**The University of British Columbia**

# Computer Science 304

**Final Examination**

**Instructor**: Rachel Pottinger **Time**: 2.5 hours **Total marks**: 48

**Name** ANSWER KEY **Student No**_____

(PRINT) (Last) (First)

**Signature**_____

**This examination has 9 pages of questions printed double-sided (5 pieces of paper total). Check that you have a complete exam.**

This is a closed book exam, closed notes exam. Answer all the questions on this paper. Give **short but precise** answers. Write down any assumptions that you make. The marks for each question are given in {}. Use this to manage your time.

Good Luck!

**READ AND OBSERVE THE FOLLOWING RULES:**

1. Each candidate should be prepared to produce, upon request, his or her UBC Card.

2. No candidate shall be permitted to enter the examination room after the expiration of one-half hour, or to leave during the first half-hour of the examination.

3. Candidates are not permitted to ask questions of the invigilators, except in cases of supposed errors or ambiguities in examination questions.

4. **CAUTION** --- Candidates guilty of any of the following, or similar, dishonest practices shall be immediately dismissed from the examination and shall be liable to disciplinary action.

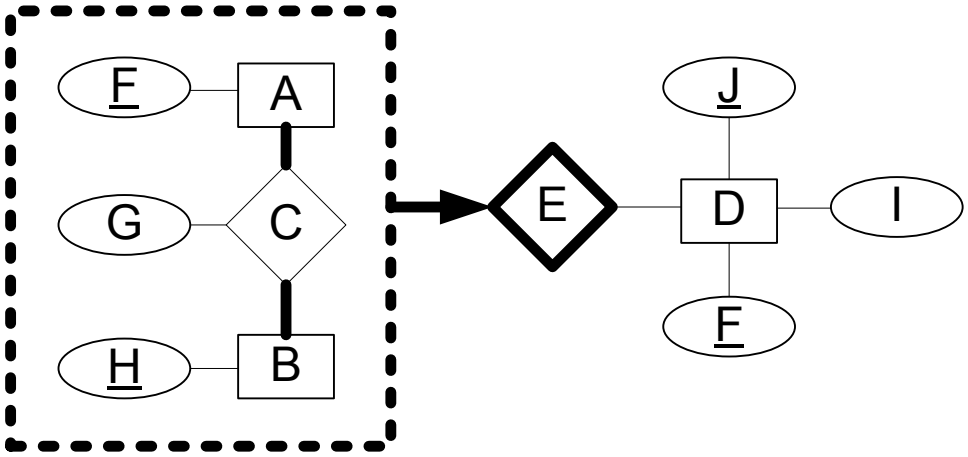
   a. Making use of any books, papers or memoranda, calculators or computers, phones, MP3 players, or other memory aid devices, other than those authorized by the examiners.

   b. Speaking or communicating with other candidates.

   c. Purposely exposing written papers to the view of other candidates. The plea of accident or forgetfulness shall not be received.

| | Mark | Out of |
|---|---|---|
| **2** | | 10 |
| **3** | | 10 |
| **4** | | 4 |
| **5** | | 4 |
| **6** | | 4 |
| **7** | | 6 |
| **8** | | 6 |
| **9** | | 4 |
| **Total** | | 48 |

**Question 1. {10 marks}**




Transform the ER diagram into a relational schema using the methods discussed in class/the book. If there are any conflicting attribute names, rename them something appropriate and easy to understand. State any assumptions that you make – but your assumptions cannot contradict the facts given.

a. {12 marks} What should the relational schema be? You do NOT have to create SQL DDL, just underline the keys and note foreign keys and not null constraints after the relation definition, e.g., you might have "M(n,o): foreign key (o) references R(q), o is not null"

b. {4 marks} Are there any constraints in the relational schema that cannot be modeled without using assertions? If so, which constraint(s)? If not, why not?

**Question 2. {10 marks}**

Consider the schema R(A, B, C, D, E) together with the functional dependencies:

BD → A
AB→ C
D→ A
B→ C
C→E

Is R 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.*

**Question 3. {4 marks}**

Given the relation: Sailors(sid, sname, rating, age), consider the following query: Find the names of sailors with a higher rating than all sailors with age < 21. The following two SQL queries attempt to obtain the answer to this question.

