Practice Problem Set: Functional Dependencies and Normal Forms

1. Suppose we have the following requirements for a university database that is used to keep track of students transcripts:

(a) The university keeps track of each student's name (SNAME), student number (SNUM), social security number (SSSN), current address (SCADDR) and phone (SCPHONE), permanent address (SPADDR) and phone (SPPHONE), birthdate (BDATE), sex (SEX), class (CLASS) (freshman, sophomore, ..., graduate), major department (MAJORDEPTCODE), minor department (MINORDEPTCODE) (if any), and degree program (PROG) (B.A., B.S., ..., Ph.D.). Both SSSN and student number have unique values for each student.

(b) Each department is described by a name (DEPTNAME), department code (DEPTCODE), office number (DEPTOFFICE), office phone (DEPTPHONE), and college (DEPTCOLLEGE). Both name and code have unique values for each department.

(c) Each course has a course name (CNAME), description (CDESC), code number (CNUM), number of semester hours (CREDIT), level (LEVEL), and offering department (CDEPT). The value of code number is unique for each course.

(d) Each section has an instructor (INSTUCTORNAME), semester (SEMESTER), year (YEAR), course (SECCOURSE), and section number (SECNUM). Section numbers distinguish different sections of the same course that are taught during the same semester/year; its values are 1, 2, 3, ...; up to the number of sections taught during each semester.

(e) A transcript refers to a student (SSSN), refers to a particular section, and grade (GRADE).

Design an relational database schema for this database application. First show all the functional dependencies that should hold among the attributes. Then, design relation schemas for the database.

2. Consider the following two sets of functional dependencies:

- F = {A $\rightarrow$C, AC $\rightarrow$D,E $\rightarrow$AD, E $\rightarrow$H} and
- G = {A $\rightarrow$CD, E $\rightarrow$AH}.

Check whether or not they are equivalent.

3. For the following relation and functional dependencies: R(A,B,C,D,E) with functional dependencies B->A, AC->E, DE->B

a. Decompose the relation, as necessary, into a collection of relations that are in **BCNF**. Show all of your work and explain which dependency violations you are correcting by your decompositions.
b. Decompose the relation into a collection that follows **3NF** instead.

4. Given universal schema R(A,B,C,D,E,F,G,H,I) and a set of functional dependencies as follows:

AB $\rightarrow$ CD
A $\rightarrow$ E
B $\rightarrow$ FH
C $\rightarrow$ G
D $\rightarrow$ B
G $\rightarrow$ C
H $\rightarrow$ I

a. What is the key for the universal schema R?
b. b. What is the highest normal form of the universal schema R? Please explain.
c. If the universal schema R is not in 3NF (the third normal form), please make lossless join

decomposition of schema R that is in 3NF with the property of functional dependency preservation.

d. List all the keys (include candidate keys) in all the schemas (tables) achieved in c.

e. List all the foreign keys in each schema (table) if any.

f. Prove that the decomposition in c. is lossless join decomposition.

g. Is the decomposition you have created a BCNF decomposition? (That is, is each of the schemas (tables) achieved in c. in BCNF?)

4. Given relation schema R(A,B,C,D,E,F,G) and functional dependencies (1) E -> ACB, (2) A-> CD, and (3) CD -> F (4) D -> G

You need to decompose the relation such that the decomposition

- Reduces redundancies
- Lossless join and
- Dependency preserving

Show your decomposition and establish its correctness based on the concepts of BCNF, 3NF, lossless join, and dependency preserving. You may not be able to find a decomposition that satisfies all requirements. Justify your preferences.