Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4282202533

COMPUTER SCIENCE **9608/43**

Paper 4 Further Problem-solving and Programming Skills **October/November 2017**

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 **16** printed pages.

CAMBRIDGE International Examinations

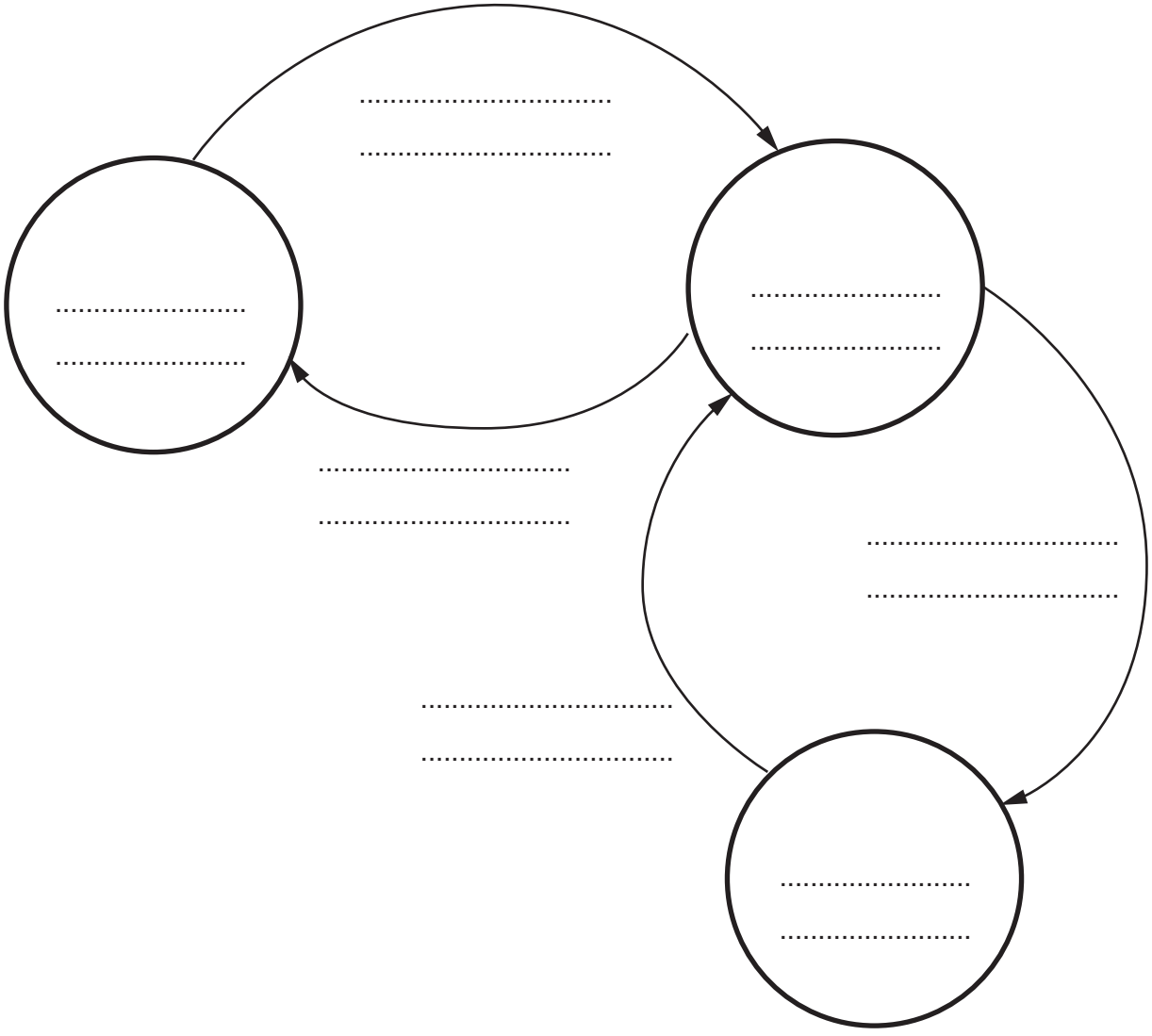
1 A greenhouse has a window that automatically opens and closes depending on the internal temperature.

If the temperature rises above 20 °C, the window half opens. If the temperature rises above 30 °C, the window fully opens. If the temperature drops below 25 °C, the window returns to being half open. If the temperature drops below 15 °C, the window fully closes.

The window has three possible states: **Closed**, **Half Open** and **Fully Open**.

Current state	Event	Next state
Closed	Temperature rises above 20 °C	Half Open
Half Open	Temperature drops below 15 °C	Closed
Half Open	Temperature rises above 30 °C	Fully Open
Fully Open	Temperature drops below 25 °C	Half Open

Complete the state-transition diagram for the window:



[7]

2 **(a)** **(i)** State how repetition is shown in a Jackson Structured Programming (JSP) structure diagram.

