

X206/701

NATIONAL
QUALIFICATIONS
2007

MONDAY, 28 MAY
1.00 PM – 3.30 PM

COMPUTING
ADVANCED HIGHER

Attempt **all** questions in Section I.

Attempt **one** sub-section of Section II.

Part A	Artificial Intelligence	Page 8	Questions 6 to 13
Part B	Computer Architecture	Page 16	Questions 14 to 18
Part C	Computer Networking	Page 19	Questions 19 to 22

For the sub-section chosen, attempt **all** questions.

Read all questions carefully.

Do not write on the question paper.

Write as neatly as possible.

Each section should be answered in a separate answer book.



SECTION I

Software Development & Developing a Software Solution

Marks

Answer ALL questions in this section

1. A government intends to improve the accuracy and communication of registration information in its schools. It proposes using biometric information such as fingerprints or iris scans to register pupils for every class. An e-mail or text will be automatically sent to the parent or guardian to notify them of any unauthorised absence. The government forms a project team to consider the proposed system.
- (a) The project team will undertake a *feasibility study* which will consider both technical and time aspects of feasibility.
- (i) Describe **two** other aspects of feasibility that may be investigated. 2
- (ii) Suggest **two** factors that the project team might investigate when considering technical feasibility. 2
- (b) The feasibility study proves favourable and the government decides to proceed with the project. A full system investigation will be undertaken resulting in an *operational requirements document*.
- (i) Who will perform the system investigation? 1
- (ii) Describe **three** items that will be included in this document. 3
- (iii) Explain how this document will protect the project team against additional demands from the government. 2
- (c) The project team realises the scale of the project requires effective management.
- (i) State **two** strategies that could be used to manage the project. 2
- (ii) For each strategy in (c)(i) describe how it improves productivity. 2
- (d) Describe **two** benefits of using *Computer-Aided Software Engineering (CASE) tools*. 2

SECTION I (continued)

2. Sudoku is a game in which numbers from 1 to 9 are placed into all the cells in a 9 by 9 grid, such that no entire row, entire column, or 3 by 3 “minigrid” contains the same number twice.

The initial state of a puzzle is shown below.

3			2		1			6
			4			5		
	1				8			7
	8				5	3		
		9				7		
		7	3				4	
9			6				7	
		3			2			
2			5		3			

A newspaper would like to include an interactive version of the puzzle on its website. A programmer is employed to write the software.

- (a) The programmer decides to store the state of the puzzle using a 2-D array.
- (i) Define a 2-D array that can store the state of the game. 3
 - (ii) The bottom right minigrid contains the value 7.
Write a line of code that would assign this value to the appropriate element of the array that you defined in (a)(i). 2
 - (iii) Explain why a 2-D array is more suitable than a single 1-D array for this puzzle. 2
- (b) The reader has the option to save the current state of the puzzle to backing storage. Write, **using detailed pseudocode**, an algorithm that would create a new file and write each number to the file. 6
- (c) Name and describe **two** methods of locating errors in the puzzle software. 4

[Turn over

SECTION I (continued)

3. A national talent competition has local heats to identify people to enter the televised stage of the competition. Competitors can enter in one of three age categories. Each competitor is issued with a number and the judges award a score out of one hundred. Each heat consists of eight competitors. Here are the results for one heat.

Competitor Number	Name	Category	Score
1200	Meena	Under 20	45
1201	Megan	Under 20	55
1202	Tariq	Under 20	89
1203	Arin	Under 20	2
1204	Louise	Under 20	43
1205	Andrew	Under 20	91
1206	Lynn	Under 20	14
1207	Liam	Under 20	36

The two competitors with the highest score are put forward to the next stage.

- (a) The program uses a *record* data structure to store each competitor's details.

(i) Define a suitable record structure for the data to be stored. 3

(ii) Describe a **variable** based on the record structure that could store the set of eight competitors. 3

- (b) At the end of the heat the competitors' scores are sorted into **descending** order. The scores to be sorted are:

45 55 89 2 43 91 14 36

(i) After the first pass using the *bubble sort* the list is:

55 89 45 43 91 14 36 2

Write down the list after **each** of the next two passes through the list. 2

(ii) Name another sort algorithm that could be used and compare it with the bubble sort in terms of efficiency. 2

(iii) Which sort algorithm would you recommend for this application? Give a reason for your answer. 2

SECTION I (continued)

4. A bank has employed a software development company to write new software to process customer accounts. All accounts have an account number and a balance and share common operations such as withdrawing and depositing money. There are different types of account such as current, savings and the gold account.

