UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

9953174971

COMPUTING **9691/31**

Paper 3 **May/June 2012**

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 on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
No marks will be awarded for using brand names for 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.

This document consists of **16** printed pages.

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UNIVERSITY *of* CAMBRIDGE International Examinations

[Turn over

1 A database is designed to store data about students at a college and the subjects that they study.

- All students are based in a tutor group
- A tutor supervises all the students in their tutor group
- Each subject has one subject teacher only
- Students study a number of subjects

The following table `StudentSubjects` was a first attempt at the database design.

Table: `StudentSubjects`

StudentName	TutorGroup	Tutor	Subject	Level	SubjectTeacher
Tom	6	SAN	Physics	A	SAN
			Chemistry	A	MEB
			Gen. Studies	AS	DIL
Joe	7	MEB	Geography	AS	ROG
			French	AS	HEN
Samir	6	SAN	Computing	A	VAR
			Chemistry	A	MEB
			Maths	A	COR
			Gen. Studies	A	DIL

(a) **(i)** Explain why the table is not in First Normal Form (1NF).

....

.... [1]

(ii) Explain your answer by referring to the above data.

....

.... [1]

(b) The design is changed to the following:

```
Student (StudentName, TutorGroup, Tutor)
StudentSubjectChoices (StudentName, Subject, Level, SubjectTeacher)
```

Using the data given in the original table, show how this data is now stored in the revised table designs.

Table: `Student`

StudentName	TutorGroup	Tutor

Table: `StudentSubjectChoices`

StudentName	Subject	Level	SubjectTeacher

[3]

(c) **(i)** Explain what is meant by a primary key.

....

....

....

.... [2]

(ii) A student is not allowed to choose the same subject at A Level and AS.

What is the primary key of table `StudentSubjectChoices`?

.... [1]

For Examiner's Use

[Turn over

For Examiner's Use

(iii) There is a relationship between tables `Student` and `StudentSubjectChoices`.

Explain how the relationship is **established** using a primary key and foreign key.

....

....

....

.... [2]

(d) The design of table `StudentSubjectChoices` is:

`StudentSubjectChoices (StudentName, Subject, Level, SubjectTeacher)`

Explain why this table is not in Second Normal Form (2NF).

....

....

....

.... [2]

(e) The design of table `Student` is:

`Student (`<u>`StudentName`</u>`, TutorGroup, Tutor)`

Explain why this table is not in Third Normal Form (3NF).

....

....

....

.... [2]

For Examiner's Use

2 A binary pattern can be used to represent different data used in a computer system.

(a) Consider the binary pattern: **0101 0011**

The pattern represents an integer.

What number is this in denary?

.... [1]

(b) Consider the binary pattern: **0001 0101 0011**

The pattern represents a Binary Coded Decimal (BCD) number.

What number is this in denary?

.... [1]

(c) Consider the binary pattern: **1001 0010**

This represents a two's complement integer.

What number is this in denary?

.... [1]

For Examiner's Use

(d) Floating point is to be used to represent real numbers with:

- 8 bits for the mantissa, followed by
- 4 bits for the exponent
- two's complement used for both the mantissa and the exponent

(i) Consider the binary pattern:

0	**1**	**1**	**0**	**1**	**0**	**0**	**0**		**0**	**1**	**0**	**0**

What number is this in denary? Show your working.

....

....

....

....

....

.... [3]

(ii) The representation shown in part **(d)(i)** is normalised.

Explain why floating point numbers are normalised.

....

.... [1]

(iii) Show the binary pattern for the smallest positive number which can be stored using a normalised 12-bit floating point representation.

Mantissa:

Exponent:

Work out its denary value.

Denary: .... [3]

For Examiner's Use

(e) The developer of a new programming language decides that all real numbers will be stored using 20-bit normalised floating point representation. She cannot decide how many bits to use for the mantissa and how many for the exponent.

Explain the trade-off between using either a large number of bits for the mantissa, or a large number of bits for the exponent.

....

....

....

.... [2]

For Examiner's Use

3 **(a)** Customer names are stored in the array `Customer`.
An algorithm is to be designed to perform a serial search of the array for a requested customer name.
The algorithm will use the variables shown in the table.

Study the table and the algorithm and fill in the gaps.

Identifier	Data Type	Description
`Customer`	`ARRAY[2000] OF STRING`	The customer names
`Index`	`INTEGER`	Index position in the customer array
`IsFound`	....	....
`SearchName`	`STRING`	The requested customer name

```
//Serial search algorithm
INPUT ..........................................
IsFound ← FALSE
Index ← 1

REPEAT
    IF Customer [ .......................................... ] = SearchName
       THEN
          IsFound ← TRUE
          OUTPUT "FOUND – at position " Index " in the array"
       ELSE
          Index ← ..........................................
    ENDIF
UNTIL (IsFound = TRUE) OR ..........................................

IF ..........................................
    THEN
       OUTPUT "Customer name was NOT FOUND"
ENDIF
```

[7]

(b) Comment on the efficiency of the serial search algorithm in part **(a)** for retrieving a data item from an array with 2000 items.

