

**DAY DATE May 2013
TIME
(Duration: 2 hours)**

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

Computing Science 1Q

ANSWERS

(Answer all 4 questions.)

This examination paper is worth a total of 100 marks

(Use SEPARATE ANSWER BOOKS for Questions 1, 2 and 3)

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

1. (a)

(i) What is a database management system (DBMS)?

[1]

Bookwork and lecture material (definitions and understanding)

A database management system is **a suite of programs that manage databases** (or an information system where the data may be shared by different applications) [1 mark].

(ii) What are the four key functions of a database management system (DBMS)?

[4]

Bookwork and lecture material (definitions and understanding)

The key functions of a DBMS are:

- (1) the sharing and integration of data [1 mark]
- (2) multiple views of the same data [1 mark]
- (3) controlled concurrent access to data [1 mark]
- (4) management of security and integrity [1 mark]

(iii) Why is it important for a database management system to control concurrent access to a database?

[2]

A database allows multiple people or applications to access the data at the same time. The DBMS can schedule and control WHO can access the system and WHEN. The DBMS can provide privileges to help co-ordinate this. [1 mark].

It is important in database management because if many people have access to the same data there has to be a way of keeping track of the correct version of the data, changes to the data, deletion of the data etc. This control prevents disruption to the integrity of the data [1 mark].

(b)

(i) Please describe briefly with examples what is meant by each of the following terms in the context of Entity Relationship models:

- Entity
- Relationship
- Attribute

[3]

[1 marks available per concept = 3 in total]

Entity - object in the real world about which we want to store data.

Relationship – a relationship is a set of associations between members of two or more entity types in the database.

Attribute – a property of an entity or relationship in a database consisting of atomic values.

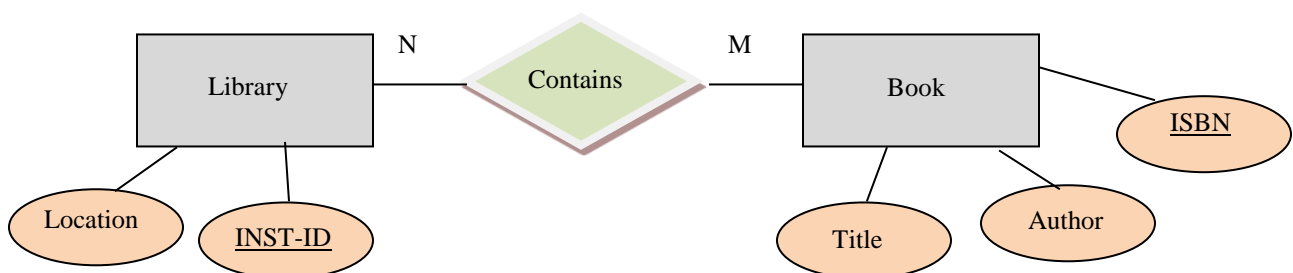
(ii) Using Entity-Relationship Modeling illustrate the following:

Books have a title, author and unique ISBN number.

Libraries have a location and Institution code (INST-ID).

Libraries contain many books and any book can belong to one or more libraries.

[5]



Entities – [1 mark] **Attributes** – [1 mark] **Primary Keys underlined** – [1 mark]

Correct Relationship – [1 mark] **Correct Cardinality** – [1 mark]

(5 marks in total)

(c)

- (i) S is the set { e, f } and T is the set { 4, 5, 7 }.

Write down the Cartesian product $S \times T$.

[1]

- (ii) If U = Footballers, P stands for 'Spanish' and Q stands for 'plays in the English Premier League', give the set builder notation for the set of all footballers who are Spanish AND play in the English Premier League.

[1]

- (iii) List the powerset for the following set: {1,2,4}

[1]

- (iv) List the elements in the relation R from $A = \{1,2,6\}$ to $B = \{1,5\}$ where $\langle x,y \rangle \in R$ if and only if $x > y$.

