

1. Many applications require the user to search for a data item from a file or one-dimensional array.

[JARGON.TXT](#) is a text file containing computing terms with one term per line. The program will read all the terms from JARGON.TXT into an array.

The user will choose if the type of search is to find:

1. An exact match
2. A match at the beginning of the term text
3. A match anywhere within the term text

Task 1.1

Design and write program code to:

- Read the entire contents of JARGON.TXT into an array
- Allow the user to repeatedly select the type of search, then input a term
- Output the matching term(s) found
- Output a count of the number of matches
- End with the input of term "XXX"

A typical run of the program is shown below:

```
+++++
1. Exact match
2. Start of term
3. Within term
+++++
Choice ?1
Term?firewall
firewall
There were 1 matching term(s)

+++++
1. Exact match
2. Start of term
3. Within term
+++++
Choice ?2
Term?data
data flow diagram
database management system
data file
database
There were 4 matching term(s)

+++++
1. Exact match
```

```
2. Start of term
3. Within term
+++++
Choice ?3
Term?box
white box testing
black box testing
There were 2 matching term(s)
```

Evidence 1

The program code.

[11]

Task 1.2

Study the contents of JARGON.TXT and then design four test cases to thoroughly test the working of your program code.

Evidence 2

State the test data used in Task 1.2 and show screenshots to confirm the successful testing of each of your four test cases.

[4]

2. A binary search (binary chop) is a technique to search for a value in an ordered dataset.

Task 2.1

Study the identifier table and incomplete recursive algorithm.
The missing parts of the algorithm are labelled A, B and C.

Variable	Data Type	Description
ThisArray	ARRAY OF STRING	Array containing the the dataset
FindValue	STRING	Item to be found
Low	INTEGER	Lowest index of the considered list
High	INTEGER	Highest index of the considered list
Middle	INTEGER	The array index for the middle position of the current list considered

```
FUNCTION BinarySearch(ThisArray, FindValue, Low, High) RETURNS INTEGER
  DECLARE Middle : INTEGER
  IF ..... A .....
    THEN
      RETURN -1 // not found
    ELSE
      // calculate new Middle value
      Middle ← ..... B .....
      IF ThisArray[Middle] > FindValue
        THEN
          RETURN BinarySearch(ThisArray, FindValue, Low, Middle - 1)
        ELSE
          IF ThisArray[Middle] < FindValue
            THEN
              ..... C .....
            ELSE
              RETURN Middle // found at position Middle
            ENDIF
          ENDIF
        ENDIF
      ENDIF
    ENDFUNCTION
```

Evidence 3

What are the three missing lines in this pseudocode?

[3]

Task 2.2

Write a program to implement binary search.
The program will

- Call procedure InitialiseAnimals
- Input an animal name

- Use the function BinarySearch
- Report whether or not this animal name was found. If found, also output the index position.

The array in the program has identifier MyAnimal.

Use the dataset given in the file [ANIMALS.TXT](#). You should paste the contents of this file into your program. The statements will form the basis of the code for the procedure InitialiseAnimals.

Evidence 4

Program code for Task 2.2 [7]

Evidence 5

Screenshot to confirm that an animal which is present in the list was found with its index position displayed. [1]

Task 2.3

Amend the program as follows:

The program must also output the number of function calls carried out.

Evidence 6

The amended program code. [4]

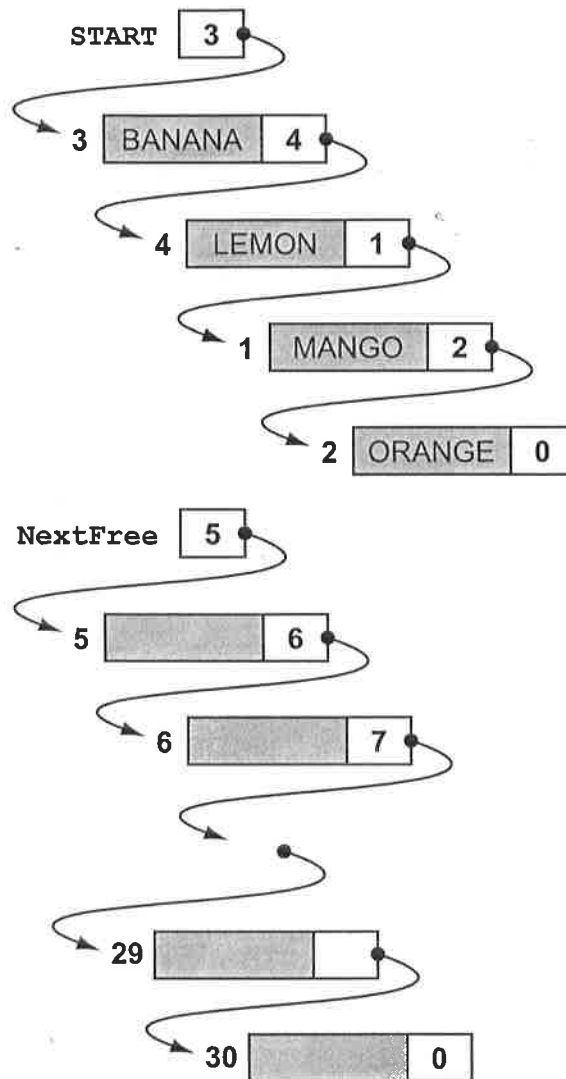
Evidence 7

Screenshots showing the amended output for runs of the program where:

- the animal is found
- the animal is not found.

