



**Day, Date, May 2014
start time – end time
(Duration: 2 hours)**

DEGREES OF MSci, MEng, BEng, BSc, MA and MA (Social Sciences)

COMPUTING SCIENCE

CS1Q

(Answer all 4 questions.)

This examination paper is worth a total of 100 marks

(Use SEPARATE ANSWER BOOKS for sections A and B and C)

You must not leave the examination room within the first hour or the last half-hour of the examination.

Section A – Human Computer Interaction

1.

- (a) Briefly describe what is meant by the iterative design lifecycle in relation to developing interactive systems in human computer interaction.

[4]

The iterative lifecycle refers to the process of gathering requirements from users [1], designing and prototyping the software/product [1], evaluating the product [1] and then generating additional requirements or redesigning and performing the loop of activities again [1].

Students must explain the iterative loop to get the full 4 marks. Use of a diagram to explain the stages rather than text is acceptable but should be supported with a brief explanation of the steps for full 4 marks.

- (b) You have been asked by a client to determine the user requirements for a new large interactive display on the history of dinosaurs for a local museum. Describe 2 aspects of human psychology that you would have to consider when designing the size, position and content for the display.

[6]

1 mark for naming and 1 mark for brief description or example up to 6 marks.

Perception/visual acuity [1] – what size and colour of text and images people can process on a large display at distance [1]

Physiology/ergonomics [1] – the size of the display and any controls (buttons etc), the distance people will be from the screen – whether they have to look up, down or to the side or whether they have to physically move to interact with the display [1].

Cognition [1] – how people will process the information on the display. Is it visual, textual, moving image, sounds? How much information (information overload) can be displayed and what type of information is required [1]?

Memory [1] – How many items of information people can store in memory at one time, and for how long (example max number of menu items).

Attention [1] – does the display use moving images or audio to grab people's attention? How can you design the display to keep people's

attention (especially for children) [1].

(c)

(i) What are usability heuristics?

[2]

Usability heuristics are rules of thumb that can be applied to guide the development of a broad range of human computer interfaces [1]. They can be used at low cost throughout the development cycle [1] but often fail to provide the same quality of insight that might be expected from direct user testing [1]. For example, designers may find it difficult to obtain a user's perspective simply by trying to apply 'consistency.

(ii) What is the Hawthorne Effect and why is it important to consider when conducting user evaluations in HCI?

[3]

The Hawthorne Effect describes when a user is either positively or adversely affected by the actual activity of taking part in the evaluation itself [1]. This means that they may behave in a way, or respond in a way that is not a true reflection of how they might in the real life context of use [1]. It is important to consider this when running user evaluations as you need to judge if, and by how much, your results may have been affected just because an experimenter was present [1].

(d)

- (i) Evaluation can be both **formative** and **summative**. Briefly describe what the main differences are between formative and summative evaluation and what stage in the software lifecycle they would be carried out.

[4]

Formative evaluation is carried out during [1] the product development to inform the design and future functionality and usability of the product [1]. Summative evaluation is usually carried out at the end when a product is fully functional [1] and it is used to evaluate whether it meets the aims and requirements [1] and/or to see how it is used in practice [1].

- (ii) Today usability evaluations are often carried out ‘in the field’. Discuss the advantages and disadvantages of evaluating the usability of a new smartphone app in the field.

[6]

In the field studies allow you to study the use of a system or product in the exact environment it will actually be used in [1]. This means that the results you observe are more likely to be valid and generalizable to actual use of the product in the ‘real world’ [1]. It allows you to measure physical and environmental factors such as the effect of light, noise, traffic, walking etc on the usability of the product [1]. It also allows the possibility to consider social factors such as sharing devices/displays in a public setting or issues such as privacy when outside or in public using a device [1].

A drawback of field studies is that they take time and effort to set up and run [1]. They also introduce ethical issue such as the safety of the user if they are walking in public near hazards such as traffic for example [1]. Another drawback of field studies is that they don’t allow the same level of control you might have in a lab study (controlling for light, noise, time of day, traffic etc.) [1] and therefore you can never be as sure what factors are affecting what you are measuring during the evaluation [1].

