1. The files WORDS1.TXT and WORDS2.TXT store a list of single word computing terms used in a textbook.

Each entry has the following format:

```
<computing term>
<number>
```

One of the file entries (in both files) is:

```
program
52
```

This means that after a complete scan of the textbook the word 'program' was found 52 times.

Task 1.1
Write program code to find and output the term with the highest number of occurrences. Use the file WORDS1.TXT to test your program.

Evidence 1:
The program code. [8]

Evidence 2:
Screenshot of output. [1]

Task 1.2
Amend your program code so that if more than one term exists with the highest number of occurrences, all terms are reported. Use the file WORDS2.TXT to test your program.

Evidence 3:
The program code. [5]

Evidence 4:
Screenshot of output. [1]

2. A company keeps data about its employees. The employee surname and employee ID are recorded.
All employee IDs are unique and have the format C999 where C is any uppercase letter and 9 is a digit.

A program is to be produced to search by either:

- The surname, which then reports the matching employee ID
- The employee ID, which then reports the matching surname

The programmer stores the data a two 1-dimensional arrays and produces the following search algorithm to search a string array and output the matching value from the second array.

```
INPUT SearchItem
FOR Index ← 1 TO UpperBound
    IF SearchItem = Array1[Index]
        THEN OUTPUT Array2[Index]
    ENDIF
ENDFOR
```

This search algorithm is inefficient.

The programmer uses the following design to produce the program code:

code to search by surname
The search algorithm has `Surname` as `Array1` and `EmployeeID` as `Array2`
followed by code to search by employee ID
The search algorithm has `EmployeeID` as `Array1` and `Surname` as `Array2`

This design would produce repetition of code.

Task 2.1
Write program code which performs each of the searches:

- Search by surname
- Search by employee ID

Your code should address the issues of inefficiency and repetition of code described in the scenario above.
Use the sample array data available from the text file `EMPLOYEEDATA.txt` and paste this into your program code.

Evidence 5:
Your program code. [11]

Task 2.2

Devise a set of four test cases with the data to be used.

Evidence 6:
A screenshot for each test case you considered. Annotate the screenshot explaining the purpose of each test. [4]

3. The task is to store a dataset (maximum size 20 items) as a binary tree structure. You should assume that the data items are unique.

The program will use a user-defined type Node for each node defined as follows:

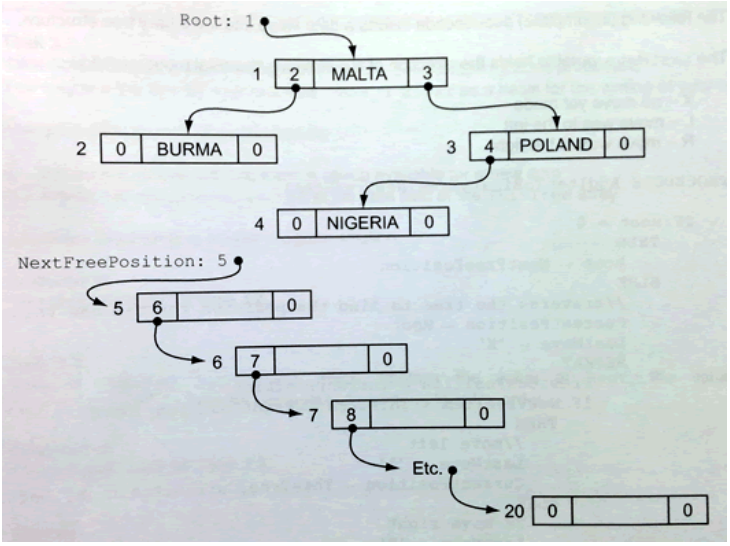
Identifier	Data Type	Description
`LeftP`	`INTEGER`	The left pointer for the node
`Data`	`STRING`	The node's data value
`RightP`	`INTEGER`	The right pointer for the node

:

A linked list is maintained of all the unused nodes which do not form part of the tree. The first available node which is used for a new term is indicated by NextFreePosition. Items in the unused list are linked using their left pointers.

The binary tree and linked list are implemented using variables as follows:

Identifier	Data Type	Description
`ThisTree`	`ARRAY[20] : Node`	The tree data
`Root`	`INTEGER`	Index for the root position of the `ThisTree` array
`NextFreePosition`	`INTEGER`	Index for the next unused node



The diagram shows the binary tree and linked list after four values have been added.

Task 3.1
Write the program code to declare all the required variables and create the initial linked list which contains all 20 nodes.

Add statement(s) to initialise the empty tree.

Evidence 7:
Your program code for Task 3.1. [11]

The following (incomplete) pseudocode inserts a data value into the binary tree structure.

