sentiments and guidance in this revision was sometimes given in their own words [the students]; and their own reflection on what worked best for different situations. But, may be it is worth noting that sometimes there can be discrepancies between the student's view of what mark they should have attained and what they actually were awarded. Reflecting on this issue may be it is worth noting and quoting the specific feedback from a student with respect to using the [suggested] self-test (or self-assessment) methodology, they said:

“With regards to the self-assessment questions definitely allowed me to retain and recall large amounts of domain knowledge.

It was especially useful in shorter questions and proved more beneficial than simply re-reading notes in a repetitive manner.”

This is pertinent as without utilising a method like the self-assessment as well as undertaking a number of past exam papers one cannot self-access one's ability to pass the exam or access what mark one may obtain; and it is even more important when one goes into industry as without a good understanding of your own abilities how can you decide which courses to take, either those presented by the company that employs you or by external courses, and hence how can you evolve your personal skill set. You could also assesses where you feel you are in the **The Four stages of Learning (4SoL)**: or **Do you know what you know?**, information on this [4SoL] is on Blackboard 9.

Good companies will encourage you to undertake CPD. Continuing professional development (CPD) or Continuing professional education (CPE) is the means by which people maintain their knowledge and skills related to their professional lives.

One could say that evolving your revision and exam skill at University is, in fact, a form of CPD.

A final point, before getting into the detailed feedback for each question, is to reflect or ask yourself questions such as:

Did I undertake past exam papers? [enough]

Did I undertake a past exam paper –timed? [to get used to the time constraint of a real exam]

Did I develop a self-test (or self-assessment)? and finally

Did you utilise the methodologies presented in RN's exam revision lecture?

One of the recurring points was the advice on diagrams does not seem to have been noted by many students; hence we repeat it hear: Remember, good – honours grade answer – in the exam – for a question – to maximise marks – should – or you should think of adding A DIAGRAM or a set of diagrams; hence a basic layout of a question answer may be:

- 1) Textual answer;
- 2) Diagram supporting answer [or code snippet]; &

3) Full explanation of diagram...  
This sort of answer will [may] maximise your marks...

Two issues (#In) that should be pointed out, which directly effects the marks awarded, are:

#I1: Readability and the tidiness of your written answer, please [in the future] try to write all your answers in: clear, legible, readable, succinct, and concise English. This becomes an issue as the examiners have to read each answer, if they find it difficult or impossible to decipher the hand written text marks cannot be awarded.

#I2: It is imperative that the correct terminology [keywords] are utilised in context in your exam answers; this is so important that the lecturer has added glossaries to each paper copy of your lectures. It is of such importance that in your notes [prior to the start of the glossary] the following advice is given:

Why build a Glossary for each course unit you undertake?

Each module you undertake uses its own jargon.

This can be a problem for new students, whom are trying to comprehend the new domain knowledge attached to a particular new module.

One way to get to know the new jargon is to build your own GLOSSARIES for each course module.

The glossary on the next few pages is a starting point for this module [unit].

Please feel free to add to the glossaries throughout the unit...

The glossary is full of potential exam questions of the form "define X" or "briefly explain X."

Please heed the advice in the future; even if your lecturers do not supply a glossary build your own as without knowledge of the appropriate terminology [keywords] when expounding your knowledge you will not be viewed as comprehending the details of any theory.

- f) What is meant by the term “programmed I/O” in the context of operating systems? In your answer give a brief answer – flowcharts are not required. (2 marks)

1.f

Bookwork (2 marks):

- f) What is meant by the term “programmed I/O” in the context of operating systems? In your answer give a brief answer – flowcharts are not required. (2 marks)

The following points should be covered to some degree in the answer:

The processor periodically polls the status of the I/O device checking on whether a data transfer should be made. Programmed [or polled] I/O’s **not interrupt driven** I/O. In this case, programmed I/O corresponding to the periodically interrogating the peripheral IO. For example, if a character has been typed, it is read and placed in memory utilising programmed IO. Basically the programmed IO routine reads the status register (of the peripheral IO device), then if it has the appropriate bit set [in the status reg.] the routine then reads the data register of the device, and finally stores this data in memory.

**2 marks** for an answer that describes and contextualises all four and gives the salient facts in a sensible way; and provides a well-defined set of brief descriptions of each;  
**1 mark** for some basic understanding (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): Lectures 14 Controlling Input and Output 1.

TOTAL marks (2 marks) [2]

### Marker’s feedback

#### Pedagogic assessment [criterion]:

The question assesses Lectures 14 Controlling Input and Output 1; programmed I/O.

The question’s answer should clearly evidence knowledge of required salient facts relating to “What is meant by the term “programmed I/O” in the context of operating systems?”

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context, for example: with respect to DMA: processor, periodically, polls, (I/O device) checking, **not interrupt driven**, periodically, interrogating, peripheral (IO), programmed IO, status register, appropriate bit set [in the status reg.], then reads the data register, stores (this), data, in memory ...

Main differentiation that must be clearly evidenced in your answer is that you must: clearly, concisely, and explicitly [showing your depth of knowledge] in order to answer the question “What is meant by the term “programmed I/O” in the context of operating systems?” The question’s answer should clearly evidence knowledge of required salient facts relating to the question “What is meant by the term “programmed I/O” in the context of operating systems?” – and should try and utilise the terminology (keywords and naming conventions) given

above; if the majority of the key words were not used this would affect the marks awarded. If the answers did not give a sufficient answer to the question: “What is meant by the term “programmed I/O” in the context of operating systems?” plainly as stated in the above (and in the Example answer), if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded.