[1]

(i) $S \times T = \{\langle e,4 \rangle, \langle e,5 \rangle, \langle e,7 \rangle, \langle f,4 \rangle, \langle f,5 \rangle, \langle f,7 \rangle\}$ – [1 mark]

(ii) $S = \{x \mid P(x) \wedge Q(x)\}$ – [1 mark]

(iii) $\{\emptyset, \{1\}, \{2\}, \{4\}, \{1,2\}, \{1,4\}, \{2,4\}, \{1,2,4\}\}$ – [1 mark]

(iv) $\{\langle 1,1 \rangle, \langle 2,1 \rangle, \langle 6,1 \rangle, \langle 6,5 \rangle\}$ – [1 mark]

(d)

(i) What is SQL and what is it used for?

[2]

SQL is a structured query language [1 mark]. It is a semi-formal declarative language for querying a database [1 mark]. It allows the programmer/user to state WHAT results they want back in a query but not the operations to get those results [1 mark].

(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.

[4]

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

1 mark per line of SQL. 1 mark if they use the dot operator.

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

2.

(a)

- (i) Within the context of HCI, what is meant by the user's mental model?

[2]

A user's mental model is an internal way for the user to understand and represent and reason about a user interface or product [1 mark]. It is a model of the interface built up using perception and cognition from past experiences, expectations, knowledge and problem solving [1 mark]. The user's mental model is often different from what the designer's mental model was when developing the software or product which can result in usability issues [1 mark].

- (ii) Briefly describe both Norman's concept of the Gulf of Evaluation and the Gulf of Execution, and how these relate to the notion of the user's mental model.

[4]

Gulf of execution is a term usually used to describe the gap between a user's goal for action and the means to execute that goal [1]. Sometimes a user's mental model of the actual operations or actions required (to make a phone call for example) does not match what is actually required (navigating through contacts first). This is the gulf of execution and can cause usability issues. [1 mark].

The gulf of evaluation is the difficulty of assessing the state of the system and how well the system/product supports the discovery and interpretation of that state [1 mark].

OR

It is the degree to which the system/artifact provides representations that can be directly perceived and interpreted in terms of the expectations and intentions of the user [1 mark].

OR

It is the psychological gap that must be crossed to interpret a user interface display, following the steps interface -> perception -> interpretation -> evaluation [1 mark]

The gulf is small when the system provides information about its state in a form that is easy to get, is easy to interpret, and matches the way the person thinks of the system [1 mark].

(b)

- (i) Within the iterative design cycle for the development of interactive systems, a key stage is determining requirements. Define, with an example for each, both **functional** and **non-functional** requirements.

[4]

(i) *Lecture material*

Functional requirements focus on the actual features of the product and what the product should do [1] like 'allow me to make a phone call', 'have a search facility', 'have links that work', 'have buttons that can be pressed' [1 for example].

Non-functional requirements are more to do with the usability or user experience of the product Examples would include learnability, ease of use, perceived usefulness, engagement, enjoyment, satisfaction. They can also be to do with practical issues such as accessibility, portability, reliability. [1 for definition, 1 for example]

4 marks total

-
- (ii) Prototyping can be a good iterative design tool when developing an interactive product. Prototyping is often split into low fidelity and high fidelity approaches. Explain these two approaches and use examples to compare their advantages and disadvantages.

[4]

(i) *Lecture material, but involving simple analysis/comparison*

Lo-fi prototypes are generally made using simple materials/techniques such as sketching screen layouts on card or paper [1 mark]. Their main advantage is that are quick to make [0.5] and easily changed [0.5], and cheap to produce. [0.5].

Hi-fi prototypes are generally made using a programming language such as Macromind Director so the appearance and behaviour of the prototype is much more realistic than in lo-fi [1 mark]. Hi-fi generally takes longer [0.5] and costs more to make than lo-fi [0.5]. On the other hand, users may mistakenly think that they have a final product at hand even though performance may be poor/patchy and the graphic design may be rough [1 mark].

