Problem 1 (20 points)
Suppose we have the following requirements for a university database that is used to keep track of student 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 ssn 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 (INSTRUCTORNAME), 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 that are each in 3NF or BCNF. Specify the key attributes of each relation. Note any unspecified requirements, and make appropriate assumptions to make the specification complete.

Problem 2 (20 points)
Consider the following two sets of functional dependencies F= \{A→C, AC→D, E→AD, E→H\} and G = \{A→CD, E→AH\}. Check whether or not they are equivalent.
Problem 3 (20 points)
Consider the relation R, which has attributes that hold schedules of courses and sections at a university; \( R = \{\text{CourseNo}, \text{SecNo}, \text{OfferingDept}, \text{CreditHours}, \text{CourseLevel}, \text{InstructorSSN}, \text{Semester}, \text{Year}, \text{Days\_Hours}, \text{RoomNo}, \text{NoOfStudents}\} \). Suppose that the following functional dependencies hold on R:

\( \{\text{CourseNo}\} \rightarrow \{\text{OfferingDept}, \text{CreditHours}, \text{CourseLevel}\} \)
\( \{\text{CourseNo}, \text{SecNo}, \text{Semester}, \text{Year}\} \rightarrow \{\text{Days\_Hours}, \text{RoomNo}, \text{NoOfStudents}, \text{InstructorSSN}\} \)
\( \{\text{RoomNo}, \text{Days\_Hours}, \text{Semester}, \text{Year}\} \rightarrow \{\text{InstructorSSN}, \text{CourseNo}, \text{SecNo}\} \)

Try to determine which sets of attributes form keys of R. How would you normalize this relation?

Problem 4 (20 points)
Given the relation schema CAR_SALE(\text{Car\#}, \text{Date\_sold}, \text{Salesman\#}, \text{Commission\%}, \text{Discount\_amt})\), assume that a car may be sold by multiple salesmen and hence \( \{\text{CAR\#, Salesman\#}\} \) is the primary key. Additional dependencies are:

\( \{\text{Date\_sold}\rightarrow\text{Discount\_amt}, \text{Salesman\#}\rightarrow\text{commission\%}, \text{Car\#}\rightarrow\text{Date\_sold}\} \)

Based on the given primary key, is this relation in 1NF, 2NF, or 3NF? Why or why not? How would you successively normalize it completely?

Problem 5 (20 points)
Consider the relation REFRIG(MODEL\#, YEAR, PRICE, MANUF\_PLANT, COLOR), which is abbreviated as REFRIG(M, Y, P, MP, C), and the following set of F of functional dependencies: \( F=\{M\rightarrow MP, \{M,Y\} \rightarrow P, MP\rightarrow C\} \)

(a) Evaluate each of the following as a candidate key for REFRIG, giving reasons why it can or cannot be a key: \( \{M\}, \{M,Y\}, \{M,C\} \).

(b) Based on the above key determination, state whether REFRIG is in 3NF and in BCNF, giving proper reasons.

(c) Consider the decomposition of REFRIG into D=\{R1(M,Y,P), R2(M,MP,C)\}. Is this decomposition lossless? Show why.