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COMPUTER SCIENCE

9608/43

Paper 4 Further Problem-solving and Programming Skills

October/November 2021

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use an HB pencil for any diagrams, graphs or rough working.
- Calculators must **not** be used in this paper.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [].
- No marks will be awarded for using brand names of software packages or hardware.

This document has **20** pages. Any blank pages are indicated.

2

- 1 Sandy is writing a program to process data in a stack. The stack is implemented as a 1D array, `DataStack`, which has up to 100 elements.

The function `Push(Value)` stores `Value` on the stack and returns `TRUE` if `Value` was added to the stack, or `FALSE` if the stack is full.

The function `Pop()` returns the item at the top of the stack, or returns `-1` if the stack is empty.

`DataStack` and `TopPointer` are declared as global.

- (a) Show the state of `DataStack` and its pointer after the following functions are executed on the current contents.

```
Pop()
Pop()
Push(19)
Pop()
Push(50)
```

TopPointer

3

Index	Data
[7]	
[6]	
[5]	
[4]	
[3]	8
[2]	6
[1]	20
[0]	10

[2]

(b) Write **program code** for the function `Pop()`.

Programming language

Program code

[5]

(c) Sandy has also used a queue in her program.

Describe the ways in which a queue differs from a stack.

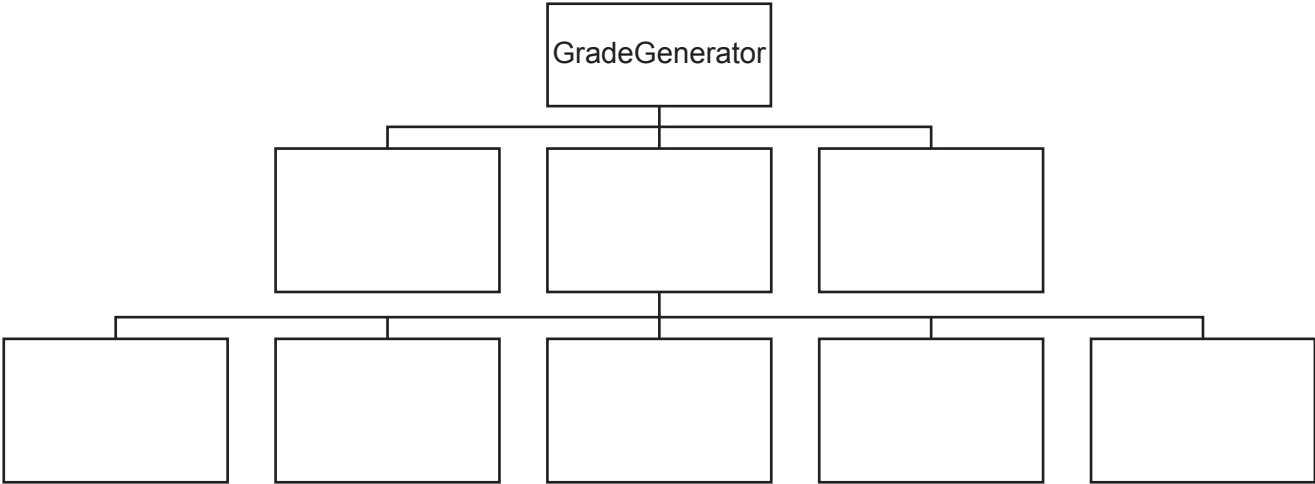
[2]

4

2 A grade generator program takes the mark a student obtained in a test as input.

The program calculates and outputs the grade that matches the mark. The grade is either A, B, C, D or U.

Complete the following JSP structure diagram for the grade generator program.



[4]

5

- 3 The following pseudocode algorithm performs a binary search on the sorted array `ThisArray`.

The algorithm returns either the location of `SearchItem` in the array, or `-1` if `SearchItem` is not in the array.

The function `DIV` returns the integer value of the division, for example, `11 DIV 2` returns 5.