If you covered all [or most] the points then full marks were awarded. However if the answer did not utilise the correct keywords in context, and did not show you exercised your academic knowledge in this domain issue by not covering most of the issues full marks could not be awarded.

This theory relating to the question “What is meant by the term “programmed I/O” in the context of operating systems?” was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

g) Differentiate between fixed partitions and multiprogramming. (2 marks)

1.g

Bookwork (2 marks):

g) Differentiate between fixed partitions and multiprogramming. (2 marks)

The following points should be covered to some degree in the answer:

**Fixed partitions:**

Fixed partition divides memory into fixed size blocks.

Fixed partitioning: involved partitioning the available primary memory into a number of regions with each region having a fixed size. The sum of the sizes of all regions [plus that used by the OS itself] equals the size of the primary memory.

**Multiprogramming:**

Multiprogramming has been used in the past; to differentiate from an operating system (OS) running a single program [or Uniprogramming] and one that runs a number of programs concurrently (or multiprogramming).

The OS must first load the multiple programs (into memory [primary {physical} memory]).

The OS will then switch between them [the different programs]; this may be due to the program requiring I/O, or at regular intervals the OS will switch to another of the other programs.

When one of the programs is finished the OS bring in a new one.

**2 marks** for an answer that depicts all the salient facts in a sensible way; and correctly delineated and briefly described;

**1 mark** for some basic understanding (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): Lectures 10 Memory Management (1).

TOTAL marks (2 marks) [4]

**Marker's feedback****Pedagogic assessment [criterion]:**

The question assesses Lectures 10 Memory Management (1); Differentiate between fixed partitions and multiprogramming.

The question's answer should clearly evidence knowledge of required salient facts relating to the differences between fixed partitions and multiprogramming.

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context, for example;

Fixed partitions: divides, memory, fixed size blocks, sum of the sizes of all regions = size of the primary memory.

Multiprogramming: runs, a number, programs, concurrently, load, multiple, programs, into memory, switch (between them), one of the programs is finished, the OS bring in a new one...

Main differentiation that must be clearly evidenced in your answer is the differences between fixed partitions and multiprogramming must be stated explicitly: both should be clearly and theoretically differentiated.

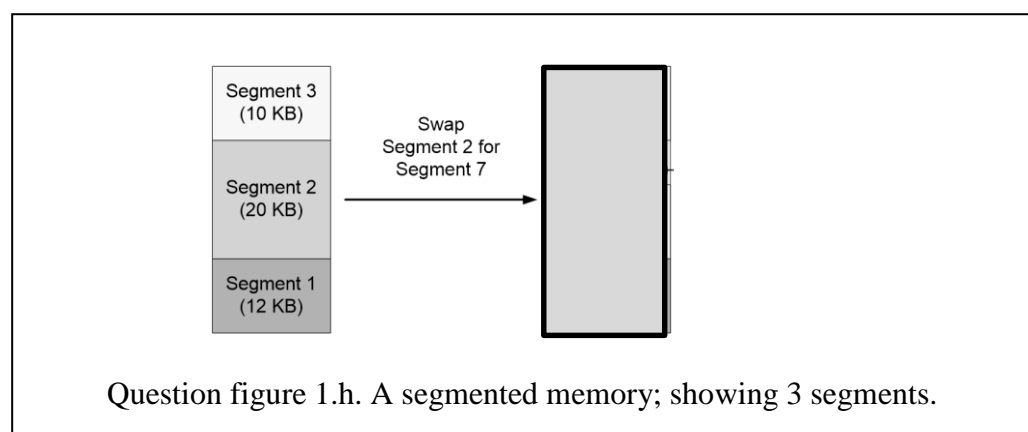
The question's answer should clearly evidence knowledge of the differences between fixed partitions and multiprogramming; this was not done explicitly in some of the answers given – as the terminology (keywords and naming conventions) given above was not used. If the answers did not detail the differences [for each issue] plainly as stated in the above (and in the Example answer); if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded.

If you covered all [or most] the points then full marks were awarded. However if the answer did not utilise the correct keywords in context, and did not show you exercised your academic knowledge in this domain issue by not covering most of the issues full marks could not be awarded.

This theory of the differences between fixed partitions and multiprogramming was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

- h) Given that a segmented memory, in figure 1.h., is to swap out segment 2 (20kB) for segment 7 (14kB). Draw up a diagram depicting the new segmented memory layout; before and after the swap. Comment on any affect swapping segment 2 for segment 7 has on the overall memory space.

(2 marks)



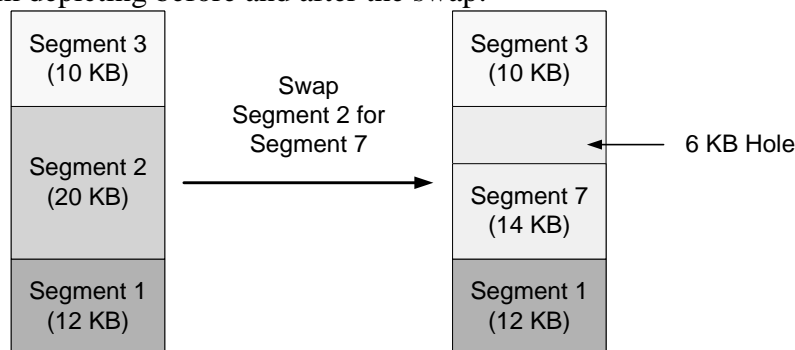
1.h.

Application, critique (2 marks).

