IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2011

BEng Honours Degree in Information Systems Engineering Part III
MEng Honours Degree in Information Systems Engineering Part III
BSc Honours Degree in Mathematics and Computer Science Part II
MSci Honours Degree in Mathematics and Computer Science Part II
BSc Honours Degree in Mathematics and Computer Science Part III
MSci Honours Degree in Mathematics and Computer Science Part III
MSc in Computing Science
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute
This paper is also taken for the relevant examinations for the Associateship of the Royal College of Science

PAPER C526

DATABASES

Thursday 5 May 2011, 14:30
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators not required

Several parts of the following questions make use of the **airline** relational database, which records details of aircraft, the engines that are used on those aircraft, and the further details about the type of aircraft and type of engines. Note that when engines are not mounted on an aircraft, the engine.reg attribute is set to null. The mountable table describes if a particular engine type may be mounted on a particular aircraft type.

engine

serial_no	etype	reg?	miles
230000901	CFM56	G-CWQS	567333
230002380	CFM56	G-CWQS	56000
230002381	CFM56	null	12345
230002382	CFM56	null	12645
230002383	CFM56	G-KLSD	902645
230002384	CFM56	null	933645
911002310	RB211	G-UGHJ	23500
911002311	RB211	G-UGHJ	23500
911002312	RB211	G-UGHJ	24500
911002313	RB211	G-UGHJ	23500

aircraft_type

model	manufacturer	no_engines
727	Boeing	3
737-200	Boeing	2
737-400	Boeing	2
737-400C	Boeing	2
737-500	Boeing	2
380	Airbus	4
747	Boeing	4
MD11	MD	3

engine_type

etype	manufacturer
CFM56	CFM
RB211	Rolls␣Royce
JT8D	P&W
JT9D	P&W

aircraft

reg	model	miles
G-CWQS	737-400C	2945321
G-FDWC	737-400	506834
G-FXDC	737-400	34760
G-KLSD	737-400	590
G-UGHJ	380	4544

mountable

etype	model
RB211	380
RB211	747
CFM56	737-400
CFM56	737-400C
JT8D	737-400
JT8D	737-400C
JT9D	747

engine(etype) → engine_type(etype)
aircraft(model) → aircraft_type(model)
mountable(etype) → engine_type(etype)
mountable(model) → aircraft_type(model)
engine(reg) → aircraft(reg)

1 The following parts all refer to the **airline** relational schema.

a Compute the result of the following RA query, and briefly explain the semantics of the query.

$\pi_{\text{manufacturer}}(\text{engine\_type} \bowtie (\pi_{\text{etype}}\ \text{engine\_type} - \pi_{\text{etype}}\ \text{engine}))$

b Write an RA query to find the list of manufacturers that make either engines or aircraft.

c Write a query to find those engine etypes that are mountable on the same aircraft as can have the CFM56 mounted:

i) Using just the primitive RA operators

ii) Using derived RA operators as appropriate

d Give an RA query using just the primitive RA operators equivalent to the following SQL query.

```
SELECT *
FROM   mountable
INTERSECT
SELECT engine.etype,aircraft.model
FROM   engine JOIN aircraft ON engine.reg=aircraft.reg
```

e The Datalog rule for none_of_manufacturer when written was intended to list those aircraft manufacturers for which the airline has no aircraft in its fleet.

```
none_of_manufacturer(Man) :-
        aircraft_type(Model, Man, _),
        ¬model_in_fleet(Model).
model_in_fleet(Model) :-
        aircraft(_, Model, _).
```

i) Briefly explain what answer is obtained for none_of_manufacturer when the Datalog program is run.

ii) Give an RA query that returns a result equivalent to none_of_manufacturer.

iii) Give a corrected Datalog program to find the intended answer.

The five parts carry, respectively, 15%, 15%, 30%, 15%, and 25% of the marks.

2 The following parts all refer to the **airline** relational schema.

a Compute the result of the following SQL query, and briefly explain the semantics of the query.

```
SELECT model,etype
FROM   mountable
WHERE  etype=ALL(SELECT etype
                 FROM   mountable AS other_type
                 WHERE  mountable.model=other_type.model)
```

b Write an SQL query to list of the etype of all engines which are currently mounted on an aircraft.

c Write an SQL query that returns all engine etypes that are mountable on all the same aircraft models that engine type 'CFM56' may be mounted on.

d Write an SQL query that returns one row per manufacturer in aircraft_type, and has columns for the name of the manufacturer, the number of two engine aircraft, the number of three engine aircraft, and the number of four engine aircraft made by that manufacturer that the airline currently has.

e Write an SQL query which returns the registration number of all aircraft, together with the number of engines the aircraft should have (found in aircraft_type.no_engines), and the number of engines recorded as mounted on that aircraft. The listing should exclude all aircraft where the number of engines mounted agrees with the aircraft type data.

f Rewrite the following RA query as an SQL query.

$$\pi_{\mathsf{manufacturer}}(\mathsf{engine\_type} \bowtie (\pi_{\mathsf{etype}}\,\mathsf{engine\_type} - \pi_{\mathsf{etype}}\,\mathsf{engine}))$$

The six parts carry, respectively, 15%, 10%, 20%, 20%, 20%, and 15% of the marks.

