**CS145 Midterm Examination**

Monday, November 3, 1997, 11AM–12:15PM

**Directions**

The exam is *open book*; any written materials may be used. Answer all four questions on the exam paper itself. The total number of points is 100. Do not forget to **sign the pledge** below.

I acknowledge and accept the honor code.

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Print your name here: ________________________________________

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**Problem 1:** (35 points) We wish to design a database consistent with the following facts. *Crimes* have a name and a degree (e.g., "murder in the first degree"), which together form a key. A crime is either a *felony* or a *misdemeanor*. Punishments are either *fines* or *jail sentences*. A fine has an associated amount, and a jail sentence has minimum and maximum numbers of years. The punishment for a misdemeanor is always a fine. The punishment for a felony can be either a jail sentence, a fine, or both.

a) Give an ODL design for the information above, remembering the design principles of Section 2.3. Indicate attribute(s) that are keys. For speed, you may use the following abbreviations: "attribute"→"att", "relationship"→"rel", and "inverse"→"inv". If possible, put several elements on a line to save space.

b) Using the ODL-to-relations strategy outlined in class and in the text, convert your design from (a) to relations. Omit any relation whose schema is a subset of another schema.

c) In the space below, draw an E/R diagram representing the information above. Try to make your design follow the design principles of Section 2.3. Indicate keys by underline and many-one or one-one relationships by arrows.

d) Convert your design from (c) into relations, using the E/R-to-relations method outlined in class and the text. Omit any relation whose schema is a subset of another schema.

**Problem 2:** (30 points) Consider the relation schema $R(A, B, C, D, E, F)$ with functional dependencies $AB \to C$, $AD \to E$, and $CE \to F$.

a) Find all the (minimal) keys for $R$.

b) $AB \to C$ is a BCNF violation for $R$. Suppose we decide to decompose $R$ into $R1(A, B, C)$ and $R2(A, B, D, E, F)$. Give a minimal basis for the functional dependencies that hold in $R1$; that is, find a set of FD's such that every FD that holds for $R1$ follows logically from this set (e.g., by using the closure construction or Armstrong's axioms).

c) Find a minimal basis for the FD's that hold in $R2$ (Hint: since $C$ is gone, the only nontrivial dependencies in $R2$ will have $E$ or $F$ on the right side.)

d) What are the key(s) for $R2(A, B, D, E, F)$?

e) Find an FD of $R2$ (tell which) that violates BCNF. Decompose $R2$ using this FD.

f) Are your relations resulting from the decomposition of (e) in BCNF? Explain briefly.

**Problem 3:** (15 points) Let us be given relations

```
OsPlat(os, platform)
AppOs(app, os)
```

`OsPlat` means that operating system `os` runs on platform `platform` (e.g.,

*OsPlat('solaris', 'pc')*

means that the Solaris operating system runs on a PC). `AppOs` means that application `app` runs under the operating system `os` (e.g., *AppOs('netscape4.0', 'macos8')* means that the Netscape 4.0 application runs under MAC OS version 8. Write the following queries in relational algebra, as succinctly as possible. You may use single expressions or a series of assignments involving temporary relations to get your answer.

a) Find the platforms on which the Windows NT operating system runs.

b) Find the platforms under which we can run the application MSWord (i.e., there is at least one operating system suitable for both the platform and MSWord).

c) Find the pairs of operating systems that support at least one application in common.

**Problem 4:** (20 points) Using the same two relations as in Problem 3:

```
OsPlat(os, platform)
AppOs(app, os)
```

write the following four queries in standard SQL2, trying to make them as succinct as possible:

a) Find the operating systems that support at least one application and whose name ends in "IX".

b) Find the operating systems mentioned in `AppOs` that do not run on any platform.

c) Find the platforms that run only one operating system *without using any subqueries.*

d) Answer the same question as part (c) but using a subquery.