- h) Given that a segmented memory, in figure 1.h., is to swap out segment 2 (20kB) for segment 7 (14kB). Draw up a diagram depicting the new segmented memory layout; before and after the swap. Comment on any affect swapping segment 2 for segment 7 has on the overall memory space. (2 marks)

Example answer:- The following points should be covered to some degree in the answer:

- i) Diagram depicting before and after the swap:



(1 mark)

- ii) The effect of swapping segment 2 for 7 is:

That a 6kB hole appears in the memory; where a 20kB segment (2) is swapped for a 14kB segment(7); this is called “External Fragmentation”; which can occur, where memory space is wasted due to ‘holes’ in the physical memory. (1 mark)

**2 marks** for a totally correct part i & ii; and explicit concise explanation for second part of ii, should mention: hole, & external fragmentation.

**1 mark** for some basic understanding (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): 12; Virtual Memory (2), Segmented Virtual Memory.

TOTAL marks (2 marks) [6]

### Marker’s feedback

#### Pedagogic assessment [criterion]:

The question assesses 12; Virtual Memory (2), Segmented Virtual Memory; question aligned to drawing up a diagram depicting the new segmented memory layout; before and after the swap.

The question’s answer should clearly evidence knowledge of required salient facts relating to what happens next when a segmented memory, in figure 1.h., is to swap out segment 2 (20kB) for segment 7 (14kB)?

fragment, or  
external  
fragment

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context, for example: with respect to DMA: segment, swap, hole, fragment, or external fragment ...

Main differentiation that must be clearly evidenced in your answer is you fully depict a diagram that visualises the facts relating to what happens next when a segmented memory, in figure 1.h., is to swap out segment 2 (20kB) for segment 7 (14kB); in detail with the appropriate annotation (and use of keywords).

The question's answer should clearly evidence knowledge of required salient facts relating to the facts relating to what happens next when a segmented memory, in figure 1.h., is to swap out segment 2 (20kB) for segment 7 (14kB); this was not done explicitly in some of the answers given – as the terminology (keywords and naming conventions) given above was not used. If the answers did not detail the differences [for each before and after phase] plainly as stated in the above (and in the Example answer); if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded.

If you covered all [or most] the points then full marks were awarded. However if the answer did not utilise the correct keywords in context, and did not show you exercised your academic knowledge in this domain issue by not covering most of the issues full marks could not be awarded.

This theory of the facts relating to what happens next when a segmented memory, in figure 1.h., is to swap out segment 2 (20kB) for segment 7 (14kB) was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.



- i) In the context of relocation of memory addresses what are base and limit registers and what do they enable a virtual memory to undertake? (2 marks)

1.i.

Bookwork (2 marks).

- i) In the context of relocation of memory addresses what are base and limit registers and what do they enable a virtual memory to undertake? (2 marks)

Example answer:- The following points should be covered to some degree in the answer:

**1/ Base and limit registers** are special hardware registers.

When a process is run, the base register is loaded with the physical location where the process begins in memory.

The limit register is loaded with the length of the process.

In other words, they define the logical [allowable] address space [in the physical memory].

**2/ They enable** virtual addresses to be relocated to physical address space.

This is achieved by adding the base address (in the base address register) to the address from the CPU [virtual address] to calculate its actual physical address.

**2 marks** for a totally correct using keywords in context and explicit description including good explanation of utilisation,

**1 mark** for some basic table (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): 10, Virtual Memory (1).

TOTAL marks (2 marks) [10]

### Marker's feedback

#### Pedagogic assessment [criterion]:

The question assesses Lecture(s) No(s): 10, Virtual Memory (1); What are base and limit registers and what do they enable a virtual memory to undertake?

The question's answer should clearly evidence knowledge of required salient facts relating to "What are base and limit registers and what do they enable a virtual memory to undertake?"

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context, for example: base, register, loaded, process begins in memory, virtual addresses, relocated to physical address space, adding the base address, address from the CPU [virtual address], calculate, actual physical address ...

Main differentiation that must be clearly evidenced in your answer to the question "What are base and limit registers and what do they enable a virtual memory to undertake?" must be concise, in plain English and related to theory.

The question's answer should clearly evidence knowledge of required salient facts relating to "What are base and limit registers and what do they enable a virtual memory to undertake?"; this was not done explicitly in some of the answers given – as the terminology (keywords and naming conventions) given above was not used. If the answers did not detail the salient details plainly as stated in the above (and in the Example answer); if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded. If you covered all [or most] the points then full marks were awarded. However if the answer did not utilise the correct keywords in context, and did not show you exercised your academic knowledge in this domain issue by not covering most of the issues full marks could not be awarded.

This theory relating to [the issue of] "What are base and limit registers and what do they enable a virtual memory to undertake?" was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

- j) What is a 'page fault'? Describe how a page fault is handled by the memory management unit and the operating system. (2 marks)

1.j.

Bookwork and analysis (2 marks),

- i) What is a 'page fault'? Describe how a page fault is handled by the Memory Management Unit and the operating system. (2 marks)

Example answer:- The following points should be covered to some degree in the answer:

In a paged virtual memory system, pages may have copies in real memory or may exist only on backing storage (usually disk or secondary memory).

If the MMU attempts an address translation but the page table indicates that there is no copy in real memory, this is a page fault. The MMU interrupts the CPU and traps to an OS page fault handler.

This [the OS page fault handler] is responsible for both selecting a page to reject from real memory – and writing it to disk if it has changed since it was last read" – and organising the read of the required page from disk to real memory.

It then updates the page tables and transfers control back to the original program to re-execute the instruction which caused the fault.

**2 marks** for a totally correct explicit delineation of the process using keywords in context – plus a complete – well presented – description.

**1 mark** for some basic table (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): 11; Virtual Memory (1).

TOTAL marks (2 marks) [8]

**Marker's feedback****Pedagogic assessment [criterion]:**

The question assesses Lecture(s) No(s): 11; Virtual Memory (1); What is a 'page fault'? and describe how a page fault is handled by the memory management unit and the operating system...

