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COMPUTER SCIENCE

9608/43

Paper 4 Further Problem-solving and Programming Skills

May/June 2016

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

No calculators allowed.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, glue or correction fluid.

DO NOT WRITE IN ANY BARCODES.

Answer **all** questions.

No marks will be awarded for using brand names of software packages or hardware.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

The maximum number of marks is 75.

This document consists of **19** printed pages and **1** blank page.

1 A linked list abstract data type (ADT) is to be used to store and organise surnames.

This will be implemented with a 1D array and a start pointer. Elements of the array consist of a user-defined type. The user-defined type consists of a data value and a link pointer.

| Identifier | Data type | Description |
|------------|-----------|-----------------------------------|
| LinkedList | RECORD | User-defined type |
| Surname | STRING | Surname string |
| Ptr | INTEGER | Link pointers for the linked list |

(a) (i) Write **pseudocode** to declare the type `LinkedList`.

.....

[3]

(ii) The 1D array is implemented with an array `SurnameList` of type `LinkedList`.

Write the **pseudocode** declaration statement for `SurnameList`. The lower and upper bounds of the array are 1 and 5000 respectively.

.....[2]

(b) The following surnames are organised as a linked list with a start pointer `StartPtr`.

`StartPtr: 3`

| | 1 | 2 | 3 | 4 | 5 | 6 | | 5000 |
|----------------|-----|------|------|----|------|-------|-------|------|
| Surname | Liu | Yang | Chan | Wu | Zhao | Huang | ... | |
| Ptr | 4 | 5 | 6 | 2 | 0 | 1 | | |

State the value of the following:

(i) `SurnameList[4].Surname`[1]

(ii) `SurnameList[StartPtr].Ptr`[1]

(c) Pseudocode is to be written to search the linked list for a surname input by the user.

| Identifier | Data type | Description |
|-------------|-----------|---|
| ThisSurname | STRING | The surname to search for |
| Current | INTEGER | Index to array SurnameList |
| StartPtr | INTEGER | Index to array SurnameList. Points to the element at the start of the linked list |
| | | |

(i) Study the pseudocode in **part (c)(ii)**.

Complete the table above by adding the missing identifier details.

[2]

(ii) Complete the pseudocode.

```

01 Current ← .....
02 IF Current = 0
03     THEN
04         OUTPUT .....
05     ELSE
06         IsFound ← .....
07         INPUT ThisSurname
08         REPEAT
09             IF ..... = ThisSurname
10                 THEN
11                     IsFound ← TRUE
12                     OUTPUT "Surname found at position ", Current
13                 ELSE
14                     // move to the next list item
15                     .....
16             ENDIF
17         UNTIL IsFound = TRUE OR .....
18         IF IsFound = FALSE
19             THEN
20                 OUTPUT "Not Found"
21             ENDIF
22 ENDIF

```

[6]

2 (a) (i) State what is meant by a recursively defined procedure.

.....
[1]

(ii) Write the line number from the pseudocode shown in **part (b)** that shows the procedure X is recursive. [1]

(b) The recursive procedure X is defined as follows:

```

01 PROCEDURE X(Index, Item)
02     IF MyList[Index] > 0
03         THEN
04             IF MyList[Index] >= Item
05                 THEN
06                     MyList[Index] ← MyList[Index + 1]
07             ENDIF
08         CALL X(Index + 1, Item)
09     ENDIF
10 ENDPROCEDURE
  
```

An array `MyList` is used to store a sorted data set of non-zero integers. Unused cells contain zero.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|--------|---|---|---|---|----|----|----|---|---|----|
| MyList | 3 | 5 | 8 | 9 | 13 | 16 | 27 | 0 | 0 | 0 |

(i) Complete the trace table for the dry-run of the pseudocode for the procedure CALL X(1, 9).

| | | MyList | | | | | | | | | |
|-------|------|--------|---|---|---|----|----|----|---|---|----|
| Index | Item | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | 9 | 3 | 5 | 8 | 9 | 13 | 16 | 27 | 0 | 0 | 0 |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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[4]

(ii) State the purpose of procedure X when used with the array MyList.