The software development company decides to use an *object-oriented programming language*.

- (a) What is meant by an *object* in the context of an object-oriented programming language? 2

- (b) The software development company decides to create a class called account and to have subclasses for each of the different types of account.

Describe **two** advantages of this approach compared to using a procedural language. 4

[Turn over

SECTION I (continued)

5. A list is stored in a 1-D array as follows.

Index	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Value	3	7	15	21	25	45	50	56	68	70	77	80	87	91	97

An item in the list can be located using a *linear search* or *binary search*.

(a) How many comparisons will be required to find the number 80 using a *linear search*? 1

(b) The following binary search algorithm could be used to search the list.

```

set lower to lowest index
set upper to highest index
loop
    set middle to (lower+upper) div 2
    if search_item > value[middle] then
        lower=middle+1
    else
        upper=middle-1
    end if
until value[middle] =search_item or lower>upper
write out 'item found at position', middle
    
```

When searching for the number 42, which is **not** in the list, the algorithm outputs:

item found at position 4.

(i) Copy and complete the following trace table indicating the values of the variables lower, upper and middle at the end of each pass until the loop terminates.

	lower	upper	middle
1st pass			
2nd pass			

5

(ii) The algorithm should give the position of a number that is present in the list and also a suitable message if the number is **not** present in the list.

Explain how the algorithm would be altered to achieve this.

3

(60)

[END OF SECTION I]

SECTION II

Attempt ONE sub-section of Section II

Part A	Artificial Intelligence	Page 8	Questions 6 to 13
Part B	Computer Architecture	Page 16	Questions 14 to 18
Part C	Computer Networking	Page 19	Questions 19 to 22

For the sub-section chosen, attempt *all* questions.

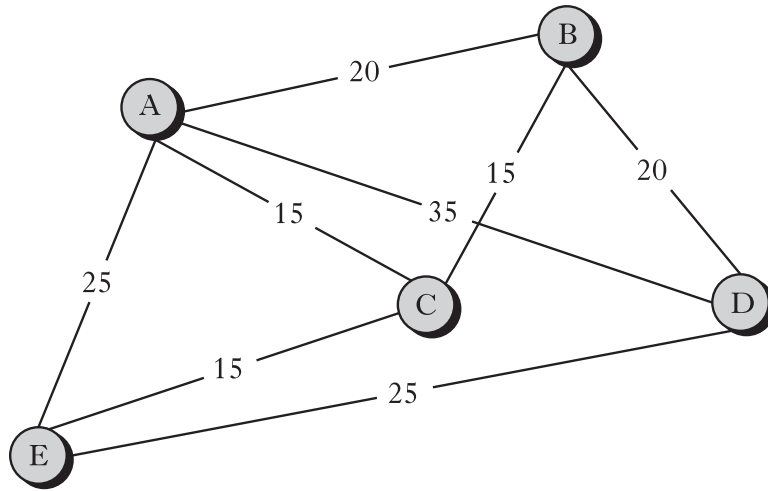
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SECTION II

Part A — Artificial Intelligence

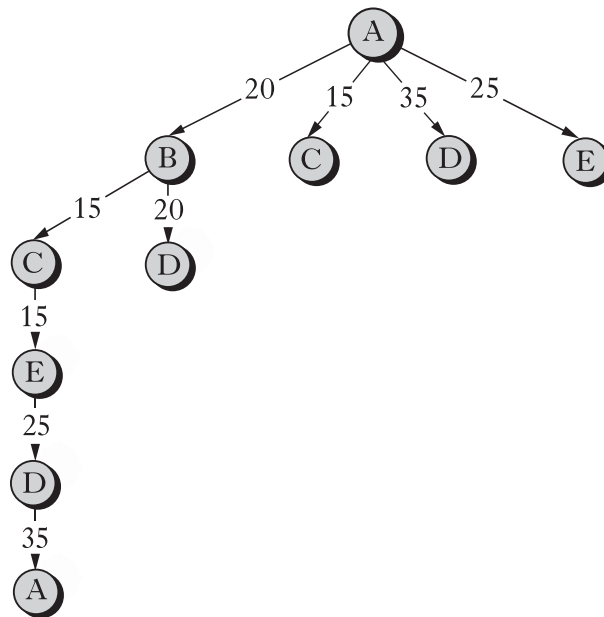
Answer ALL questions in this part.

