Exercise Sheet 3

Question 1: Suggesting functional dependencies

Consider the following schema which describes M.O.T. inspections of motor vehicles.

inspection(date_of_inspection,
owner,
owner_address,
owner_contact_phone,
registration_number,
model,
year_of_first_registration,
diesel_or_petrol,
date_of_previous_MOT,
engineer,
garage,
garage_address,
garage_MOT_licence_number,
passed_or_not)

a. Find plausible (and non-trivial) functional dependencies. In doing so, list your assumptions and discuss whether they are reasonable.

b. Determine the candidate key(s).

Question 2: Deriving functional dependencies

For each of the following assumed sets of functional dependencies (over the schema (A, B, C, D)) determine whether they imply $A \to D$. If yes, justify your answer with the closure algorithm; if no, give a table which satisfies the assumed dependencies but not $A \to D$.

a. $AB \to C$, $C \to B$, $B \to D$

b. $AB \to C$, $CB \to D$, $A \to B$

c. $ABC \to D$, $AB \to C$, $A \to B$

Question 3: Checking functional dependencies against a table

List a basis from which one can derive all functional dependencies that are compatible with the following table:

A	B	C	D
s_1	t_1	u_1	v_1
s_1	t_2	u_2	v_1
s_2	t_2	u_3	v_1
s_3	t_3	u_4	v_2
s_3	t_3	u_5	v_3

(PTO)

Question 4: Working with functional dependencies

Consider a schema $T(A, B, C, D, E)$ with the following functional dependencies: $A \to B$, $BC \to E$, $ED \to A$.

a. Find *all* the candidate keys for the schema T.

(Hint: Note that the collection of all attributes $ABCDE$ forms a candidate key. You can progressively remove from this collection one attribute at a time, and determine whether it still remains a candidate key. A *minimal* candidate key is one from which you cannot remove any further attributes. You should attempt to find at least one minimal candidate key during the lab session, and hunt for the remaining ones at home.)

b. Is the table in Boyce-Codd normal form (BCNF)?

c. If it is not, decompose it into BCNF using the normalisation procedure of Section 9.

a. (1) A->B: ACDE then (3) ED->A, then CDE
(2)BC->E: ABCD then (1) A->B, then ACD
(3)ED->A: BCDE then (2) BC->E, then BCD

Question 5: Judging decompositions

a. Assume that the functional dependencies $AB \to C$, $AB \to D$ and $BC \to D$, hold for the schema (A, B, C, D). Which set(s) of attributes form a candidate key?

Consider each of the following decompositions and determine whether it is lossless. If so, say whether it is redundancy reducing and dependency preserving. If all three properties hold determine whether the resulting tables are in Boyce-Codd Normal Form.

1. AB -> C, => ABD
AB -> D, => ABC
BC -> D, => ABC

redundancy reducing: if the candidate key is in only one of the table.

i. (A, B) & (B, C, D) — lossy
ii. (A, B, C) & (B, C, D) — lossless → dependency preserving, redundancy reducing
iii. (A, B, D) & (B, C, D) — lossy
iv. (A, B, C, D) & (B, C, D) — lossless → dependency preserving, not redundancy reducing

BCNF, can't be differentiate more

2. AB -> D, ABD => AB
AB -> C, ABC => AB
AB -> C, ABC => AB

Candidate key: AB

b. Like the previous item: Assume $A \to B$, $A \to C$, $A \to D$, $A \to E$, $B \to C$, and $CD \to E$ hold in schema (A, B, C, D, E), and consider the decompositions

Candidate key: A

i. AB & BC, CDE
ABC, CDE
C is not functional dependency
so not lossless

i. (A, B) & (B, C) & (C, D, E) — lossy, not dependency preserving, because there is no C in B, D, E
ii. (A, B, D) & (B, C) & (B, D, E) — lossless
iii. (A, B, C, D) & (B, C) & (C, D, E) — lossless, dependency preserving, redundancy reducing

ii. ABD & BC, BDE
ABCD, BDD
BD is common, but we need to check if BD is functional dependency (FD)
Because B->C, CD->E, then BD->E
Then it is FD.

Not BCNF
Because ABCD A->C, also B->C
Take closure algorithm of B->C (non-traivial) Should be ABD, BC

Question 6: Normalisation example

Consider the following schema for a table that arose in building a database system for aircraft testing in a amall airport. The tests are represented by an 'IATA number' (assigned by the International Air Travel Agency). The maximum score that can be received in the test is known. A particular airplane might receive smaller score than the maximum in an individual test.

test(IATAno, name, date, airplane, technician, duration, score, maxscore)

The attributes satisfy the following functional dependencies:

IATAno	$\to$	name
IATAno	$\to$	maxscore
IATAno, airplane, date	$\to$	technician
IATAno, airplane, date	$\to$	duration
IATAno, airplane, date	$\to$	score

a. Use the normalisation procedure to decompose the table into BCNF.

b. Briefly describe how each of the anomalies mentioned in Section 9 might arise with the original table, but are avoided in the decomposed tables.

Question 7: Evaluating functional dependencies

Each of the following relational schemata contains a (non-trivial) functional dependency. Discuss how harmful it is likely to be with regards to "AUDI" (the anomalies of aggregation, update, deletion and insertion). You should attempt to discuss at least one of them. If you have a study partner, it would be fun to discuss the issues between you.

a. Consider a schema for a table describing airline bookings. It would have attributes describing the customer (name, address, etc), attributes describing the flight (airline, flight number, etc), date, and details of the credit card that was used to pay for the flight. Discuss in this context the functional dependency

$$\text{credit\_card\_number} \rightarrow \text{customer\_details}$$

b. Consider a schema for a table that describes the machines available from a computer store. There would be attributes for model name, price, amount of RAM memory, etc. Discuss the functional dependency

$$\text{processor} \rightarrow \text{clock\_speed}$$

c. Consider a schema for a table describing students, with the obvious attributes. Discuss the functional dependency

$$\text{home\_or\_overseas\_status}, \text{degree\_programme} \rightarrow \text{tuition\_fee}$$

d. Consider a schema for a table containing scientific articles published in academic journals. We would have attributes such as author, title, start page, end page, submission date, etc. There is also the year of publication and the "journal volume". (Journals publish between one and 10 volumes per year.) Discuss the functional dependency

$$\text{journal\_name}, \text{volume\_number} \rightarrow \text{year}$$