The question's answer should clearly evidence knowledge of required salient facts relating to "What is a 'page fault'?" and describe how a page fault is handled by the memory management unit and the operating system.

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context, for example: paged, virtual, memory, system, (pages may have) copies, in real memory, exist only, on backing storage, page table, no copy, real memory, page fault, MMU interrupts, CPU, writing, to disk, changed, read, required page, from disk, real memory, updates the page tables ...

Main differentiations that must be clearly evidenced in your answer is you facts relating to "What is a 'page fault'?" and describe how a page fault is handled by the memory management unit and the operating system: relate to using the correct keywords in context. The question's answer should clearly evidence knowledge of required salient facts relating to facts relating to "What is a 'page fault'?" and describe how a page fault is handled by the memory management unit and the operating system; this was not done explicitly in some of the answers given – as the terminology (keywords and naming conventions) given above was not used. If the answers did not detail the differences [for each step] plainly as stated in the above (and in the Example answer); if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded.

If you covered all [or most] the points then full marks were awarded. However if the answer did not utilise the correct keywords in context, and did not show you exercised your academic knowledge in this domain issue by not covering most of the issues full marks could not be awarded.

This theory of the three areas was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

**Section B**

3.

- a) To address the question: “What happens in an interrupt?” it is important to align the appropriate set of steps to the proper interrupt sequence. Figure 3.a. is a list of out-of-order steps relating to an interrupt sequence.

Reorder the steps, into the correct order, in your answer; so it enables an interrupt to sequence through the proper interrupt steps. (3 marks)

a) return
b) code executed
c) interrupt acknowledgement
d) interrupt service routine
e) processor saves registers
f) interrupt line
g) interrupt vector

Question figure 3.a. A table; showing a sequence of out-of-order steps for an interrupt.

3.a.

Application (example re-ordering) (3 marks):

The following points should be covered to some degree in the answer:

The typical ordered of STEPs is:

- a/ interrupt line
- b/ interrupt acknowledgement
- c/ processor saves
- d/ interrupt vector
- e/ interrupt service routine
- f/ code executed
- g/ return

From the previously out-of-order STEPs:

- g/ return
- f/ code executed
- b/ interrupt acknowledgement
- e/ interrupt service routine
- c/ processor saves
- a/ interrupt line
- d/ interrupt vector

3-2 marks for majority of above; e.g. for an answer that orders all lines correctly,

1 marks for some basic understanding (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): Lecture 15: Input/Output (2).

TOTAL marks (3 marks) [3]

### Marker's feedback

#### Pedagogic assessment [criterion]:

The question assesses Lecture 15: Input/Output (2); Re-order the steps, into the correct order, in your answer; so it enables an interrupt to sequence through the proper interrupt steps.

The question's answer should clearly evidence knowledge of required salient facts relating to "Reorder the steps, into the correct order, in your answer; so it enables an interrupt to sequence through the proper interrupt steps."

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context, for example: with respect to DMA: [or correct sequence of re-ordered steps (all given – out of order)] interrupt line, interrupt acknowledgement, processor saves registers, interrupt vector, interrupt service routine, code executed, return ...

Main differentiation that must be clearly evidenced in your answer to "reorder the steps, into the correct order, in your answer; so it enables an interrupt to sequence through the proper interrupt steps": the re-ordered sequence must be clearly tabulated.

The question's answer should clearly evidence knowledge of required salient facts relating to "reorder the steps, into the correct order, in your answer; so it enables an interrupt to sequence through the proper interrupt steps"; this was not done explicitly in some of the answers given – as the order was incorrect. If the answers did not detail the facts relating to "reorder the steps, into the correct order, in your answer; so it enables an interrupt to sequence through the proper interrupt steps"; if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded.

If you covered all [or most] the points then full marks were awarded. However if the answer did not utilise the correct keywords in context, and did not show you exercised your academic knowledge in this domain issue by not covering most of the issues full marks could not be awarded.

This theory of the facts relating to "reorder the steps, into the correct order, in your answer; so it enables an interrupt to sequence through the proper interrupt steps" was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

- b) Given the now in-order steps enables an interrupt to follow the appropriate sequence.
- i) The table, in figure 3.b., shows a set of (out-of-order) steps for an interrupt sequence. Copy the re-ordered table (3.a) into your answer book plus a detailed explanation of step column and then describe in full what happens at each step.

In the table clearly put each step into context and describe exactly what function each performs. (5 mark)

Steps [please re-order]	Detailed explanation of step
a) return	
b) code executed	
c) interrupt acknowledgement	
d) interrupt service routine	
e) processor saves	
f) interrupt line	
g) interrupt vector	

Question figure 3.b. A keyword table; requiring re-ordering (3.a) and adding a comprehensive explanation of each step.

3.b.