6. The travelling salesman is a problem which can be solved using search techniques. The problem is to find the shortest route by which a traveller can visit several towns. Consider this map which shows all the possible routes between five towns.



The traveller must start at town A, visit every town only once, then return to A.

- (a) Copy and complete this *search tree* to represent all the possible routes the traveller could take.



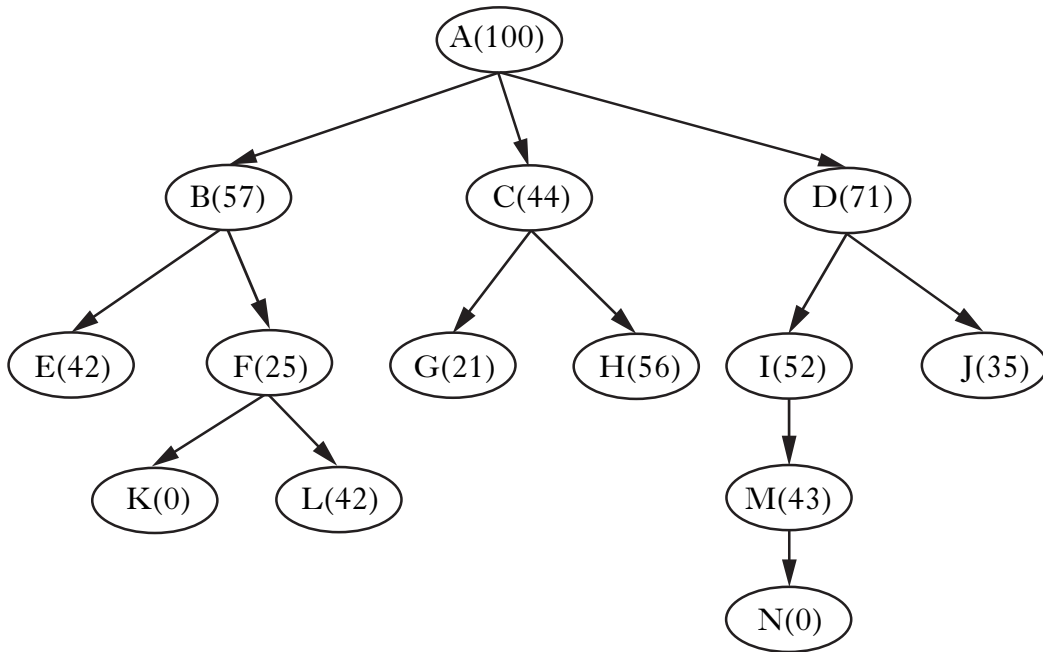
4

- (b) (i) The routes could also be represented using a *state space graph*. Describe **three** differences between a *search tree* and a *state space graph*. 3
- (ii) Use your completed search tree to calculate the length of all possible routes, and explain why there are two equally short routes. 2

SECTION II

Part A — Artificial Intelligence (continued)

7. The following *search tree* represents the *state space* for a problem. An *evaluation function* has been calculated for each *node*, with lower values indicating more promising states. The *start state* has value 100, and any *goal state* has value 0.



The following heuristic algorithm is used to search the tree.

