Please write clearly in block capitals.

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

Surname ______________________________

Forename(s) ______________________________

Candidate signature ______________________________

# A-level
# COMPUTER SCIENCE
## Paper 2

Tuesday 11 June 2019 Morning Time allowed: 2 hours 30 minutes

**Materials**

For this paper you must have:

- a calculator.

**Instructions**

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

**Information**

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 100.

**Advice**

- In some questions you are required to indicate your answer by completely shading a lozenge alongside the appropriate answer as shown.
- If you want to change your answer you must cross out your original answer as shown.
- If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

| For Examiner's Use | |
|---|---|
| Question | Mark |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |
| 11 | |
| 12 | |
| 13 | |
| 14 | |
| TOTAL | |

Answer **all** questions.

**0 1 . 1** Shade **one** lozenge to indicate to which category of system software a virus checker belongs.

**[1 mark]**

| Category | Shade one lozenge |
|---|---|
| Operating systems | ⬭ |
| Translators | ⬭ |
| Utilities | ⬭ |

**0 1 . 2** The operating system is responsible for resource management.

Describe **two** different types of resource management that an operating system is responsible for.

**[2 marks]**

Type 1: ________________________________________

______________________________________________

______________________________________________

______________________________________________

Type 2: ________________________________________

______________________________________________

______________________________________________

______________________________________________

3

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**0 2 . 1** A company is setting up a computer network to help manage its business.

The company sets up a computer that will act as a server. The server's primary role will be to act as an email server. It will also allow technicians to remotely login so that the server can be managed from other computers.

State the names of **two application layer** protocols that the server must implement and explain what each will be used for.

**[4 marks]**

Protocol 1: ______________________________

Use: ______________________________

______________________________

______________________________

Protocol 2: ______________________________

Use: ______________________________

______________________________

______________________________

**0 2 . 2** Explain how the **transport layer** of the TCP/IP stack determines which application layer software on the server should deal with a received request.

**[1 mark]**

______________________________

______________________________

______________________________

______________________________

**0 2 . 3** Describe **one** function of the **network layer** of the TCP/IP stack.

**[1 mark]**

______________________________

______________________________

______________________________

______________________________

6

**Turn over for the next question**

*Do not write outside the box*

**0 3** The paragraph of text in **Figure 1** is to be compressed using a dictionary-based compression method.

**Figure 1**

Unfortunately time after time it is the case that programmers fail to put enough effort into commenting their code. Effort put into commenting could make the code easier to maintain when the time comes to do this.

**0 3 . 1** Dictionary-based compression is an example of a lossless encryption method.

Explain the key difference between lossless and lossy compression methods.

**[1 mark]**

**0 3 . 2** Explain how the paragraph of text in **Figure 1** could be compressed using a dictionary-based method.

**[2 marks]**

**0 3 . 3** After the text in **Figure 1** has been compressed it is to be transmitted across a computer network.

Explain why dictionary-based compression is not very effective for compressing small amounts of text for transmission.

**[1 mark]**

4

Do not write outside the box

**0 4** A student has attempted to add together the binary numbers `00110011` and `10110110`, but has made a mistake.

The student's calculation is shown in **Figure 2** below.

**Figure 2**

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| + | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| Carry | 0 | 1 | 1 | 0 | 1 | 1 | 0 | |
| Result | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |

Explain what mistake the student has made.

The columns in the addition have been labelled **A** to **H** to help you make your explanation clear.

**[1 mark]**

1

**0 5** A student has written a computer program using an imperative high-level programming language. The program could be translated using either a compiler or an interpreter.

Describe the steps that must be completed to translate and execute the program.

Your description should include:

- why translation is necessary
- the differences between how a compiler and an interpreter would translate the program
- how the machine code instructions that are used to carry out the program will be fetched and executed by the processor from main memory.

**[12 marks]**

*Do not write outside the box*

*Do not write outside the box*

12

**Turn over for the next question**

Do not write outside the box

**0 6** A veterinary practice with four different surgeries intends to use a relational database to store the data that it needs to manage its business.

Customers of the practice are pet owners who bring their pets to one of the surgeries for appointments. The surgeries are staffed by vets.

- Each customer is identified by a unique identity number and the customer's forename, surname and telephone number are recorded.
- Each pet is identified by a unique identity number and the pet's name, type and date of birth are recorded.
- Each surgery is identified uniquely by its name. The town in which it is located and the surgery's telephone number are recorded.
- Each vet is identified by a unique identity number and the vet's forename and surname are recorded.

A pet is owned by one or more customers and each customer may own any number of pets. Over their lifetimes, pets may attend many appointments.

