MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE
General Certificate of Education Advanced Level
Higher 2

COMPUTING

9597/01

Paper 1

October/November 2017

3 hours 15 minutes

Additional Materials: Pre-printed A4 paper
Removable storage device
Electronic version of `INVENTORY.TXT` data file
Electronic version of `ISBNPRE.TXT` data file
Electronic version of `PSEUDOCODE_TASK_3_2.TXT` file
Electronic version of `SEARCHTREE.TXT` file
Electronic version of `EVIDENCE.DOCX` document

READ THESE INSTRUCTIONS FIRST

Type in the `EVIDENCE.DOCX` document the following:
- Candidate details
- Programming language used

Answer **all** questions.

All tasks must be done in the computer laboratory. You are not allowed to bring in or take out any pieces of work or materials on paper or electronic media or in any other form.

All tasks and required evidence are numbered.

The number of marks is given in brackets [ ] at the end of each task.

Copy and paste required evidence of program listing and screenshots into the `EVIDENCE.DOCX` document.

At the end of the examination, print out your `EVIDENCE.DOCX` document and fasten your printed copy securely together.

This document consists of **12** printed pages.

Singapore Examinations and Assessment Board

CAMBRIDGE
International Examinations

DC (ST/SW) 138544/5

1 A role-playing computer game includes a list of items called the inventory. This inventory can be represented using a one-dimensional (1-D) array or a list structure.

`INVENTORY.TXT` is a text file containing the items from the computer game inventory. Each item type can have many occurrences. For example:

Inventory	**ItemType**
Iron Ore	Iron Ore
Stone	Stone
Sticky Piston	Sticky Piston
Glass	Glass
Stone	Sand
Stone	
Sand	
Sticky Piston	
Iron Ore	

Task 1.1

Design and write program code to:

- read the entire contents of `INVENTORY.TXT` to an appropriate data structure called `Inventory`
- find each item type in this inventory and write these into a second similar data structure called `ItemTypes`
- count the number of each item type in the inventory and store this in a third similar data structure called `ItemCounts`
- display the contents of the `ItemTypes` and `ItemCounts` data structures using the format given below.

Example run of the program:

Input file:
Iron Ore
Stone
Sticky Piston
Glass
Stone
Stone
Sand
Sticky Piston
Iron Ore

The output generated from this input file would be:

ItemType	**Count**
Iron Ore	2
Stone	3
Sticky Piston	2
Glass	1
Sand	1

Evidence 1
Your program code. [14]

Evidence 2
Screenshot of output. [1]

Question 2 begins on the next page.

2 Every published book has an International Standard Book Number (ISBN). This ISBN is a 9-digit number plus a check digit which is calculated and added to the end of the number. A weighted-modulus method is used to calculate the check digit.

This method uses a weighted modulus 11. If the check digit is calculated as 10, it is replaced with the character 'X'. Where the check digit is calculated as 11, it will be replaced with 0.

184146208 will be calculated as:

1 × 10 = 10
8 × 9 = 72
4 × 8 = 32
1 × 7 = 7
4 × 6 = 24
6 × 5 = 30
2 × 4 = 8
0 × 3 = 0
8 × 2 = 16

Total = 199
199 / 11 = 18 remainder 1
11 – 1 = 10

Therefore, 10 is replaced with X:

ISBN is 184146208**X**

034085045 will be calculated as:

0 × 10 = 0
3 × 9 = 27
4 × 8 = 32
0 × 7 = 0
8 × 6 = 48
5 × 5 = 25
0 × 4 = 0
4 × 3 = 12
5 × 2 = 10

Total = 154
154 / 11 = 14 remainder 0
11 – 0 = 11

Therefore, 11 is replaced with 0:

ISBN is 034085045**0**

075154926 will be calculated as:

0 × 10 = 0
7 × 9 = 63
5 × 8 = 40
1 × 7 = 7
5 × 6 = 30
4 × 5 = 20
9 × 4 = 36
2 × 3 = 6
6 × 2 = 12

Total = 214
214 / 11 = 19 remainder 5
11 – 5 = 6

Therefore, 6 is added to the end of the ISBN:

075154926**6**

Task 2.1
Study the identifier table and the incomplete recursive algorithm on the opposite page.