Section B – Information Management

2. (a)

- (i) What is an ER diagram and what is it used for in Information Management?

[2]

An ER diagram is an Entity-Relationship diagram [1] and it is used to model the information we want to store and manage in a database [1].

- (ii) What is composite attribute in ER modeling and why is it useful when it comes to implementing a database?

[2]

A composite attribute is one which is split into several component parts such as address (house number, street name, post code) [1]. It is useful because when it comes to implementing the database tables, each component part is assigned its own columns (attributes) meaning that each of the atomic attributes can be used individually in queries [1].

(b)

- (i) One of the key functions of a database management system (DBMS) is to control concurrent access to the same data. Explain what this is and why it is important that it is 'controlled'.

[2]

Controlled concurrent access refers to the ability to support multiple users (possibly using different applications) to have access to the same underlying data [1]. It needs to be controlled because if two users try to update the data at the same time there needs to be a way to manage which version of the data should be updated [1].

- (ii) What are each of the following: candidate key, primary key, and foreign key?

[3]

A candidate key is an attribute or group of attributes capable of acting as a primary key [1]. A primary key is an attribute or group of attributes that is actually used to uniquely identify the tuples of a relation [1]. A foreign key is an attribute of a relation which references the primary key of some other relation [1].

- (c) A magazine publisher keeps data on its publications. A publication has a reference code, a title, and a type (editorial, report, poem). A member of staff has a unique employee code, a name, and a job title. Each publication has staff working on it. All staff are assigned to at least one publication, but may work on more than one.

Draw an ER diagram that could be used in the development of a database to support the publisher.

[6]

Correct entities – 1 mark

Correct attributes – 1 mark

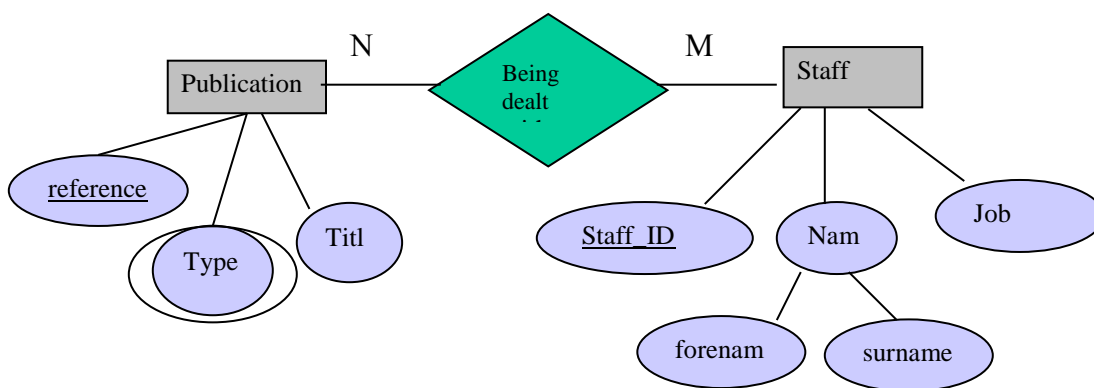
Primary keys present – 1 mark

Relationship with correct cardinalities – 1 mark

Multivalued 'type' attribute – 1 mark

Composite attribute for Name – 1 mark

Staff or publication MAY be considered totally participative so do not penalize for double lines (or absence of them) at either side of the relationship



(d)

- (i) If U = Football Players, B stands for 'play in British clubs' and W stands for 'play for their home country', give a description in English of the following set:

$$S = \{ x \mid B(x) \wedge Q(x) \}$$

[1]

The set of all football players that play both for a British club AND their own home countries national team [1 mark].

- (ii) If $S = \{5,8\}$ and $T = \{1,2,9\}$, list the elements of the Cartesian product of the two sets S and T .

[1]

$$\{ \langle 5,1 \rangle, \langle 5,2 \rangle, \langle 5,9 \rangle, \langle 8,1 \rangle, \langle 8,2 \rangle, \langle 8,9 \rangle \}$$

- (iii) Let $S = \{7, 8, 9\}$. Let $V = \{7, 8, 8, 9, 9\}$.

