CS 452
Fall 2000
Midterm Exam II
November 6-7, 2000

Name: ____________________________________________

SSN: ______________________________________________

Closed Book
Closed Notes
No Calculators
No Time Limit
7 Questions

Instructor: David W. Embley
1. (16 points) Create an ORM diagram for the following description.

A Publisher publishes many Books, but a Book is published by only one Publisher. A Publisher is uniquely identified by a Name and has offices in several Cities. A CityName and State together uniquely identify a City. A Book has a Title, but the Title does not uniquely identify the Book. A Book, however, does have a unique identifying BookNumber. A Book may be adopted by several Universities, and we also want the Date the Book was first adopted. A University is uniquely identified by its UniversityName and is also uniquely identified by its Address. Books are either SoftCoverBooks or HardCoverBooks, but not both.

Each noun starting with a capital letter identifies an object set that must appear in your diagram. (Use singular names for object sets even if the noun is plural in the description.) Use generalization/specialization for soft- and hard-covered books. Be sure to capture all mentioned relationships and constraints. Choose reasonable constraints for any unspecified participation constraints.
2. Consider the following relations.

\[ r = \begin{array}{ccc}
6 & 2 & 1 \\
6 & 1 & 0 \\
4 & 2 & 0 \\
4 & 2 & 1 \\
4 & 2 & 3 \\
8 & 2 & 5 \\
8 & 9 & 1 \\
\end{array} \quad s = \begin{array}{cc}
1 & 4 \\
0 & 5 \\
\end{array} \]

(a) (5 points) Give a closed predicate-calculus formula that makes \( C \) a key for \( s \).

(b) (5 points) Give a closed predicate-calculus formula for the referential-integrity constraint guaranteeing that values in \( C \) for \( s \) appear as values for \( C \) in \( r \).

(c) (5 points) Evaluate: \( \{ < x, y > \mid \exists z (r(x, 2, z) \land s(z, y)) \} \)

(d) (5 points) Evaluate: \( \{ < x > \mid \forall y \forall z (s(y, z) \Rightarrow \exists w (r(x, w, y))) \} \)
3. Consider the following database scheme:

\[
\begin{align*}
\text{employee}(SSN, \text{Name}, \text{Salary}, \text{City}) & \quad \text{key}: SSN \\
\text{worksOn}(\text{Employee} - SSN, \text{Project}) & \quad \text{key}: \{\text{Employee} - SSN, \text{Project}\} \\
\text{managerOf}(\text{Manager} - SSN, \text{Employee} - SSN) & \quad \text{key}: \text{Employee} - SSN
\end{align*}
\]

(a) (6 points) Write a relational-calculus query to list the names, salaries, and cities of employees who do not work on project p3.

(b) (6 points) Write a relational-calculus query to list pairs of names of employees if they have the same manager. Do not list a pair of employees twice, once in one order and once in the other order, and do not list a person paired with himself/herself.
4. (8 points) Consider a model-theoretic view of a relational database instance that has two relations $r(AB)$ and $s(CD)$, and has the following integrity constraints.

\[
\begin{align*}
\forall x \exists y & \leq_1 r(x, y) \\
\forall x \forall y & (s(x, y) \Rightarrow \exists z (r(z, x))) \\
\forall x \forall y & (r(x, y) \Rightarrow x \in \{a, b, c, d, e\} \land y \in \{a, b, c, d, e\}) \\
\forall x \forall y & (s(x, y) \Rightarrow x \in \{a, b, c, d, e\} \land y \in \{a\})
\end{align*}
\]

Add values and tuples to the following tables so that the interpretation will be valid. Add values and tuples as needed, but do not add any unnecessary values or tuples. Do not delete or change any given values. Be sure to make all constraints hold.

\[
\begin{array}{ccc}
\text{r} & \text{A} & \text{B} \\
a & a & C \\
c & b & D \\
d & e & \\
\end{array}
\]
5. Translate the following OSM application model into the set of predicates and rules that characterize it as specified below.

(a) (2 points) Give the object-set predicates.

(b) (2 points) Give the relationship-set predicates.

(c) (4 points) Give the referential integrity rules.

(d) (4 points) Give the generalization/specialization rules.

(e) (4 points) Give the participation-constraint rules.
6. Consider the following ORM diagram.

(a) (8 points) Convert the diagram into an ORM hypergraph.

(b) (2 points) Do the FDs of your ORM hypergraph imply \( CD \rightarrow E \)?

(c) (2 points) Do the FDs of your ORM hypergraph imply \( C \rightarrow B \)?

(d) (2 points) Do the FDs of your ORM hypergraph imply \( AD \rightarrow BCE \)?
7. For each of the following, determine whether the sets of FDs are equivalent. If so, give the closure of all the left-hand-side attributes of $F$ with respect to $G$ and the closure of all the left-hand-side attributes of $G$ with respect to $F$. If not, give all the FDs of $F$ not implied by $G$ and all the FDs of $G$ not implied by $F$. (Circle your answers so that the grader can distinguish your answer from your scratch work.)

(a) (7 points)

\[ F = \{ A \rightarrow B, B \rightarrow C, C \rightarrow A \} \]
\[ G = \{ AB \rightarrow C, C \rightarrow AB \} \]

(b) (7 points)

\[ F = \{ A \rightarrow BC, C \rightarrow B, B \rightarrow A, D \rightarrow E \} \]
\[ G = \{ C \rightarrow AB, A \rightarrow C, A \rightarrow B, B \rightarrow A, D \rightarrow E \} \]