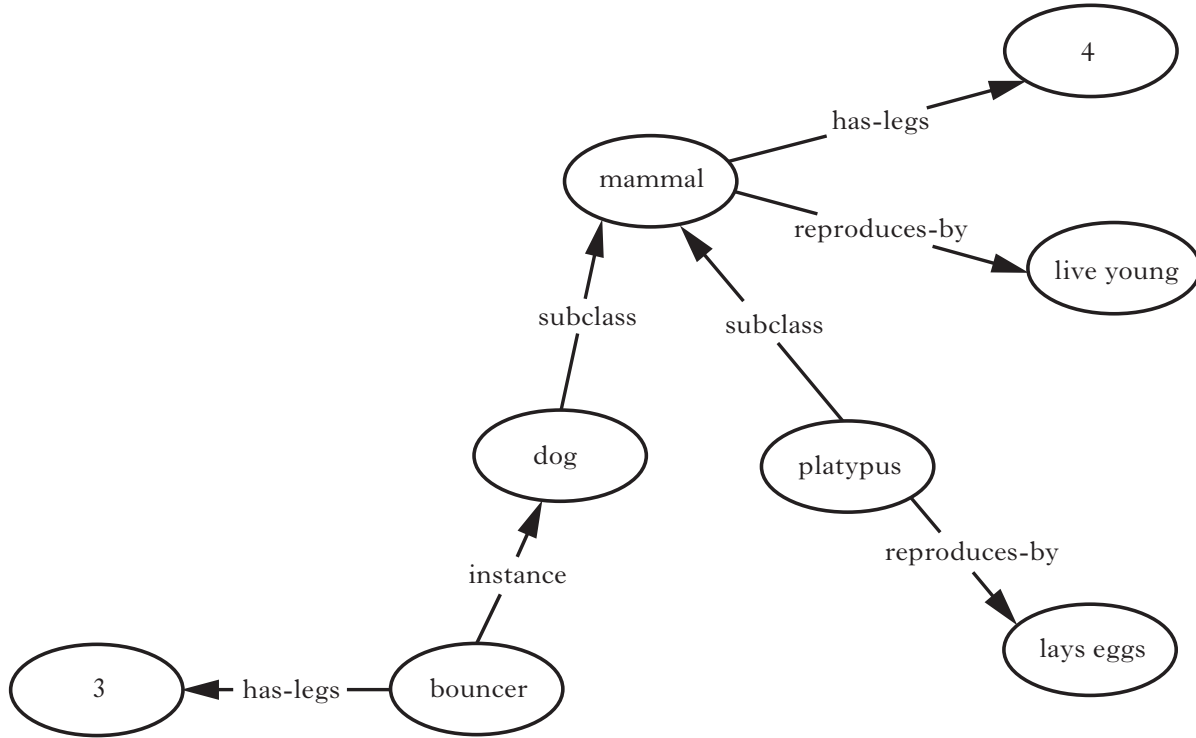
1. current_state = initial_state
2. found = false
3. repeat
 - a. get successors of current_state
 - b. select successor with lowest evaluation function
 - c. if evaluation function of chosen successor < evaluation function of current_state, make this the new current_state
4. until current_state = goal_state or no change in current_state

- (a) What is the name of this algorithm? 1
- (b) There are other heuristic algorithms which could be used.
- (i) Name **one** other heuristic algorithm which could be used to search the tree. 1
- (ii) For the algorithm you named in (b)(i), list the order of nodes visited until a goal state is found, and explain why the nodes are visited in this order. 5
- (c) What further information would be required to apply the A* algorithm? 1
- (d) When would the *minimax procedure* be used when searching a tree? 1

SECTION II

Part A — Artificial Intelligence (continued)

8. This semantic net represents some incomplete information about mammals, including Bouncer, a dog which lost a leg in an accident.



- (a) (i) Represent this information using frames. 4
 (ii) Using this example, explain the meaning of the term *default value*. 2

SECTION II

Part A — Artificial Intelligence (continued)

8. (continued)

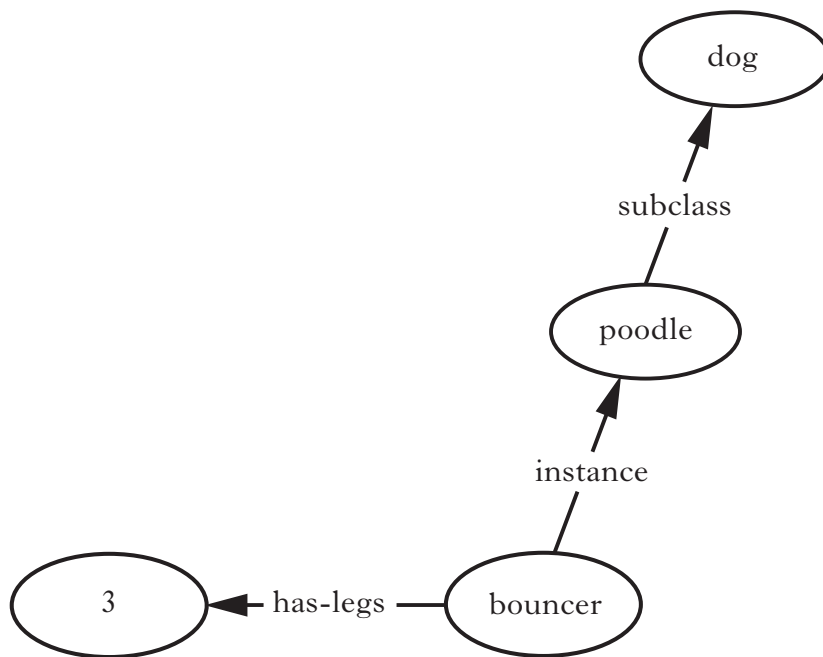
(b) The same information could be represented in Prolog by these facts.