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.....[1]

(ii) State how selection is shown in a JSP structure diagram.

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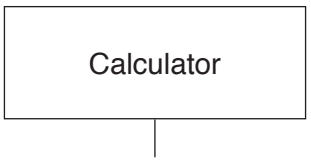
.....[1]

(b) A simple calculator is to be created.

The calculator is to be used as follows:

- User inputs 2 numbers (x and y).
- User inputs an operator (`+, -, * or /`).
- The calculator computes the answer.
- The calculator displays the answer.

Draw a JSP diagram for the calculator. The first element is provided.



[5]

3 A declarative programming language is used to represent the following knowledge base:

```
01 person(jane).
02 person(ahmed).
03 person(caroline).
04 person(stuart).
05 food(chocolate).
06 food(sushi).
07 food(pizza).
08 food(chilli).
09 likes(jane, pizza).
10 likes(ahmed, chocolate).
11 likes(ahmed, pizza).
12 likes(jane, chilli).
13 likes(stuart, sushi).
14 dislikes(stuart, chocolate).
15 dislikes(jane, sushi).
16 dislikes(caroline, pizza).
```

These clauses have the following meanings:

Clause	Explanation
01	Jane is a person
05	Chocolate is a food
09	Jane likes pizza
14	Stuart dislikes (does not like) chocolate

(a) Mimi is a person who likes chocolate but does not like sushi or lettuce.

Write additional clauses to represent this information.

17 .....

18 .....

19 .....

20 .....

21 .....

[5]

(b) Using the variable `PersonName`, the goal:

```
likes(PersonName, pizza).
```

returns:

```
PersonName = jane, ahmed.
```

Write the result that is returned by the goal:

```
likes(ahmed, FoodItem).
```

`FoodItem =` .....

.....[2]

(c) B might like A, if B is a person, A is a food and B does not dislike A.

Write this as a rule.

`might_like(`..... **,** .....`)`

`IF` .....

.....

.....[6]

4 The following table shows part of the instruction set for a processor. The processor has one general purpose register, the Accumulator (ACC), and an Index Register (IX).

Instruction		Explanation
Op code	**Operand**	
LDM	#n	Immediate addressing. Load the number n to ACC.
LDD	<address>	Direct addressing. Load the contents of the location at the given address to ACC.
LDI	<address>	Indirect addressing. The address to be used is at the given address. Load the contents of this second address to ACC.
LDX	<address>	Indexed addressing. Form the address from <address> + the contents of the index register. Copy the contents of this calculated address to ACC.
LDR	#n	Immediate addressing. Load the number n to IX.
STO	<address>	Store the contents of ACC at the given address.
STX	<address>	Indexed addressing. Form the address from <address> + the contents of the index register. Copy the contents from ACC to this calculated address.
ADD	<address>	Add the contents of the given address to the ACC.
INC	<register>	Add 1 to the contents of the register (ACC or IX).
DEC	<register>	Subtract 1 from the contents of the register (ACC or IX).
JMP	<address>	Jump to the given address.
CMP	<address>	Compare the contents of ACC with the contents of <address>.
CMP	#n	Compare the contents of ACC with number n.
JPE	<address>	Following a compare instruction, jump to <address> if the compare was True.
JPN	<address>	Following a compare instruction, jump to <address> if the compare was False.
LSL	#n	Bits in ACC are shifted n places to the left. Zeros are introduced on the right hand end.
LSR	#n	Bits in ACC are shifted n places to the right. Zeros are introduced on the left hand end.
IN		Key in a character and store its ASCII value in ACC.
OUT		Output to the screen the character whose ASCII value is stored in ACC.
END		Return control to the operating system.

(a) A program stores a letter. The user is allowed nine attempts to guess the stored letter. The program outputs "?" and the user guesses a letter. If the user guesses the letter, the program outputs "*".

The following is pseudocode for this program.

```
REPEAT
   OUTPUT '?'
   INPUT GUESS
   IF GUESS = LETTERTOGUESS
      THEN
        OUTPUT '*'
        BREAK
   ELSE
      ATTEMPTS ← ATTEMPTS + 1
   ENDIF
UNTIL ATTEMPTS = 9
```

Write this program. Use the op codes from the instruction set provided.

Label	Op code	Operand	Comment
START:	LDM	#63	// load ASCII value for '?'
			// OUTPUT '?'
			// input GUESS
			// compare with stored letter
			// if correct guess, go to GUESSED
			// increment ATTEMPTS
			// is ATTEMPTS = 9 ?
			// if out of guesses, go to ENDP
			// go back to beginning of loop
GUESSED:	LDM	#42	// load ASCII for '*'
			// OUTPUT '*'
ENDP:	END		// end program
ATTEMPTS:	0		
LETTERTOGUESS:	'a'		

[11]

(b) Five numbers are stored, starting in the location labelled `NUMBERS`. A program is needed to multiply each of the numbers by 4 and store them back in their original location.

Write this program. Use the op codes from the instruction set on the opposite page.