3 a Suppose you have to design a new database to hold information about airlines, the airports they serve, and the countries in which the airports are located.

Each airline is identified by an airline code, and we need to keep a record of the number of aircraft, the name, the country where the airline is head-quartered, and the airport where the airline has its main hub. We also need to record the routes served by the airline (*i.e.* recording the pairs of airports that the airline flies between).

Each country is identified by its ISO code, and have its full name recorded. We record the population of some countries, and some countries have one airline which is nominated as the flag carrier.

Each airport is identified by its three character code, and we record the city it is closest to, the elevation, and the country the airport is located within. Any airport that is a main hub of an airline must have an IATA code recorded, and the date that the airport became the main hub.

i) Design an ER schema to represent this new database.

ii) Map the ER schema you designed in (a) into a relational schema.

b The following histories describe the sequence of operations performed by three transactions.

$T_1 : r_1(\mathsf{a}_{\mathsf{G-CWQS}}), w_1(\mathsf{a}_{\mathsf{G-CWQS}}), r_1(\mathsf{a}_{\mathsf{G-FDWC}}), w_1(\mathsf{a}_{\mathsf{G-FDWC}})$

$T_2 : r_2(\mathsf{a}_{\mathsf{G-FDWC}}), r_2(\mathsf{a}_{\mathsf{G-FXDC}}), r_2(\mathsf{a}_{\mathsf{G-KLSD}}), r_2(\mathsf{a}_{\mathsf{G-UGHJ}})$

$T_3 : r_3(\mathsf{a}_{\mathsf{G-FXDC}}), w_3(\mathsf{a}_{\mathsf{G-FXDC}}), r_3(\mathsf{a}_{\mathsf{G-CWQS}}), w_3(\mathsf{a}_{\mathsf{G-CWQS}})$

i) Briefly explain if the following concurrent execution of T_1, T_3 is serialisable and recoverable.

$b_3, r_3(\mathsf{a}_{\mathsf{G-FXDC}}), w_3(\mathsf{a}_{\mathsf{G-FXDC}}), b_1, r_1(\mathsf{a}_{\mathsf{G-CWQS}}), w_1(\mathsf{a}_{\mathsf{G-CWQS}}),$
$r_3(\mathsf{a}_{\mathsf{G-CWQS}}), w_3(\mathsf{a}_{\mathsf{G-CWQS}}), c_3, r_1(\mathsf{a}_{\mathsf{G-FDWC}}), w_1(\mathsf{a}_{\mathsf{G-FDWC}}), c_1$

ii) Briefly explain if a concurrent execution of just T_1 and T_2 could ever deadlock.

iii) Give a concurrent execution of T_1, T_2, T_3 which produces a deadlock involving all three transactions, and draw a waits-for graph for the deadlock situation.

The two parts carry, respectively, 60%, and 40% of the marks.

4a Suppose that a relation $R(A, B, C, D, E, F)$ has the functional dependencies $S = \{A \rightarrow BCE, CDE \rightarrow AC, B \rightarrow CE, DE \rightarrow FAB\}$.

i) Compute a minimum cover S_c of S.

ii) Identify and justify all the candidate keys of R.

iii) Decompose the relation R into 3NF.

iv) Decompose the relation R into BCNF.

b The table below lists the contents of a database log, which uses a cache consistent checkpoint procedure.

LOG	b_7
UNDO	$w_7[a_{G-CWQS}$, miles=2939320]
REDO	$w_7[a_{G-CWQS}$, miles=2939391]
LOG	b_2
UNDO	$w_2[a_{G-KLSD}$, miles=402]
REDO	$w_2[a_{G-KLSD}$, miles=579]
LOG	b_6
UNDO	$w_6[a_{G-UGHJ}$, miles=4200]
REDO	$w_6[a_{G-UGHJ}$, miles=4344]
LOG	b_1
UNDO	$w_1[a_{G-UGHJ}$, miles=4344]
REDO	$w_1[a_{G-UGHJ}$, miles=4544]
UNDO	$w_6[a_{G-FDWC}$, miles=505030]
REDO	$w_6[a_{G-FDWC}$, miles=506834]
LOG	c_6
LOG	*checkpoint(1,2)*
UNDO	$w_2[a_{G-CWQS}$, miles=2939391]
REDO	$w_2[a_{G-CWQS}$, miles=2945321]
LOG	b_8
LOG	c_2
UNDO	$w_1[a_{G-KLSD}$, miles=579]
REDO	$w_1[a_{G-KLSD}$, miles=590]
LOG	b_9
UNDO	$w_9[a_{G-CWQS}$, miles=2945321]
REDO	$w_9[a_{G-CWQS}$, miles=3000022]
LOG	c_9

i) If the aircraft table on disc was found to have the data listed at the start of this paper, describe the actions performed by the recovery procedure, and give the recovered version of the aircraft table.

ii) If no REDO log entries had been made, describe precisely any additional actions that must have been taken when other log entries were being made.

The two parts carry, respectively, 65%, and 35% of the marks.

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