Complete the algorithm by writing the missing pseudocode statements.

```

FUNCTION BinarySearch(ThisArray[], LowerBound, UpperBound,
                      SearchItem : INTEGER) RETURNS INTEGER

DECLARE Flag : BOOLEAN

DECLARE Mid : INTEGER

Flag ← -2

WHILE Flag <> -1

    Mid ← LowerBound + ((UpperBound - LowerBound) DIV 2)

    IF ..... < .....

        THEN

            RETURN .....

        ELSE

            IF ThisArray[Mid] > SearchItem

                THEN

                    UpperBound ← Mid .....

                ELSE

                    IF ThisArray[Mid] < SearchItem

                        THEN

                            LowerBound ← Mid .....

                        ELSE

                            RETURN .....

                        ENDIF

                    ENDIF

                ENDIF

            ENDIF

        ENDIF

    ENDWHILE

ENDFUNCTION

```

[6]

6

- 4 Teachers in a school may work on Mondays, Tuesdays and Wednesdays. There are three time slots on each day: time slot 1, time slot 2 and time slot 3.

A teacher is either busy or free.

The school is using a declarative language to write a program to record which teachers are busy in each time slot on each day.

The following knowledge base is used:

```

01 teacher(james).
02 teacher(jill).
03 teacher(karl).
04 teacher(kira).
05 day(monday).
06 day(tuesday).
07 day(wednesday).
08 timeSlot(1).
09 timeSlot(2).
10 timeSlot(3).
11 busy(james, monday, 1).
12 busy(james, tuesday, 2).
13 busy(karl, monday, 1).
14 busy(kira, wednesday, 3).

```

These clauses have the following meaning:

Clause	Explanation
01	James is a teacher
05	Monday is a day
08	1 is a time slot
11	James is busy in time slot 1 on Monday

- (a) More facts need to be included.

Fred is a teacher who is busy in time slot 1 on Tuesday.

Write additional clauses for these facts.

15

16

[2]

7

- (b) Additional clauses are needed to identify whether Jill is busy in time slot 1 on Monday, Tuesday, or Wednesday.

Write these additional clauses.

17

18

19

[2]

- (c) Write a goal, using the variable x , to find all the teachers who are busy in time slot 3 on Monday.

.....

..... [1]

- (d) Write a rule to find whether a teacher x is free in a specific time slot y on day z .

IsTeacherFree(x , z , y)

IF

.....

.....

.....

..... [4]

8

- 5 The recursive algorithm for the `Recursion()` function is defined in pseudocode as follows:

```

FUNCTION Recursion(A, B : INTEGER) RETURNS INTEGER
    IF A <= 100
        THEN
            RETURN 1
        ELSE
            IF A > B
                THEN
                    RETURN 5 + Recursion(A - 1, B)
                ELSE
                    RETURN 10 + Recursion(A - 10, B)
            ENDIF
        ENDIF
    ENDIF
ENDFUNCTION

```

- (a) The function is called with the following pseudocode statement:

```
OUTPUT Recursion(104, 102)
```

Dry run the function and complete the trace table. Give the output the program will produce.

Trace table:

Function call	A	B	Return value

Output =

Working

.....

.....

(b) Rewrite the function `Recursion()` in **pseudocode**, using an **iterative algorithm**.

[4]

10

6 Kobi is writing an application that uses a record structure to store data.

(a) (i) Describe what is meant by a **record structure**.

.....

.....

.....

..... [2]

(ii) The record structure stores the unique ID number (a whole number), first name and last name of a customer.

Write a **pseudocode** declaration for the record structure `CustomerData`.

.....

.....

.....

.....

.....

.....

..... [2]

(b) Kobi's application stores the records in a random access file.

The function `StoreRecord()`:

- takes a customer record as a parameter
- uses the function `CustomerHash()` to calculate and return the hash value for its parameter
- stores the customer record in the returned hash value address.

Assume there are no collisions.

Complete the following pseudocode algorithm to write a new record to the random access file.

```
PROCEDURE StoreRecord(NewData : .....)
```

`HashValue` ← `CustomerHash(NewData.CustomerID)`

`Filename` ← "CustomerRecords.dat"

 OPENFILE `Filename` FOR

 SEEK `Filename`,

 PUTRECORD `Filename`,

 `Filename`

ENDPROCEDURE

[5]

11

- (c) Identify **two** typical features of a debugger **and** describe how Kobi could use each one during the development of the application.

Feature 1

.....

.....

.....

Feature 2

.....

.....

.....

[4]

- (d) Give **one** benefit and **one** drawback of Kobi using a program generator whilst developing his application.

Benefit

.....

Drawback

.....

[2]

12

- 7 Sonya is writing a computer program that requires a user input. The user should input an integer between 1 and 100. Sonya wants to use exception handling.

(a) Explain the reasons why Sonya should use exception handling in her program.

.....

.....

.....