To make an appointment for a pet, a customer contacts a surgery. The appointment is made for the pet to take place on a particular date and time at a specific surgery.

Each vet is associated with one surgery which they work at; each surgery is staffed by several vets.

**0 6 . 1** Complete the entity-relationship diagram below for a **fully normalised** relational database to store the data required by the veterinary practice.

Some of the entities and relationships have been drawn for you. You need to draw the remaining **three** entities and clearly show the relationships between the entities and their degree.

**[3 marks]**

*Do not write outside the box*

**0 6 . 2** Develop a **fully normalised design** for a relational database to store the information required by the veterinary practice. To help you, the Pet, Surgery and Vet relations have already been defined in **Figure 3**.

**Figure 3**

Pet(<u>PetID</u>, PetName, Type, DateOfBirth)

Surgery(<u>SurgeryName</u>, Town, TelephoneNumber)

Vet(<u>VetID</u>, VetForename, VetSurname, SurgeryName)

Using the format shown in **Figure 3** list all the other relations that will need to be created, together with the attributes that each will contain.

Underline the attribute(s) that will form the entity identifier (primary key) in each relation.

**[4 marks]**

**Question 6 continues on the next page**

Do not write outside the box

**0 6 . 3** The SQL query in **Figure 4** has been written to produce a list of all of the vets who work at the surgery in the town of Torquay. Some errors have been made in the query.

**Figure 4**

```
SELECT VetForename, VetSurname
FROM Surgery, Vet
WHERE Town = Torquay
```

Describe **two** errors that have been made in the query. You should **not** give the omission of a semi-colon (;) as one of the errors.

**[2 marks]**

Error 1: ____________________

Error 2: ____________________

**0 6 . 4** The database is stored at the practice's head office. Staff at the individual surgeries access it using a client-server database system, which enables the management of concurrent access to the database.

Describe an example of a problem that could occur if no system were in place to manage concurrent access to the database.

**[3 marks]**

Do not write outside the box

**0 6 . 5** Two methods that can be used to manage concurrent access are:

- record locks
- timestamp ordering.

Select **one** of these methods and describe how it manages concurrent access.

**[2 marks]**

Method selected: ______________________________

How it works: ______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

**14**

**Turn over for the next question**

*Do not write outside the box*

**0 7** **Figure 5** shows three commonly used mathematical functions: `add`, `square` and `pred`.

**Figure 5**

$$\texttt{add(x,y)} = x + y$$

$$\texttt{square(x)} = x^2$$

$$\texttt{pred(x)} = x - 1$$

For example:

- `add(3,2)` evaluates to 5
- `square(2)` evaluates to 4
- `pred(8)` evaluates to 7

The domain of the functions `square` and `pred` in **Figure 5** is the set of integers $\mathbb{Z}$ and the domain of the `add` function is $\mathbb{Z} \times \mathbb{Z}$.

**0 7 . 1** What is the co-domain of the `pred` function?

**[1 mark]**

**0 7 . 2** What is the result of applying `square ∘ pred` to the argument 3?

**[1 mark]**

**0 7 . 3** The `add` function takes two arguments.

Describe how the `add` function could be partially applied to the arguments 4 and 6.

**[3 marks]**

5

**0 8 . 1** Complete the truth tables for the OR and NAND gates.

**[1 mark]**

**OR Gate**

| Inputs | | Output |
|---|---|---|
| 0 | 0 | |
| 0 | 1 | |
| 1 | 0 | |
| 1 | 1 | |

**NAND Gate**

| Inputs | | Output |
|---|---|---|
| 0 | 0 | |
| 0 | 1 | |
| 1 | 0 | |
| 1 | 1 | |

**0 8 . 2** Draw a logic circuit for the Boolean expression:

$$Q = \overline{A.B + C.\overline{B}}$$

**[4 marks]**


**Question 8 continues on the next page**

*Do not write outside the box*

**0 8 . 3** Identities are often applied to help simplify Boolean expressions. One such identity is:

$$\mathrm{A}\,.\,\overline{\mathrm{A}} = 0$$

Without using a truth table, explain why this identity is true.

**[2 marks]**

**0 8 . 4** Using the rules of Boolean algebra, simplify the following Boolean expression.

$$\overline{\overline{\overline{\mathrm{B}}\,.\,\mathrm{A}}\,.\,\overline{\mathrm{B}}} + \mathrm{A}\,.\,\mathrm{B}$$

You **must** show your working.

**[4 marks]**

Answer ______________________

**11**

*Do not write outside the box*

**0 9** A data communication system uses asynchronous serial communication.

**0 9 . 1** Explain the difference between asynchronous and synchronous communication.

**[1 mark]**

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

**0 9 . 2** The ASCII code for the digit `'0'` is 48 in decimal. In ASCII, other digits follow on from this value in sequence.