.....
[1]

3 A car hire company hires cars to customers. Each time a car is hired, this is treated as a transaction.

For each transaction, the following data are stored.

For the customer:

- customer name
- ID number

For the hire:

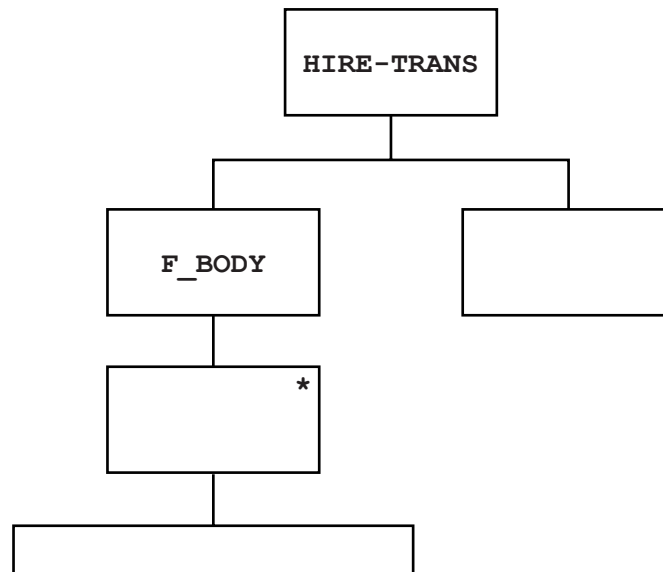
- car registration
- hire start date
- number of days hired

The transaction data are stored in a text file `HIRE-TRANS`. The file is made up of a file body, `F_BODY`, and a file trailer, `F_TRAILER`.

`F_BODY` has one transaction, `TRANS`, on each line.

(a) The first step in Jackson Structured Programming (JSP) design is to produce a JSP data structure diagram.

Complete the following JSP data structure diagram.



(b) The computer system will produce many printed reports.

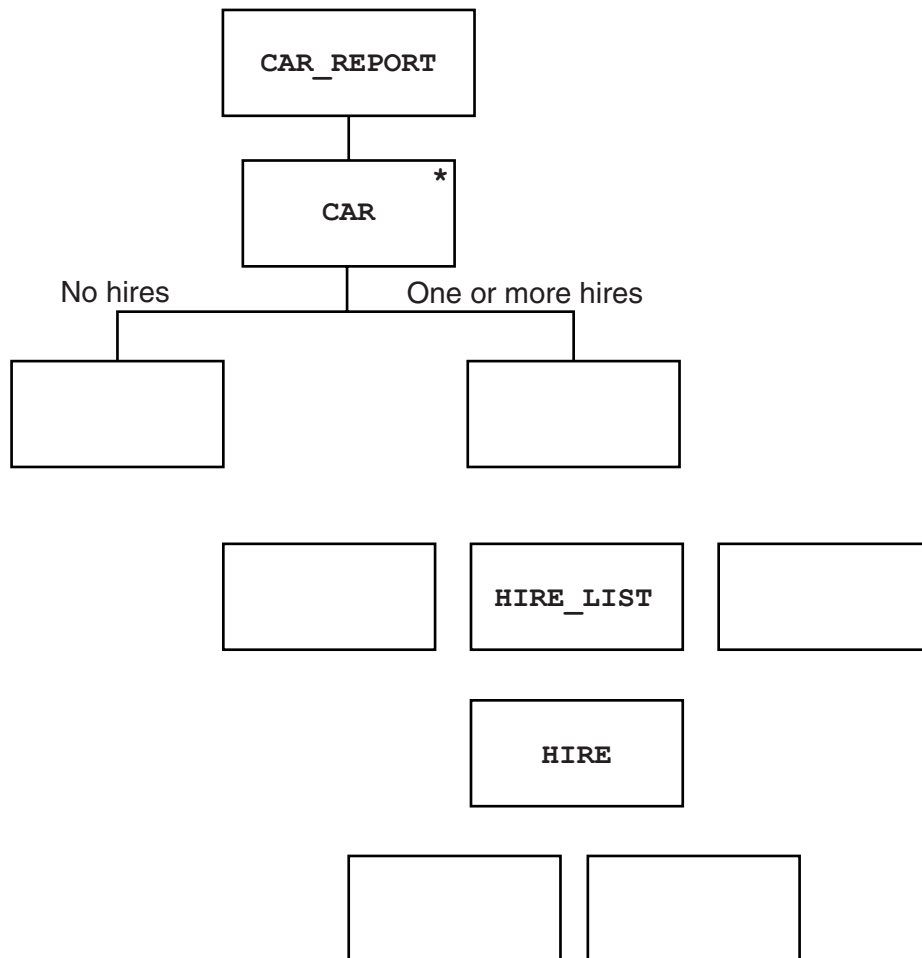
One report is `CAR_REPORT`. This displays all hire data for all cars.

