Oxford Cambridge and RSA

# Monday 10 June 2024 – Afternoon

## A Level Computer Science

**H446/01** Computer Systems

**Time allowed: 2 hours 30 minutes**

**You can use:**
- an HB pencil

**Do not use:**
- a calculator

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

**INSTRUCTIONS**
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.

**INFORMATION**
- The total mark for this paper is **140**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **28** pages.

**ADVICE**
- Read each question carefully before you start your answer.

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**1** The stored program concept uses the Fetch-Decode-Execute cycle to get the next instruction from memory and then execute it.

**(a)** Describe what happens during the **fetch** stage of the Fetch-Decode-Execute cycle.

You should state the different registers and buses that are used in your answer.

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..... **[4]**

**(b)** One of the instructions that may be fetched and executed as part of this cycle is a branch instruction.

State the name of the register that would be altered in the **execute** phase during a branch instruction.

..... **[1]**

**(c)** Three ways of improving the performance of a CPU are increasing the clock speed, adding more cores and using pipelining.

Explain how pipelining improves the performance of a CPU.

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..... **[3]**

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**(d)** The Fibonacci sequence is a series of numbers. It starts with the number 0 and then 1. Each number after that is a sum of the two numbers before it.

The first seven numbers in the series are:

0
1
1 (i.e. 1 + 0)
2 (i.e. 1 + 1)
3 (i.e. 1 + 2)
5 (i.e. 2 + 3)
8 (i.e. 3 + 5)

Orla has written some code to show the first five numbers in the Fibonacci sequence (0,1,1,2,3) using the Little Man Computer (LMC) instruction set.

The LMC code that Orla has written contains an error.

```
START    LDA   MAX
         BRZ   END
         LDA   A
         OUT
         ADD   B
         STA   B
         LDA   B
         STA   A
         LDA   MAX
         SUB   ONE
         STA   MAX
         BRA   START
END      HLT
A        DAT   0
B        DAT   1
MAX      DAT   5
ONE      DAT   1
```

**(i)** State the **five** outputs that Orla's code would give.

Output 1 .....

Output 2 .....

Output 3 .....

Output 4 .....

Output 5 .....

**[3]**

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**(ii)** Orla has rewritten her LMC code to fix the error and added an additional `DAT`.

Complete the LMC code to output the first five correct numbers in the Fibonacci sequence (0,1,1,2,3).

```
        START      LDA    MAX
                   BRZ    END
                   LDA    A
                   OUT
                   ........................................
                   STA    TEMP
                   ........................................
                   ADD    B
                   STA    B
                   ........................................
                   STA    A
                   LDA    MAX
                   SUB    ONE
                   STA    MAX
                   BRA    START
        END        HLT
        A          DAT    0
        B          DAT    1
....................................  DAT    0
        MAX        DAT    5
        ONE        DAT    1
```

**[4]**

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**(e)** In Orla's LMC code, she used direct memory addressing.

Give **three** other modes of memory addressing.

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2 .....

3 .....

**[3]**

**(f)** Since the development of high level languages, the use of assembly languages has reduced.

Give **two** reasons why in some circumstances programmers will choose to write code in assembly language.

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**[2]**

**(g)** The performance of a computer system can be improved by adding more RAM.

Explain why adding more RAM will improve the performance of a computer system.

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..... **[3]**

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**2** An embedded system is often a small device that is designed to carry out a limited number of specialised tasks. Professional athletes sometimes wear small embedded systems called fitness trackers in their shirts. These can be used to track their speed, position, heart rate and other performance data during an event. The tracker transmits this data to a pitch-side server which collates the data from all the athletes.

**(a)** State the name of **one** input device that might be used in this embedded system and state what it would be used for.

Device .....

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Use .....

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**[2]**

**(b)** The fitness tracker manufacturers had to decide which type of secondary storage to use.

Explain **two** reasons why flash (solid state) storage would be the best type of secondary storage for the fitness tracker system.

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**[4]**

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**(c)** One use of ROM is to store the Basic Input Output System (BIOS). The BIOS is used when the computer is first turned on.

