University of Glasgow

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DEGREE of MSc

Or

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

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

CS 1Q

Exam Rubric: Answer All Questions

INSTRUCTIONS TO INVIGILATORS

Please collect all exam question papers and exam answer scripts and retain for school to collect. Candidates must not remove exam question papers.

Section A 25 Marks

1(a) In the context of interactive systems design, explain the following concepts and methods:

i. Containment hierarchy

This is the hierarchy of screen areas in a GUI—usually rectangles—that describes the nesting of windows, widgets and other GUI components [1]. It is used in the management of windows, e.g. for finding which component to send a mouse click event to [1].

[2]

ii. Field studies

[2]

Field studies are a form of evaluation done in uncontrolled environments such as workplaces and homes[1]. Data is collected by notes, audio/video recording and/or system logs, and then analysed to find categories and examples useful for understanding and design. [1]

iii. The serif hypothesis

[2]

This is the claim that typefaces with the small tails and tags on letters, such as Times, are easier to read than non-serif fonts such as Helvetica [1]. Experiments have often had conflicting results, as it seems people find it easiest to read whatever style of typeface they are most used to [1].

iv. Distributed cognition

[2]

A theoretical approach to psychology and design, in which cognition is treated as something involving many people and objects, i.e. distributed across them all in one wider system [1]. The key role of external representations helps us understand design features/requirements such as representation of complex data in visualisations [1].

v. Low fidelity prototype

[2]

A prototype is a model or rough version of a system design, used to refine requirements and other design features [1]. A low fidelity prototype uses materials unlike those of the finished digital product, e.g. paper or cardboard [1].

1(b) Event-driven programming is a better paradigm for interactive systems design than command-driven programming. Why?

[4]

The most essential advantage is the flexibility of response of event-driven programming, in that an event can be

fired (and the system can respond) whenever a user action or sensor input happens [1]. In contrast, command-driven programming delays such a response until any previous command's response has finished [1]. Event-driven systems can therefore react quickly to the many widgets of GUIs, such as icons, menus and scrollbars [1]. This makes event-driven systems feel much more interactive [1].

1(c) Trainline.com is a web site that gives train timetable information and sells train tickets. It has a new web site prototype, ready for A/B testing. It is intended to better serve the train travellers' needs and interests, and to increase ticket revenues. Explain what A/B testing is, and describe how you could use it to achieve Trainline's aims.

[11]

In A/B testing, traffic to versions of an application, such as a web site, is randomly split among users [1]. Usually one ('A') is the current or control version, and a second version ('B') implements some new design idea [1]. A/B testing shows causal relationships in a real world setting, but may not explain exactly why a given version is better or worse [1].

Usually, B will be introduced to a small proportion (e.g. 1% of users). Then, if initial analysis shows that it is working satisfactorily, then the proportion can gradually be increased up to 50%. We would do the same here, ramping up from a small proportion to half of the user population. [1]

Metrics based on logged use, such as product sales and users clicking through to chosen pages, are then used to assess the strengths and weaknesses of each version [1]. If B is much better than A then it gives a strong argument for shifting all users to the new version [1].

Here we choose just one overall evaluation criterion mentioned in the spec: ticket revenues [1].

Usually, B will be introduced to a small proportion (e.g. 1% of users). Then, if initial analysis shows that it is working satisfactorily then the proportion can gradually be increased up to 50%. We would do the same here, ramping up from a small proportion to half of the user population if the revenue from B is significantly greater than A. [1]

In parallel, data from different subgroups of users given the same version should be tested (i.e. A/A testing, or B/B testing) [1] to see if random variation within groups is leading to statistically significant variation in the main metric (or metrics) and to see if the sample sizes are large enough [1].

Care must be taken in randomisation, e.g. each user repeatedly returning to the site must be given the same version each time (via cookies, for example) [1].

Section B 25 Marks

2(a) Provide short descriptions of any three of the following terms. Use examples and/or diagrams to illustrate your answers.

(i) The union set operator (provide an example of usage and a Venn diagram).
Combines two sets, taking items from both sets [1]. Example would show that items from both sets should be kept [1]. Correct Venn diagram [1].

(ii) The difference between conceptual and implementation models for a database.
The conceptual model for a database is a description of the real-world entities and their relationships [1]. The implementation model is the conceptual scheme: what relations (tables) will be created, primary & foreign keys [1]. The example could show an E/R diagram and resulting DB relational schema [1].

(iii) Weak entities in an ER diagram.
Weak entities do not have sufficient attributes to be uniquely identified by themselves [1]. They are represented in an ER diagram with a double lined box, with the partial key dotted underlined [1]. An example would be a building and a room. [1]

(iv) A many-to-many relationship in an ER diagram.
A relationship where both entity types can participate more than once in the relationship [1]. An example of the notation in the ER diagram should be given [1]. An example could be students and supervisors. [1]

(v) The degree and cardinality of a relation.
The degree of a relation is the number of attribute [1]; the cardinality is the number of rows [1]. An example should show a table and give the counts. [1].