The missing lines in the algorithm are labelled **A**, **B** and **C**.
Write the **three** missing lines of code. Label each as **A**, **B** or **C**.

Evidence 3
The **three** missing lines of code. [3]

Identifier	Data type	Description
`Number`	`STRING`	The ISBN to be processed
`Digit`	`INTEGER`	A digit from the ISBN to be processed
`Total`	`INTEGER`	Running total for modulus calculation
`NewNumber`	`STRING`	A version of the list string shortened by removing the first character
`CheckDigit`	`STRING`	The calculated check digit value
`CalcModulus`	`INTEGER`	Used to store the result of `(Total MOD 11)`
`CheckValue`	`INTEGER`	Used to store the result of `(11 – CalcModulus)`

```
FUNCTION CalCheckDigit(Number AS STRING, Total AS INTEGER) RETURNS STRING

      IF LENGTH(Number) > 1 THEN
            Digit ← INTEGER(LEFT(Number,1))
            Total ← Total + (Digit * (LENGTH(Number)+1))
            NewNumber ← RIGHT(Number, LENGTH(Number)-1)
            CheckDigit ← .................. A .................
      ELSE
            Digit ← INTEGER(LEFT(Number,1))
            Total ← Total + (Digit * (LENGTH(Number)+1))
            CalcModulus ← Total MOD 11
            CheckValue ← 11 - CalcModulus
            IF CheckValue = 11 THEN
                  RETURN STRING(0)
            ELSE
               IF CheckValue = 10 THEN
               ....................... B ..........................
               ELSE
                  RETURN STRING(CheckValue)
               ENDIF
            ENDIF
      ENDIF
      IF LENGTH(Number) = 9 THEN
            RETURN .................... C ....................
      ELSE
            RETURN CheckDigit;
      ENDIF
END FUNCTION

// Calculate ISBN, an example of how the function is called.
// Second parameter is always 0.
ISBN = CalCheckDigit("184146208",0)
```

Task 2.2

Write a program to implement the ISBN program using the `CalCheckDigit` function.

The program will:

- read the entire contents of the file `ISBNPRE.TXT` (seven 9-digit ISBNs without check digits) into an appropriate data structure
- use the function `CalCheckDigit` to calculate the result (ISBN with check digit) for each entry in the file
- write each result (ISBN with check digit) to the screen.

Evidence 4
Your program code for Task 2.2. [11]

Evidence 5
Screenshot of the results of processing the `ISBNPRE.TXT` file. [1]

3 A data structure is required to store 25 nodes. A linked list is maintained of all the nodes. A node contains a data value and two pointers: a left pointer and a right pointer.
Items in the list are initially linked using their `LeftChild` pointers.

Each node is implemented as an instance of the class `ConnectionNode`. The class `ConnectionNode` has the following properties:

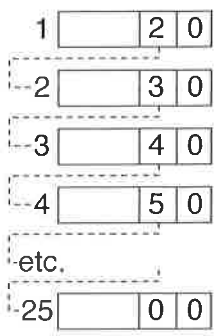
Class: `ConnectionNode`		
Attributes		
Identifier	Data Type	Description
`DataValue`	`STRING`	The node data
`LeftChild`	`INTEGER`	The left node pointer
`RightChild`	`INTEGER`	The right node pointer

The structure for the linked list is implemented as follows:

Identifier	Data Type	Description
`RobotData`	`ARRAY[1 : 25] OF ConnectionNode`	An array used to store the 25 nodes.
`Root`	`INTEGER`	Index for the root position of the `RobotData` array.
`NextFreeChild`	`INTEGER`	Index for the next available empty node.