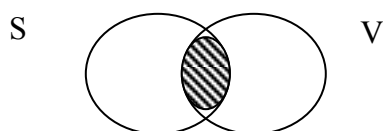
Is it true that $S = V$? Why or why not?

[1]

Yes, $S=V$ because order and repetition does not matter – they still contain the same element [1 mark].

- (iv) Express as a Venn diagram the intersection of sets S and V from (iii).

[1]



- (v) List the elements in the relation R from $A = \{7, 8, 9\}$ to $B = \{2,3, 9\}$ where:

$$\langle x,y \rangle \in R \text{ if and only if } x < y.$$

[1]

$\{<7,9>, <8,9>\}$ – 1 mark

(e)

- (i) Other than querying a database – what else can SQL (structured query language) be used for in information management?

[2]

SQL can be used for data manipulation (inserting, updating or deleting) [1 mark].

It can be used for data definition (defining new tables or elements – like CREATE) – 1 mark.

It can be used for data control (granting and revoking access and editing privileges and rights) – 1 mark.

Award one mark per function – up to a total of 2 marks.

- (ii) Employee and Department are two tables in a relational database.

Employee (Name, NI-Number, Email, Phone-No, Works_In)

Department (Name, Code, Building)

The attribute **Works_In** is a foreign key in Employee relating to the primary key **Code** in Department.

Express the SQL required to extract the names of all the employees of the “Accounts” department.

[3]

```
SELECT      E.Name
FROM        Employee E, Customer C
WHERE       (Works_In = Code) AND (C.Name = “Accounts”)
```

Reserve full marks if student has three clauses in correct order, all arguments correct, and use of dot operator.

1 mark per line of SQL.

Award part marks if student shows some understanding of structure of SQL but has small errors in arguments. Areas where students are likely to lose marks are by failing

to join the two tables (no marks for this line), or by failing to compare the PK (Code) and FK (Works_In). Award 0.5 for this line if string comparison is made in WHERE clause without comparison of PK and FK and this is the only error present.

Section C – Computer Systems

3.

- (a) Convert 1001 0011 to a decimal number, assuming binary representation.

[2]

128 + 16 + 2 + 1 = 147 by adding the powers of 2 corresponding to the positions where there is a 1 bit in the word.

Problem solving.

- (b) Convert 1001 0011 to a decimal number, assuming two's complement representation.

[4]

Since the leftmost bit is 1, this is a negative number. Negate it to get a nonnegative number. To negate, first invert giving 0110 1100. Then increment, giving 0110 1101. Now this is nonnegative so its binary representation is the same as its two's complement value; this is $64 + 32 + 8 + 4 + 1 = 109$. Since the negation of the original word is 109, the answer is -109.

Problem solving. 1 mark for identifying it as negative; 2 marks for negation, 1 mark for final result.

- (c) Translate the statement $x = a - b * c$ into assembly language for Sigma16. You may assume that the variables have been declared with data statements; just write the instructions needed to execute the statement.

[7]

```
load R1,a[R0] ; R1 = a
load R2,b[R0] ; R2 = b
load R3,c[R0] ; R3 = c
mul R4,R2,R3 ; R4 = b*c
sub R5,R1,R4 ; R5 = a - b*c
store R5,x[R0]
```

Unseen problem. 2 marks for loads, 3 marks for arithmetic, 2 marks for storing result.

- (d) Suppose `index` is a variable in memory that contains an integer, and `x` and `y` are both arrays of integers. Translate the statement `y[index] = x[index]` into assembly language. You may assume that the variables and arrays have been declared; just write the instructions needed to execute the statement.

[5]

```
Load R1,index[R0] ; R1 = index
load R2,x[R1] ; R2 = x[index]
store R2,y[R1] ; y[index] = x[index]
```

Problem solving, requires full understanding of indexed addressing. 2 marks for loading index, 3 marks for correct addressing.

- (e) Define the term *type* in a programming language. Give two reasons why machine language does not have types. Explain how a compiler uses types to make the machine language object code it generates more reliable.