(vi) A foreign key in the context of a relational database.
A foreign key is an attribute of a relation (field) which references the primary key of some other relation [1]. This is required in order to uniquely identify a row in another table [1]. OR It is a column that is used to establish and enforce a link between two tables [1]. An example could be Staff.DeptNo references Department.Id.

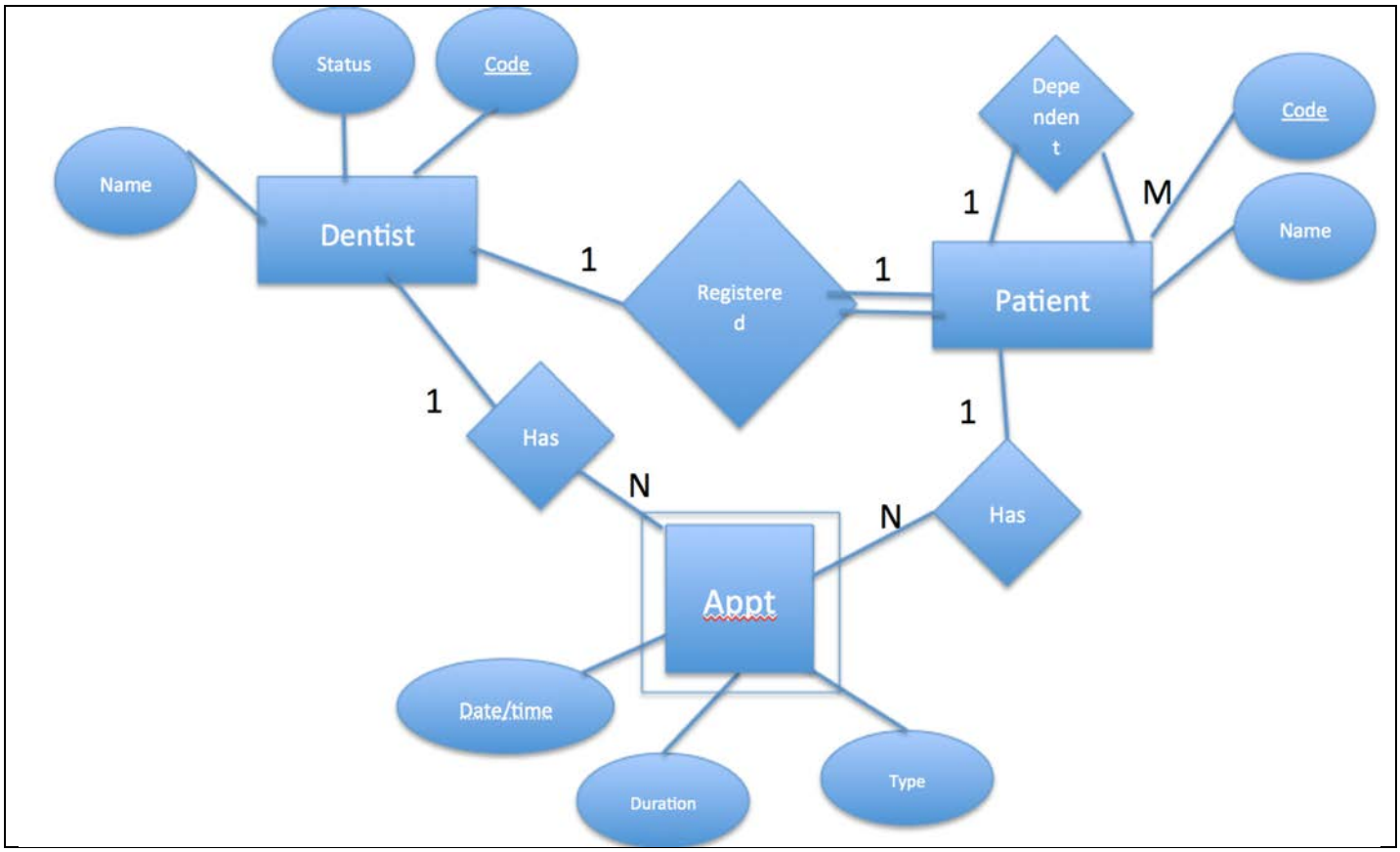
(vii) The projection and selection operations in relational algebra.
The projection operator selects attributes from a relation to return as a new relation, identified using the PI symbol [1]. The selection operator, identified by the SIGMA symbol, identifies rows to be returned in a new relation, identified using the conditions. [1] The provided example should show clearly the symbols, input relations and what rows and attributes are identified [1].

[9]

2(b) A dental practice keeps data on its dentists and patients. A patient has a unique code and name, and may be a dependent of another patient. Each dentist also has a unique code, a name and a status (part-time or full-time). Each patient must be registered with a single dentist. An appointment is when a single patient meets a dentist at a given date & time (not necessarily the patient's own registered dentist). Appointments also have durations and appointment types (checkup, operation).

