UNIVERSITY COLLEGE LONDON

EXAMINATION FOR INTERNAL STUDENTS

MODULE CODE : **COMP0009**

ASSESSMENT PATTERN : **COMP0009A5UD**

MODULE NAME : **COMP0009 - Logic and Database Theory**

LEVEL: : **Undergraduate**

DATE : **27-Apr-2022**

TIME : **10:00**

Controlled Condition Exam: 2 Hours exam

You cannot submit your work after the date and time shown on AssessmentUCL – you must ensure to allow sufficient time to upload and hand in your work

This paper is suitable for candidates who attended classes for this module in the following academic year(s):

Year
2021/22

Additional material	N/A
Special instructions	N/A
Exam paper word count	N/A

TURN OVER

UCL Computer Science Examination paper

Paper details

Academic year:	2021/22
Module title:	Logic and databases
Module code:	COMP0009
Exam period:	Main summer examination period
Duration:	24 hours
Deliveries for which intended:	A5U (undergraduate, level 5
Cohorts for which intended:	2021/22; 2020/21; 2019/20

Instructions

Answer ALL THREE questions.

A maximum of 100 marks is available: 34 marks for Question 1 and 33 marks from Questions 2 and 3. The marks available for each part of each question are indicated in square brackets. Some parts of Question 1 are negatively marked for wrong answers.

Submit your answers as a single PDF file. Any handwritten answers should be scanned and compiled according the guidance provided by the UCL Examinations Office.

1) Answer all parts of the question.

(a) Some of the statements (i) to (xii) below may be false. Say whether the statement is true, or false, or you don't know whether it is true or false. You will gain a mark for a correct answer (e.g., saying true when the statement is true) but you will lose half of a mark for an incorrect answer. No explanation for your answer is required and no marks are lost for answering that you don't know. The lowest mark you can receive for all of this part is zero.

(i) The benefits of Database Management Systems over file-based systems may include any of the following: more information from the same amount of data; sharing of data; improved data integrity; improved security; enforcement of standards.

(ii) To retrieve any piece of data stored in a relational database, you just need to know the name of the relevant table and the relevant value of the primary key.

(iii) The minimum clauses required in an SQL query are the SELECT, FROM and WHERE clauses.

(iv) Aggregates can only be used in SELECT and in HAVING clauses.

(v) This is a legal query, assuming the table called Staff contains fields that record the codes identifying members of staff (staffNo) and the codes identifying branch offices (officeNo):
SELECT officeNo, COUNT(staffNo) FROM Staff;

(vi) This is a legal query, assuming the table Staff is the same as in (v):
SELECT officeNo, COUNT(staffNo) FROM Staff GROUPBY officeNo;

(vii) If the final results projected by a query come from more than one table, then a join rather than a sub-query must be used.

(viii) Queries using joins are much more efficient than their equivalent queries that use sub-queries.

(ix) In this query:
SELECT branchNo, COUNT(staffNo) FROM Staff GROUP BY branchNo HAVING COUNT(staffNo)>1 ORDER BY branchNo;

the order of execution of the clauses is: FROM, GROUP BY, HAVING, SELECT, ORDER BY.

(x) The EXISTS term returns true if and only if there exists at least one row in the result table returned by a subquery.

(xi) When translating an entity relationship diagram into a database schema, if two entities have a many-to-many relationship, then you should create a table for each entity and each of those tables should contain the fields representing the primary and foreign key relationships between them.

(xii) The following statement would be represented by a many-to-many relationship in an entity relationship diagram: “each property is managed by at least one member of staff and a member of staff may manage zero, one or many properties”.

[12 marks]

(b) The schema for a retailer’s database is shown below (the primary key fields are underlined)

customers	(<u>custID</u>, firstname, familyname, town, state)
orders	(<u>orderID</u>, custID, date)
lineitems	(<u>orderID</u>, <u>itemID</u>, quantity, despatched)
items	(<u>itemID</u>, description, unitcost, stocklevel)

Write a SQL query to find which states had customers that ordered at least one umbrella and how many of those customers there were in each such state.

[12 marks]

(c) The schema shown on the next page is of a database that records who played what role in which film and for how many minutes they were on screen etc. Primary key fields are underlined, each table has a composite primary key.

Some of the statements (i) to (v) below may be false. Say whether the statement is true, or false, or you don’t know whether it is true or false. You will gain two marks for a correct answer (e.g., saying true when the statement is true) but you will lose one mark for an incorrect answer. No explanation for your answer is required and no marks are lost for answering that you don’t know. The lowest mark you can receive for all of this part is zero.

(i) The database is in first normal form.

(ii) Update anomalies are possible with the Film/Director table.

(iii) The composite key of FilmNo and actorNo won't be sufficient for the Film/Actor/Role table because an actor may play the same role in different films.

(iv) Removing all partial dependencies from this schema results in three additional tables.

(v) One additional table will be created in moving this database from second to third normal form.