For each car, the following data are displayed:

- the car data
- a list of all the hires
- the total number of hires

A car with zero hires is not included on the report.

Complete the following `CAR_REPORT` JSP data structure diagram.



[5]

- 4 When a car reaches a certain age, a safety assessment has to be carried out. A car's brakes and tyres must be tested. The tyre test result and the brakes test result for each car are recorded. If the car passes the assessment, a safety certificate is issued.

Cars have a unique three-character registration.

The following knowledge base is used:

```

01 car(a05).
02 car(h04).
03 car(a03).
04 car(h07).
05 car(a23).
06 car(p05).
07 car(b04).
08 carRegYear(a05, 2015).
09 carRegYear(h04, 2013).
10 carRegYear(a03, 2008).
11 carRegYear(h07, 2011).
12 carRegYear(a23, 2008).
13 carRegYear(p05, 2014).
14 carRegYear(b04, 2014).
15 testBrakes(h07, pass).
16 testTyres(h07, fail).
17 testBrakes(a03, fail).
18 testTyres(a03, fail).
19 testBrakes(a23, pass).
20 testTyres(a23, pass).
21 carAssessmentDue if carRegYear(Car, RegYear)
                        and RegYear <= DeadlineYear.
22 issueCertificate(Car) if testTyres(Car, Result) and
                        testBrakes(Car, Result) and Result = pass.

```

- (a) (i) DeadlineYear is assigned value 2011.

Identify the car registrations for cars which are due to be tested.

.....[1]

- (ii) State how clause 22 determines whether or not a safety certificate will be issued.

.....
[1]

(b) If a car fails one of the two tests, a retest is allowed.

Write a new rule for this.

retestAllowed(.....) if

[3]

(c) Logic programming uses a data structure called a list.

A new fact is added to the knowledge base.

23 carList = [a03,p05,b04,h04,h07,a23].

The following notation and operators are to be used with a list:

[X|Y] denotes a list with:

- X the first list element
- Y the list consisting of the remaining list elements

[] denotes an empty list

(i) The list [a07,p03] is denoted by [A|B]

State the value of A and B.

A =

B = [2]

(ii) The lists [c03,d02,n05|C] and [c03,d02,n05,p05,m04] are identical.

State the value of C.

C = [1]

(iii) The list [a06,a02] is denoted by [D,E|F]

State the value of F.

F = [1]

(d) The predicate `conCatCompare` is defined as a rule and returns `TRUE` or `FALSE` as follows:

```
conCatCompare(X, Y, Z)
```

Concatenates the lists `X` and `Y` and compares the new list with list `Z`.

If equal, the clause evaluates to `TRUE`, otherwise `FALSE`.

Consider the clause:

```
conCatCompare(X, Y, [a7,b6,c4])
```

If:

- the clause evaluates to `TRUE`
- and `Y` represents the list `[a7, b6, c4]`

State the value of `X`.

`X` =[1]

- 5 (a) A program calculates the exam grade awarded from a mark input by the user. The code is written as a function `CalculateGrade`.

