Cambridge Assessment International Education

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9344667390

COMPUTER SCIENCE **9608/41**

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.

[Turn over

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

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

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

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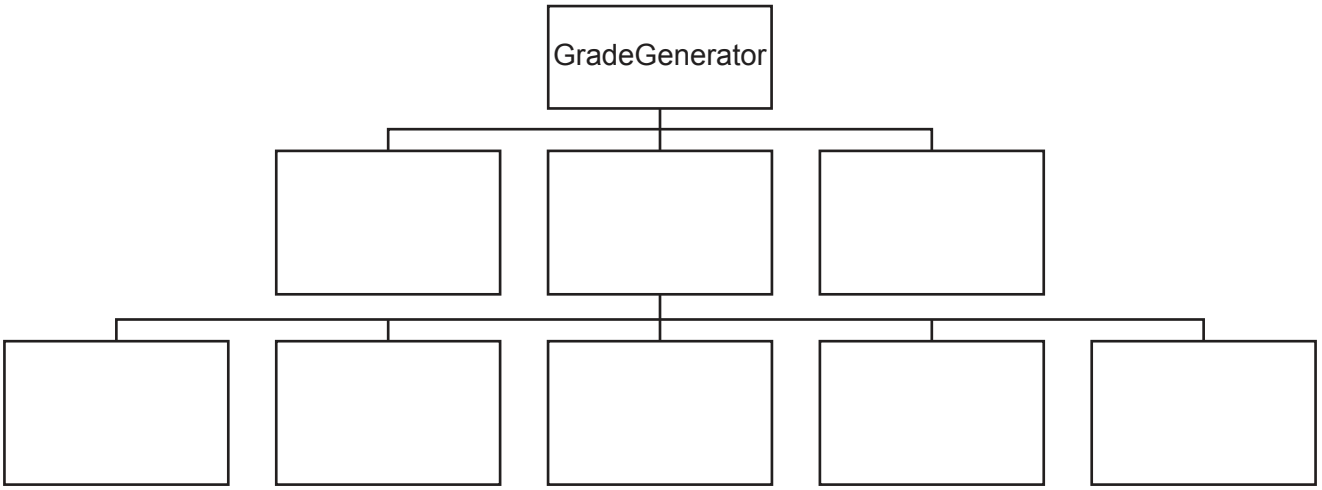
..... [2]

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]

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

ENDWHILE

ENDFUNCTION
```

[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]

(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.

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..... [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
```

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..... [4]

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
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 .....

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[4]

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

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

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

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(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`.

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(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]

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

Feature 1 .....

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Feature 2 .....

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[4]

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

Benefit .....

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Drawback .....

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[2]

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.

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(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

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

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2 .....

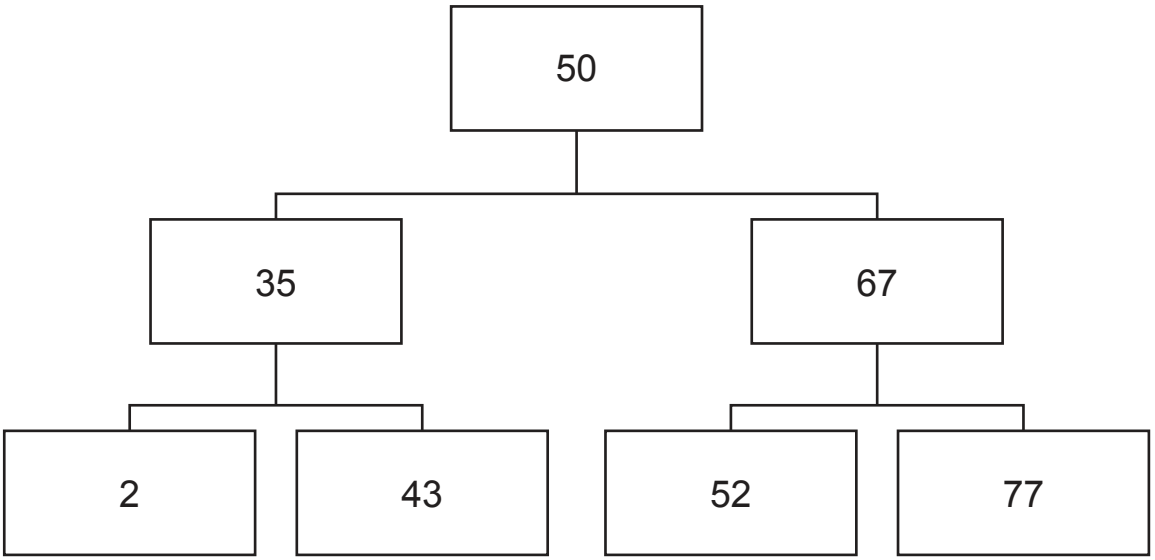
[2]

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]

(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`.

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..... [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

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