Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

8425739040

COMPUTING **9691/22**

Paper 2 **May/June 2016**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **15** printed pages and **1** blank page.

CAMBRIDGE International Examinations

1 A high-level programming language has built-in string handling functions specified as follows:

```
ONECHAR(ThisString : STRING, x : INTEGER) RETURNS STRING
```

returns a string value consisting of one character from the string `ThisString` at position `x`.

For example: `ONECHAR("STOP", 4)` returns `"P"`

```
CONCAT(String1 : STRING, String2 : STRING) RETURNS STRING
```

returns a string value consisting of `String1` followed by `String2`.

For example: `CONCAT("HE", "LLO")` returns `"HELLO"`

Use the pseudocode on the following page to complete the trace table for the function call

```
Process("011101", "001100")
```

String1	String2	Position	Digit1	Digit2	Sum	Carry	Result
"011101"	"001100"					"0"	""

[6]

```
FUNCTION Process(String1, String2 : STRING) RETURNS STRING
   Carry ← "0"
   Result ← ""
   FOR Position ← 6 DOWN TO 1
      Digit1 ← ONECHAR(String1, Position)
      Digit2 ← ONECHAR(String2, Position)
      IF Carry = "0"
         THEN
            CASE OF Digit1
               "0": Sum ← Digit2
               "1": CASE OF Digit2
                       "0": Sum ← "1"
                       "1": Sum ← "0"
                            Carry ← "1"
                    ENDCASE
            ENDCASE
         ELSE
            CASE OF Digit1
               "0": CASE OF Digit2
                       "0": Sum ← "1"
                            Carry ← "0"
                       "1": Sum ← "0"
                    ENDCASE
               "1": CASE OF Digit2
                       "0": Sum ← "0"
                       "1": Sum ← "1"
                    ENDCASE
            ENDCASE
      ENDIF
      Result ← CONCAT(Sum, Result)
   ENDFOR
   RETURN Result
ENDFUNCTION
```

2 Ryan wrote the following recursive function using pseudocode.

```
01 FUNCTION Power(Number : INTEGER, Exponent : INTEGER) RETURNS INTEGER
02    IF Exponent = 0
03       THEN
04          Result ← 1
05       ELSE
06          Result ← Number * Power(Number, Exponent - 1)
07    ENDIF
08    RETURN Result
09 ENDFUNCTION
```

(a) (i) How can you recognise that this function is recursive?

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..... [1]

(ii) A recursive solution to a problem always has a **base case** (the stopping condition) and a **general case**.

Give the line number of the statement that is executed in the base case.

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Give the line number of the statement that is executed in the general case.

..... [2]

(b) (i) State the value returned by `Power(3, 0)`.

..... [1]

(ii) State the value returned by `Power(3, 1)`.

..... [1]

(c) (i) Explain what happens when the call is `Power(3, -1)`.

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..... [2]

(ii) Describe the changes that will need to be made to function `Power` to address the problem that you described in **part (c)(i)**.

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..... [2]

(d) An alternative method for the `Power` function is to use an iterative solution.

Using **pseudocode**, write `Power` as an iterative function.

```
FUNCTION Power(Number : INTEGER, Exponent : INTEGER) RETURNS INTEGER
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..... [4]

(e) A problem may have both an iterative solution and a recursive solution. Each has its own benefits.

State **one** benefit of each solution.

Iterative .....

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Recursive .....

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..... [2]

(f) Ryan uses his recursive function `Power` in a program. He will use debugging tools to check the `Power` function works as expected. The debugging tools include breakpoints, variable watches and stepping.

(i) Identify where it is appropriate to set a breakpoint. Justify your answer.

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..... [2]

(ii) Ryan wants to set up a variable watch window for his function.