has_legs(mammal, 4).
 has_legs(bouncer, 3).
 reproduces_by(mammal, live_young).
 reproduces_by(platypus, lays_eggs).
 subclass(dog, mammal).
 subclass(platypus, mammal).
 instance(bouncer, dog).

(i) Write **two** rules which will ensure that Bouncer (or any other mammals added to the knowledge base) will inherit the property “reproduces by live young”.

4

(ii) The knowledge base is to be extended to show that Bouncer is a poodle.



Explain why this would require the use of a recursive rule to ensure that Bouncer still inherits the property “reproduces by live young”.

2

[Turn over

SECTION II

Part A — Artificial Intelligence (continued)

9. The names of the four planets nearest to the sun can be represented in Prolog by the list [mercury, venus, earth, mars].

List membership can be defined as

member(X, X|Tail).

member(X,[Head|Tail]) IF member(X, Tail).

- (a) What would be the result of the following queries?

(i) ?member(moon, [mercury, venus, earth, mars]).

1

(ii) ?member(X, [mercury, venus, earth, mars]).

1

- (b) Explain how Prolog would use both parts of the membership rule to solve the query:

?member(mars, [mercury, venus, earth, mars]).

5

10. A rule-based expert system to control an industrial plant is based on four inputs: temp, pressure, warning_light_3 and warning_light_4.

The expert system includes the following three rules:

1. IF temp>50 AND pressure<0.5 THEN pump B is faulty.

2. IF warning_light_3 is on AND warning_light_4 is flashing THEN pump C is faulty.

3. IF pump B is faulty AND pump C is faulty THEN emergency shutdown.

- (a) The expert system results in unnecessary emergency shutdowns. In 10% of occasions when temp>50 and pressure<0.5, it has been found that pump B is **not** actually faulty. Also, in 25% of occasions when warning_light_3 is on, and warning_light_4 is flashing, pump C is **not** actually faulty.

(i) Rewrite rules 1 and 2 to represent this new information.

2

(ii) Calculate the certainty factory for the advice “emergency shutdown” when the inputs are temp=70, pressure=0.3, warning_light_3 is on, warning_light_4 is flashing. Justify your answer.

2

- (b) This expert system uses *forward chaining* to reach its conclusions.

(i) Explain what is meant by the *conflict set* in a forward chaining system.

1

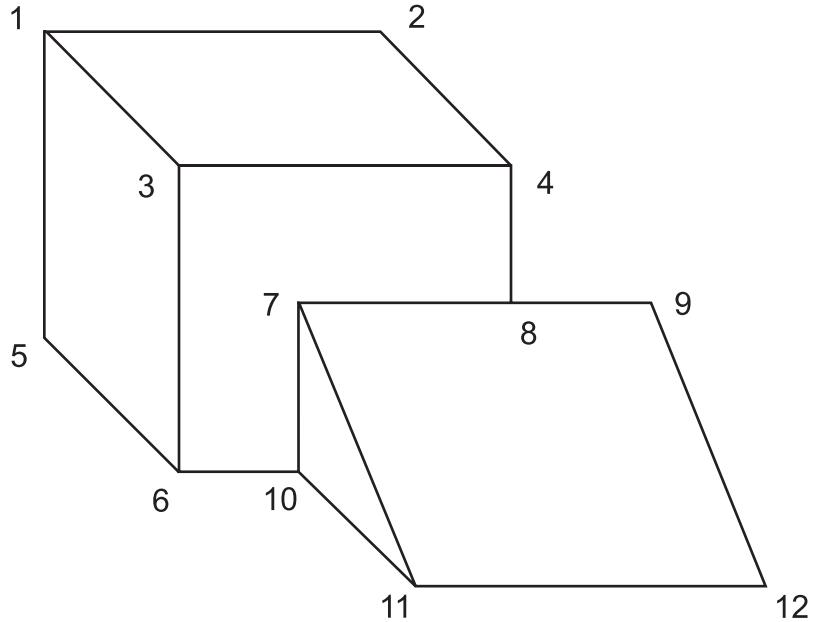
(ii) Explain why *conflict resolution* may be necessary.