Label	Op code	Operand	Comment
START:			// initialise the Index Register
			// load the value from NUMBERS
			// multiply by 4
			// store the new value in NUMBERS
			// increment the Index Register
			// increment COUNT
			// is COUNT = 5 ?
			// repeat for next number
ENDP:	END		
COUNT:	0		
NUMBERS:	22		
	13		
	5		
	46		
	12		

[10]

Instruction		Explanation
Op code	**Operand**	
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LDD	<address>	Direct addressing. Load the contents of the location at the given address to ACC.
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IN		Key in a character and store its ASCII value in ACC.
OUT		Output to the screen the character whose ASCII value is stored in ACC.
END		Return control to the operating system.

[Turn over

5 Large development projects require careful resource management.

(a) (i) Name an appropriate project management tool that helps the manager to work out the estimated length of time it takes for the project to complete.

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(ii) Explain how, during the planning stage of the project, the manager would use the tool you named in **part (a)(i)**.

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(b) (i) Different programmers have been writing independent modules. The modules now need to be combined to create the final system.

Name the type of testing required at this stage.

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(ii) Name the final testing stage required before the system becomes operational.

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.....[1]

6 A programmer wants to create a computer simulation of animals searching for food in a desert. The desert is represented by a 40 by 40 grid. Each position in the grid is represented by a pair of coordinates. `'A'` represents an animal and `'F'` represents food. At the start of the simulation, the grid contains 5 animals and 1 food source.

The following is an example of part of the grid.

	0	1	2	3	4	...	37	38	39
0	A					..			
1			F			..			
2						..		A	
3				A		..			
...	..	..	..	..	..	..	..	..	..
38				A		..	A		
39						..			

A timer is used. In each time interval, each animal randomly moves 0 or 1 position in a random direction. The program generates this movement by computing two random numbers, each of which can be –1, 0 or 1. The program adds the first random number to the across number and the second random number to the down number representing the animal's position.

For example:

- if 0 and 1 are generated, the across value does not change, the down value increases by 1
- if –1 and 1 are generated, the across value decreases by 1, and the down value increases by 1.

Each animal has an individual score. If the animal moves to a position in the grid with food (`'F'`):

- the animal's score increases by 1
- the food disappears
- one new animal (`'A'`) is randomly generated and added to the grid (to a maximum of 20 animals)
- one new food (`'F'`) is randomly generated and added to the grid.

The simulation is to be implemented using object-oriented programming.

The programmer has designed two classes, `Desert` and `Animal`.

The `Desert` class consists of:

- attributes
  - `Grid`
  - `StepCounter`
  - `AnimalList`
  - `NumberOfAnimals`
- methods
  - `Constructor`
  - `IncrementStepCounter`
  - `GenerateFood`
  - `DisplayGrid`

Each attribute consists of a value and a get and set method that allow access to the attributes.

The following table describes the attributes and methods for the `Animal` class.

Identifier	Data type	Description
`Constructor()`		Instantiate an object of the `Animal` class • Generate a pair of random numbers between 0 and 39. • Place animal at that random position. • Initialise the animal's score to 0.
`EatFood()`		• Delete the food. • Increase the score of the animal that called the method. • Call the `GenerateFood` method of the `Desert` class. • Call the `Constructor` method of the `Animal` class.
`Move()`		• Call the `GenerateChangeInCoordinate` method for each coordinate (across or down number) of the animal's position. • Moves the animal to the new space. • If there is food in the new position, call the `EatFood` method.
`Score`	`INTEGER`	Initialised to 0
`Across`	`INTEGER`	The across value, between 0 and 39
`Down`	`INTEGER`	The down value, between 0 and 39

(a) Write **program code** to declare the attributes and constructor for the `Animal` class.

You only need to write the set and get methods for the attribute `Across`.

You should also write:

- the constructor for the class
- set and get methods for the `Across` attribute only.

Programming language .....

Program code

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(b) The `Constructor` method of the `Desert` class:

- initialises an empty grid
- creates 5 animal objects which are added to the `AnimalList` (an array of animal objects currently on the grid)
- generates one food
- sets the `StepCounter` to 0.

Write **program code** for the `Constructor` method.

Programming language .....

Program code

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(c) (i) The function `GenerateChangeInCoordinate`:

- receives a coordinate (across or down number) as a parameter
- checks whether the coordinate's value is at a boundary of the grid
- returns a random change (–1, 0 or 1) that will keep the animal's position within the grid.

Write **program code** for the `GenerateChangeInCoordinate` function.

Programming language .....

Program code

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(ii) The `Move` method uses the `GenerateChangeInCoordinate` function to calculate the new `Across` and `Down` values for an animal. If there is food in the new position in the grid, the animal eats the food.

Write **program code** for the `Move` method.

Programming language .....

Program code

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(d) The programmer plans to add a graphic display to the program. The programmer will make use of a program library.

Explain what is meant by a program library.

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