10.2.2 Arrays - combined exam practice

Name: _____ Class: _____ Date: _____ **Total: 62 marks**

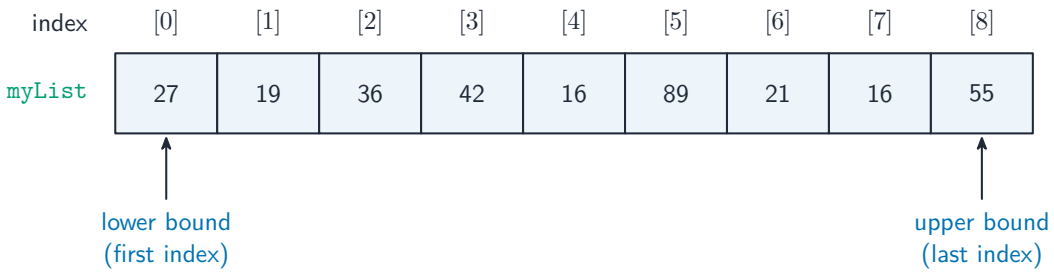
KEY WORDS array • bounds • capacity • lookup table • combination

Objective

Combine the methods from sheet **10.2** to solve longer array exam questions: stop input safely, build a **lookup table** and select matching IDs into another array. Complete **10.2.1** separately for bubble sort and insertion/deletion.

1 Key knowledge and worked examples

■ Capacity, count and a stopping rule



An **array** has fixed **bounds** . **Capacity** is the number of allocated elements; `Count` is how many are used. With `Data[1:20]`, a count of 3 means the next free position is 4. Check capacity **before** asking for the next input, so a full array does not request or store a 21st value.

Worked example: the first value has already been stored at `Data[1]`; `Count = 1`. The following loop stores positive integers until a non-positive input or a full array. `Data`, `Count` and `Value` are integers; `Stopped` is Boolean.

```
Stopped ← FALSE
WHILE Count < 20 AND Stopped = FALSE
    INPUT Value
    IF Value > 0 THEN
        Count ← Count + 1
        Data[Count] ← Value
    ELSE
        Stopped ← TRUE
    ENDIF
ENDWHILE
```

For increasing input, compare with the **last stored value** instead of zero, and update that value after accepting an input. Equality must stop a strictly increasing sequence. Do not count or store a rejected value.

■ Boolean lookup: a score becomes an index

A **lookup table** stores an answer at the index that represents its input. It can replace repeated selection statements: fewer branches to write and simpler data changes. A Boolean element tells us whether a score is achievable. A declaration does not initialise the elements.

Worked example: two questions are worth 3 points each; one is worth 4 points. The maximum is $2 \times 3 + 4 = 10$. Include score zero, so there are 11 elements.

```
DECLARE Valid : ARRAY[0:10] OF BOOLEAN
DECLARE Index, Easy, Hard : INTEGER
FOR Index ← 0 TO 10
    Valid[Index] ← FALSE
NEXT Index
FOR Easy ← 0 TO 6 STEP 3
    FOR Hard ← 0 TO 4 STEP 4
        Valid[Easy + Hard] ← TRUE
    NEXT Hard
NEXT Easy
```

The loops cover every **combination** : `0, 3, 6` plus `0, 4`, giving scores `0, 3, 4, 6, 7, 10`. Before looking up `Valid[Score]`, check `0 <= Score <= 10`. If outside, return `FALSE` without indexing. In words: check range, reject an out-of-range score, otherwise return the stored Boolean.

■ Combine a function, rows and a result array

For array `Result[1:100, 1:2]`, the first index selects a row and the second a column. With marks in column 1 and IDs in column 2, test `Result[Row, 1]` and copy `Result[Row, 2]`. A function returns one value: a Boolean result can be used directly in an `IF`.

- Within two marks of a boundary means `Mark >= Boundary - 2` **and** `Mark <= Boundary + 2`, including both endpoints. Return `FALSE` only after **all** boundaries have failed.

- Keep a separate count for selected IDs. Increment it only when a row matches, then store the ID at that index. The selected entries occupy consecutive positions, even when matching source rows are far apart.
- A **sentinel** ends input and is not stored. `REPEAT ... UNTIL` runs at least once: stop when the sentinel arrives **or** capacity is reached. A sentinel as the first input leaves the count at zero.