4 marks total

(c)

A client has asked your company 'Spaghetti Code Design' to help them create a new smartphone app that would allow people to track their health and fitness on the phone. A previous team have already carried out requirements capture. They have specified that the app should allow users to log when they visit the gym, how long they exercise for, and what type of exercise they do. The users surveyed also wanted the GPS functionality of the phone to allow them to track their running routes. Some people said they wanted graphs and images of their fitness levels and progress to motivate them to keep going.

The client said that they want the app to be functional and usable but also that they want to know that they are providing a rich user experience. They have two prototype apps to try out but want you to evaluate these properly with potential users before they decide which one to take forward to full development.

Write a short technical report detailing how you would propose to evaluate the mobile phone 'fitness' app. Include details of the methods you would use and the data you would gather to demonstrate both the usability and user experience of the product.

[11]

[Unseen problem] There are several possible solutions to this question. There is a distinction between the rote answers that simply consider evaluation without considering the application domain and those solutions that directly address summative evaluation for mobile devices, such as different phones and their features. A good answer that considers the users, the time and place, the methods and the data and interpretation required should get between 6 and 9. An answer that does this but also critically reflects on the methods and adapts their answer to the context of mobile phone apps/fitness should be awarded 10/11. An answer that details methods but does not consider the users, the context, or the application domain should get no higher than 5

Users – If the student says who the users are [0.5], why [0.5] and describes their demographic [0.5] award marks. For example young adults who use the gym.

When and where – if the user describes where and when they would conduct an evaluation award up to [2 marks]. They might decide to use questionnaires or focus groups for example (this is fine) but they may opt to conduct the evaluation in the field (the gym for example). Award full 2 marks only if they justify their choice.

Methods – if the users states an appropriate method or methods then award [1 mark]. If they tell you what data that will produce (quantitative Vs qualitative for example) provide a mark [1]. If they tell you the pros and cons of the methods – [up to 2 marks]. Award marks per method up to 6 marks total for methods.

Examples include: questionnaire/focus group/interview – cheap, easy, reach a lot of people but not so good for usability and user experience, esp in this ‘mobile’ context. Observation, field trials, data logging on phone all acceptable if they justify. Lab-based evaluations can be expensive [0.5] and time consuming [0.5]. They usually involve recruiting potential users to interact with a system under carefully controlled conditions [0.5]. Although this can help with the statistical analysis of any results [0.5] it can also lead to problems in establishing that an evaluation provides valid insights into the less controlled world of a final implementation etc. [0.5]. In field trials good in this context perhaps but are more time consuming and more open to noise in the data. Ethnographic studies and diaries might be used.

If the user describes limitations/risks/constraint – award up to extra 2 marks.

Good solutions might consider the issues that arise when users are geographically distributed and mobile for example. Issues such as signal interruption and battery loss might be considered as potential problems

3. (a) Describe how to compute the 2s complement representation for a negative binary number and list what advantages the 2s complement representation has over the sign-magnitude representation for negative binary integers.

[3]

The 2s complement of a negative binary integers is computer by complementing each bit of the corresponding positive binary integer and then adding one, ignoring any overflow. [1]

