Warm-up (10 Points)
1. (5 points) Write your name and student-id on your blue book.
2. (5 points) What is the difference between the primary key and the candidate key of a table?
   Provide an example. Candidate key is a minimal superkey that uniquely identifies either an entity or a relationship, e.g., Social security number, phone number. A primary key is a candidate key that is chosen by the database designer to identify the entities of an entity set or relationships in a relationship set.

Magnetic Disk Drives (10 points)
3. (5 points) What does a disk do during a seek operation? Reposition its read/write head from their current cylinder to the destination cylinder.
4. (5 points) How does a Record identifier (RID or TID) uniquely identifies the location of a record on the surface of the disk drive? RID is (Page#, Slot#). The DBMS formats the underlying disk drive as a sequence of disk pages numbered from 1 to n. The Page# refers to one of these disk pages. With indexed heap organization of records in the page, the slot number refers to the location of the record in the disk page.

SQL (30 points)
Assume a university database that maintains a listing of faculty, departments and courses offered by these departments, students and their courses.

Student (Id, Sname, address, GPA)
Transcript (StudId, CrsId, Year, Grade)
Faculty (Id, Fname, DeptId, Salary)
Dept (Id, Dname, Address)
Course (CrsId, DeptId, CrsName, CreditHours)

5. (10 points) Give a 10% raise to those faculty earning the minimum salary.
   Update Faculty
   Set Salary = 1.1 * Salary
   Where Salary in (Select min(Salary) from Faculty)

6. (10 points) How many students have secured the maximum GPA?
   Select count(*)
   From Student
   Where GPA = all (Select max(GPA) from student)

7. (10 points) List the students who have enrolled in all computer science courses.
   Select s.*
   From Student S, Course c
   Where
   (select t.CrsId
   From Transcript t
   Where s.id = t.StudID)
   CONTAINS
   (select CrsId
   From Course C, Dept d
   Where C.DeptId = d.Id and d.Dname = “CS”)

Relational algebra (30 points)
8. Assume that R and S are relations containing T(R) and T(S) records, respectively. What is the maximum number of records that can possibly be in the result of each of the following expressions:
   8a. (5 points) R U S T(R) + T(S)
8b. (5 points) $R - S \quad T(R)$

Recall the departmental store that maintains a listing of its employees using the following table:
Emp (SS#, name, age, salary, dno, mgrSS#)

9. (5 points) Write the algebraic expression to retrieve those employees whose salary is higher than one thousand times their age.
10. (15 points) Write the algebraic expressions to fire those employees whose salary exceeds their manager’s salary.

**Index structures (20 points)**

11. (10 points) Assume 10 records of the Emp(SS#, name, age, salary, mgrSS#) relation fits per disk page. Moreover, assume that this relation consists of one million records. With a clustered hash index consisting of 200,000 buckets, what is the loading factor of the index structure assuming there are no overflow buckets?

12. (10 points) True or False: One may construct both (a) a secondary, non-clustered B'⁻tree on the salary attribute, and (b) a non-clustered hash index on the SS# of the Emp relation. Explain your response as I will consider your description when grading this question.