Please write clearly in block capitals.

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

Surname ______________________

Forename(s) ______________________

Candidate signature ______________________

I declare this is my own work.

# GCSE
# COMPUTER SCIENCE

## Paper 1 Computational Thinking and Problem-Solving

Monday 11 May 2020 Morning Time allowed: 1 hour 30 minutes

**Materials**

There are no additional materials required for this paper.

**Instructions**

- Use black ink or black ball-point pen. Use pencil only for drawing.
- Answer **all** questions.
- You must answer the questions in the spaces provided.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Unless the question states otherwise, you are free to answer questions that require a coded solution in whatever format you prefer as long as your meaning is clear and unambiguous.
- You must **not** use a calculator.

**Information**

The total number of marks available for this paper is 80.

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

**Advice**

For the multiple-choice questions, completely fill in the lozenge alongside the appropriate answer.

CORRECT METHOD WRONG METHODS

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.

Answer **all** questions.

**0 1 . 1** A bitmap image is represented as a grid of pixels.

State what is meant by the term pixel.

**[1 mark]**

**0 1 . 2** State the maximum number of different colours that can be used if a bitmap image has a colour depth of six bits.

**[1 mark]**

**0 1 . 3** What is the minimum file size for an 800 pixel by 1000 pixel bitmap image that uses 20 different colours? You should give your answer in **kilobytes**.

You should show your working.

**[3 marks]**

Answer ______________________________ kB

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**0 1 . 4** The algorithm shown in **Figure 1** converts binary data entered as a string by the user into a representation of a black and white image.

The algorithm uses the + operator to concatenate two strings.

Characters in the string are indexed starting at zero. For example `bdata[2]` would access the third character of the string stored in the variable `bdata`

The `MOD` operator calculates the remainder after integer division, for example `17 MOD 5 = 2`

**Figure 1**

```
bdata ← USERINPUT
image ← ''
FOR i ← 0 TO LEN(bdata) - 1
   IF bdata[i] = '0' THEN
      image ← image + '*'
   ELSE
      image ← image + '/'
   ENDIF
   IF i MOD 3 = 2 THEN
      OUTPUT image
      image ← ''
   ENDIF
ENDFOR
```

Complete the trace table for the algorithm shown in **Figure 1** when the variable `bdata` is given the following value from the user:

`110101`

You may not need to use every row in the table. The algorithm output is not required.

**[3 marks]**

| i | image |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
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**0 2** Describe how the linear search algorithm works.

**[3 marks]**

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**11**

**0 3 . 1** State the name of the logic gate represented by the following truth table.

**[1 mark]**

| Input A | Input B | Output |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

Logic gate ______________________________________________

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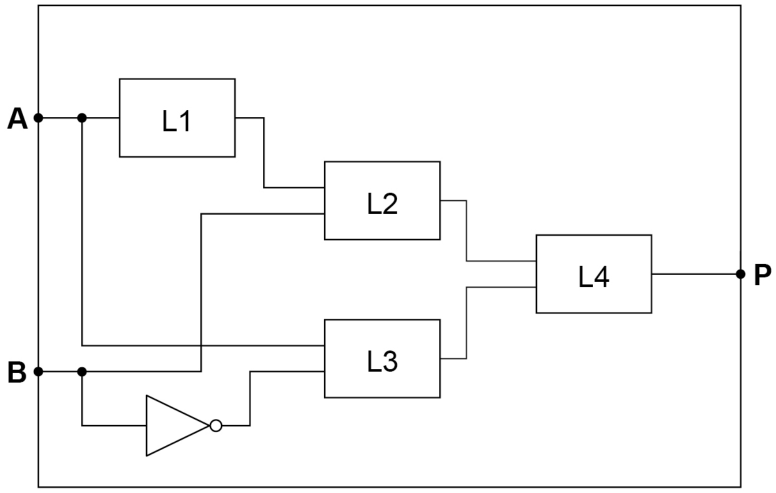
A partially complete logic circuit is shown in **Figure 2** that detects if a computer system has been set up correctly. There are two keyboard input devices, keyboard **A** and keyboard **B**, and either one can be connected to the computer system. However, if they are both connected then the computer system will not work.