The function:

- has a single parameter `Mark` of `INTEGER` data type
- returns the grade awarded `Grade` of `STRING` data type

The logic for calculating the grade is as follows:

| Mark | Grade |
|--------------------------|-------------|
| Under 40 | FAIL |
| 40 and over and under 55 | PASS |
| 55 and over and under 70 | MERIT |
| 70 and over | DISTINCTION |

The programmer designs the following table for test data:

| Mark | Description | Expected result (Grade) |
|------|------------------|-------------------------|
| | Normal | |
| | Abnormal | |
| | Extreme/Boundary | |

- (i) Complete the table above. [3]
- (ii) State why this table design is suitable for black box testing.

.....

.....[1]

(b) When designing and writing program code, explain what is meant by:

- an exception
- exception handling

.....
.....
.....
.....
.....
.....
.....[3]

(c) A program is to be written to read a list of exam marks from an existing text file into a 1D array.
Each line of the file stores the mark for one student.

State **three** exceptions that a programmer should anticipate for this program.

1
.....
2
.....
3
.....[3]

(d) The following pseudocode is to read two numbers:

```
01 DECLARE Num1 : INTEGER
02 DECLARE Num2 : INTEGER
03 DECLARE Answer : INTEGER
04 TRY
05     OUTPUT "First number..."
06     INPUT Num1
07     OUTPUT "Second number..."
08     INPUT Num2
09     Answer ← Num1 / (Num2 - 6)
10     OUTPUT Answer
11 EXCEPT ThisException : EXCEPTION
12     OUTPUT ThisException.Message
13 FINALLY
14     // remainder of the program follows
...
29
30 ENDTRY
```



The programmer writes the corresponding program code.

A user inputs the number 53 followed by 6. The following output is produced:

```
First number...53
Second number...6
Arithmetic operation resulted in an overflow
```

(i) State the pseudocode line number which causes the exception to be raised.

..... [1]

(ii) Explain the purpose of the pseudocode on lines 11 and 12.

.....
.....
.....
.....
.....
..... [3]

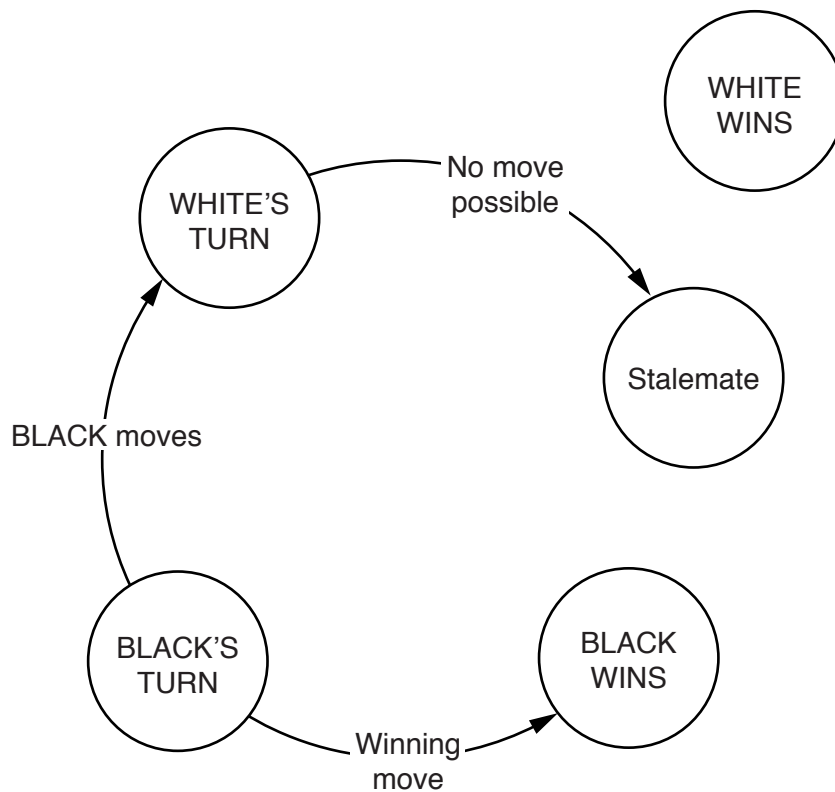
6 In a board game, one player has white pieces and the other player has black pieces. Players take alternate turns to move one of their pieces. White always makes the first move.

