This examination has 6 pages.

Check that you have a complete paper.

This is a closed book, closed notes exam. No books or other material may be used.

Answer all the questions on this paper.

Give very short but precise answers.

State any assumptions you make

Work fast and do the easy questions first. Leave some time to review your exam at the end.

Good Luck
1. {6 marks, 1 mark per question} Circle only **one** answer per question – no points will be taken off for incorrect answers (i.e., you might as well guess):

<table>
<thead>
<tr>
<th>Question</th>
<th>True</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. If X is a key of a relation R, X is also a superkey of R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. A relationship in an ER diagram must be uniquely determined by the entities in that relationship</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Every relation that is in BCNF is also in 3NF</td>
<td></td>
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<tr>
<td>d. A, B, and C above should be represented by two tables, B(m,n), C(m,o), in a corresponding relational schema if the IS-A relationship is partial</td>
<td></td>
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<tr>
<td>e. MN→O, P→Q, Q→O is a minimal cover for the set of functional dependencies MN→O, P→Q, MN→Q, Q→O.</td>
<td></td>
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<tr>
<td>f. An insertion anomaly is when it may not be possible to store certain information unless some other, unrelated, information is stored as well</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. {11 marks} Consider the schema $R = (A, B, C, D, E)$ together with the functional dependencies:

- $AB \rightarrow C$
- $CD \rightarrow A$
- $C \rightarrow E$
- $C \rightarrow B$

   a. {4 marks} What are the key(s) of $R$? Show your work to prove why each key is a key

   b. {5 marks} Is $R(A, B, C, D, E)$ in BCNF? Why or why not? 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.

   c. {2 marks} Is $R(A, B, C, D, E)$ in 3NF? Why or why not?
3. {4 marks} ER relationship types.

a. i. {1 mark} Change the ER diagram below so that B to D is a Many to One relationship

ii. {1 mark} Give a set of entities for B and D that violate the above constraint, and explain why they violate it

```
B __ Y __ D
\  /  \\
/ l ___ \\
\   /
\  /__   __/
\r   s
```

b. i. {1 mark} Change the ER diagram below so that every C must participate in Z

ii. {1 mark} Give a set of entities for A and C that violate the above constraint, and explain why they violate it

```
A ___ Z ___ C
\  /  \\
/ l ___ \\
\  /
\m   \\
\  /
\r   s
```
4. {10 marks} Given the following ER diagram:

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.

a. {8 marks} Give the SQL DDL necessary to create the relational schema. You do not have to include types for any attributes

b. {2 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?
5. {7 marks} Consider the following relation instance:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Eric</td>
<td>2</td>
<td>Dempster</td>
</tr>
<tr>
<td>Eric</td>
<td>2</td>
<td>ICICS/CS</td>
</tr>
<tr>
<td>Ting</td>
<td>3</td>
<td>ICICS/CS</td>
</tr>
<tr>
<td>Ting</td>
<td>3</td>
<td>Dempster</td>
</tr>
<tr>
<td>Ying</td>
<td>5</td>
<td>SUB</td>
</tr>
<tr>
<td>Ying</td>
<td>6</td>
<td>Koerner</td>
</tr>
</tbody>
</table>

a) {5 marks} Observe that \( B \rightarrow A \) appears to hold with respect to the given instance. Check to see if all of the following dependencies hold with respect to the instance, and give a reason if they do not.

- \( A \rightarrow B \)
- \( A \rightarrow C \)
- \( B \rightarrow C \)
- \( C \rightarrow A \)
- \( C \rightarrow B \)

b) {2 marks} Determine the minimum number of tuples that can be added to the above instance to invalidate \( B \rightarrow A \). Demonstrate your answer by showing example(s) of such tuple(s).