The first available node is indicated by `NextFreeChild`. The initial value of `Root` is 1 and the initial value of `NextFreeChild` is 1.

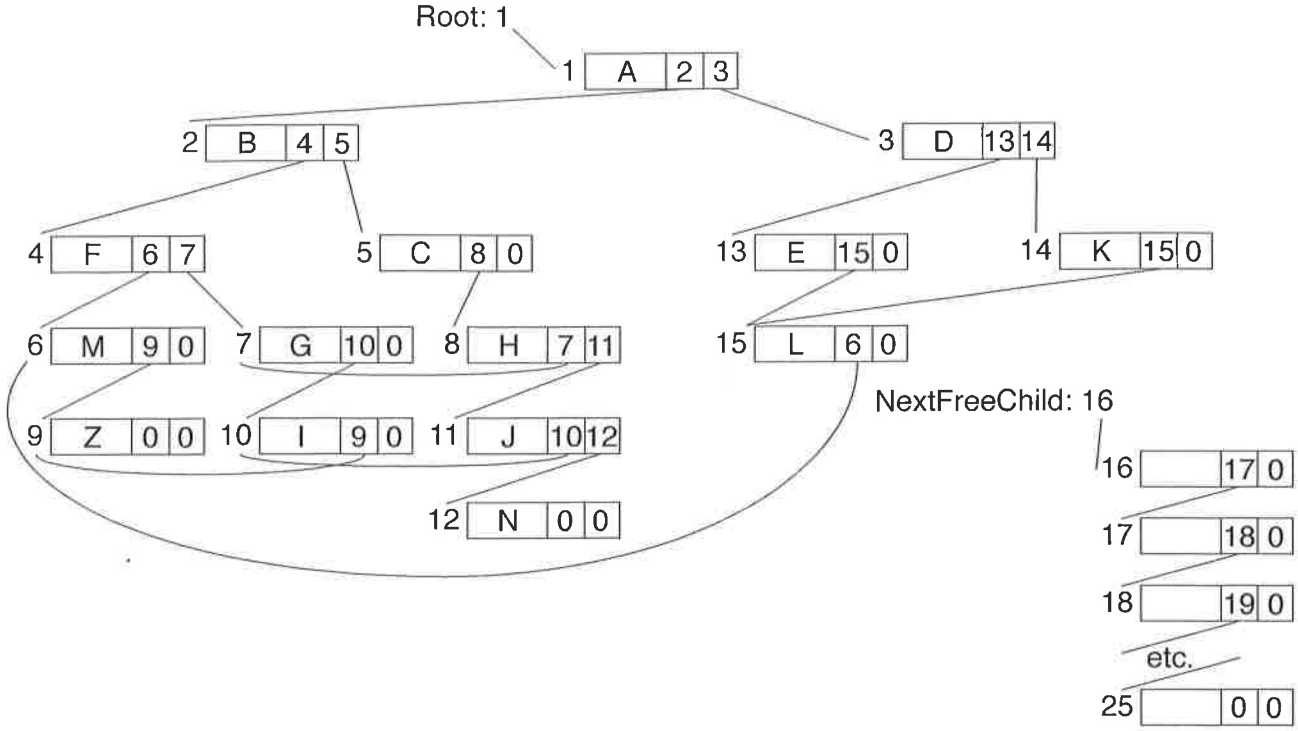
The diagram shows the empty data structure with the linked list to record the unused nodes.



Task 3.1
Write the program code to declare the **empty** data structure and linked list of 25 unused nodes. Add statement(s) to initialise the empty data structure.

Evidence 6
Your program code for Task 3.1. [12]

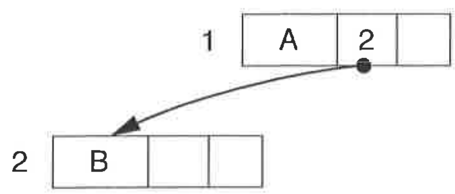
This data structure is used to record the possible routes for a robot to travel from a node A to a node Z. The following data structure illustrates many possible routes, for example, A→D→K→L→M→Z. It is only possible to move to one of two possible nodes; for example, from node A, the only move is to node B or node D.



