

THE UNIVERSITY OF BRITISH COLUMBIA
CPSC 304: MIDTERM EXAMINATION
MAY 30, 2014

Sample solution

Notes about this examination

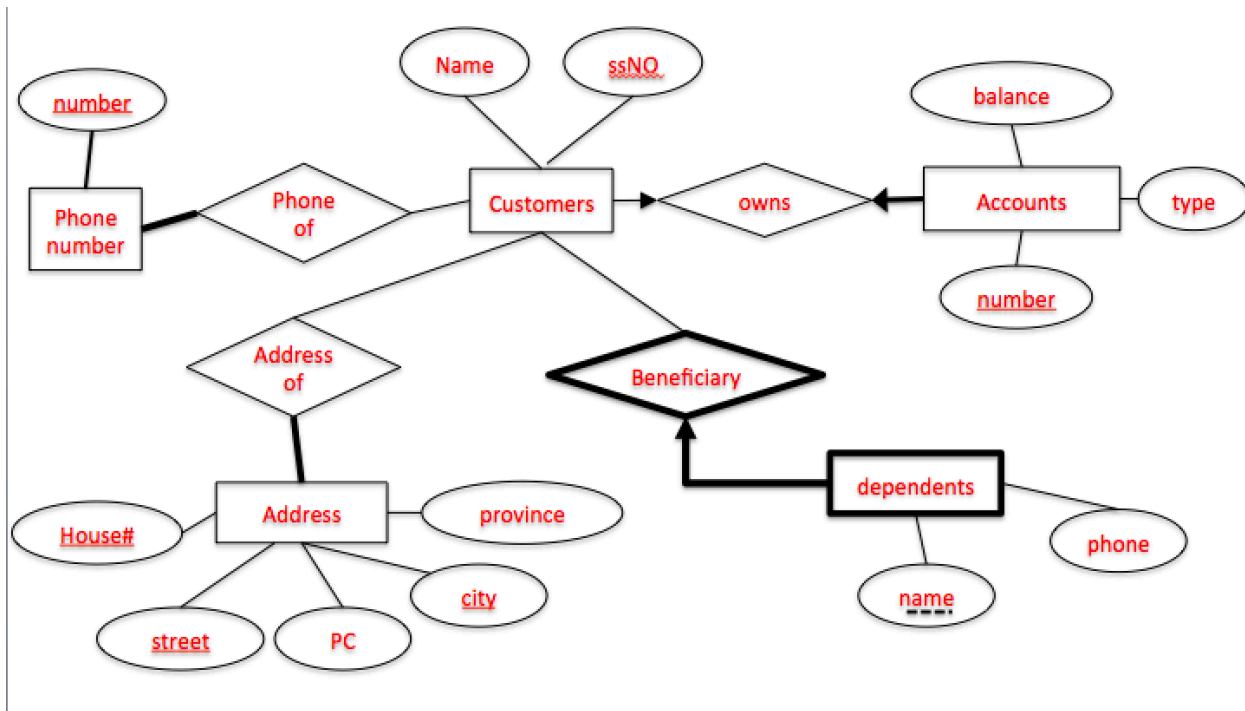
1. You have **65 minutes** (1 hour and 5 minutes) to write this examination.
2. Write your name, student #, and signature in ink (pen). You may use a pencil to write your solutions.
3. Answer all the questions on this paper.
4. The marks for each question are given in [].
5. Good luck!