1

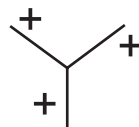
SECTION II

Part A — Artificial Intelligence (continued)

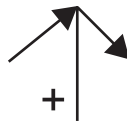
11. A vision system is analysing the following 3-dimensional object, using the Waltz algorithm. Each vertex has been numbered.



(a) The Waltz algorithm would associate vertex 3 with this standard pattern:



(i) Identify all the vertices which would be associated with this standard pattern:



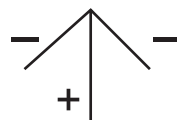
2

(ii) Identify all the vertices which would be associated with this standard pattern:



2

(iii) Identify the vertex which would be associated with this standard pattern:



1

(b) Explain why the labelling of vertices in a complex shape may be a recursive process.

2

SECTION II

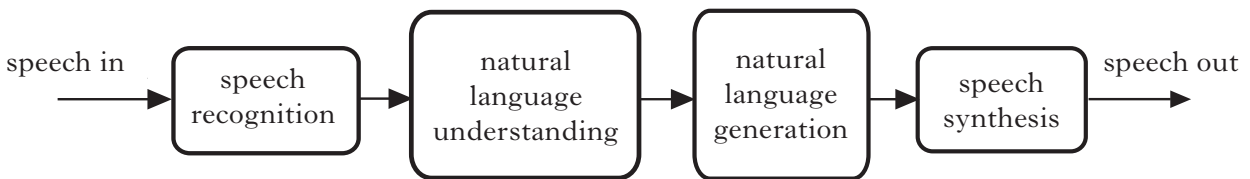
Part A — Artificial Intelligence (continued)

12. *Machine learning* is an important area of development within artificial intelligence. There are many methods of learning which have been investigated and developed. One of these methods is *learning by analogy*.

Describe, using an example, what is meant by *learning by analogy*.

2

13. An automatic system is being designed to provide simple advice to tourists arriving at an airport. The system can be represented as:



- (a) The test plan for the system includes both module and acceptance testing. With reference to the diagram above, describe **two** clear differences between module and acceptance testing.

4

- (b) *Natural language understanding* requires three types of analysis: *syntactic*, *semantic* and *pragmatic*.

(i) During which of these types of analysis is *parsing* used?

1

(ii) What is the purpose of *semantic analysis*?

1

(iii) Give an example of an ambiguity which can occur during *pragmatic analysis*.

2

(60)

[END OF SECTION II — Part A]

[Turn over for Part B—Computer Architecture

SECTION II

Part B — Computer Architecture

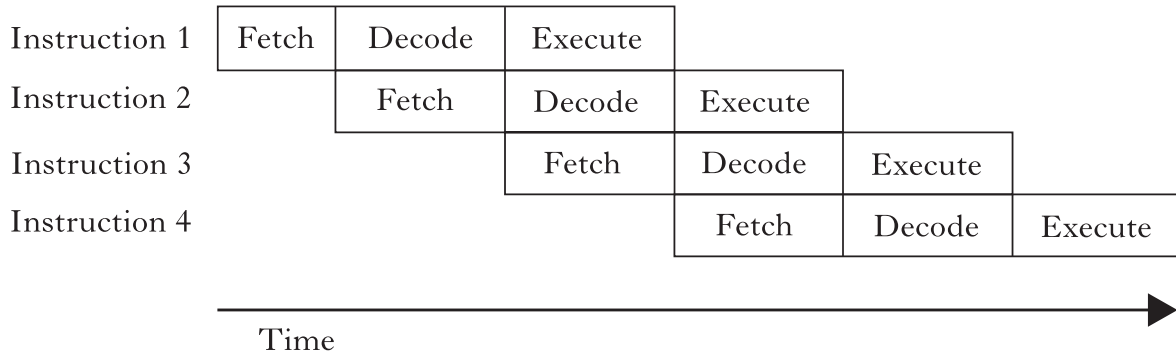
Answer ALL questions in this part.