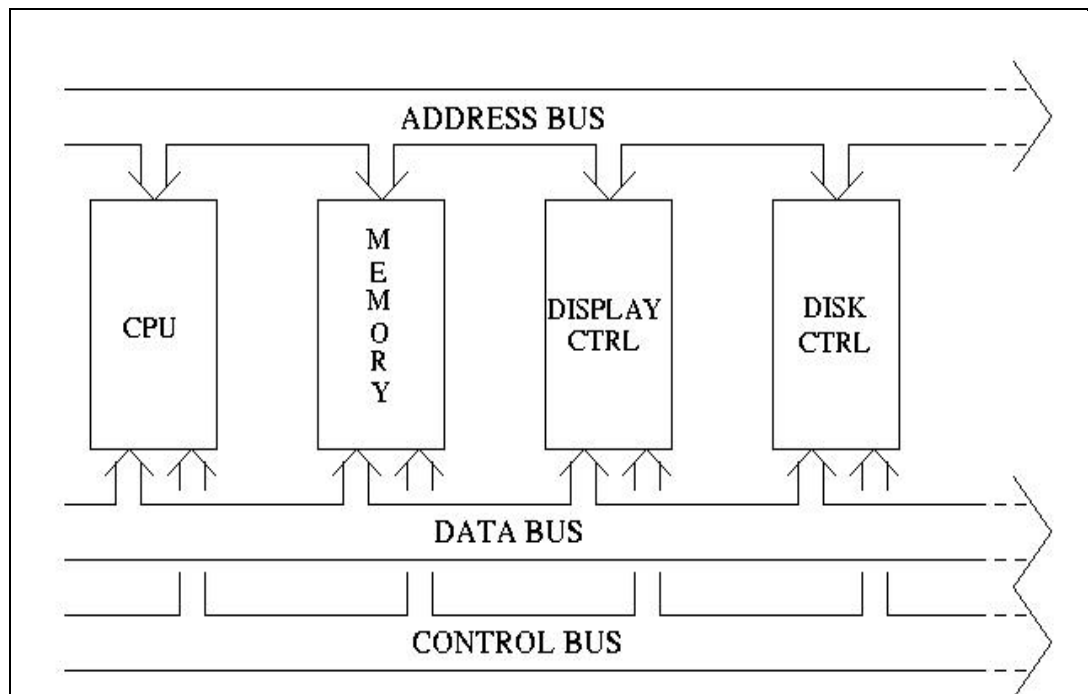
2s complement allows negative binary numbers to be added using the standard addition operations [1] whereas this does not work for the sign-magnitude representation. 2s complement provides a single representation of zero as opposed to having both +zero and -zero for the sign-magnitude representation.

(will accept variation on this part to a maximum of 2 marks)

[3]

- (b) With the aid of a diagram describe the main components of a basic computer and their interconnection.

[4]



[2]

A basic computer comprises a CPU, memory display and some form of mass storage, communications etc. [1] these components are connected by address, data and control buses[1] (I will allow some variation on this answer)

- (c) Explain, by giving examples, the concept of *parity* when describing a binary numbers comprising a fixed number of bits, e.g. 4 bits, and suggest where the concept of parity checking might be useful in computer systems.

[3]

The *parity* of a binary word is determined by the number of 1s in it:

if it contains an odd number of 1s then the parity is 1 (or *odd*);

if it contains an even number of 1s then the parity is 0 (or *even*). [1]

(Mathematically the parity of a number is sometimes said to be *odd* for odd numbers and *even* for even numbers. But for binary words, parity is based on the number of 1s.)

Example: 1010 has even parity. 1101 has odd parity.

11111111 has even parity. 00101010 has odd parity. [1]

Parity checking can be used for error detection, for example in computer memory, or communications channels, such as WIFI or broadband Internet controllers. [1]

I shall allow for variation in the above answer.

- (d) You are required to design an encryption circuit which, given an input xyz representing a 3 bit binary number n , produces a pseudo-random output abc mapped from the following list: 101, 011, 000, 110, 001, 100, 111, 010. For example, if the input is 110 ($x = 1, y = 1, z = 0$), representing $n = 6$, then the output is 111, representing 7. If the input is 000 then the output is 101.

(i) Draw a truth table which shows a, b, c as functions of x, y, z .

[3]

x	y	z	a	b	c	out
0	0	0	1	0	1	5
0	0	1	0	1	1	3
0	1	0	0	0	0	0
0	1	1	1	1	0	6
1	0	0	0	0	1	1
1	0	1	1	0	0	4
1	1	0	1	1	1	7
1	1	1	0	1	0	2

(1 mark for each correct output column.)

(ii) Draw a Karnaugh map for each of a, b, c .

[3]

Karnaugh map for a: (1 mark)				
	not(y)	y	y	not(y)
not(x)	1	0	1	0
x	0	1	0	1
	not(z)	not(z)	z	z
Karnaugh map for b: (1 mark)				
	not(y)	y	y	not(y)
not(x)	0	0	1	1
x	0	1	1	0
	not(z)	not(z)	z	z
Karnaugh map for c: (1 mark)				
	not(y)	y	y	not(y)
not(x)	1	0	0	1
x	1	1	0	0
	not(z)	not(z)	z	z

(iii) Use the Karnaugh maps to work out formulae for a, b and c in terms of x, y and z .