Rules Governing Formal Examinations

1. Each examination candidate must be prepared to produce, upon the request of the invigilator or examiner, his or her UBCcard for identification.
2. Examination candidates are not permitted to ask questions of the examiners or invigilators, except in cases of supposed errors or ambiguities in examination questions, illegible or missing material, or the like.
3. No examination candidate shall be permitted to enter the examination room after the expiration of one-half hour from the scheduled starting time, or to leave during the first half hour of the examination. Should the examination run forty-five (45) minutes or less, no examination candidate shall be permitted to enter the examination room once the examination has begun.
4. Examination candidates must conduct themselves honestly and in accordance with established rules for a given examination, which will be articulated by the examiner or invigilator prior to the examination commencing. Should dishonest behaviour be observed by the examiner(s) or invigilator(s), pleas of accident or forgetfulness shall not be received.
5. Examination candidates suspected of any of the following, or any other similar practices, may be immediately dismissed from the examination by the examiner/invigilator, and may be subject to disciplinary action:
 - i. speaking or communicating with other examination candidates, unless otherwise authorized;
 - ii. purposely exposing written papers to the view of other examination candidates or imaging devices;
 - iii. purposely viewing the written papers of other examination candidates;
 - iv. using or having visible at the place of writing any books, papers or other memory aid devices other than those authorized by the examiner(s); and,
 - v. using or operating electronic devices including but not limited to telephones, calculators, computers, or similar devices other than those authorized by the examiner(s)—(electronic devices other than those authorized by the examiner(s) must be completely powered down if present at the place of writing).
6. Examination candidates must not destroy or damage any examination material, must hand in all examination papers, and must not take any examination material from the examination room without permission of the examiner or invigilator.
7. Notwithstanding the above, for any mode of examination that does not fall into the traditional, paper-based method, examination candidates shall adhere to any special rules for conduct as established and articulated by the examiner.
8. Examination candidates must follow any additional examination rules or directions

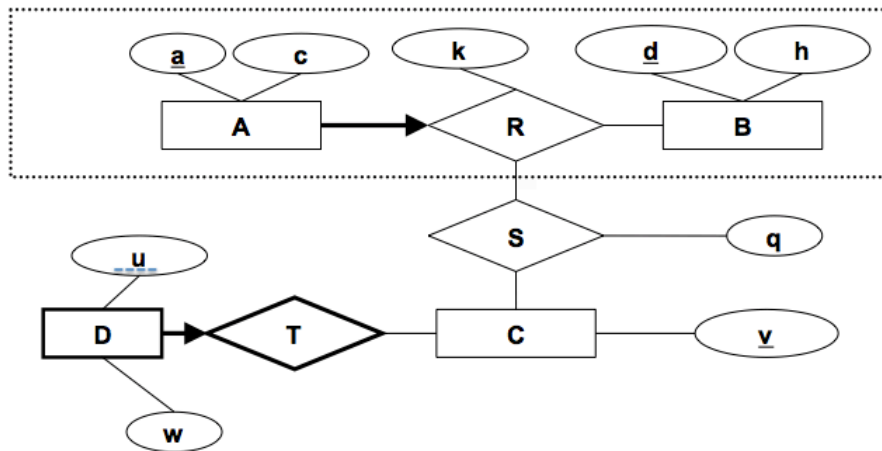
Questio	Mark	Max
Q1		15
Q2		15
Q3		25
Q4		25
Total		80

Design a database for a bank, including information about customer and their accounts. Information about a customer includes their name, address, phone, and Social Security number. Accounts have numbers, types (e.g., saving, checking) and balances. A customer can only have one account and an account can only be owned by one customer. A customer can have a set of addresses and a set of phones. An address is stored by house#, street, postal code, city, province. A customer can have one or more beneficiaries that would own the account in case the customer dies. The bank stores information on the name and the phone number of beneficiaries for an account. Draw an E/R diagram for this database. State any assumptions that you make – but your assumptions cannot contradict the facts given.



Additional assumption: Name of beneficiaries of customer are unique.

Q2. [15 marks] Transform the ER diagram into a relational schema using the methods discussed in class/the book. State any assumptions that you make – but your assumptions cannot contradict the facts given. You only need to show the schema (Use underline to show primary key and circle to show foreign key constraints).