**(i)** Describe what the BIOS will do to start up the computer.

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..... **[3]**

**(ii)** Apart from storing the BIOS, ROM can also be used in other ways.

Describe how the embedded system can make a different use of ROM and why it is an advantage.

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..... **[2]**

**(d)** The embedded system will have an operating system. Two roles of an operating system are to handle interrupts and manage scheduling.

**(i)** Describe **two** other roles of an operating system.

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**[4]**

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**(ii)** Draw a line to match each scheduling algorithm to the correct description.

| Scheduling Algorithm | Description |
|---|---|
| Round Robin | Splits processes into different priority queues based on the amount of processor time they need. It allows them to move between the queues as their characteristics change |
| First come first served | Selects the process that takes the shortest amount of time to complete. The processes are run until they are fully complete |
| Multi-level feedback queues | Each process is allocated a fixed amount of CPU time. If the process is not complete it will be suspended and the next process will start |
| Shortest job first | Each process is given equal priority and they are processed in the order they arrive |
| Shortest remaining time | Selects the process that takes the shortest amount of time. The process can be suspended if another shorter process is added |

**[5]**

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**(e)*** The fitness trackers will send athletes' performance data to a pitch-side server. A program needs to be developed to analyse this data and display the results.

Different words, colours and charts will be displayed to indicate how well athletes are performing.

The program will be used by athletes from different cultures all over the world.

Discuss the layout considerations that the programmer needs to consider when creating the program user interface for different cultures.

You should include the following in your answer:
- layout considerations
- colour considerations
- character set considerations.

**[9]**

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**3** OCR Solutions is a software development company. Employees use a wide range of application software to complete admin tasks. Tasks include writing letters to clients and creating graphics.

**(a)** State the most appropriate application software for each task in the table.

| Task | Application Software |
|---|---|
| Creating graphics such as a logo | |
| Writing letters to clients to confirm their appointment date and time | |
| Calculating the company profits at the end of each month | |
| Storing, searching and updating client details and purchases | |
| Creating brochures and flyers about the organisation | |

**[5]**

The application software is run on thin client computers. A thin client computer is a very low-powered computer connected to a powerful central server. The operating system and all the applications run within a virtual machine on the server. The thin client computer will only display the output of the virtual machine and capture and send input to the virtual machine.

**(b)** State **one** advantage of running the application software within the virtual machine.

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..... **[1]**

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**(c)** The thin client computer needs to send data that is input by the user to the server so that the virtual machine can process it. For example, it will send text entered by the user on the thin client computer to the application software running on the virtual machine.

Data is compressed in order to improve the speed of data transmission between the client and the server.

Explain why lossless compression should be used instead of lossy compression.

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..... **[3]**

**(d)** OCR Solutions make use of software libraries when writing their programming code. They also make use of linkers and loaders to compile and run the program.

**(i)** Describe what **linker** means.

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..... **[2]**

**(ii)** Describe what **loader** means.

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..... **[2]**

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**4**

**(a)** Two's complement can be used to represent negative binary numbers.

**(i)** Convert the denary number -124 into an 8-bit two's complement binary number.

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..... **[1]**

**(ii)** State **one** other way to represent negative binary numbers.

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..... **[1]**

**(b)** Convert the denary number 298 into hexadecimal.

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..... **[2]**

**(c)** The binary number **10011101 0110** is stored in **normalised** floating point form with an 8-bit mantissa and a 4-bit exponent both written in two's complement.

Convert this binary number into denary.

You must show your working.

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..... **[3]**

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**(d)** The binary number **00001011 0111** is represented in **unnormalised** floating point form with an 8-bit mantissa and a 4-bit exponent both written in two's complement.

Convert this binary number into a **normalised** floating point binary number, represented using an 8-bit mantissa and 4-bit exponent format.

You must show your working.

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..... **[4]**

**(e)** Calculate the binary addition of these two 8-bit (unsigned) binary numbers.

Show your working.

**00110111**
**10011001 +**

**[2]**

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**5** Ben installs burglar alarms. The alarm is made up of a door sensor and a motion sensor. When the alarm is set, the siren will sound if either the door sensor or the motion sensor detect movement.