The `LastMove` variable holds the direction of the previous traversal move as follows:

X - no move yet made
L - move was to the left
R - move was to the right

```
PROCEDURE AddItemToBinaryTree(NewFreeItem)

    IF Root = 0
        THEN
            Root ← NextFreePosition
        ELSE
            // traverse the tree to find the position for the new value
            CurrentPosition ← Root
            LastMove ← 'X'
            REPEAT
                PreviousPosition ← CurrentPosition
                IF NewFreeItem < ThisTree[CurrentPosition].Data
                    THEN
                        // move left
                        LastMove ← 'L'
                        CurrentPosition ← ThisTree[CurrentPosition].LeftP
                    ELSE
                        // move right
                        LastMove ← 'R'
                        CurrentPosition ←
ThisTree[CurrentPosition].RightP
                ENDIF
            UNTIL CurrentPosition = 0
    ENDIF

    IF LastMove = 'R'
        THEN
            ThisTree[PreviousPosition].RightP ← NextFreePosition
        ELSE
            ThisTree[PreviousPosition].LeftP ← NextFreePosition
    ENDIF
    NextFreePosition  ThisTree[NextFreePosition].LeftP
ENDPROCEDURE
```

Note: The above text is available in the text file PSEUDOCODE_TASK_3_2.TXT

Task 3.2
Write non-recursive code to implement the `AddItemToBinaryTree` procedure.
You may use the text file `PSEUDOCODE_TASK_3_2.TXT` as a basis for the writing of your

code.

The given pseudocode is incomplete as:

- it does not initially test that there is space available for a new item
- it does not assign `NewTreeItem` to the data field of the `ThisTree` array

Add these requirements to your program solution.

Evidence 8:
Your program code for Task 3.2. [6]

Task 3.3
Write a procedure `OutputData` which displays the value of `Root`, the value of `NextFreePosition` and the contents of `ThisTree` in index order.

Evidence 9:
Your program code for Task 3.3. [5]

Task 3.4
Write a main program to:

- Input new data items and add them to the binary tree by calling procedure `AddItemToBinaryTree`. The input is terminated with value `"XXX"`.
  Do not attempt to validate the input of the country names.
- Your program will then call procedure `OutputData`.

Run the program with the input of the single value `"XXX"`.

Evidence 10:
Screenshot showing the output from running the program in Task 3.4. [3]

Task 3.5
Test your program using the following data items input in the order shown:

```
INDIA, NEPAL, MALAYSIA, SINGAPORE, BURMA, CANADA, LATVIA, XXX
```

Evidence 11:
Provide screenshot test evidence for Task 3.5. [5]

Further program code is required to carry out an **in-order traveral**.

Task 3.6
Write a recursive procedure to carry out an in-order tree traversal.
Include a call to the procedure from your main program.

Evidence 12:
Your program code. [8]

Evidence 13:
Produce a screenshot for the Task 3.5 dataset confirming the output of the countries in alphabetical order. [2]

4. The task is to input data for a frequency distribution and then output to the screen a horizontal bar chart.

The data is input as an X value followed by its frequency. Assume the frequency is always in the range 0 to 60 and there are no more than six X values.

The input shown below shows the number of sweatshirts sold in a retail shop over a one week period; for example there were 39 XL items sold

```
Next X value ... <ZZZ to END> XS
Frequency ... 12
Next X value ... <ZZZ to END> S
Frequency ... 22
Next X value ... <ZZZ to END> M
Frequency ... 45
Next X value ... <ZZZ to END> L
Frequency ... 56
Next X value ... <ZZZ to END> XL
Frequency ... 39
Next X value ... <ZZZ to END> XXL
Frequency ... 11
Next X value ... <ZZZ to END> ZZZ


++++++++++++++++++++++++++++++++++++++++
Frequency distribution
++++++++++++++++++++++++++++++++++++++++

  XS      @@@@@@@@@@@@
  S       @@@@@@@@@@@@@@@@@@@@@@
  M       @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
  L       @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
  XL      @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
  XXL     @@@@@@@@@@@
```

Task 4.1
Write a program which inputs a set of X values and frequencies and produces output in the format shown.

Evidence 14:
Your program code for Task 4.1. [8]

Evidence 15:
A screenshot to confirm the dataset used and the output produced. [2]

The appearance of the bar chart display is to be improved as follows:

- Each bar is to be represented by more than one line of the same character to that its bar width is increased.
- Each bar will be shown with the same number of lines.

- The complete bar chart, including the heading, is to take up no more than 40 lines.
- The line width for the output is exactly 80 characters.
- Its appearance could be improved by changing the @ character.

Task 4.2
Write code to produce a new chart for the data used in Task 4.1 showing the maximum possible bar width and any other refinements you have introduced.

Evidence 16:
Your program code for Task 4.2. [4]

Evidence 17:
A screenshot showing the data entry followed by the bar chart. [2]

Some datasets will have a frequency which is greater than 60 and so the frequencies of the dataset can no longer be shown with a corresponding number of characters in the line. The frequencies will need to be scaled before the output is attempted.

The bar chart would benefit by the inclusion of a horizontal axis labelled with a scale showing the frequency values.

Task 4.3
Revise your program code to meet these new requirements.

Evidence 18:
Your program code for Task 4.3. [8]

Evidence 19:
Screenshots demonstrating:
- Dataset 1 as used in Task 4.1 which needs no scaling
- Dataset 2 of your choice to demonstrate frequencies which must be scaled
- Dataset 3 of your choice to demonstrate frequencies which must be scaled differently to Dataset 2

[6]