Worked example: copy IDs of used rows whose mark is below 40 into a second array. `Result` and integer `Used` are global; `0 <= Used <= 100`.

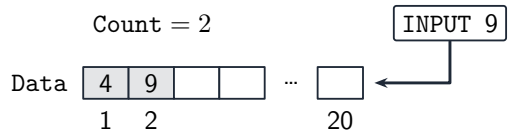
```
DECLARE SelectedID : ARRAY[1:100] OF INTEGER
DECLARE Row, Count, Index : INTEGER
Count ← 0
FOR Row ← 1 TO Used
    IF Result[Row, 1] < 40 THEN
        Count ← Count + 1
        SelectedID[Count] ← Result[Row, 2]
    ENDIF
NEXT Row
OUTPUT Count, " candidates selected"
FOR Index ← 1 TO Count
    OUTPUT SelectedID[Index]
NEXT Index
```

For marks `39, 40, 12` with IDs `101, 102, 103`, the first two selected elements are `101` and `103`, and the count is 2. With `Used = 0`, neither loop processes an element and the count is zero. Only positions `1:Count` contain selected IDs; the rest are unused.

2 Practice

2.1 `Data[1:20]` holds `4, 9` in its first two elements. `Count = 2`; the remaining elements are unused. The next input is `9`.

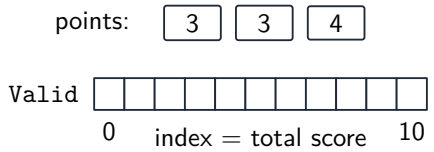
(a) In a strictly increasing sequence, should this input be stored? Explain. [2]



(b) State the next free index **before** this input, and explain what must happen when `Count = 20`. [2]

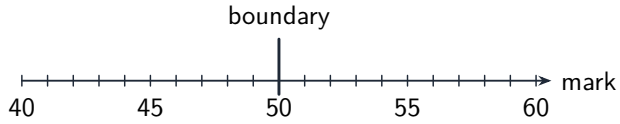
2.2 Use the worked example's array `Valid[0:10]`.

(a) State the results of looking up scores `7` and `8`. [2]

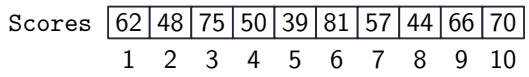


(b) Explain why testing `Valid[11]` is an error rather than a way to return `FALSE`. [1]

2.3 A boundary is `50`. State the lowest and highest marks within two marks of it. Explain why joining the two comparisons with `OR` would be wrong. [3]

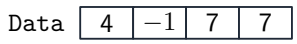


2.4 Global array `Scores[1:10]` contains integer marks. Write pseudocode to output their mean and the number of marks at least `50`. Declare any local variables used. [5]



2.5 `Data` is declared as `ARRAY[0:3] OF INTEGER` and contains `4, -1, 7, 7` in index order.

(a) State its lower bound, upper bound and number of elements. [2]



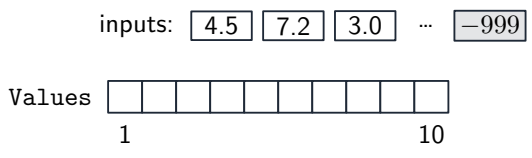
(b) Trace this algorithm. Give `Total` and `Count` after **each** iteration, then the final output. [4]

```
Total ← 0
Count ← 0
FOR Index ← 0 TO 3
    IF Data[Index] > 0 THEN
        Total ← Total + Data[Index]
        Count ← Count + 1
    ENDIF
NEXT Index
OUTPUT Total, ", ", Count
```

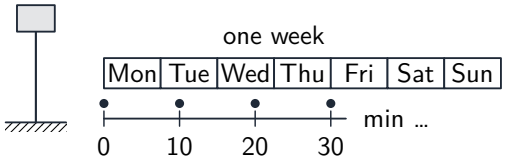
2.6 Complete the code to input up to ten real values into global array `Values[1:10]`. Input `-999` ends the sequence and must not be stored. It may be the first input. Do not request another input when the array is full. [5]

```
DECLARE Count : INTEGER
DECLARE Value : REAL
Count ← ..................
REPEAT
    INPUT Value
    IF Value <> ..................... THEN
        Count ← ..................
        Values[Count] ← ...................
    ENDIF
UNTIL Value = -999 OR Count = ...................
```