..... [2]

- (b) Write **program code** to read in the number from the user and raise an exception if the data is not valid.

Programming language

Program code

.....

.....

.....

.....

.....

.....

..... [3]

- (c) Give **two other** examples of where exception handling can be used in a program.

1

2 [2]

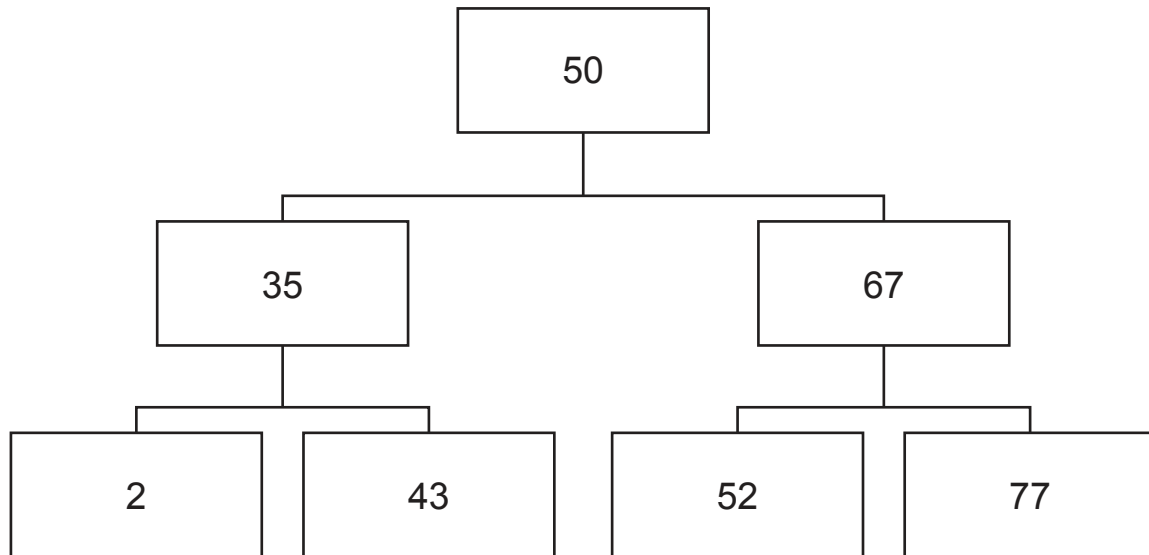
13

8 Data entered into a computer is stored in an ordered binary tree.

The binary tree is stored in a 2D array, `BinaryTree`.

The first element of the array is index 0.

(a) The current contents of the binary tree are:



Complete the `LeftPointer` and `RightPointer` values in the following table for the binary tree shown.

A null pointer is represented by `-1`.

RootNode 0

Index	LeftPointer	Data	RightPointer
[0]		50	
[1]		67	
[2]		77	
[3]		35	
[4]		2	
[5]		43	
[6]		52	
[7]			
[8]			
[9]			
[10]			

[2]

14

(b) A post-order tree traversal outputs the left node, then the right node, then the root node.

In the tree given in **part (a)**, the post-order tree traversal would output:

2 43 35 52 77 67 50

Complete the following recursive pseudocode algorithm `PostOrder()`.

```
PROCEDURE PostOrder (..... : INTEGER)

    IF BinaryTree[RootNode, 0] <> -1
        THEN
            ..... (BinaryTree[RootNode, .....])

        ENDIF

    IF BinaryTree[RootNode, 2] <> -1
        THEN
            ..... (BinaryTree[RootNode, 2])

        ENDIF

    OUTPUT BinaryTree[RootNode, .....]

ENDPROCEDURE
```

[5]

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9 A program uses a hashing algorithm to store data in the global array, `StoredData`.

The first element of the array is index 0. The array has 10 000 integer elements.

(a) Write a **pseudocode** declaration for the array `StoredData` **and** initialise each element to `-1`.

..... [3]

(b) The hashing algorithm calculates the remainder after dividing the data by 1000, and then adds 6 to it.

The function `AddItem()` takes the data as a parameter. It calculates the index to store the data using the hashing algorithm.

If there is a collision, the function:

- checks the next index until it finds an index that does not have data in it
- continues to search from the start of the array, if it reaches the end of the array.

The function returns `TRUE` if the item was successfully added, and `FALSE` if the array is full.

Write **program code** for the function `AddItem()`.

Programming language

Program code

[illegible]

[7]

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