Film/Actor/Role table:

FilmNo	**Ftitle**	**Date**	**ActorNo**	**ActorName**	**Role**	**ScreenTime**
F1099	Blood Simple	1985	A1500	John Getz	Ray	62
F1101	A serious man	2009	A1567	Mike Stuhlbarg	Larry Gopnik	49
F1101	A serious man	2009	A1020	Tilda Swinton	Judith Gopnik	48
F1122	Palindromes	2004	A1001	Val Shusterov	Katie Cox	25
F1122	Palindromes	2004	A1002	Hannah Freiman	Katie Cox	30
F1122	Palindromes	2004	A1003	Rachel Corr	Katie Cox	20
F0030	Kind hearts and coronets	1949	A0045	Alex Guiness	Henry D'Ascoyne	23
F0030	Kind hearts and coronets	1949	A0045	Alex Guiness	Horatio D'Ascoyne	22
F0030	Kind hearts and coronets	1949	A0045	Alex Guiness	Agatha D'Ascoyne	20
F1312	Casino Royale	2006	A2006	Daniel Craig	James Bond	89
F1313	Quantum of Solace	2008	A2006	Daniel Craig	James Bond	86

Film/Director table:

FilmNo	**DirNo**	**DirectorName**
F1099	D077	J. Coen
F1101	D077	J. Coen
F1101	D078	E. Coen
F1122	D091	T. Solondz
F0030	D 024	R. Hamer
F1312	D150	M Campbell
F1313	D151	M Forster

[10 marks]

[Total for Question 1: 34 marks]

2. Answer all parts of the question.

a. For each of these formulas construct a tableau with the formula at the root and state whether the formula is satisfiable or not.

1. $(\forall x \forall y(P^2(x,y) \rightarrow \neg P^2(y,x)) \wedge \exists x P^2(x,x))$
2. $(\exists x Q^1(x) \wedge \forall x \exists y P^2(x,y))$
3. $\exists x \forall y P^2(x,y) \wedge \neg \forall x \exists y P^2(y,x)$
4. $\exists x \exists y \exists z(P^2(x,y) \wedge P^2(y,z) \wedge \neg P^2(x,z))$.

[8 marks]

b. A first-order formula is said to be in *Prenex Normal Form* (PNF) if it is consists of a prefix followed by a quantifier-free part, where the prefix is a string of quantifiers ($\forall$ or $\exists$) and variables. For each of the following sentences find an equivalent PNF formula.

1. $\neg \exists x P(x)$
2. $\neg \exists x \exists y \forall z(Q(x,y) \rightarrow Q(y,z))$
3. $(\forall x P(x) \rightarrow \exists y \exists z(Q(y,z) \vee Q(z,y)))$
4. $(\forall x(P(x) \rightarrow P(f(x))) \wedge \neg \exists x Q(x, f(x)))$.

[8 marks]

c. Let L be a first-order language with one binary predicate symbol E, denoting the set of edges of directed graph G. Let $n \geq 3$ be a fixed integer. Write down an L-formula ϕ_n that is true in a directed graph G if and only if G contains a cycle of n nodes $(g_0, g_1, \ldots, g_{n-1})$ where (g_i, g_{i+1}) is an edge of G, for each $i < n-1$, and (g_{n-1}, g_0) is an edge of G.

[7 marks]

d. Prove that the class of all graphs containing a cycle of at least three nodes cannot be defined by any L-theory.

[10 marks]

[Total=33 marks]

[Question 3 cont. over page]

3. Answer all parts of the question.

a. Consider Temporal Proposition Logic (TPL), built from propositions with propositional connectives $\neg, \vee$ and temporal connectives $\mathbf{F}, \mathbf{P}$, denoting the strict future and strict past respectively, over a linear flow of time. Let the propositions d, m, y, l, b be propositions meaning "I drink", "I am here', "you are here", "you lock the door" and "burglars come", respectively.

Find the nearest TPL translations of the following statements. You may use standard abbreviations for $\wedge, \rightarrow, \mathbf{G}, \mathbf{H}$, provided you define them.

1. I will never drink again
2. You have never been here before but you will come and I will stay here until then
3. If you did not lock the door burglars will come.

[9 marks]

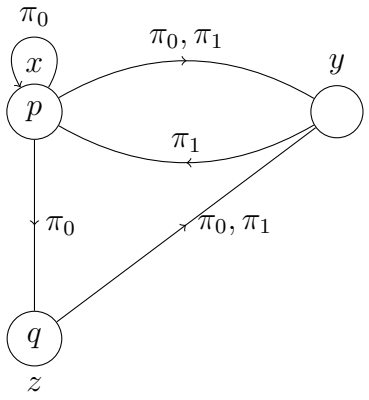
b. For each formula below, state whether the formula is satisfiable in some transitive frame. If the formula is satisfiable, state the size of the smallest model.

1. $\Diamond p \wedge \Diamond(\neg p) \wedge \Box(p \rightarrow \Diamond p)$
2. $\Box p \wedge \Diamond(\Diamond \neg q \wedge \Box(\neg p \vee q))$
3. $\Box(p \rightarrow \Diamond(\neg p)) \wedge \Box(\neg p \rightarrow \Diamond p)$
4. $\Box(p \rightarrow \Diamond(\neg p)) \wedge \Box(\neg p \rightarrow \Diamond p) \wedge \Diamond(\Box p)$.

[12 marks]

[Question 3 cont. on next page]

c. Consider Propositional Dynamic Logic (PDL) with primitive programs π_0, π_1 and propositions p, q. In the Labelled transition system below there are three states, x, y, z, where the transitions π_0, π_1 and the valuation $V : \{p, q\} \to \wp(\{x, y, z\})$ to propositions is shown.



For each PDL formula below say which states $w \in \{x, y, z\}$ satisfy the given formula.

1. $[\pi_1](p \wedge \langle \pi_0^* \rangle p)$
2. $\langle \pi_0; \pi_0; \pi_1 \rangle [(\pi_0; \pi_0; \pi_1)^*](p \vee \neg q)$
3. $\langle \pi_0; \pi_1 \rangle [(\pi_0; \pi_1)^*] p$.

[12 marks]

[Total=33 marks]