The alarm also has a test mode setting. When the test mode setting is enabled, an engineer can check the sensors are working without the siren going off.

**(a)** The inputs to the alarm are as follows.

| Input | System |
|---|---|
| A | Door sensor |
| B | Motion sensor |
| C | Alarm has been set |
| D | Test mode enabled |

Draw a logic circuit to show the logic that is used in the burglar alarm to determine if the siren goes off.

**[4]**

**(b)**
**(i)** Simplify the Boolean expression **¬A v ¬B** using De Morgan's First Law.

..... **[1]**

**(ii)** Simplify the Boolean expression **¬(¬B)** using double negation.

..... **[1]**

**(iii)** Simplify the Boolean expression **(A v B) ∧ (A v C)** using distribution.

..... **[2]**

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**6*** A company wants more customers to be able to find their website on the internet.

**(a)** Discuss why search engine indexing and page ranking will be important in achieving this.

You should include the following in your answer:
- what search engine indexing means and what information is collected
- what PageRank means and possible factors that can affect a PageRank score of a website
- possible ways for the company to improve the PageRank score of pages on its website.

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**(b)** The company would like to start selling their products on their website. They will use both client side and server side processing to do this.

Tick (✓) **one** box on each row to identify whether each task would be best performed on the client side or the server side.

| Task | Client Side | Server Side |
|---|---|---|
| Loading the website HTML code | | |
| Applying CSS styles to a website | | |
| Running JavaScript code to check that the customer surname has been entered on the order form | | |
| Running queries on the database to check if an item is available in stock | | |

**[4]**

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**(c)** When customers contact the company, their computers will use a number of protocols such as TCP/IP and HTTP to make connections with other devices over the internet.

Explain what a protocol is and why they are important in network communications.

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**(d)** Describe **three** different pieces of networking hardware in a client–server network apart from the clients and servers themselves.

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**[6]**

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**7*** Rosa has recently opened a new leisure centre. Currently she has 150 members, however, she is estimating that this will increase to around 10 000 members.

Rosa will store members' details in a database. She will also store gym class bookings and appointments with fitness instructors.

Rosa is considering using either a flat file database or a relational database.

Discuss the benefits and drawbacks of flat file databases and relational databases and which one would be the most suitable for Rosa.

You should include the following in your answer:
- the features of flat file databases and relational databases
- the benefits and drawbacks of each type of database
- which type of database would be the most suitable for Rosa.

**[9]**

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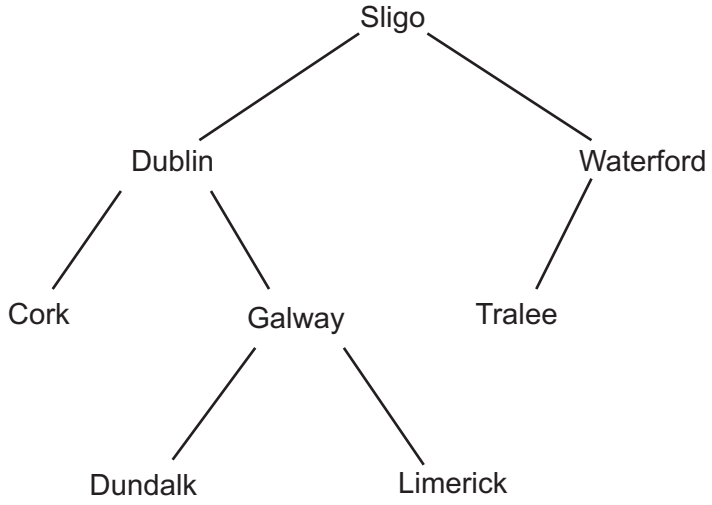
**8** **Fig. 8** shows a binary search tree that contains the names of different towns in Ireland.

**Fig. 8**




The binary search tree is held in a 2-dimensional array called `towns` with 8 rows and 3 columns.

**(a)** Write a line of program code or pseudocode to declare the array `towns`.

..... **[2]**

**(b)**
**(i)** In the 2-dimensional array `towns`:

- the **first** column contains a pointer to the left side
- the **second** column contains the data
- the **third** column contains a pointer to the right side.