```
01 FUNCTION Power(Number : INTEGER, Exponent : INTEGER) RETURNS
                                                        INTEGER
02    IF Exponent = 0
03       THEN
04          Result ← 1
05       ELSE
06          Result ← Number * Power(Number, Exponent - 1)
07    ENDIF
08    RETURN Result
09 ENDFUNCTION
```

State the variable(s) that would be appropriate to list in the variable watch window. Justify your choice.

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..... [2]

(iii) Explain how Ryan uses these debugging tools to check the execution of his recursive function.

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..... [3]

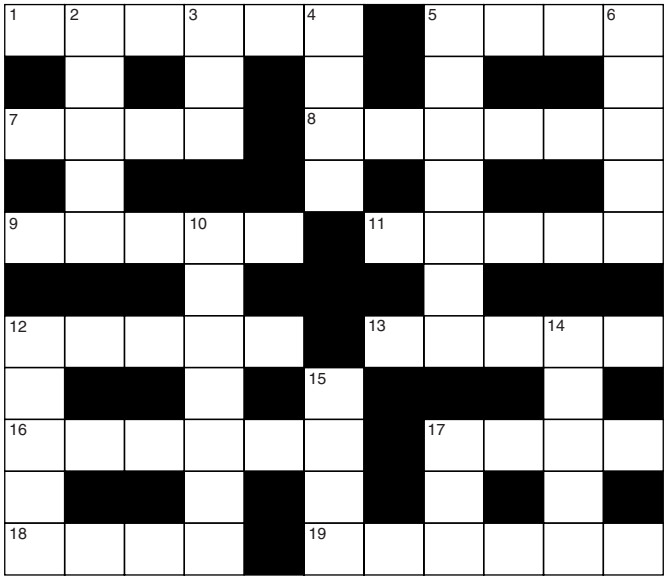
Question 3 begins on page 8.

3 A crossword puzzle is based on a grid made up of white and black squares. The white squares are to be filled with letters to form words across the grid and down the grid.

The crossword puzzle designer provides clues for each word. Words consist of at least 2 letters.

The square where a word starts, across or down, is numbered. The numbering starts at the top left of the grid and is consecutive, row by row.

Here is an example of a crossword grid:



(a) Zara is given a grid design of white and black squares. This design does not yet contain numbers. Zara wants to write a program to set up a data structure for the grid data.

The data for each square will represent either:

- a white square
- a black square
- a white square with a number

(i) A white square with a number is represented by the integer value of the number.

Suggest a suitable value to represent:

A white square .....

A black square ..... [2]

(ii) Write **program code** to declare the data structure with identifier `Puzzle` for a grid design of size 11 × 11 squares.

Programming language .....

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..... [3]

(iii) Initially, all squares are to be white squares.

Write **program code** to initialise `Puzzle`.

Programming language .....

Code .....

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(iv) The seventh square in the first row of the example crossword grid is black.

Write **program code** for the assignment statement to set the corresponding element of `Puzzle` to represent black.

Programming language .....

..... [2]

Where there are other black squares in the design, Zara writes additional assignment statements.

(b) The next stage for Zara is to design a procedure that numbers the relevant white squares.

A word begins in a square if the square is:

- a white square, and
- the first of a sequence of at least 2 white squares
  - across or
  - down

Zara starts to write the pseudocode for the procedure `CheckForStartOfWord`. This will check whether a square at `ThisRow` and `ThisColumn` is the start of a word.

(i) Complete the pseudocode for the global declarations.

```
CONSTANT WHITE =.....// value from part(a)(i)

CONSTANT BLACK =.....// value from part(a)(i)
```
[2]

(ii) Complete the pseudocode:

```
PROCEDURE CheckForStartOfWord(Puzzle, ThisRow, ThisColumn, Across, Down)
   Across ← FALSE // will change to TRUE
                  // if a word across starts in this square
   Down ← ..........
   IF Puzzle[ThisRow, ThisColumn] = ..........
      THEN   // this square is white
         // check for sequence across
         IF ThisColumn < 11  // check not in last column
            THEN
               // check this is the first column or a black square to the
                                                                     left
               IF (ThisColumn = 1
                  OR Puzzle[ThisRow, ThisColumn - 1] = BLACK)
                  // check that the square to the right is white
                  AND (Puzzle[..........] = WHITE)
                  THEN
                     Across ← TRUE
               ..........
         ENDIF
         // check for sequence down
         IF ThisRow < 11  // check not in last row
            THEN
               // check this is the first row or a black square above
               IF (ThisRow = ..........
                  OR Puzzle[..........] = BLACK)
                  // check that the square below is white
                  AND (..........)
                  THEN
                     Down ← ..........
               ENDIF
         ENDIF
   ENDIF
ENDPROCEDURE
```

[8]

(iii) The procedure `CheckForStartOfWord(Puzzle, ThisRow, ThisColumn, Across, Down)` has five parameters. Parameters can be passed **by reference** or **by value**.

For each parameter, tick (✓) to show how it should be passed.

Parameter	By reference	By value
`Puzzle`		
`ThisRow`		
`ThisColumn`		
`Across`		
`Down`		

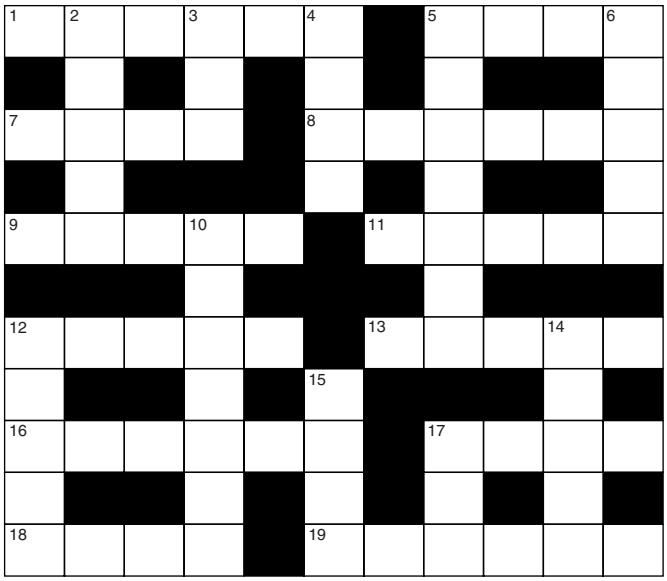
[3]

(c) Zara wants her program to number the squares where a word starts. She also wants the program to create two lists, `AcrossList` and `DownList`.

`AcrossList` will contain the numbers of the starting squares of words going across.
`DownList` will contain the numbers of the starting squares of words going down.

Note that a square can be a starting square for a word going across **and** a word going down. The same number would therefore be contained in both lists.

For example, the given puzzle has these lists. Squares numbered 5, 12 and 17 are starting squares for words going across and words going down.



AcrossList
1
5
7
8
9
11
12
13
16
17
18
19

DownList
2
3
4
5
6
10
12
14
15
17

Zara designs this part of the program by writing pseudocode.

Convert this pseudocode into **program code**.

```
NextNumber ← 1  // first number for numbering starting squares
a ← 1   // pointer to first element of AcrossList
d ← 1   // pointer to first element of DownList
FOR ThisRow ← 1 TO 11
   FOR ThisColumn ← 1 TO 11
      CALL CheckForStartOfWord(Puzzle, ThisRow, ThisColumn, Across, Down)
      IF Across = TRUE
         THEN
            AcrossList[a] ← NextNumber  // update AcrossList
            a ← a + 1
      ENDIF
      IF Down = TRUE
         THEN
            DownList[d] ← NextNumber  // update DownList
            d ← d + 1
      ENDIF
      IF Across = True OR Down = TRUE
         THEN
            Puzzle[ThisRow, ThisColumn] ← NextNumber  // number the square
            NextNumber ← NextNumber + 1
      ENDIF
   ENDFOR
ENDFOR
```

Programming language ....

Code ....

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(d) The pseudocode Zara wrote in **part (b)** and **part (c)** has some features that make it easier to read and understand.

State **four** such features.

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2 .....

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3 .....

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4 .....

..... [4]

(e) Zara wants to save the contents of the data structure `Puzzle` to a sequential file `Puzzle.TXT`

Write **program code** for the procedure `SavePuzzleToFile(Puzzle)`.

Programming language .....

Code .....

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(f) One of Zara's friends suggests that the number of squares for a word should be counted.

Zara decides that she needs a function to count the number of squares for a word going across. She needs another function to count the number of squares for a word going down.

The program will call the function `CountSquaresAcross` when `ThisRow` and `ThisColumn` refer to a square that is the start of a word across.

Write **pseudocode** for the function `CountSquaresAcross`. Declare any local variables required.

```
FUNCTION CountSquaresAcross(Puzzle, ThisRow, ThisColumn) RETURNS
                                                         INTEGER
```

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..... [7]

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