Application (example re-coding) (5 marks):

The following points should be covered to some degree in the answer:

The typical fully commented ordered interrupt sequence is:

Steps	Detailed explanation of step
a/ interrupt line.	The <u>I/O device</u> will <u>signal</u> that an <u>interrupt</u> has <u>occurred</u> by using the “ <b><u>interrupt line</u></b> ,”
b/ interrupt acknowledgement .	The <u>processor</u> then <u>sends</u> a special type of memory read (called an “ <b><u>interrupt acknowledgement</u></b> ”);
c/ processor saves .	The “ <b><u>processor saves</u></b> ” the current value of the <u>Program Counter</u> and the contents of its <u>registers</u> into <u>memory</u> ;
d/ interrupt vector.	The <u>value</u> that the <u>processor</u> <u>received</u> from the <u>IACK</u> cycle identifies <u>what device</u> <u>interrupted</u> the <u>processor</u> ; this is known as the “ <b><u>interrupt vector</u></b> ,”
e/ interrupt service routine	The <u>interrupt vector</u> is used to <u>access</u> a <u>table</u> that holds the <u>starting addresses</u> of all programmes that <u>handle interrupts</u> ; the <u>interrupt vector</u> is used to <u>find</u> the <u>starting address</u> for the <u>appropriate device handler</u> ; this program is called an “ <b><u>Interrupt Service Routine</u></b> ” (ISR) and contains code that handles the type of interrupt;
f/ code executed	This <u>code</u> is now <b><u>executed</u></b> until a special instruction ( <u>return from interrupt</u> ) is <u>executed</u> ; and finally
g/ return	When the “ <b><u>return</u></b> ” from <u>interrupt instruction</u> is reached; the PC and registers that were stored earlier are loaded back into the processor.

5-4 marks for majority of above; e.g. for an answer that orders all lines correctly,

3 marks for correct answer but not concise [enough],

2 mark for some information & for a right-lines approach,

1 marks for some basic understanding (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): Lecture 15: Input/Output (2).

TOTAL marks (5 marks) [8]

### Marker’s feedback

#### Pedagogic assessment [criterion]:

The question assesses Lecture 15: Input/Output (2); a detailed explanation of step column and then describe in full what happens at each step; of the re-ordered sequence.

The question’s answer should clearly evidence knowledge of required salient facts relating to a detailed explanation of step column and then describe in full what happens at each step; of the re-ordered sequence of an interrupt.

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context, for example: with respect to DMA: I/O device, signal, interrupt, occurred, **interrupt line**, processor, sends **interrupt acknowledgement**, **processor saves**, current value, Program Counter, registers, value, processor received, IACK, identifies what device interrupted, processor, **interrupt vector**, interrupt vector, access a table, starting addresses, handle interrupts, interrupt vector, find, starting address, appropriate device handler, **“Interrupt Service Routine”** (ISR), **code**, **executed**, *(return from interrupt)* executed...

Main differentiation that must be clearly evidenced in your answer is you relating to a detailed explanation of step column and then describe in full what happens at each step; of the re-ordered sequence of an interrupt explicitly: the descriptions must be clearly delineated; your description of each step must include the appropriate terms – as per the listed keywords. The question’s answer should clearly evidence knowledge of required salient facts relating to the steps involved in the detailed explanation of step column and then describe in full what happens at each step; of the re-ordered sequence of an interrupt; this was not done explicitly in some of the answers given – as the terminology (keywords and naming conventions) given above was not used. If the answers did not detail the differences [for each step] plainly as stated in the above (and in the Example answer); if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded.

If you covered all [or most] the points then full marks were awarded. However if the answer did not utilise the correct keywords in context, and did not show you exercised your academic knowledge in this domain issue by not covering most of the issues full marks could not be awarded.

This theory of the detailed explanation of step column and then describe in full what happens at each step; of the re-ordered sequence of an interrupt was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.



- c) With respect to relocation and swapping; state why the ability to relocate programs is useful in the context of swapping?

(2 marks)

3.c.

Application of your knowledge - Bookwork (2 marks).

- c) With respect to relocation and swapping; state why the ability to relocate programs is useful in the context of swapping? (2 marks)

Example answer:- The following points should be covered to some degree in the answer:

In any multiprogrammed system, it is highly useful if any subset of a large number of processes can be resident in real memory at any one time. This means that a user can have the illusion that he/she is running a large number of processes, even if they won't fit into main memory all together. This is achieved by 'swapping'.

It [swapping] is useful [in the context of relocation of programs in memory] as the processes can be moved to and from [in and out of] background storage (disk) automatically by the system thus providing the above illusion.

**2 marks** for a totally correct content, and all issues addressed comprehensively;

**1 mark** for some basic knowledge (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): 10; Memory Management (1).

TOTAL marks (2 marks) [10]

### Marker's feedback

#### Pedagogic assessment [criterion]:

The question assesses 10; Memory Management (1); 3) what is 'swapping' in the context of operating system memory management and why is it useful in the context of relocation of programs in memory?

The question's answer should clearly evidence knowledge of required salient facts relating to "What is 'swapping' in the context of operating system memory management and why is it useful in the context of relocation of programs in memory?"

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context, for example: with respect to What is 'swapping' in the context of operating system memory management and why is it useful in the context of relocation of programs in memory?: subset, processes, resident, real memory, 'swapping', moved to, from [in and out of], background storage, disk, automatically ...

Main differentiation that must be clearly evidenced in your answer is your description must be explicit: and must be clearly delineated; your description must include the appropriate terms as per those in the keyword list.

The question's answer should clearly evidence knowledge of required salient facts relating to "What is 'swapping' in the context of operating system memory management and why is it useful in the context of relocation of programs in memory?"; this was not done explicitly in some of the answers given – as the terminology (keywords and naming conventions) given above was not used. If the answers did not detail "what is 'swapping' in the context of operating system memory management and why is it useful in the context of relocation of programs in memory?" plainly as stated in the above (and in the Example answer); if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded.

If you covered all [or most] the points then full marks were awarded. However if the answer did not utilise the correct keywords in context, and did not show you exercised your academic knowledge in this domain issue by not covering most of the issues full marks could not be awarded.

This theory of the "what is 'swapping' in the context of operating system memory management and why is it useful in the context of relocation of programs in memory?" was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

- d) Given an 8G address spaces and associated 256K page sizes; calculate the number of pages that result in the virtual address space. NOTE: To gain full marks you must show full working. (2 marks)

3.d.