**Query A:**

```
SELECT  S.sname
FROM    Sailors S
WHERE  S.rating > ANY ( SELECT S2.rating
                        FROM   Sailors S2
                        WHERE S2.age < 21)
```

**Query B:**

```
SELECT S.sname
FROM   Sailors S
WHERE NOT EXISTS ( SELECT *
                   FROM    Sailors S2
                   WHERE  S2.age < 21 AND S.rating <= S2.rating)
```

For each of the two questions below, circle your answer:

A. Does Query A compute the correct answer? Yes No

B. Does Query B compute the correct answer? Yes No

**Question 4. {4 Marks}**

Consider the relation Arc with the following current values:

**Arc**

| x | y |
|---|---|
| 1 | 2 |
| 1 | 2 |
| 2 | 3 |
| 3 | 4 |
| 3 | 4 |
| 4 | 1 |
| 4 | 1 |
| 4 | 1 |
| 4 | 2 |

Compute the result of the query:

```
SELECT a1.x, a2.y Count(*)
FROM Arc a1, Arc a2
WHERE a1.y = a2.x
GROUP BY a1.x, a2.y
```

Which of the following is a row in the result? Circle a single correct answer.

a. (1,3,2)
b. (4,2,6)
c. (4,3,1)
d. All of the above
e. None of the above

**Question 5. {4 Marks}**

Suppose R(a,b) and S(b,c) are relations. Consider the Datalog query:

```
T(x,y) :- R(2,x), S(y,x)
```

Write an equivalent relational algebra expression:

**Question 6. {6 marks}**

Consider the following concurrency protocols: 2PL, Strict 2PL, Time Stamp without the Thomas Write rule, Timestamp with the Thomas Write Rule, and Multiversion Timestamps. For each of the following schedules, circle whether it is allowed under the above protocols. If you cannot decide whether a schedule is allowed based on the listed actions, explain briefly.

The actions are listed in the order they are scheduled and prefixed with the transaction name. If a commit or abort is not shown, the schedule is incomplete; assume that abort or commit must follow all the listed actions.

**a. T1:R(X), T2:R(X), T1:W(X), T2:W(X)**

1. 2PL? Yes No Can't tell:
2. Strict 2PL? Yes No Can't tell:
3. Timestamp w/ TWR? Yes No Can't tell:
4. Timestamp w/o TWR? Yes No Can't tell:
5. Multiversion timestamps? Yes No Can't tell:

**b. T1:W(X), T2:R(Y), T1:R(Y), T2:R(X)**

1. 2PL? Yes No Can't tell:
2. Strict 2PL? Yes No Can't tell:
3. Timestamp w/ TWR? Yes No Can't tell:
4. Timestamp w/o TWR? Yes No Can't tell:
5. Multiversion timestamps? Yes No Can't tell:

**Question 7. {6 marks}**

Consider the following sequence of actions using the ARIES protocol:

```
LSN LOG
… …
00 begin checkpoint
10 end checkpoint
20 update: T1 writes P5
30 update: T2 writes P3
40 T2 commit
50 T2 end
60 update: T3 writes P3
70 T1 abort
<CRASH, RESTART>
```

Assume that the Dirty Page Table and Transaction Table were empty before the start of the log.

a. What is done during Analysis? (Be precise about the points at which Analysis begins and ends and describe the contents of any tables constructed in this phase.)

b. What is done during Redo? (Be precise about the points at which Redo begins and ends.)

c. What is done during Undo? (Be precise about the points at which Undo begins and ends.)

**Question 8. {4 marks}**

Consider the following XML DTD:

```
<?xml version="1.0"?>
<!DOCTYPE Newspaper[
    <!ELEMENT Basket (Cherry+, (Apple | Orange)*) >
        <!ELEMENT Cherry EMPTY>
            <!ATTLIST Cherry flavour PCDATA #REQUIRED>
        <!ELEMENT Apple EMPTY>
            <!ATTLIST Apple colour PCDATA #REQUIRED>
        <!ELEMENT Orange EMPTY>
            <!ATTLIST Orange location 'Florida'>

]>
```

Where #PCDATA and CDATA are equivalent.
Consider the following instance, which is designed to adhere to the above DTD.

```
<Basket>
     <Apple/>
     <Cherry flavour='good'/>
     <Orange/>
</Basket>
```

a. Is this instance valid? Why or why not?

b. Is this instance well-formed? Why or why not?