Output **P** has the value 1 if either keyboard **A** or keyboard **B**, but not both, is connected to the computer system and 0 otherwise.

**Figure 2**




**0 3 . 2** State the name of the logic gates that should be placed in the positions indicated by the labels **L1**, **L2**, **L3** and **L4** in **Figure 2**.

**[3 marks]**

| Label | Logic gate |
|---|---|
| **L1** | |
| **L2** | |
| **L3** | |
| **L4** | |

4

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**0 4** The algorithm shown in **Figure 3** is used to check if the start of an instruction for a particular assembly language is valid.

The string representation of the assembly language instruction is stored in the variable `instr`

Characters in the string are indexed starting at zero. For example `instr[2]` would access the third character of the string stored in the variable `instr`

**Figure 3**

```
code ← ''
i ← 0
WHILE instr[i] ≠ ':' AND i < 4
   code ← code + instr[i]
   i ← i + 1
ENDWHILE
valid ← False
IF code = 'ADD' OR code = 'SUB' OR code = 'HALT' THEN
   valid ← True
ENDIF
```

**0 4 . 1** Shade **one** lozenge to show the most appropriate data type of the variable `i` in the algorithm in **Figure 3**.

**[1 mark]**

**A** Character ⬭

**B** Integer ⬭

**C** Real ⬭

**D** String ⬭

**0 4 . 2** State the data type of the variable `valid` in the algorithm in **Figure 3**.

**[1 mark]**

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**0 4 . 3** State the final value of the variable `valid` in the algorithm in **Figure 3** for the following different starting values of `instr`

**[3 marks]**

| **Value of** `instr` | **Final value of** `valid` |
|---|---|
| `ADD R0, R1` | |
| `ADD: R0, R1` | |
| `HALT` | |

**0 4 . 4** State what an assembly language program must be translated into before it can be executed by a computer.

**[1 mark]**

______________________________________________

______________________________________________

**0 4 . 5** State **two** reasons why a programmer, who can program in both high-level and low-level languages, would usually choose to develop in a high-level language rather than a low-level language.

**[2 marks]**

Reason 1 ______________________________________________

______________________________________________

______________________________________________

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Reason 2 ______________________________________________

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**0 4 . 6** Develop an algorithm, using either pseudo-code **or** a flowchart, that:

- initialises a variable called `regValid` to `False`
- sets a variable called `regValid` to `True` if the string contained in the variable `reg` is an uppercase `R` followed by the character representation of a single numeric digit.

Examples:
- if the value of `reg` is `R0` or `R9` then `regValid` should be `True`
- if the value of `reg` is `r6` or `Rh` then `regValid` should be `False`

You may wish to use the subroutine `isDigit(ch)` in your answer. The subroutine `isDigit` returns `True` if the character parameter `ch` is a string representation of a digit and `False` otherwise.

**[3 marks]**

11

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**ANSWER IN THE SPACES PROVIDED**

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**0 5** The algorithms shown in **Figure 4** and **Figure 5** both have the same purpose.

The operator `LEFTSHIFT` performs a binary shift to the left by the number indicated.

For example, `6 LEFTSHIFT 1` will left shift the number `6` by one place, which has the effect of multiplying the number `6` by two giving a result of 12

**Figure 4**

```
result ← number LEFTSHIFT 2
result ← result – number
```

**Figure 5**

```
result ← 0
FOR x ← 1 TO 3
   result ← result + number
ENDFOR
```

**0 5 . 1** Complete the trace table for the algorithm shown in **Figure 4** when the initial value of `number` is 4

You may not need to use all rows of the trace table.

**[2 marks]**

| result |
|---|
| |
| |
| |

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**0 5 . 2** Complete the trace table for the algorithm shown in **Figure 5** when the initial value of `number` is 4

You may not need to use all rows of the trace table.