[2]

- 3 A program is to be written to represent and implement a linked list of nodes. Each node contains a string data value and a pointer. The pointers link the data items in alphabetical order. The unused nodes are linked as shown below. The first unused node is the position where the next new data item is to be stored.



The diagram shows the linked list with:

- the items MANGO, ORANGE, BANANA and LEMON (added in that order).
- the unused nodes linked together.

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

Class: <code>ListNode</code>		
Properties		
Identifier	Data Type	Description
<code>DataValue</code>	STRING	The node data
<code>PointerValue</code>	INTEGER	The node pointer

A linked list is implemented as an instance of the class `LinkedList`. The class `LinkedList` has the following properties and methods:

Class: <code>LinkedList</code>		
Properties		
Identifier	Data Type	Description
Node	ARRAY[30] OF <code>ListNode</code>	The linked list data structure – data values and pointers. The array index starts at 1. For testing purposes the dataset has a maximum of 30 items.
Start	INTEGER	Index position of the node at the start of the linked list
NextFree	INTEGER	Index position of the next unused node
Methods		
Identifier		Description
Initialise	PROCEDURE	Sets all the node data values to 'empty string'. Set pointers to indicate all nodes are unused and linked. Initialise values for <code>Start</code> and <code>NextFree</code> .
AddNode	PROCEDURE	Add a new data item to the linked list.
Traversal	PROCEDURE	Display the data items in order.
ReverseTraversal	PROCEDURE	Display the data items in reverse order.
DisplayLinkedList	PROCEDURE	Display the current state of pointers and the array contents.
IsEmpty	FUNCTION RETURNS BOOLEAN	Tests for empty linked list.
IsFull	FUNCTION RETURNS BOOLEAN	Tests for no unused nodes.

Task 3.1

Write program code that repeatedly:

- displays a menu with the following choices:
 - Add an item
 - Traverse the linked list of used nodes and output the data values
 - Output all pointers and data values
 - Exit
- calls an appropriate procedure depending on the user's choice.

Evidence 8

Program code for Task 3.1.

[5]



Task 3.2

Write program code for the classes `ListNode` and `LinkedList` including the `IsEmpty` method. The code should follow the specification given.

Do not attempt to write the methods `AddNode`, `Traversal`, `ReverseTraversal` or `IsFull` at this stage.

Evidence 9

Program code for the `ListNode` and `LinkedList` classes (Task 3.2).

[12]

Task 3.3

Write code to create a `LinkedList` object in the main program.

Run the program and select menu choice 3 to confirm the initial values of the pointers and data values when the linked list is empty.

Evidence 10

Screenshot confirming all values after initialisation of the `LinkedList` object (Task 3.3).

[3]

Task 3.4

Consider the `AddNode` method. The following algorithm will add a new data item to the linked list.

The algorithm uses the variables below:

Identifier	Data Type	Description
<code>NewItem</code>	<code>STRING</code>	New data item input by the user
<code>Found</code>	<code>BOOLEAN</code>	Flags to <code>TRUE</code> when the position at which to insert the new item has been found
<code>Current</code>	<code>INTEGER</code>	Current array index position during list traversal
<code>Previous</code>	<code>INTEGER</code>	Previous array index position during list traversal
<code>Temp</code>	<code>INTEGER</code>	Temporary storage of pointer value

```

PROCEDURE AddNode
  INPUT NewItem
  Node[NextFree].DataValue ← NewItem

  IF Start = 0
    THEN
      Start ← NextFree
      Temp ← Node[NextFree].PointerValue
      Node[NextFree].PointerValue ← 0
      NextFree ← Temp
    ELSE
      // traverse the list - starting at Start to find
      // the position at which to insert the new item
      Temp ← Node[NextFree].PointerValue

      IF NewItem < Node[Start].DataValue
        THEN
          // new item will become the start of the list
          Node[NextFree].PointerValue ← Start
          Start ← NextFree
          NextFree ← Temp
        ELSE
          // the new item is not at the start of the list
          Previous ← 0
          Current ← Start
          Found ← False

          REPEAT
            IF NewItem <= Node[Current].DataValue
              THEN
                Node[Previous].PointerValue ← NextFree
                Node[NextFree].PointerValue ← Current
                NextFree ← Temp
                Found ← True
              ELSE
                // move on to the next node
                Previous ← Current
                Current ← Node[Current].PointerValue
              ENDIF
            UNTIL Found = True OR Current = 0

            IF Current = 0
              THEN
                Node[Previous].PointerValue ← NextFree
                Node[NextFree].PointerValue ← 0
                NextFree ← Temp
              ENDIF
            ENDIF
          ENDIF
        ENDIF
      ENDPROCEDURE

```

Note: The above pseudocode is available in the text file PSEUDOCODE_TASK_3_4.TXT



Write code to implement for the `LinkedList` class:

- the `AddNode` method
- the `IsFull` method.