14. (a) Describe the steps involved when a processor fetches an instruction from memory, clearly outlining the role of the relevant *buses* and *registers*. 4
- (b) A computer system with 1 Gb of main memory is fitted with an *IA-64 processor* with 256 registers, a 128-bit data bus, 16 Kb *L1 cache memory* and 128 Kb *L2 cache memory*. The cache memory is implemented using *static RAM*.
- (i) Compare registers and main memory in terms of *cost per bit* and *access time*. 2
- (ii) The *IA-64 processor* has many more registers than the *Intel 80286 processor*. Explain why this increase in the number of registers results in an improvement in performance. 2
- (iii) Give **one** reason why *static RAM* is used for cache memory and **one** reason why it is **not** used for main memory. 2
- (iv) In **one** fetch from memory the *IA-64* retrieves three 41-bit instructions and one 5-bit pointer. 1
- State a feature of its design which makes this possible.
15. A processor is being designed to process video data. The designer is given the task of including features in the design to maximise performance. The designer chooses *RISC* rather than *CISC* architecture.
- (a) (i) State **three** features of *RISC* architecture. 3
- (ii) Explain in detail the implications for processor performance of **each** of the three features you have stated in (a)(i). 6
- (b) The system will be required to transfer large amounts of video data rapidly from memory to the video I/O system for display. The designer decides to implement *Direct Memory Access* to handle the data transfer.
- (i) Describe how *Direct Memory Access* operates. 3
- (ii) Describe **two** benefits of using *Direct Memory Access* to implement data transfer. 2

SECTION II

Part B — Computer Architecture (continued)

16. A processor implements *pipeline processing*. Its pipeline has three stages: fetch, decode and execute, each of the stages taking one clock cycle.



- (a) (i) Referring to the above diagram describe how a pipeline functions. 2
- (ii) Explain why the maximum performance gain to be derived from this pipeline is a three fold increase in throughput. 3
- (b) A branch instruction is entered into the pipeline which prevents it from delivering a threefold increase in throughput.
- Explain why a branch instruction prevents the pipeline from delivering a threefold increase in throughput. 2
- (c) The processor can use *branch prediction* to limit the negative effect of *branch instructions* on the pipeline’s performance.
- (i) Describe how this technique operates. 2
- (ii) Explain why this technique will only limit the negative effect on pipeline performance caused by branch instructions but **not** eliminate it. 2
- (d) Another processor uses *predication* rather than branch prediction.
- Explain how **predication** is able to eliminate processing delays caused by branch instructions. 3
17. Supercomputers have many processors working in parallel.
- (a) Describe how memory is structured in a *parallel processing* system. 2
- (b) Describe how processors use *packet switching* to communicate in *parallel processing* systems. 3

[Turn over

SECTION II

Part B — Computer Architecture (continued)

18. A design specification for an operating system states that it should be capable of multi-tasking and should implement a *pre-emptive scheduling* system.
- (a) (i) Explain why *scheduling* is required in a multi-tasking system. 1
- (ii) Explain the benefit for an operating system of implementing a **pre-emptive** scheduling system. 2
- (b) Some of the processes which this operating system will have to deal with will take a relatively long time. Other processes will involve Input/Output requests, involving the use of DMA, which must be dealt with as rapidly as possible. The design team have a choice of pre-emptive scheduling strategies: either *round-robin* or *multi-level feedback queue*.
- Select and describe the scheduling strategy most suited to dealing with this range of processes effectively and give reasons for your selection. 5
- (c) The operating system must use an algorithm to manage the process of fitting processes into available memory space. The choice is between the *first fit*, *best fit* or *worst fit* algorithms.
- (i) Describe the *first fit* algorithm. 1
- (ii) A computer’s memory has four free blocks available. Three of them are 20 Mb in size and one is 90 Mb.
- | Block A | Block B | Block C | Block D |
|-----------|-----------|-----------|-----------|
| 20Mb free | 20Mb free | 20Mb free | 90Mb free |
- The operating system has to allocate memory to three processes, each of which demands 17 Mb of space.
- How much memory will be free in each block once these three processes have been allocated to memory using the following algorithms?
- A The *best fit* algorithm
- B The *worst fit* algorithm 3
- (d) The operating system provides a *GUI* which enables the user to have several overlapping windows open at once. Each window relates to a different application or file and the user can open, close, move and resize each one independently.
- Describe **two** demands on memory and **two** demands on processor time made by the operating system in order to provide the user with the facility to have several windows open at once and to be able to manipulate them freely. 4
- (60)**

[END OF SECTION II — Part B]

SECTION II

Part C — Computer Networking

Answer ALL questions in this part.