**[2 marks]**

| `x` | `result` |
|---|---|
| | |
| | |
| | |
| | |
| | |

**0 5 . 3** The algorithms in **Figure 4** and **Figure 5** have the same purpose.

State this purpose.

**[1 mark]**

**0 5 . 4** Explain why the algorithm shown in **Figure 4** can be considered to be a more efficient algorithm than the algorithm shown in **Figure 5**.

**[1 mark]**

6

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**0 6** Show the steps involved, for either the bubble sort algorithm **or** the merge sort algorithm, to sort the array shown in **Figure 6** so the result is `[1, 4, 5, 8]`

**Figure 6**

`[8, 4, 1, 5]`

**Circle** the algorithm you have chosen:

Bubble sort      Merge sort

**[4 marks]**

Steps:

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**0 7 . 1** Four subroutines are shown in **Figure 7**.

**Figure 7**

```
SUBROUTINE main(k)
   OUTPUT k
   WHILE k > 1
      IF isEven(k) = True THEN
         k ← decrease(k)
      ELSE
         k ← increase(k)
      ENDIF
      OUTPUT k
   ENDWHILE
ENDSUBROUTINE

SUBROUTINE decrease(n)
   result ← n DIV 2
   RETURN result
ENDSUBROUTINE

SUBROUTINE increase(n)
   result ← (3 * n) + 1
   RETURN result
ENDSUBROUTINE

SUBROUTINE isEven(n)
   IF (n MOD 2) = 0 THEN
      RETURN True
   ELSE
      RETURN False
   ENDIF
ENDSUBROUTINE
```

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Complete the table showing **all** of the outputs from the subroutine call `main(3)`

The first output has already been written in the trace table. You may not need to use all rows of the table.

**[4 marks]**

| Output |
|---|
| 3 |
| |
| |
| |
| |
| |
| |
| |
| |
| |

**0 7 . 2** Describe how the developer has used the structured approach to programming in **Figure 7**.

**[2 marks]**

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10

**Turn over ►**

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**0 8** The subroutine `CODE_TO_CHAR` can be used to convert a character code into the corresponding Unicode character. For example:

`CODE_TO_CHAR(97)` will return the character `'a'`
`CODE_TO_CHAR(65)` will return the character `'A'`

The subroutine `CHAR_TO_CODE` can be used to convert a Unicode character into the corresponding character code. For example:

`CHAR_TO_CODE('a')` will return the integer `97`
`CHAR_TO_CODE('A')` will return the integer `65`

**0 8 . 1** Shade **one** lozenge to show what value would be returned from the subroutine call `CODE_TO_CHAR(100)`

**[1 mark]**

**A** `'c'` ○

**B** `'d'` ○

**C** `'e'` ○

**D** `'f'` ○

**0 8 . 2** State the value that will be returned from the subroutine call:

`CODE_TO_CHAR(CHAR_TO_CODE('E') + 2)`

**[1 mark]**

Value returned ________________________________________

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**0 8 . 3** Write a subroutine TO_LOWER, using either pseudo-code **or** a flowchart, that takes an upper case character as a parameter and returns the corresponding lower case character.

For example, if the subroutine TO_LOWER is passed the character 'A' as a parameter, the subroutine should return the character 'a'.

You should make use of the subroutines CODE_TO_CHAR and CHAR_TO_CODE in your answer.

You can assume that the parameter passed to the subroutine will be in upper case.

**[5 marks]**

7

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**0 9** A developer needs to store data about thousands of songs in a program. She needs to be able to hold information on every song's title, singer and year of release.

Explain how the developer could use a combination of an array and records to store this information.

In your answer you should refer to the data types that would be used by the developer.

**[4 marks]**

**4**

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**1 0** An application allows only two users to log in. Their usernames are stated in **Table 1** along with their passwords.

**Table 1**

| username | password |
|---|---|
| `gower` | `9Fdg3` |
| `tuff` | `888rG` |

Develop an algorithm, using either pseudo-code **or** a flowchart, that authenticates the user. The algorithm should:

- get the user to enter their username and password
- check that the combination of username and password is correct and, if so, output the string `'access granted'`
- get the user to keep re-entering their username and password until the combination is correct.