Application (2 marks).

- f) Given a 8G address spaces and associated 256K page sizes; calculate the number of pages that result in the virtual address space. NOTE: To gain full marks you must show full working. (2 marks)

Example answer:- The following points should be covered to some degree in the answer:

If the virtual address space is 8 GB and the block size is 256 KB there are:

$$\text{Number of Pages} = \frac{\text{Address space}}{\text{Page size}}$$

$$= \frac{8 \text{ GB}}{256 \text{ KB}} = \frac{8,589,934,592}{262,144} = \frac{2^{33}}{2^{18}} = 2^{33-18} = 2^{15} = 32,768 = 32k \text{ (256K) pages}$$

**2 marks** for an answer that calculates the correct answer and is laid out correctly e.g.

**2 marks** for a correct answer and full working out,

**1 mark** for a 'right lines' approach. Moderate marks will be awarded in the case of correct application for a wrongly calculated.

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): 11; Virtual Memory (1).

TOTAL marks (2 marks) [12]

**Marker's feedback 3.f.****Pedagogic assessment [criterion]:**

The question assesses lecture 11; Virtual Memory (1) learning objective 1 and 2 directly; 1. Explain what is meant by a paged virtual memory system; 2. Determine the structure of an address in a paged virtual memory system.

Well done, the majority of you were able to first: 1. remember the equation (address space divided by page size); second 2. substitute the correct numbers from address space and page size; third 3. convert these to power of 2; fourthly 4. utilise the mathematical norm for dividing power (i.e. subtract the power of two of the page size [the divisor] from the power of two of the address space [the dividend]); fifth 5. convert the resultant answer (which is a power of 2) in to an integer number – this is the number of pages. If you undertook 1 to 5 and at each stage attained the correct answers – you will have been full marks – if not full marks could not be awarded.

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context; for example: address space, & page size.

This theory of the three areas was covered in the lecture series in three different audio visual medias: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

- e) Given a physical address size of 2G and associated 128K block size. Calculate the number of page frames in the physical address space. NOTE: To gain full marks you must show full working. (2 marks)

3.e.

Application (2 marks).

- e) Given a physical address size of 2G and associated 128K block size. Calculate the number of page frames in the physical address space. NOTE: To gain full marks you must show full working. (2 marks)

Example answer:- The following points should be covered to some degree in the answer:

Virtual address space 2GB and block size 128KB.

If the virtual address space is 2 GB and the page size is 128 KB there are:

$$\begin{aligned} \text{Number of Page frames} &= \frac{\text{Address space}}{\text{Block size}} \\ &= \frac{2 \text{ GB}}{128 \text{ KB}} = \frac{2,47,483,648}{131,072} = \frac{2^{31}}{2^{17}} = 2^{31-17} = 2^{14} = 16,384 = 16k \text{ (128 K) pages frames} \end{aligned}$$

**2 marks** for an answer that calculates the correct answer and is laid out correctly e.g.

**2 marks** for a correct answer and full working out,

**1 mark** for a 'right lines' approach. Moderate marks will be awarded in the case of correct application for a wrongly calculated.,

**½ marks** for some basic understanding (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): 11; Virtual Memory (1).

TOTAL marks (2 marks) [14]

**Marker's feedback 3.d.****Pedagogic assessment [criterion]:**

The question assesses lecture 11; Virtual Memory (1) learning objective 1 and 2 directly; 1. Explain what is meant by a paged virtual memory system; 2. Determine the structure of an address in a paged virtual memory system.

Well done, the majority of you were able to first: 1. remember the equation (address space divided by block size); second 2. substitute the correct numbers from address space and page size; third 3. convert these to power of 2; fourthly 4. utilise the mathematical norm for dividing power (i.e. subtract the power of two of the page size [the divisor] from the power of two of the address space [the dividend]); fifth 5. convert the resultant answer (which is a power of 2) in to an integer number – this is the number of pages frames. If you undertook 1 to 5 and at each stage attained the correct answers – you will have been full marks – if not full marks could not be awarded.

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context; for example: address space, & block size.

This theory of the three areas was covered in the lecture series in three different audio visual medias: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

- d) One of the page replacement policies is the not recently used (NRU) algorithm; answer the following question with respect to this policy
- f) State the function of the “R” and “M” bits, which appear in a page table using the NRU algorithm. (2 mark)

3.f

Bookwork (2 marks).

- i) State the function of the “R” and “M” bits, which appear in a page table using the NRU algorithm. (3 mark)

The following points should be covered to some degree in the answer:

The R and M bits in a page table are used [in the following way]:

The R bit is set when the page is **referenced**; while

The M bit is set when the page is **modified** (or written to).

**2 marks** for an answer that depicts all the salient facts in a sensible way; and the use of keywords in context: ‘referenced’, and ‘modified’;

**1 mark** for some basic understanding (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): Lectures 13 Virtual Memory (3).

TOTAL marks (2 marks) [16]

**Marker's feedback****Pedagogic assessment [criterion]:**

The question assesses Lectures 13 Virtual Memory (3); state the function of the “R” and “M” bits, which appear in a page table using the NRU algorithm.

The question's answer should clearly evidence knowledge of required salient facts relating to “State the function of the “R” and “M” bits, which appear in a page table using the NRU algorithm.”

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context, for example: referenced, modified, written to...

Main differentiation that must be clearly evidenced in your answer must explain the facts explicitly: the terms must be clearly delineated; your description of each must include terms like: the R bit is set when the page is referenced; while the M bit is set when the page is written to).