You may use the text file `PSEUDOCODE_TASK_3_4.TXT` as a basis for the writing of your code.

The main program should check each time that the `LinkedList` object is not full before using the `AddNode` method.

Run the program as follows:

- Menu choice 1 four times, inputting the data values:
MANGO, ORANGE, BANANA, LEMON in that order.
- Menu choice 3 to display.

Evidence 11

Program code for method `AddNode`.

[8]

Evidence 12

Screenshot showing the pointers and the addition of the four nodes to the linked list.

[3]

Task 3.5

Write program code to implement the `LinkedList` class method `Traversal` by calling the `TraversalInOrder` procedure given below.

```
PROCEDURE TraversalInOrder (Index)
  IF Index <> 0
    THEN
      OUTPUT Node[Index].DataValue
      // follow the pointer to the next data item in the linked
      list
      TraversalInOrder (Node[Index].PointerValue)
    ENDIF
  ENDPROCEDURE
```

Evidence 13

Program code for procedures `Traversal` and `TraversalInOrder`.

[2]

Task 3.6

Run the program as follows:

- Menu choice 1 four times, inputting the data values:
MANGO, ORANGE, BANANA, LEMON in that order.
- Menu choice 2 to display.

Evidence 14

Screenshot showing the program execution to test the `Traversal` method.

[2]

Task 3.7

Make a copy of the `TraversalInOrder` and `Traversal` procedures.

Paste to form two new procedures `TraversalInReverseOrder` and `ReverseTraversal`.

Make the necessary changes/additions to these procedures in order that the data items are output in reverse order by calling the new method `ReverseTraversal`.

Run the program code from a new menu choice 4.

Test the method using the four items given in Task 3.6.

Evidence 15

Program code for the new procedures.

[2]

Evidence 16

Screenshot showing option 4 selected and the resulting output.

[1]



4 Design and code a computer program to simulate the following:

A garden has a rectangular fish pond measuring 15 metres by 8 metres.

The pond is to be represented on the screen by a rectangular grid. Each square metre of the pond is represented by an x-coordinate and a y-coordinate. The top left square metre of the pond display has $x = 1$ and $y = 1$.

A boy throws a stone into the pond. The user will input the x-coordinate and y-coordinate of the stone impact position.

A grid representing the pond is then displayed with the stone's impact position:

```
X coordinate <1 to 15>? 9
Y coordinate <1 to 8>? 3
```

```
.....
.....
.....S.....
.....
.....
.....
.....
.....
```

Task 4.1

The following are the suggested characters to use for the visual representation of the pond:

Character	ASCII code (decimal)	Represents
.	46	One square metre of water
S	83	Stone impact position

Decide on the design to be used for:

- The data structure to represent the grid
- The contents of each square metre of the pond
- Procedure(s) and/or function(s) to be used

Evidence 17

Show your program design (Task 4.1).

[6]

Task 4.2

Write program code to display the pond contents after a single stone has been thrown.

Evidence 18

The program code.

[7]

Evidence 19

Screenshot for a single run of the program.

[1]

Task 4.3

The boy has been told to stop throwing stones into the pond because the pond now has three fish. The fish randomly swim around. Each fish will occupy a unique grid position.

Using a random number generator, simulate the positioning of the three fish.

Use the following character for a fish:

Character	ASCII code (decimal)	Represents
F	70	Fish

Write program code to show the pond containing the three fish at a particular instance of time. The program will now only display the pond and fish.

Evidence 20

The program code for Task 4.3.

[6]

Evidence 21

Screenshot for a single run of the program.

[1]

Task 4.4

The boy has been asked to feed the fish. He cannot see the fish in the pond. He throws a food pellet into the pond which lands inside one of the square metres. If one of the fish is in this square, it eats the food and becomes a happy fish.

Use character symbols for the pond's grid display as follows:

Character	ASCII code (decimal)	Represents
.	46	One square metre of water
P	80	Pellet (if not eaten by one of the fish)
H	72	Happy (fed) fish
F	70	Fish

Write program code to simulate the boy throwing one food pellet into the pond. The user will input an x-coordinate and y-coordinate for the food pellet position. You should consider the possible reuse of any code from Tasks 4.2 and 4.3.

Evidence 22

The program code.

[6]



Evidence 23

Screenshot evidence similar to that shown which shows:

- one throw which did not feed a fish

X coordinate <1 to 15> ? 2
Y coordinate <1 to 8>? 5

```

.....
.....
.....F.....
.....
.P.....F....
.....
....F.....
.....

```

- a second throw where a fish was fed

X coordinate <1 to 15> ? 1
Y coordinate <1 to 8>? 5

```

.....
.....
.....F.....
.....
H.....
.....
....F.....
.....

```

[3]