....

....

....

.... [2]

For Examiner's Use

(c) A binary search may be an alternative algorithm to a serial search.

(i) Describe how this algorithm works. (Do **not** attempt to write the pseudocode.)

....

....

....

....

....

....

....

.... [4]

(ii) A binary search is made to locate `Cherry`.

1	`Apple`
2	`Banana`
3	`Cherry`
4	`Kiwi`
5	`Lemon`
6	`Mango`
7	`Plum`

List, in order, the comparisons which are made.

....

....

.... [3]

For Examiner's Use

4 Expressions can be written in either infix or reverse Polish notation.

(a) Evaluate this reverse Polish expression:

```
4 6 * 3 -
```

.... [1]

(b) Write the following infix expressions in reverse Polish.

(i) `(a-5)/(b+c)`

....

.... [1]

(ii) `2 * 3 + 6 / 2`

....

.... [2]

(c) Describe **one** benefit of storing an expression in reverse Polish.

....

.... [1]

(d) An expression in reverse Polish can be evaluated on a computer system using a stack.

(i) Describe the operation of a stack.

....

.... [1]

(ii) A stack is to be implemented as an array with an integer variable to point to the ‘top of stack’ index position.

State whether this is a static data structure or a dynamic data structure and explain your choice.

....

....

....

.... [2]

(iii) The reverse Polish expression `3 7 * 6 + 9 /` is to be evaluated using a stack. The first available location on the stack is 1.

For Examiner's Use

Show how the contents of the stack change as this expression is evaluated.

5							
4							
3							
2							
1							

[4]

5 The table shows the assembly language instructions for a processor which has one general purpose register – the Accumulator.

Instruction		Explanation
Op Code	Operand	
`LDD`	`<address>`	Load using direct addressing
`STO`	`<address>`	Store the contents of the Accumulator at the given address
`LDI`	`<address>`	Load using indirect addressing
`LDX`	`<address>`	Load using indexed addressing
`INC`		Add 1 to the contents of the Accumulator
`END`		End the program and return to the operating system

(a) Write on the diagram to explain the instruction shown.
Show the contents of the Accumulator after the execution of the instruction.

`LDD 105`

Accumulator

Main memory

100	0100 0000
101	0110 1000
102	1111 1110
103	1111 1010
104	0101 1101
105	0001 0001
106	1010 1000
107	1100 0001
⁓	⁓
200	1001 1111

[2]

(b) Write on the diagram to explain the instruction shown.
Show the contents of the registers after the execution of the instruction.

`LDX 101`

Accumulator

Index Register: 0000 0011

Main memory

100	0100 0000
101	0110 1000
102	1111 1110
103	1111 1010
104	0101 1101
105	0001 0001
106	1010 1000
107	1100 0001
⁓	⁓
200	1001 1111

[4]

For Examiner's Use

For Examiner's Use

(c) Trace this assembly language program using the trace table below.

```
500    LDD  507
501    INC
502    STO  509
503    LDD  508
504    INC
505    STO  510
506    END
507     22
508    170
509      0
510      0
```

Accumulator

Memory Address			
507	508	509	510
22	170	0	0

[5]

(d) Explain the relationship between assembly language instructions and machine code instructions.

....

....

.... [1]

6 In a multiprogramming environment the operating system includes a scheduler.

For Examiner's Use

(a) Explain the purpose of the scheduler.

....

....

....

.... [2]

(b) A process will at any time be in one of three states.

(i) Name and describe each possible state.

1 ....

....

....

2 ....

....

....

3 ....

....

.... [6]

(ii) How will the operating system keep details about the state of all processes?

....

.... [1]

For Examiner's Use

(c) Any process can be described as either 'processor bound' or 'input/output bound'.

(i) Explain what is meant by these terms and give a typical application of each.

Processor bound ....

....

Application which is processor bound ....

....

Input/Output bound ....

....

Application which is I/O bound ....

.... [4]

(ii) A particular scheduler allocates a priority to each process for the use of the processor.

State which type of process – processor bound or I/O bound – would be given higher priority for the use of the processor. Explain why.

....

....

.... [2]

7 **(a)** Define what is meant by the term computer simulation.

....

....

....

.... [2]

(b) Give **two** reasons why a computer system is particularly suited to carrying out a simulation.

1 ....

....

2 ....

.... [2]

(c) A supermarket is about to open a new branch and is to use a computer simulation to estimate the number of checkouts which will be required.

Identify **three** variables which need to be controlled by the software simulation of the checkout operation.

1 ....

2 ....

3 .... [3]

(d) The values input to the simulation will affect the outputs produced.

Give **one** example for this checkout scenario of a change to an input which will directly affect the output.

Input change ....

....

Effect on the output ....

.... [2]