19. During a recent interview the Chief Executive of a large computing company claimed that organisations that define standards for computer networking are no longer required.

(a) Make a case, on behalf of the standards organisations, which makes it clear why their existence is crucial. 4

(b) A computing engineer recently submitted a document to a standards organisation outlining a single e-mail protocol for the **sending** of messages containing a wide range of data types.

(i) Name the **two** standard protocols currently in use that this one new protocol might replace. 1

(ii) In the current e-mail system each message has a header and a body. Name, giving reasons for your choice:

- **two** header items that are likely still to be required;
- **two** header items that will no longer be required. 4

[Turn over

SECTION II

Part C — Computer Networking (continued)

20. A new secondary school to accommodate 1200 pupils is to be built. The school will have a Local Area Network. Many of the services available on the network will be hosted from the Local Authority IT department in a neighbouring town.

(a) The connection from the school to the local authority IT department will be through a fibre cable. The school LAN will use UTP cable.

Explain, in detail, the reasoning behind the choice of transmission media for both the connection to the IT department and within the school.

4

(b) One of the services supplied across the network will be period-by-period registration. It is planned that the Physical Education department will use wireless enabled palmtops to register their classes.

(i) Name another piece of hardware that will be required in the Physical Education department to deliver this service.

1

(ii) Implementation of this strategy is being considered using 802.11a and 802.11g. State the range and frequency specifications for each of these protocols.

4

(iii) Recommend whether 802.11a or 802.11g should be used and justify your answer.

3

(iv) Identify **three** steps that the school should take to ensure that the wireless access to their network is as secure as possible from unauthorised access.

3

(c) All clients access the WWW through a proxy server located at the local authority IT department.

Occasionally, despite the URL being correct, a web page requested by a pupil might not be successfully retrieved. A pupil could use the *tracert* utility to identify the source of the problem.

(i) Identify **three** sources of the problem which the *tracert* utility may help to locate.

3

(ii) Explain, in detail, how *tracert* operates.

4

SECTION II

Part C — Computer Networking (continued)

21. Webwile, a website design and development company, is creating a website for the Yellow Hat Building Company.
- (a) The website is created using HTML coding. What effect will the following two examples of HTML coding have?
- (i) `<title>Yellow Hat Building Company</title>` 1
- (ii) `<p>Current developments include a new shopping centre in Edinburgh called the Edinburgh Plaza.</p>` 3
- (b) *Objects* and *operations* is one of many unifying themes that occur in computing. Identify **one** item that could be considered as an object on a web page and identify an operation that may be applied to it. 2
- (c) Explain the difference between *syntax* and *semantics* by referring to the coding shown below.
- ``
 Yellow Hat Building Company
`` 2
- (d) Java or ActiveX could be used to collect data from potential customers.
- (i) Describe **two** problems that customers might experience if ActiveX is used for this task. 2
- (ii) Explain why using Java would overcome the problems mentioned in part (i) above. 2
- (e) Once completed, the website will be hosted on a web server and will be accessed using a browser. HTTP is used to request a page from a web server. Describe, in detail, the response from the web server if the page requested is available. 2

[Turn over

SECTION II

Part C — Computer Networking (continued)

22. A Glasgow based firm of lawyers specialises in international business contracts. Customers, often from other countries, can contact the law firm via a secure section of the law firm's website. The website collects customer details and further communication is done via e-mail. The security of all communications is crucial to the law firm's operations.
- (a) The law firm demands that encryption is used for all electronic communication with customers. Explain why *public-key encryption* is more suitable than conventional encryption in this scenario. 2
- (b) The law firm uses *digital signatures* in their e-mail communications with customers. Describe how digital signatures operate. 5
- (c) The web server on which the company's website resides has previously suffered from a *smurf* attack.
- (i) How does a smurf attack operate? 4
- (ii) Suggest **one** step that could be taken by the owner of the web server hosting the site to ensure that another smurf attack would not be successful. 1
- (iii) Suggest a reason why this particular website was the target of a smurf attack. 1
- (d) The firm has an intranet that can connect to the Internet.
- (i) Explain why the firm may utilise the L2TP protocol. 1
- (ii) Name another protocol that may be used instead of L2TP. 1
- (60)**

[END OF SECTION II — Part C]

[END OF QUESTION PAPER]

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