The question's answer should clearly evidence knowledge of required salient facts relating to the question: state the function of the “R” and “M” bits, which appear in a page table using the NRU algorithm; this was not done explicitly in some of the answers given – as the terminology (keywords and naming conventions) given above was not used. If the answers did not detail the differences [for each issue] plainly as stated in the above (and in the Example answer); if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded.

If you covered all [or most] the points then full marks were awarded. However if the answer did not utilise the correct keywords in context, and did not show you exercised your academic knowledge in this domain issue by not covering most of the issues full marks could not be awarded.

This theory that stated the function of the “R” and “M” bits, which appear in a page table using the NRU algorithm was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

- ii) State, in some detail, how it works (the NRU algorithm), explicitly stating how it utilises the “R” bit. (4 marks)

**Bookwork (4 marks):**

The following points should be covered to some degree in the answer:

How it works:

1. At fixed intervals, the clock interrupt triggers and clears the referenced bit (R = 0) of all the pages.
  2. Referenced bit marks pages referenced in interval.
  3. So during interval if page referenced R=1 then it is used.
  4. If not R=0 then it is NOT used; and
- At the end of interval R=1 and M=1 the page is a candidate for replacement.

**4 marks** for an answer that depicts all the salient facts in a sensible way; and the use of keywords in context;

**2 marks** for an average answer;

**1 mark** for some basic understanding (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lectures 13 Virtual Memory (3).

TOTAL marks (4 marks) [20]

**Marker’s feedback**

**Pedagogic assessment [criterion]:**

The question assesses Lectures 13 Virtual Memory (3); state, in some detail, how it works (the NRU algorithm), explicitly stating how it utilises the “R” bit.

The question’s answer should clearly evidence knowledge of required salient facts relating to “State, in some detail, how it works (the NRU algorithm), explicitly stating how it utilises the “R” bit.”

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context, for example: with respect to DMA: fixed intervals, clears the referenced bit, R = 0, all the pages, marks, pages, referenced, interval, R=1, used, R=0, NOT used, page, candidate, replacement ...

Main differentiation that must be clearly evidenced in your answer is your explanation must be explicit: and must be clearly delineated [in your answer]; the description of how the bit is utilised.

The question’s answer should clearly evidence knowledge of required salient facts relating to the bit; this was not done explicitly in some of the answers given – as the terminology (keywords and naming conventions) given above was not used. If the answers did not detail the differences [for each step] plainly as stated in the above (and in the Example answer); if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded.

If you covered all [or most] the points then full marks were awarded. However if the answer did not utilise the correct keywords in context, and did not show you exercised your academic

knowledge in this domain issue by not covering most of the issues full marks could not be awarded.

This theory that stated, in some detail, how it works (the NRU algorithm), explicitly stating how it utilises the “R” bit was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

4.

- a) On a paged machine with 3 page frames (PFs) available for it, a particular process makes accesses to the following pages in the order given:

0, 3, 7, 1, 3, 2, 1, 3, 7

Show the contents of the 3 page frames and the cumulative total number of page faults (PF) after each memory access assuming that an LRU page replacement algorithm is in use and that the page frames are initially empty. The type of diagram you should draw up is depicted in figure 4.a. (4 marks)

Access:	0	3	7	1	3	2	1	3	7	
Most recent:	X	X	X	X	X	X	X	X	X	)
Second most :	X	X	X	X	X	X	X	X	X	)
Third most:	X	X	X	X	X	X	X	X	X	)
Total PFs:	X	X	X	X	X	X	X	X	X	

Contents of page frames in memory

Question [Figure] 4.a. Typical diagram showing 3 page frames and the cumulative total number of page faults (PF).

4.a

Application (4 marks).

Example answer:- The following points should be covered to some degree in the answer:

Access:	0	3	7	1	3	2	1	3	7	
Most recent:	0	3	7	1	3	2	1	3	7	)
Second most :	-	0	3	7	1	3	2	1	3	)
Third most:	-	-	0	3	7	1	3	2	1	)
Total PFs:	1	2	3	4	4	5	5	5	6	

Contents of  
page frames  
in memory

Note: 3, 1, & 3 are not page faults (PF) as in physical memory.

**4 marks** for a totally correct content, 3 marks for all 3 page frames totally correct and 1 mark for the cumulative total number of page faults totally correct.

**2 marks** for half issues covered,

**1 mark** for some basic calculations (or attempt).

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): 13; Virtual Memory (3).

TOTAL marks (4 marks) [4]

### Marker's feedback

#### Pedagogic assessment [criterion]:

The question assesses Lecture(s) No(s): 13; Virtual Memory (3); show the contents of the 3 page frames and the cumulative total number of page faults (PF) after each memory access assuming that an LRU page replacement algorithm is in use.

The question's answer should clearly evidence knowledge of required salient facts relating to "Show the contents of the 3 page frames and the cumulative total number of page faults (PF) after each memory access assuming that an LRU page replacement algorithm is in use."

Main differentiation that must be clearly evidenced in your answer is you list the 6 accesses: the six accesses must be clearly tabulated; your tabulation of each access must include the number of the 3 most recently accessed pages – in the [your] table.

The question's answer should clearly evidence knowledge of required salient facts relating to the accesses; this was not done explicitly in some of the answers given – as the tabulation given above was not drawn. If the answers did not detail the differences [for each access] plainly as stated in the above (and in the Example answer); if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded.

If you tabulated all [or most] the access [correctly] then full marks were awarded. However if the answer did not depict the correct tabulation, and did not show you exercised your academic knowledge in this domain issue by not covering most of the issues full marks could not be awarded.