[3]

$$a = \bar{x} \bar{y} \bar{z} + xy\bar{z} + \bar{x}yz + x\bar{y}z$$

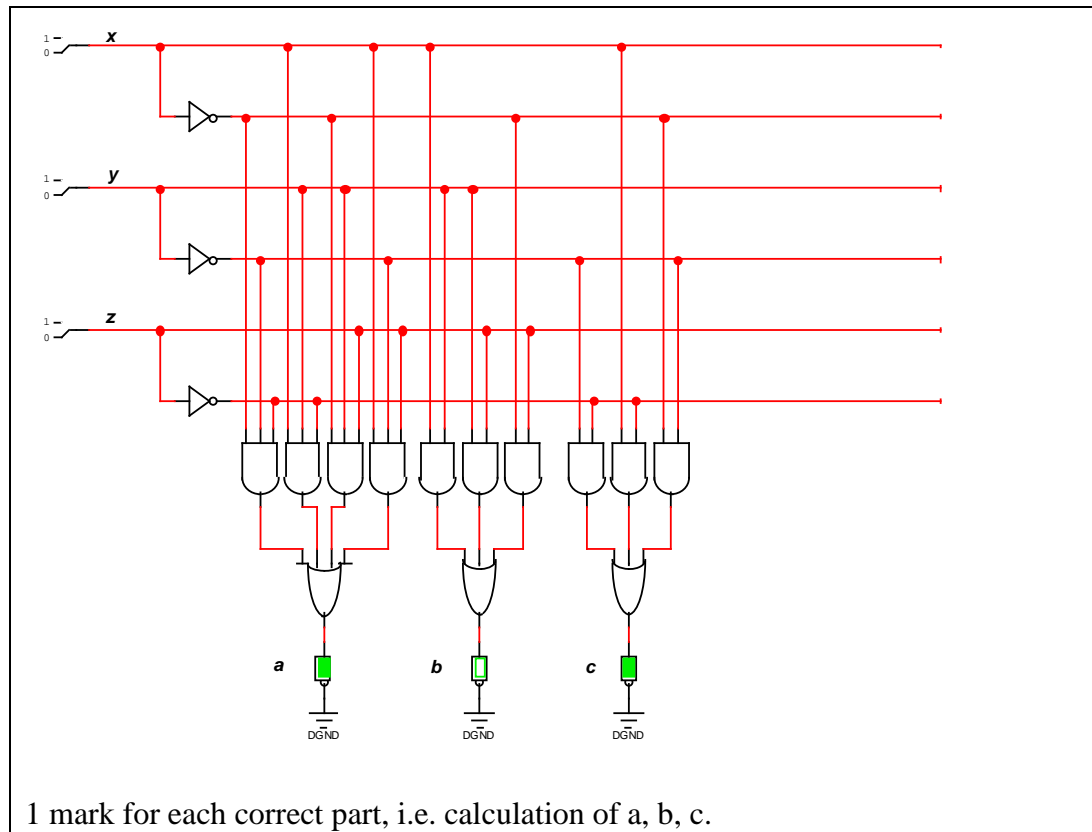
$$b = xy + yz + \bar{x}z$$

$$c = \bar{y} \bar{z} + x\bar{z} + \bar{x} \bar{y}$$

(1 mark for each formula, there is scope for further simplification)

(iv) Draw a diagram of the circuit which calculates a , b and c from x , y and z .