This data structure has 15 nodes (A to N and Z) but for future development a maximum of 25 nodes is specified. All nodes are unique.

The pseudocode on the next page can be used to add a node to the data structure. The procedure `AddToRobotData` uses the parameters `NewDataItem`, `ParentItem` and `ThisMove`.

The parameter `ThisMove` holds the move made to create this new item ('L' for LeftChild, 'R' for RightChild, 'X' for initial state/root), and the `ParentItem` parameter holds the value of the parent item which points to this `NewDataItem`.



To add node B as shown, the procedure call would be `AddToRobotData('B', 'A', 'L')`. The parameters used would be:

`B`, the new node
`A`, the parent node
`L`, the location of the child (which has an index of 2) is recorded in `LeftChild` of A.

The following pseudocode (available in `PSEUDOCODE_TASK_3_2.TXT`) can be used to add a node to the data structure.

```
FUNCTION FindNode(NodeValue) RETURNS INTEGER
   Found ← FALSE
   CurrentPosition ← Root
   REPEAT
      IF RobotData[CurrentPosition].DataValue = NodeValue THEN
         Found ← TRUE
      ELSE
         CurrentPosition ← CurrentPosition + 1
      ENDIF
   UNTIL Found = TRUE OR CurrentPosition > 25
   IF CurrentPosition > 25 THEN
      RETURN 0
   ELSE
      RETURN CurrentPosition
   ENDIF
ENDFUNCTION

PROCEDURE AddToRobotData(NewDataItem, ParentItem, ThisMove)
      IF Root = 1 AND NextFreeChild = 1 THEN
         NextFreeChild ← RobotData[NextFreeChild].LeftChild
         RobotData[Root].LeftChild ← 0
         RobotData[Root].DataValue ← NewDataItem
      ELSE
         // does the parent exist?
         ParentPosition ← FindNode(ParentItem)
         IF ParentPosition > 0 THEN // parent exists
            // does the child exist?
            ExistingChild ← FindNode(NewDataItem)
            IF ExistingChild > 0 THEN // child exists
               ChildPointer ← ExistingChild
            ELSE
               ChildPointer ← NextFreeChild
               NextFreeChild ← RobotData[NextFreeChild].LeftChild
               RobotData[ChildPointer].LeftChild ← 0
               RobotData[ChildPointer].DataValue ← NewDataItem
            ENDIF
            IF ThisMove = 'L' THEN
               RobotData[ParentPosition].LeftChild ← ChildPointer
            ELSE
               RobotData[ParentPosition].RightChild ← ChildPointer
            ENDIF
         ENDIF
      ENDIF
ENDPROCEDURE
```

Task 3.2

Write code to implement `AddToRobotData` and `FindNode` from this pseudocode.
You may use the text file `PSEUDOCODE_TASK_3_2.TXT` as a basis for writing your code.

Evidence 7
Your program code for Task 3.2. [7]

Task 3.3

Write a procedure `OutputData` which displays the value of `Root`, the value of `NextFreeChild` and the contents of `RobotData` in index order.

Evidence 8
Your program code for Task 3.3. [6]

Task 3.4

The file `SEARCHTREE.TXT` contains the data for the search tree. Each row of the file contains three comma separated values, for example, the first row contains 'A', '0' and 'X'. The file is organised as:

```
NewDataItem,ParentItem,ThisMove
NewDataItem,ParentItem,ThisMove
...
<End of File>
```

There are a total of 20 lines in the `SEARCHTREE.TXT` file representing possible routes.

Write a main program to read the contents of this file and use `AddToRobotData` and `FindNode` to insert these routes into `RobotData`. Your program will then call the `OutputData` procedure.

Evidence 9
Your program code for Task 3.4. [6]

Evidence 10
Screenshot showing the output from running the program in Task 3.4. [2]

Task 3.5

Write a recursive pre-order tree traversal that will display all valid routes from A to Z by following the routes described in `RobotData`.

