1. (5 points) Draw the three-schema DBMS architecture and describe each schema.

2. (5 points) Identify five characteristics that distinguish the database approach from traditional file-processing application.

3. (5 points) Draw a B'-tree of order p = 3 and p_{max} = 2 step by step to insert the data 13, 10, 6, 12, 8, 17, 14, 11 and then delete 17.

4. (6 points) Describe and compare extendible hashing and linear hashing.

5. (6 points) How does a category differ from a regular shared subclass? What is a category used for? Illustrate your answer with examples.

6. (6 points) Explain by example weak entity and total participation in ER-model.

7. (3 points) Explain the following terms:
   - Tuple, attribute, domain, and their relationship.

8. (3 points) Given a relation schema R with attributes A1, A2, ..., An, express a relation instance r in terms of the schema R and m n-tuples (m is the number of n-tuples in r).

9. (4 points) Give a simple example to illustrate the concept of "referential integrity constraint."

10. (3 points) Name six operations of relational algebra, and briefly explain each of them.

11. Given the following five relations:

    Student: Name  |  StudentNumber |  Class  |  Major
    S.C. Chou   |  33            |  freshman |  IE
    D.R. Yang   |  45            |  sophomore |  IE

    Course: CourseName  |  CourseNumber  |  CreditHour |  Department
    Intro. To Computer  |  IE1366        |  4          |  IE
    Data Structure      |  IE3033        |  4          |  IE
    Discrete Math       |  MA2011        |  3          |  Math
    Data Base           |  IE4056        |  3          |  IE

    Section: SectionIdentifier | CourseNumber | Semester  | Year  | Instructor
    85                    |  MA2011       | Fall      | 98    | Chen
    92                    |  IE1366       | Fall      | 98    | Lin
    102                   |  IE3033       | Spring    | 99    | Lee
    112                   |  MA2011       | Fall      | 99    | Chang
    119                   |  IE1366       | Fall      | 99    | Tsai
    135                   |  IE4056       | Fall      | 99    | Chin

    GradeReport: StudentNumber  |  SectionIdentifier  |  Grade
    33                      |  112              |  85
    33                      |  119              |  75
    45                      |  85               |  95
    45                      |  92               |  95
    45                      |  102              |  85
    45                      |  135              |  95
Prerequisite: CourseNumber  PrerequisiteNumber
IE4056    IE3033
IE4056    MA2011
IE3033    IE1366

Write SQL queries to:

1) (4 points) retrieve the names of all senior students majoring in "IE" (Industrial Engineering).
2) (4 points) For each section taught by Professor Chen, retrieve the course number, semester, year, and number of students who took the section.
3) (4 points) Retrieve the names and major departments of all students who have a grade above 90 in all their courses.

Write SQL update statements to:

1) (4 points) Insert a new course "Web Engineering", "IE5033", 3, "IE".
2) (4 points) Delete the record for the student whose name is "S.C.Chou" and whose student number is 33.

12. (15 points) Explain why the redundant information may produce update anomalies, especially from the viewpoints of insertion, deletion, and modification operations.

13. (9 points) Determine X*, the closure of X under a set of functional dependencies F: 
   F = {SSN → ENAME; PNUMBER → {PNAME, PLOCATION}; (SSN, PNUMBER → HOURS}
   a. X = {SSN}
   b. X = {PNUMBER}
   c. X = {SSN, PNUMBER}

14. (10 points) Four functional dependencies FD1, FD2, FD3, FD4 of attributes in a database are illustrated below.
   a. Decompose this database into its 2nd normal form.
   b. Decompose this database into its 3rd normal form.