Explain why **both** stopping conditions are needed. [2]

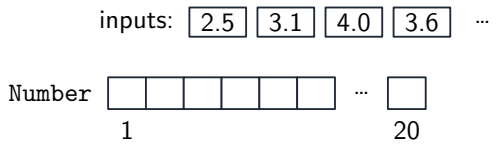


2.7 A weather station takes one real temperature reading every **ten minutes** for one week. Calculate how many readings are taken and declare a 1-D array `WeekReading`, indexed from 1, with exactly enough elements. State the upper bound if the same number of elements were instead indexed from 0. [3]



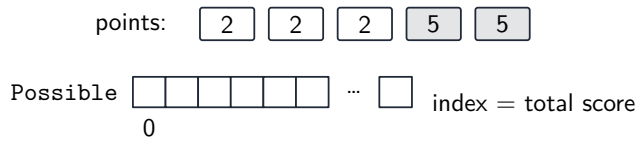
3 Exam-style questions

3.1 Global real array `Number[1:20]` is initially unused. Write procedure `Store()` to input and store a strictly increasing sequence. Always store the first input. Store later inputs only while each is greater than the last stored value. Stop at the first value that is not greater, or when 20 values have been stored. Do not request another input once full. Output the number stored with a message. Declare local variables. [6]



3.2 A quiz has three questions worth `2` points each and two questions worth `5` points each. Global Boolean array `Possible` will indicate which total scores can be achieved; the index represents the total score.

(a) Declare `Possible` with lower bound `0` and the smallest suitable upper bound. Initialise every element to `FALSE`. Declare the loop variable. [4]

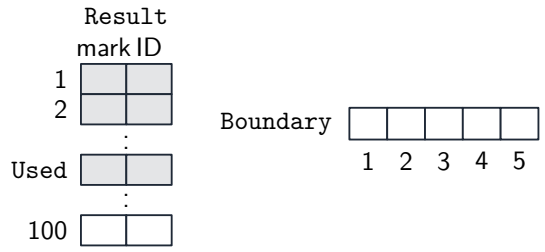


(b) Use nested loops to set every achievable score to `TRUE`, including zero. [4]

(c) Describe, in words, how a function checks whether an integer score is achievable. Include scores outside the array bounds. [3]

3.3 A college uses global integer array `Result[1:100, 1:2]`. Column 1 stores marks; column 2 stores candidate IDs. Only the first `Used` rows contain data, where `0 <= Used <= 100`. Global integer array `Boundary[1:5]` contains five grade boundaries.

(a) Write function `NeedsCheck(Mark : INTEGER) RETURNS BOOLEAN`. Return `TRUE` if `Mark` is within two marks of **any** boundary, including the endpoints; otherwise return `FALSE`. [5]



(b) Global integer array `ReviewID[1:100]` and integer `ReviewCount` are available. Write procedure `CheckAll(Used : INTEGER)` to reset the count, call `NeedsCheck()` for each used row, and copy matching IDs consecutively into `ReviewID`. Update and output the count with a message. Declare locals; leave unused elements unchanged. [7]

(c) Explain the result when `Used = 0`, including the count and whether any array element is accessed or changed. [2]

Solutions

2.1

(a) no; it equals the last stored value `9` and is not greater, so the sequence stops.

(b) index `3`; at `Count = 20`, stop before another input, preventing an out-of-bounds write at index 21.

2.2

(a) `Valid[7] = TRUE`; `Valid[8] = FALSE`.

(b) index 11 is outside the declared range `0:10` and must not be accessed.

2.3

- minimum `48`; maximum `52`.
- both comparisons must hold for the same mark. With `OR`, even `40` passes because `40 <= 52`; values outside the interval would be accepted.

2.4

- declarations and initial values; loop over ten values; total values; conditional count; output mean and count.

```
DECLARE Index, Total, Count : INTEGER
Total ← 0
Count ← 0
FOR Index ← 1 TO 10
    Total ← Total + Scores[Index]
    IF Scores[Index] >= 50 THEN
        Count ← Count + 1
    ENDIF
NEXT Index
OUTPUT "Mean: ", Total / 10, ", passes: ", Count
```

2.5

(a) lower bound `0`, upper bound `3`; $3 - 0 + 1 = 4$ elements.