Foreign keys are shown with bold letters

AR(a,c,k,**d**) d cannot be null

B(d,h)

S(a,**v**,q)

C(v)

DT(u,w,**v**)

Q3. [25 marks] Answer the following questions.

Q3A. [6 marks] Suppose you are given a relation $R(A,B,C,D)$ with the following functional dependencies:

- $AB \rightarrow C, AB \rightarrow D, C \rightarrow A, D \rightarrow B$

Is R in BCNF? If not, decompose this relation into BCNF using the algorithm we covered in class and in the book; circle all answers in your final decomposition. **Show all your work.**

$$AB^+ = ABCD$$

$$C^+ = CA$$

$$D^+ = DB$$

$C \rightarrow A$ violates BCNF in R Decompose

$$R_1(A,C) R_2(B,C,D)$$

$D \rightarrow B$ violates BCNF in R_2 Decompose

$$R_3(D,B) R_4(C,D)$$

Final answer : $R_1(A,C), R_3(D,B),$ and $R_4(C,D)$

Q3B. [7 marks] Suppose you are given a relation $R(B,O,I,S,Q,D)$ with the following functional dependencies:

- $S \rightarrow D, I \rightarrow B, IS \rightarrow Q, B \rightarrow O$

Is R in BCNF? If not, decompose this relation into BCNF using the algorithm we covered in class and in the book; circle all answers in your final decomposition. **Show all your work.**

$$S^+ = SD$$

$$I^+ = IBO$$

$$IS^+ = ISQBOD \text{ (Key)}$$

$$B^+ = BO$$

$S \rightarrow D$ violates BCNF in R

$$R_1(S,D) R_2(B,I,O,S,Q)$$

$I \rightarrow B$ violate BCNF in R_2

$$R_3(I,B) \text{ and } R_4(O,I,S,Q)$$

$I \rightarrow O$ (implicit FD through transition)

$$R_5(I,O), R_6(I,S,Q)$$

Final answer : $R_1(S,D)$, $R_3(I,B)$ and $R_5(I,O)$, $R_6(I,S,Q)$

Q3C. [12 marks] Consider the schema $S(A, B, C, D, E)$ together with the functional dependencies:

- $BD \rightarrow A$
- $AB \rightarrow C$
- $D \rightarrow A$
- $B \rightarrow C$
- $C \rightarrow E$

Is S in 3NF? Why or why not? If not, decompose into 3NF using the method we used in class and the book and circle all relations in your final answer. Show all your work.

$BD^+ = BDACE$

$AB^+ = ABCE$

$D^+ = AD$

$B^+ = BCE$

$C^+ = CE$

There is no way to get BD any other way, so BD is the only key. But the others do violate 3NF, so we need to decompose.

First we have to take the minimal cover. $BD \rightarrow A$ is redundant to $D \rightarrow A$. $AB \rightarrow C$ is redundant to $B \rightarrow C$. So the only functional dependencies to consider are $D \rightarrow A$, $B \rightarrow C$, and $C \rightarrow E$. Note that because the cover only removes redundant functional dependencies, the original closures still holds.

$D \rightarrow A$ violates 3NF as D is not a key and A is not part of a key, so decompose:

$S_1(A,D)$, $S_2(D,B,C,E)$. S_1 is in BCNF since it is a two attribute relation.

S_2 : $B \rightarrow C$ still holds, but B is not a key of S_2 , and C is not part of a key, so decompose:

$S_3(B,C)$, $S_4(B,D,E)$. S_3 is in BCNF since it has only two attributes.

S_4 is not in 3NF since $B \rightarrow E$ holds in S_4 , and B is not a key of S_4 and E is not part of a key, so decompose

$S_5(B,E)$, $S_6(B,D)$. All are two attribute relations, so all are in BCNF. At this point our answer set is $S_1(A,D)$, $S_3(B,C)$, $S_5(B,E)$, $S_6(B,D)$.