The digit `'4'` is to be transmitted in ASCII using asynchronous serial transmission and **even parity**, with the parity bit stored in the most significant bit of the byte of data containing the ASCII code.

Complete **Figure 6** below to show a valid bit pattern for transmitting the digit `'4'`

**[3 marks]**

**Figure 6**

| Stop Bit | Parity Bit | | | | | | | | Start Bit |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

**Question 9 continues on the next page**

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**0 9 . 3** It is proposed that the communication system is modified so that:

- a majority voting system is used instead of the parity bit
- Unicode is used to encode the characters to be transmitted instead of ASCII.

Discuss the **improvements** that will occur in the communication system as a result of these changes and any **disadvantages** that will result from them.

**[4 marks]**

8

*Do not write outside the box*

**1 0** The greatest common divisor of two positive integers A and B is the largest positive integer that divides both of the numbers without leaving a remainder.

For example, if A = 4 and B = 6 then:

- 4 has the divisors 1, 2 and 4
- 6 has the divisors 1, 2, 3 and 6

Therefore, the greatest common divisor of 4 and 6 is 2, since this is the biggest number which appears in the list of divisors of both 4 and 6.

The method shown in **Figure 7** is a famous method for determining the greatest common divisor of two positive integers, A and B:

**Figure 7**

```
WHILE A ≠ B
  IF A > B THEN
    A = A – B
  ELSE
    B = B – A
  ENDIF
ENDWHILE
```

When the procedure described in the algorithm terminates, the value in A (and also B) is the greatest common divisor of A and B.

**Question 10 continues on the next page**

**Table 1 – standard AQA assembly language instruction set**

| | |
|---|---|
| LDR Rd, <memory ref> | Load the value stored in the memory location specified by <memory ref> into register d. |
| STR Rd, <memory ref> | Store the value that is in register d into the memory location specified by <memory ref>. |
| ADD Rd, Rn, <operand2> | Add the value specified in <operand2> to the value in register n and store the result in register d. |
| SUB Rd, Rn, <operand2> | Subtract the value specified by <operand2> from the value in register n and store the result in register d. |
| MOV Rd, <operand2> | Copy the value specified by <operand2> into register d. |
| CMP Rn, <operand2> | Compare the value stored in register n with the value specified by <operand2>. |
| B <label> | Always branch to the instruction at position <label> in the program. |
| B<condition> <label> | Branch to the instruction at position <label> if the last comparison met the criterion specified by <condition>. Possible values for <condition> and their meanings are:<br>EQ: equal to NE: not equal to<br>GT: greater than LT: less than |
| AND Rd, Rn, <operand2> | Perform a bitwise logical AND operation between the value in register n and the value specified by <operand2> and store the result in register d. |
| ORR Rd, Rn, <operand2> | Perform a bitwise logical OR operation between the value in register n and the value specified by <operand2> and store the result in register d. |
| EOR Rd, Rn, <operand2> | Perform a bitwise logical XOR (exclusive or) operation between the value in register n and the value specified by <operand2> and store the result in register d. |
| MVN Rd, <operand2> | Perform a bitwise logical NOT operation on the value specified by <operand2> and store the result in register d. |
| LSL Rd, Rn, <operand2> | Logically shift left the value stored in register n by the number of bits specified by <operand2> and store the result in register d. |
| LSR Rd, Rn, <operand2> | Logically shift right the value stored in register n by the number of bits specified by <operand2> and store the result in register d. |
| HALT | Stops the execution of the program. |

**Labels**: A label is placed in the code by writing an identifier followed by a colon (:). To refer to a label, the identifier of the label is placed after the branch instruction.

**Interpretation of <operand2>**

<operand2> can be interpreted in two different ways, depending on whether the first character is a # or an R:

- # – use the decimal value specified after the #, eg #25 means use the decimal value 25.
- Rm – use the value stored in register m, eg R6 means use the value stored in register 6.

The available general purpose registers that the programmer can use are numbered 0 to 12.

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**1 0 . 1** Write a program **using the AQA assembly language instruction set**, shown on page 18 in **Table 1**, that uses the method described in **Figure 7** to calculate the greatest common divisor of two positive integers.

- At the start, the positive integer A will be stored in memory location 102 and the positive integer B in memory location 103. Your program should use these values to find their greatest common divisor.
- When your program terminates it should store the greatest common divisor of these two numbers in memory location 104.