The game ends if:

- a player is unable to make a move when it is their turn. In this case, there is no winner. This is called 'stalemate'.
- a player wins the game as a result of their last move and is called a 'winner'.

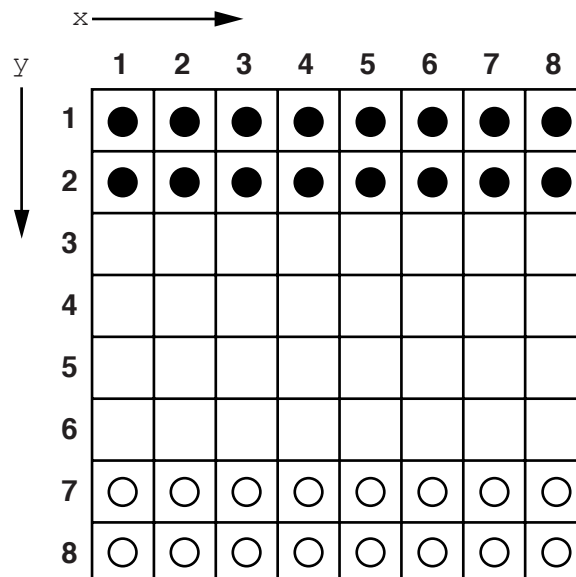
(a) A state-transition diagram is drawn to clarify how the game is played.

Complete the following state-transition diagram.



[4]

(b) The layout of the board at the start of the game is shown below:



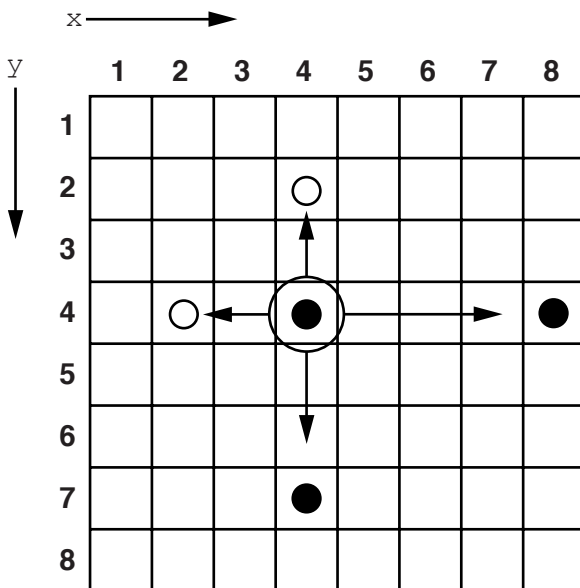
- (ii) When a piece is to be moved, a procedure will calculate and output the possible destination squares for the moving piece.

A piece can move one or more squares, in the x or y direction, from its current position.

This will be a move:

- either to an empty square, with no occupied squares on the way
- or to a square containing a piece belonging to another player, with no occupied squares on the way. The other player's piece is then removed.

For example, for the circled black piece there are nine possible destination squares. Each of the two destination squares contains a white piece which would be removed.



The program requires a procedure `ValidMoves`.

It needs three parameters:

- `PieceColour` – colour of the moving piece
- `xCurrent` – current x position
- `yCurrent` – current y position

The procedure will calculate all possible destination squares **in the x direction only**.

Example output for the circled black piece is:

```
Possible moves are:
Moving LEFT
3 4
2 4 REMOVE piece
Moving RIGHT
5 4
6 4
7 4
```

Write **program code** for procedure `ValidMoves` with the following procedure header:

```
PROCEDURE ValidMoves(PieceColour : CHAR, xCurrent : INTEGER,
                    yCurrent : INTEGER).
```


(c) The problem is well suited to an object-oriented design followed by object-oriented programming.

(i) Describe how classes and objects could be used in this problem.

.....
.....
.....
.....
.....[2]

(ii) For a class you identified in **part(c)(i)**, state **two** properties and **two** methods.

Class

Properties

1

2

Methods

1

2

[2]

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