Evidence 11
Your program code for Task 3.5. [6]

Evidence 12
Screenshot showing the output from running the program in Task 3.5. [1]

4 A computer program can generate a simple Sudoku puzzle using a 4 × 4 two-dimensional array.

An example of this puzzle is:

4	3	2	1
1	2	4	3
3	4	1	2
2	1	3	4

The first step to creating this puzzle is to develop a program to display the 4 × 4 two-dimensional array as a grid. This program will display the grid as:

```
4  3  2  1
1  2  4  3
3  4  1  2
2  1  3  4
```

Task 4.1
Create a program design that will declare, initialise and display the example puzzle shown. This design will:

- make use of top-down design
- include the data structure to represent the puzzle as a grid
- initialise the grid using the values shown
- make use of appropriate procedures and/or functions.

Evidence 13
Your program design for Task 4.1. [6]

Task 4.2
Write program code to display the puzzle designed in Task 4.1.

Evidence 14
Your program code. [5]

Evidence 15
Screenshot of the displayed grid. [1]

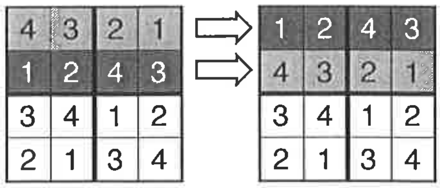
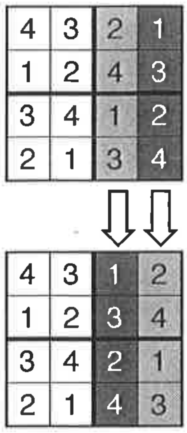
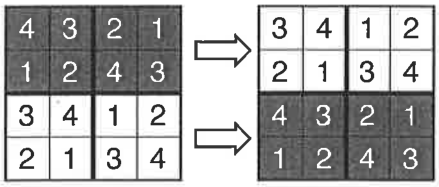
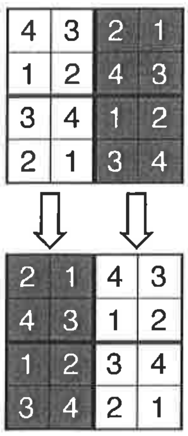
The puzzle is said to be valid if it follows these rules:

- It consists of four quadrants.
- The numbers in each quadrant must add up to ten.
- Each horizontal and vertical row of the puzzle must also add up to ten.
- No number can be repeated in the same row, same column or same quadrant of the puzzle.

A good strategy for creating puzzles is to start with a valid 'base' puzzle and perform transformations on it to create new puzzles.

You will write program code to create new valid puzzles.

Each puzzle created will have **two** randomly selected transformations, from a possible four, performed on it. The following are the four possible transformations that can be carried out.

Transformation	Explanation	
1	Swaps two rows in the same quadrants	
2	Swaps two columns in the same quadrants	
3	Swaps the top and bottom quadrant rows entirely	
4	Swaps the left and right quadrant columns entirely	

Task 4.3

Write additional program code, with brief **internal commentary** to identify each transformation.

The program code will:

- create a method of selecting, at random, two of the four possible transformations to be applied to the puzzle
- call a sub-program for each of the required transformations
- randomly select which rows will be transformed for transformations 1 and 2, for example, either the top or bottom two rows (for transformation 1) OR either the left-most or right-most two columns (for transformation 2) respectively
- display the puzzle before each transformation is applied and after the final transformation. Before each transformation, it will also display the name of the transformation being carried out. For example:

```
4321
1243
3412
2134

Transformation 1: Swaps two rows in the same quadrants
1243
4321
3412
2134

Transformation 4: Swaps the left and right quadrant columns entirely
4312
2143
1234
3421
```

Evidence 16
Your program code that includes **internal commentary**. [14]

Evidence 17
Screenshots of the output that shows each of the four transformations applied. [4]