**[8 marks]**

8

*Do not write outside the box*

**1 1** Questions **11.1**, **11.2**, **11.3** and **11.4** use a **normalised** floating point representation with an **8-bit** mantissa and a **4-bit** exponent, both stored using **two's complement**.

**1 1 . 1** Write the **smallest positive** number that can be represented by the floating point system in the boxes below.

**[2 marks]**

| | ● | | | | | | |
|---|---|---|---|---|---|---|---|

Mantissa

| | | | |
|---|---|---|---|

Exponent

**1 1 . 2** The following is a floating point representation of a number:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 ● | 0 | 1 | 1 | 0 | 0 | 1 | 0 |

Mantissa

| | | | |
|---|---|---|---|
| 0 | 0 | 1 | 0 |

Exponent

Calculate the decimal equivalent of the number.

You **must** show your working.

**[2 marks]**

Answer ____________________

**1 1 . 3** Write the normalised floating point representation of the decimal value 0.15625 (5/32 as a fraction) in the boxes below.

You **must** show your working.

**[3 marks]**

**Answer**

| | ● | | | | | | |
|---|---|---|---|---|---|---|---|

Mantissa

| | | | |
|---|---|---|---|

Exponent

*Do not write outside the box*

**1 1 . 4** The two floating point numbers below are multiplied together.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | ●1 | 0 | 1 | 0 | 0 | 0 | 0 | | 0 | 1 | 1 | 1 |

Mantissa — Exponent

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | ●1 | 1 | 0 | 0 | 1 | 0 | 0 | | 0 | 0 | 1 | 1 |

Mantissa — Exponent

A problem occurs as a result of the multiplication operation.

Explain what problem has occurred and how the floating point representation could be redesigned to avoid it.

**[3 marks]**

10

**1 2** A particular computer system uses a 32-bit address bus and a 32-bit data bus. Each addressed memory location can store one byte of data.

**1 2 . 1** What is the maximum amount of memory, in bytes, that could be accessed?

**[1 mark]**

**Question 12 continues on the next page**

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**1 2 . 2** A different computer system has a wider data bus; this will speed up the execution of programs.

Explain how the wider data bus has resulted in this effect.

**[1 mark]**

2

**1 3** Discuss the **advantages** and **disadvantages** of representing an image as a vector graphic instead of as a bitmap.

In your answer, include an example for which it would be most appropriate to use a vector graphic and an example for which it would be most appropriate to use a bitmap.

**[6 marks]**

6

*Do not write outside the box*

**1 4 . 1** The ciphertext message "BVP" has been received. The message was encrypted using the Vernam cipher and the key "TIN".

Conversion between letters and their equivalent binary patterns was carried out using a special code called the Baudot-Murray code. A version of the Baudot-Murray codes for each letter is shown in **Figure 8**.

**Figure 8**

| Letter | Encoding |
|---|---|
| A | 11000 |
| B | 10011 |
| C | 01110 |
| D | 10010 |
| E | 10000 |
| F | 10110 |
| G | 01011 |
| H | 00101 |
| I | 01100 |
| J | 11010 |
| K | 11110 |
| L | 01001 |
| M | 00111 |

| Letter | Encoding |
|---|---|
| N | 00110 |
| O | 00011 |
| P | 01101 |
| Q | 11101 |
| R | 01010 |
| S | 10100 |
| T | 00001 |
| U | 11100 |
| V | 01111 |
| W | 11001 |
| X | 10111 |
| Y | 10101 |
| Z | 10001 |

Decrypt the ciphertext to work out what the original plaintext message was.

Express the plaintext as letters.

You **must** show your working.

**[3 marks]**

**Plaintext** ____________________

*Do not write outside the box*

The Vernam cipher can offer perfect security. Most encrypted transmissions that are made by computers use ciphers that are computationally secure but not perfectly secure.

**1 4 . 2** Explain what it means for a cipher to be described as being computationally secure.

**[1 mark]**

Many computerised cipher systems use asymmetric encryption methods to resolve the key exchange problem that is associated with symmetric ciphers, such as the Vernam and Caesar ciphers.

**1 4 . 3** Explain what the key exchange problem is, in relation to a symmetric cipher.

**[2 marks]**

Do not write outside the box

**1 4 . 4** A message is to be transmitted from computer A to computer B. The message will be encrypted using asymmetric encryption. To enable computer B to authenticate that the message was sent by computer A, a digital signature will also be sent with the message.

Explain how computer B will decrypt the message and verify that it was sent by computer A.

In your response you should refer to the specific keys that will be used in this process.

You do **not** need to explain how computer A will encrypt the message or create the digital signature.

**[4 marks]**

**10**

**END OF QUESTIONS**

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