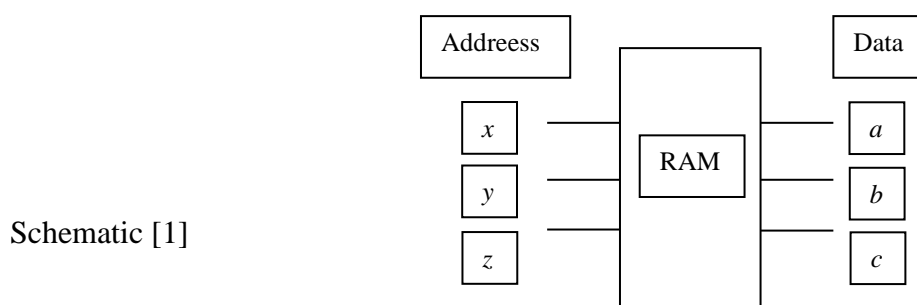
[3]



(v) Explain how to implement the circuit in part (iv) such that the random mapping could potentially be updated rather than being fixed and draw an outline circuit to support your explanation.

[3]

Instead of implementing the circuit in fixed logic, a programmable memory could be used to implement a look-up table, where the inputs address the memory and the outputs provide the mapping as below. [1] Additional circuitry would be required to allow a CPU to take control of the address bus and data inputs of the memory in order to update it. [1]



4. (a) (i) Explain what is a compiler, what it does and suggest two circumstances that would instead require a cross-compiler to be used.

[4]

A compiler is a program that converts high-level source language statements into low-level machine codes that can execute directly on the same machine architecture executing the compiler.

[2]

A cross-compiler is used when a compiler executing on the target machine architecture is not available (because it has not yet been developed), or the target architecture is not suitable for hosting a compiler.

[2]

- (ii) A C compiler is available, running on an X86 computer, that translates C source statements into machine codes that can execute on an ARM architecture machine and this compiler has also been coded in C. Explain how to migrate this C compiler to execute on an ARM architecture machine.

[2]

(i) Compile the C compiler source statements by the C compiler itself [1] and copy this compiler executable code to the ARM machine. This C compiler will now run directly on the ARM and will translate source C statements into ARM machine codes. [1]

- (b) Explain, the difference between multi-tasking and parallel processing and how these concepts relate to each other.

[5]

A multi-tasking operating system gives the appearance of running several processes or tasks simultaneously (1 mark) but in fact time-slices the execution of each task on a single CPU (1 mark). In parallel processing n (for $n \geq 2$) CPUs (or CPU cores) can execute n instruction streams (i.e. processes or tasks) in parallel (1 mark). A parallel processing computer can also multi task each processor (1 mark) to give the appearance of executing a greater number of processes than physically present processors. (1marks)

- (c) Explain the concept of *interrupts* and how these are used within operating systems, for example to implement multi-tasking.

[4]

An interrupt is a hardware generated signal that causes the CPU to halt execution of a current program [1] and save its current state [1] and change its program counter to enter the operating system. [1] Inside the operating system, the task scheduler decides what to do next depending upon the type of interrupt, [1] for example it may cause execution to be transferred to another program to afford a "time-slice" of execution. [1] Interrupts are generated by the hardware on a regular basis [1] or by hardware events that must be serviced such as mouse clicks or by communications buffers filling or emptying. [1] (I will accept variations to 4 marks)

- (c) Explain why there isn't a central database which stores the IP address for each domain name in the internet, and briefly describe how this information is actually stored and accessed.

[6]

A central database would generate too much traffic (1 mark) and failure would be disastrous (1 mark) and it would be enormous, so performance would be a problem (1 mark). Actually have a hierarchy of domain name servers, each of which is an authority for a domain (1 mark), and knows which server is an authority for the next domain up (1 mark). DNS lookup requests return either an IP address or the address of another server to try (1 mark).

- (d) “Cloud”-based computing is becoming popular where storage servers contain a user’s data, which is then accessible via the Internet. Give two potential advantages and two potential disadvantages of the cloud-based approach.

[4]

Cloud-based computing allows the user to access their data from anywhere in the world, is backed up by a the provider and does not require the user to provide physical media and storage space and power. However, the cloud user is reliant upon access to an adequate Internet connection to allow useful access to their data, incur ongoing data charges, must rely on the provider for data security and ongoing access. The user might be constrained by data storage size/charges. [4] I will accept variations on the above answer to 4 marks.