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

[7]



Strong Entities: Dentist, Patient & attributes [1]

Identification of Strong entity Primary Keys [1]

Weak Entities: Appointment & partial key (date/time) [1]. *Student identifying Appointment as a relationship doesn't get the mark, and may also lose a mark for cardinalities below.*

Identification of relationships with cardinalities. [2] ½ for Registered; 1 for Dependent; 1 for the two involved in the Appointment weak entity.

Identification of participations [2]: 1 for total of patient in Registered ("must"), 1 for total of Appt in Dentist & Patient (weak entity).

(c) Assume a relational database with two tables, as follows:

Staff(NI_Num, Firstname, Surname, PartTime, Dept)

Department(DeptNo, Name, Building)

Building(BuildingId, StreetNum, StreetAddress, City)

where Staff.Dept is a foreign key reference to Department.DeptNo and Department.Building is a foreign key reference to Buidling.BuildingId.

(i) Write a relational algebra expression to find the surnames of all staff who work in department 5.[1]

$\Pi_{Surname}\ (\sigma_{Dept = 5}\ (\ Staff\ )\ )$

(ii) Write the SQL query to find the names of the departments based in Glasgow city. [2]

```
SELECT Name
FROM Department, Building
WHERE Department.Building = Building.BuildIngId
AND Building.City = "Glasgow"
```

Projection (1/2 mark); WHERE on City (1/2 mark); FROM & join condition (1 mark)

(iii) Write the SQL query to find how many part time staff work in each department number. [2]

```
SELECT Dept, Count(NI_Num)
FROM Staff
WHERE PartTime = 1
GROUP BY Dept
```

COUNT & Group BY (1 mark); WHERE on PartTime (1/2 mark), project Dept (1/2 mark)

(d) Given the following sets:

A = {1,4,5} B = {a,e}

give the following sets. Assume that $\square$ is the Cartesian product.

(i) | A |

(ii) A $\square$ B

(iii) A $\cup$ B

(iv) {<x,y> | x $\in$ A $\wedge$ y $\in$A $\wedge$ x<y}

[4]

(i) 3

(ii) { <1,a>, <1,e>, <4,a>, <4,e>, <5,a>, <5,e> }

(iii) {1,4,5,a,e}

(iv) { <1,4>, <4,5> }

Section C 25 Marks

1. (a) Convert 1101 1010 to a decimal number, assuming binary representation.

[2]

128 + 64 + 16 + 8 + 2 = 218 by adding the powers of 2 corresponding to the positions where there is a 1 bit in the word. [Problem solving.]

(b) Convert 1101 1010 to a decimal number, assuming two's complement representation.

[3]

Since the leftmost bit is 1, this is a negative number. Negate it to get a nonnegative number. To negate, first invert giving 0010 0101. Then increment, giving 0010 0110. Now this is nonnegative so its binary representation is the same as its two's complement value; this is 32 + 4 + 2 = 38. Since the negation of the original word is 38, the answer is -38. [Problem solving. 1 mark for identifying it as negative; 2 marks for negation.]

(c) Translate the following program fragment into assembly language for Sigma16. You may assume that the variables have been declared with data statements; just write the instructions needed.

```
if x<y
   then  a = a + 3
   else  b = a - b
```

[10]

```
   load   R1,x[R0]    ; R1 = x
   load   R2,y[R0]    ; R2 = y
   cmplt  R3,R1,R2    ; R3 = x<y
   jumpf  R3,else     ; if not (x<y) then goto else
   load   R4,a[R0]    ; R4 = a
   lea    R5,3[R0]    ; R5 = 3
   add    R4,R4,R5    ; R4 = a + 3
   store  R4,a[R0]    ; a = a + 3
   jump   done        ; goto done
else
   load   R4,a[R0]    ; R4 = a
   load   R5,b[R0]    ; R5 = b
   sub    R4,R4,R5    ; R4 = a – b
   store  R4,b[R0]    ; b = a – b
done
```

[Unseen problem. 2 marks for comparison, 3 marks for branching, 5 marks for assignments.]

(d) Suppose `x` is an array containing `n` integers, where `n` is an integer variable in memory. There is another integer variable `const`. Write a loop that adds `const` to every element of the array. You may assume that the variables `n` and `const`, and the array `x` have been declared; just write the necessary instructions.

[10]

```
   add    R1,R0,R0       ; R1 = index = 0
   load   R2,n[R0]       ; R2 = n
   load   R3,const[R0]   ; R3 = const
   lea    R4,1[R0]       ; R4 = 1
loop
   cmplt  R5,R1,R2       ; R5 = (index < n)
   jumpf  R5,done[R0]    ; if not (index < n) then goto done
   load   R5,x[R1]       ; R5 = x[index]
   add    R5,R5,R3       ; R5 = x[index] + const
   store  R5,x[R1]       ; x[index] = x[index] + const
   add    R1,R1,R4       ; index = index + 1
   jump   loop[R0]       ; goto loop
```

[Problem solving, requires understanding of indexed addressing and loops. 3 marks for initialization, 3 marks for loop, 4 marks for array update.]