Leaf nodes have the pointer `null`.

Complete the table showing the contents of the `towns` array to store the binary search tree shown in **Fig. 8**.

| | **Left** | **Data** | **Right** |
|---|---|---|---|
| 0 | | Sligo | |
| 1 | | Dublin | |
| 2 | | Cork | |
| 3 | | Waterford | |
| 4 | | Galway | |
| 5 | | Limerick | |
| 6 | | Tralee | |
| 7 | | Dundalk | |

**[4]**

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**(ii)** **Four** more towns are added to the binary search tree shown in **Fig. 8** in this order:

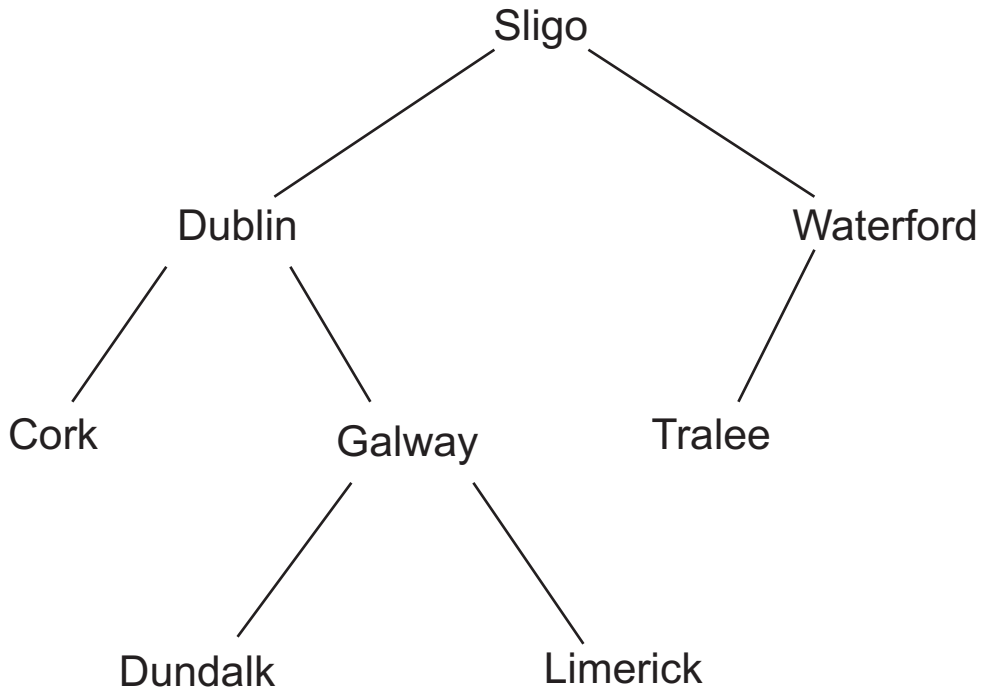
Mallow

Cavan

Tuam

Wexford

Complete this binary search tree by adding the new towns to it.




**[4]**

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**9** OCR DogCare look after dogs while their owners are at work. They use a program developed in an object-oriented paradigm to store details about each dog.

Each dog is declared by using an instance of the class `Dog`. This has these private attributes:

- `name`
- `breed`
- `height`
- `weight`

The constructor method sets all the attributes to the values passed in as parameters.

Write pseudocode or program code to define the class `Dog`. You should include the attributes and constructor method.

You **do not** need to write the set or get methods.

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..... **[5]**

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**10** An investigative firm wants to start investigating cyber security issues.

**(a)** Government bodies have been given additional powers under the Regulation of Investigatory Powers Act.

State **three** additional powers that this law gives to some government bodies.

1 .....

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2 .....

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3 .....

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**[3]**

**(b)** As part of their new roles, employees will be accessing personal data. In order to facilitate this, all employees are enrolled on a course about the Data Protection Act.

Identify **three** principles of the Data Protection Act.

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**[3]**

**END OF QUESTION PAPER**

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## EXTRA ANSWER SPACE

If you need extra space use this lined page. You must write the question numbers clearly in the margin.

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