Now, we consider if there are any functional dependencies that need to be added back in. $D \rightarrow A$ and $B \rightarrow C$ are both covered (S_1 and S_3 respectively). $C \rightarrow E$ is not. So we add in a new relation $S_7(C,E)$, bringing our final answer to $S_1(A,D)$, $S_3(B,C)$, $S_5(B,E)$, $S_6(B,D)$, $S_7(C,E)$

Q4. [25 marks] This question introduces an example, concerning World War 2 capital ships. It involves the following relations:

- ShipModels(model, type, country, numGuns, bore, displacement)
- Ships(shipName, model, launched)
- Battles(battleName, date)
- Outcomes(shipName, battleName, result)

The relation ShipModels records the name of the model, the type ('bb' for battleship or 'bc' for battlecruiser), the country that build the ship, the number of main guns, and their size (bore), and the displacement (weight, in tons). Relation Ships records the name of the ship, the model of the ship, and the year in which the ship was launched. Relation Battles gives the name and date of battles involving these ships, and relation Outcomes gives the result (sunk=0, damaged=1, or ok=2) for each in each battle.

Q4A. [6 marks] Write a suitable SQL command for declaring the ShipModels and Outcomes relations.

```
CREATE TABLE ShipModels (  
model          CHAR(20), ok if primary key added here  
type           CHAR(5),  
country        CHAR(20),  
numGuns        INTEGER,  
bore           DECIMAL(3,1), (Integer is also fine)  
displacement   INTEGER  
PRIMARY KEY (model)  
);
```

```
CREATE TABLE Outcomes (  
shipName       CHAR(20),  
battleName     CHAR(20),  
result         INTEGER  
  
PRIMARY KEY (shipName, battleName)  
FOREIGN KEY (shipName) REFERENCES Ships (shipName), (ok if name of attribute is omitted)  
FOREIGN KEY (battleName) REFERENCES Battles (battleName), (ok if name of attribute is omitted)  
);
```

Q4B. [4 marks] Write a relational algebra expression to get the model names and countries of the ShipModels that carried guns of at least 16-inch bore.

. $\pi_{\text{model, country}} (\sigma_{\text{bore} \geq 16} (\text{ShipModels}))$

Q4C. [4 marks] The treaty of Washington in 1921 prohibited capital ships heavier than 35,000 tons. Write a relational algebra expression to list the name of the ships that violated the treaty of Washington.

$$\pi_{\text{ShipName}} (\sigma_{\text{launched} > 1921 \text{ AND } \text{displacement} > 35000} (\text{ShipModels} \bowtie \text{Ships}))$$

Q4D. [4 marks] Write a relational algebra expression to find those countries that had both battleships and battlecruisers.

$$\pi_{\text{country}} (\sigma_{\text{type}=\text{bb}} (\text{ShipModels})) \cap \pi_{\text{country}} (\sigma_{\text{type}=\text{bc}} (\text{ShipModels}))$$

Q4E. [7 marks] Write a relational algebra expression to find those ships that “lived to fight another day”; they were damaged in one battle, but later fought in another.

$$\begin{aligned} \text{Damaged}(\text{ship}, \text{result1}, \text{date1}) &\leftarrow (\pi_{\text{shipName}, \text{result}, \text{date}} (\text{Battles} \bowtie (\sigma_{\text{results}=1} (\text{Outcomes}))) \\ \text{Battled}(\text{ship}, \text{result2}, \text{date2}) &\leftarrow (\pi_{\text{shipName}, \text{result}, \text{date}} (\text{Battles} \bowtie \text{Outcomes})) \end{aligned}$$

$$\pi_{\text{shipName}} (\sigma_{\text{date1} < \text{date2}} (\text{Battled} \bowtie \text{Damaged}))$$

This space is intentionally left blank. You can use it to answer questions or as scratch paper

(if you use this, CLEARLY indicate the connection between this work and the problem it is for both here and where the problem is stated!)