(b) correct total column, correct count column, unchanged values at index 1, final output `18, 3`.

Index	Total	Count
0	4	1
1	4	1
2	11	2
3	18	3

2.6

- `0`; `-999`; `Count + 1`; `Value`; `10`.

- the sentinel condition stops when input is finished; the capacity condition stops after ten stored values, preventing another input or an out-of-bounds write. The `IF` keeps `-999` out of the array.

2.7

- $6 \times 24 \times 7 = \mathbf{1008}$ readings.
- `DECLARE WeekReading : ARRAY[1:1008] OF REAL`.
- if indexed from zero, the upper bound is `1007`, because $1007 - 0 + 1 = 1008$.

3.1

- declare locals; store first input; capacity-controlled loop; comparison and stop on non-increasing input; update count and store correctly; final count/message.

```
PROCEDURE Store()
    DECLARE Count : INTEGER
    DECLARE Value, Last : REAL
    DECLARE Stopped : BOOLEAN
    INPUT Last
    Number[1] ← Last
    Count ← 1
    Stopped ← FALSE
    WHILE Count < 20 AND Stopped = FALSE
        INPUT Value
        IF Value > Last THEN
            Count ← Count + 1
            Number[Count] ← Value
            Last ← Value
        ELSE
            Stopped ← TRUE
        ENDIF
    ENDWHILE
    OUTPUT Count, " values stored"
ENDPROCEDURE
```

- Equal input ends the sequence. The rejected value is not stored. The loop requests no 21st input.

3.2

(a) maximum score $3 \times 2 + 2 \times 5 = 16$, so the array has 17 elements.

```
DECLARE Possible : ARRAY[0:16] OF BOOLEAN
DECLARE Index : INTEGER
FOR Index ← 0 TO 16
    Possible[Index] ← FALSE
NEXT Index
```

- array declaration; local declaration; correct loop bounds; assign `FALSE`.

(b) declare loop variables; all four easy-score values; all three hard-score values; mark the sum, including zero.

```
DECLARE Easy, Hard : INTEGER
FOR Easy ← 0 TO 6 STEP 2
    FOR Hard ← 0 TO 10 STEP 5
        Possible[Easy + Hard] ← TRUE
    NEXT Hard
NEXT Easy
```

(c) check whether the score lies from 0 to 16; if outside, return `FALSE` before indexing; otherwise return the Boolean stored at that score's index. Valid scores are `0, 2, 4, 5, 6, 7, 9, 10, 11, 12, 14, 16`.

3.3

(a) parameter/return type and local declaration; examine the five boundaries; inclusive lower comparison; inclusive upper comparison with `AND`; correct success/failure returns.

```
FUNCTION NeedsCheck(Mark : INTEGER) RETURNS BOOLEAN
    DECLARE Index : INTEGER
    DECLARE Near : BOOLEAN
    FOR Index ← 1 TO 5
        Near ← Mark >= Boundary[Index] - 2
        IF Near AND Mark <= Boundary[Index] + 2 THEN
            RETURN TRUE
        ENDIF
    NEXT Index
    RETURN FALSE
ENDFUNCTION
```

- Both comparisons must be true for the same boundary. Return `FALSE` only after all five boundaries fail.

(b) header and local declaration; reset global count; iterate only used rows; call with the mark column; increment only on a match; store the corresponding ID at the new count; final count/message.

```
PROCEDURE CheckAll(Used : INTEGER)
    DECLARE Row : INTEGER
    ReviewCount ← 0
    FOR Row ← 1 TO Used
        IF NeedsCheck(Result[Row, 1]) THEN
            ReviewCount ← ReviewCount + 1
            ReviewID[ReviewCount] ← Result[Row, 2]
        ENDIF
    NEXT Row
    OUTPUT ReviewCount, " candidates need checking"
ENDPROCEDURE
```

- A candidate near more than one boundary is still copied once. `ReviewCount` is both

the number selected and the last used index in `ReviewID`.

(c) `ReviewCount` becomes zero and the message reports zero candidates; no array elements are accessed or changed because the loop has no iterations. Any old values in `ReviewID` are unused.