This theory of the 3 page frames and the cumulative total number of page faults (PF) after each memory access assuming that an LRU page replacement algorithm is in use was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

b) When a page fault occurs the CPU uses a DMA unit to move pages from/to disk (termed disk I/O); in this context:

(i) Name and briefly describe the two registers that are normally used during the DMA process. (2 mark)

4.b.i (ii)

Bookwork [Differentiate] (2 marks):

b.i. Name and briefly describe the two registers that are normally used during the DMA process.. (2 marks)

**Example answer:-** The following points should be covered to some degree in the answer:

The disk I/O has two registers:

Command register where commands such as: READ, WRITE, FORMAT can be written;

Status register that indicates whether the disk is ready for the data or not.

Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): Lecture 15: Input/Output (2).

**2 marks, 1 for names and 1 for descriptions.**

TOTAL marks (2 marks) [6]

Transfer of data to a disk can actually be undertaken by programmed:  
polling (or programmed) I/O; or interrupt I/O.

Draw two flow charts [diagrams] that depict the sequence of events needed to perform disk writing using polling [programmed] I/O and interrupt I/O.  
(4 mark)

4.b.ii.

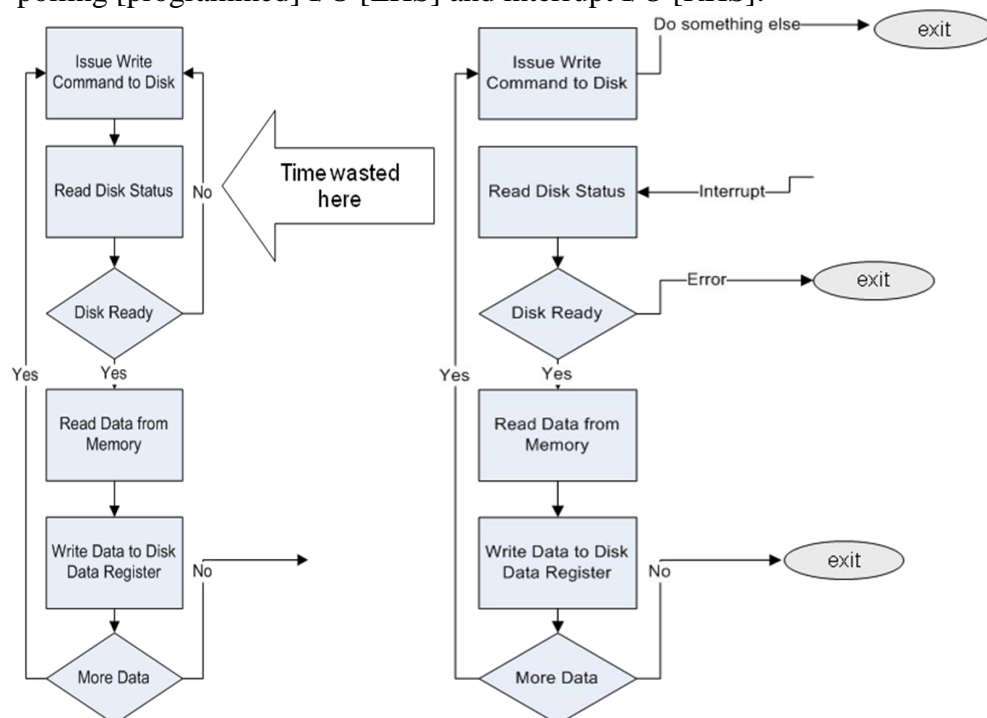
Bookwork [Differentiate] (4 marks):

- (i) Transfer of data to a disk can actually be undertaken by programmed:  
input/output (I/O); or interrupt I/O. Draw two flow charts [diagrams] that depict the  
sequence of events needed to perform disk writing using polling [programmed] I/O and  
interrupt I/O.  
(4 mark)

**Example answer:-** The following points should be covered to some degree in the  
answer:

The two diagrams below depict:-

polling [programmed] I/O [LHS] and interrupt I/O [RHS]:



Reference Learning Resources, Background Reading, and Lecture itself for detailed information; Lecture(s) No(s): Lecture 15: Input/Output (2).

**4 marks** for an answer that depicts all steps in both diagrams.

**2 marks** for correct answer but not detailed [enough],

**1 mark** for a right-lines approach,

**½ marks** for some basic understanding (or attempt).

**Marker's feedback**

**Pedagogic assessment [criterion]:**

The question assesses Lecture 15: Input/Output (2); name and briefly describe the two registers that are normally used during the DMA process.

The question's answer should clearly evidence knowledge of required salient facts relating to "name and briefly describe the two registers that are normally used during the DMA process."

In the answer [some of] the following terminology (keywords and naming conventions) should be utilised in context, for example: issue, write, command, disk, ready, read, data, memory, write, register, issue, command, status, exit ...

Main differentiation that must be clearly evidenced in your answer is your diagrams must be correctly labelled explicitly: the labels [in boxes and diamonds] must be clearly delineated; your description of the control [or process] flow.

The question's answer should clearly evidence knowledge of required salient facts relating to the steps involved; this was not done explicitly in some of the answers given – as the terminology (keywords and naming conventions) given above was not used. If the answers did not detail the differences [for each step] plainly as stated in the above (and in the Example answer); if for example the answer does not give evidence of knowledge of required salient facts, full marks were not awarded.

If you covered all [or most] the points then full marks were awarded. However if the answer did not utilise the correct keywords in context, and did not show you exercised your academic knowledge in this domain issue by not covering most of the issues full marks could not be awarded.

This theory of [behind] the two registers that are normally used during the DMA process was covered in the lecture series in three different audio visual media: 1) the actual live lecture; 2) the audio recording of the live lecture; and 3) the real time video of the lecture.

**END OF EXAMINATION**