**[6 marks]**

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6

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**1 1** Develop an algorithm, using either pseudo-code **or** a flowchart, that helps an ice cream seller in a hot country calculate how many ice creams they are likely to sell on a particular day. Your algorithm should:

- get the user to enter whether it is the weekend or a weekday
- get the user to enter the temperature forecast in degrees Celsius (they should enter a number between 20 and 45 inclusive; if the number falls outside of this range then they should be made to re-enter another number until they enter a valid temperature)
- calculate the number of ice creams that are likely to be sold using the following information:
  - 100 ice creams are likely to be sold if the temperature is between 20 and 30 degrees inclusive,
  - 150 ice creams are likely to be sold if the temperature is between 31 and 38 degrees inclusive,
  - and 120 ice creams are likely to be sold if the temperature is higher than 38 degrees
- double the estimate if it is a weekend
- output the estimated number of ice creams that are likely to be sold.

**[9 marks]**

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**1 2** A developer has written a set of subroutines to control an array of lights. The lights are indexed from zero. They are controlled using the subroutines in **Table 2**.

**Table 2**

| **Subroutine** | **Explanation** |
|---|---|
| `SWITCH(n)` | If the light at index `n` is on it is set to off.<br><br>If the light at index `n` is off it is set to on. |
| `NEIGHBOUR(n)` | If the light at index `(n+1)` is on, the light at index `n` is also set to on.<br><br>If the light at index `(n+1)` is off, the light at index `n` is also set to off. |
| `RANGEOFF(m, n)` | All the lights between index `m` and index `n` (but **not** including `m` and `n`) are set to off. |

Array indices are shown above the array of lights.

For example, if the starting array of the lights is

| 0 | 1 | 2 | 3 |
|---|---|---|---|
| off | on | off | on |

Then after the subroutine call `SWITCH(2)` the array of lights will become

| 0 | 1 | 2 | 3 |
|---|---|---|---|
| off | on | on | on |

And then after the subroutine call `NEIGHBOUR(0)` the array of lights will become

| 0 | 1 | 2 | 3 |
|---|---|---|---|
| on | on | on | on |

Finally, after the subroutine call `RANGEOFF(0, 3)` the array of lights will become

| 0 | 1 | 2 | 3 |
|---|---|---|---|
| on | off | off | on |

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**1 2 . 1** If the starting array of lights is

| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| on | off | off | on | off | off | on |

What will the array of lights become after the following algorithm has been followed?

```
a ← 2
SWITCH(a)
SWITCH(a + 1)
NEIGHBOUR(a - 2)
```

Write your final answer in the following array

**[3 marks]**

| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | | | | | | |

**1 2 . 2** If the starting array of lights is

| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| off | off | on | off | on | on | on |

What will the array of lights become after the following algorithm has been followed?

```
FOR a ← 0 TO 2
   SWITCH(a)
ENDFOR
b ← 8
RANGEOFF((b / 2), 6)
NEIGHBOUR(b - 4)
```

Write your final answer in the following array

**[3 marks]**

| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | | | | | | |

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**12.3** If the starting array of lights is

| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| off | on | off | on | off | on | off |

What will the array of lights become after the following algorithm has been followed?

```
a ← 0
WHILE a < 3
   SWITCH(a)
   b ← 5
   WHILE b ≤ 6
      SWITCH(b)
      b ← b + 1
   ENDWHILE
   a ← a + 1
ENDWHILE
```

Write your final answer in the following array

**[3 marks]**

| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | | | | | | |

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**1 2 . 4** If the starting array of lights is

| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| on | on | on | on | on | on | on |

Write an algorithm, using **exactly three** subroutine calls, that means the final array of lights will be

| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| off | off | off | off | off | off | off |

You must use each of the subroutines `SWITCH`, `NEIGHBOUR` and `RANGEOFF` **exactly once** in your answer. If you do not do this you may still be able to get some marks.

**[3 marks]**

12

**END OF QUESTIONS**

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