[7]

A type is a set of values that a variable can have. Machine language does not have types because the hardware does not know the meaning of a word. There are many ways to interpret what a word means (e.g. binary, two's complement, character, floating point, and instruction). The particular interpretation used depends only on what operation is executed; thus the machine will do arithmetic on an instruction or attempt to execute an integer if that's what the program says to do. Such invalid operations will lead to bugs that are extremely hard to find. Not having types makes the hardware much simpler, and also more flexible: for example the operating system needs to be able to load a program into memory using store instructions, so it's treating the program as data. However, a compiler can check the types in a high level program in order to ensure that data values are used correctly; for example it can generate floating point instructions to operate on floating point variables and integer instructions to operate on integer variables. This will reduce errors at runtime.

Synthesis of material covered in lectures. 2 marks for definition of type. 2 marks for reasons that machine language is untyped. 3 marks for improvement of reliability for typechecking.

4. (a) Write the truth table for a half adder circuit, which takes two input bits x and y, and produces two output bits c and s. The pair (c,s) gives the carry output and sum resulting from adding x and y. Draw a diagram of the circuit using logic gates.

[4]

The truth table is

| x | y | c | s |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 |

The circuit, in algebraic notation is

$c = \text{and2 } x \ y$
 $s = \text{xor2 } x \ y$

Bookwork. 2 marks for truth table, 1 each for c and s.

- (b) State what the behavior of a delay flip flop (dff) is. Explain what would happen in a synchronous circuit containing delay flip flops if the clock runs too fast.

[5]

A dff contains a 1-bit state which it outputs continuously. It has a data input x which is normally ignored. There is also a clock input. The clock signal provides regular defined points in time called ticks. When a tick occurs, the dff discards its old state and loads the value of the input signal x. In a synchronous circuit, all dffs are connected to the same clock, and the clock is run slowly enough to allow all combinational signals to become valid. This means that the entire system has a state comprising the states of the dffs, and the state transitions are always well defined as they use the valid combinational signals. If the clock runs too fast, an invalid signal can be loaded into a dff, causing the circuit to produce incorrect results.

Behaviour of dff is bookwork [2 marks]. Analysis of fast clock requires knowledge and insight [3 marks].

- (c) State what happens when an interrupt occurs. Explain how the operating system uses interrupts to implement concurrent processes, and how all processes can make progress even if one of them goes into an infinite loop.

[8]

An interrupt is a transfer of control (a load to the pc) that is not caused by a jump instruction, but instead is performed by the control unit when an external event occurs. The user program does not cause the interrupt, and cannot prevent it. When the interrupt happens, control is transferred to the interrupt handler, which will save the state of the running program and then enter the scheduler. The scheduler executes a group of processes, typically in round robin order, giving each a time slice of limited duration. It does this by setting a timer which will generate an interrupt after a fixed period of time. Over long time scales, all the processes appear to be making progress, but at a short time scale the processor is executing just one process at a time. Since the user program

cannot disable the timer interrupt, it will be preempted even if it goes into an infinite loop.

Bookwork plus synthesis. 3 marks for interrupt, 3 marks for scheduler, 2 marks for understanding the preemption.

- (d) Define the terms circuit switching and packet switching. Give one reason that circuit switching was used in the old analogue telephone network. Give two reasons for using packet switching in the Internet.

[8]

In circuit switching, the nodes of the network establish a fixed connection from one host to another. This takes significant time to establish the connection, but allows continuous traffic after that happens. This was appropriate for analogue telephone networks because the lines needed to stay connected to allow for continuous voice traffic. In packet switching there is never a permanent connection between hosts. Instead, messages are broken into fixed size packets, and each packet contains a header with address information. As they move through the network, routers decide how to pass each packet on independently. Advantages of this for the internet include: (1) there is no fixed setup time in advance of sending messages; (2) for bursty traffic packet switching is more efficient; (3) if a link fails or is overloaded, routers can pass packets along a different route.

Definitions are bookwork [2 marks]. Advantage for telephone network is bookwork plus synthesis [2 marks] Advantages for use in Internet require synthesis [4 marks]

END OF EXAM