University of California, Berkeley
College of Engineering
Computer Science Division – EECS

Fall 2004 Prof. Michael J. Franklin

MIDTERM II

CS 186 Introduction to Database Systems

NAME:___D.B. Guru_____ **STUDENT ID:**_____

IMPORTANT: **Circle the last two letters of your class account:**

cs186 a b c d e f g h i j k l m n o p q r s t u v w x y z

a b c d e f g h i j k l m n o p q r s t u v w x y z

DISCUSSION SECTION DAY & TIME:_____ **TA NAME:** _____

This is a **closed book** examination – but you are allowed one 8.5" x 11" sheet of notes (double sided). You should answer as many questions as possible. Partial credit will be given where appropriate. There are 100 points in all. You should read **all** of the questions before starting the exam, as some of the questions are substantially more time-consuming than others.

Write all of your answers directly on this paper. **Be sure to clearly indicate your final answer** for each question. Also, be sure to state any assumptions that you are making in your answers.

GOOD LUCK!!!

Problem	Possible	Score
1. SQL	**27**	
2. Join Cost Calculations	**9**	
3. Query Optimization	**24**	
4. ER Diagrams	**25**	
5. Functional Dependencies	**15**	
TOTAL	**100**	

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Question 1 –SQL [6 parts, 27 points total]

For parts a-d, consider the following schema (primary keys are underlined):

Student (sname, sid, gpa, level, deptno)
Course (cno, cname, deptno, units)
Dept (dname, deptno)
Takes (sid, cno)

a) [7 points] Write a SQL query that returns the names (i.e., snames) of students who have taken more courses outside their department than inside their department. For this question, you can assume that all students in the database have taken at least one course inside their department. **(note: you should do scratch work elsewhere and just put your final answer here!)**

b) [3 points] Which of the following queries returns the department numbers of those departments for which there are no courses being offered? **More than one choice may be correct.**

A)
```
SELECT D.deptno
FROM Dept D, Course C
WHERE D.deptno NOT EQUAL C.deptno;
```

B)
```
SELECT C.deptno, COUNT(C.deptno)
FROM Course C
GROUP BY C.deptno
HAVING COUNT (C.Deptno) = NULL;
```

C)
```
SELECT C.deptno
FROM Course C
WHERE C.deptno NOT IN (SELECT * FROM Dept);
```

D)
```
SELECT D.deptno
FROM Dept D
WHERE NOT EXISTS  (SELECT * FROM Course C
                   WHERE C.deptno = D.deptno);
```

E) None of the above

c) [3 points] Which of the following queries returns the id of the student with the highest GPA? **More than one choice may be correct.**

A)
```
SELECT S.sid
FROM Students S
```

```
    WHERE S.gpa = MAX(S.gpa);
```

B)
```
SELECT S.sid, MAX(S.gpa);
FROM Students S
GROUP by S.gpa
```

C)
```
SELECT S.sid
FROM Student S
WHERE S.gpa > ALL (SELECT S.gpa FROM Student S);
```

D)
```
SELECT S.sid
FROM Student S
Where S.gpa = (SELECT MAX(S.gpa)
        FROM Student S);
```

E) None of the above

d) [3 points] Which of the following queries returns the sid of the students and the total units they are taking? **More than one choice may be correct**.

A)
```
SELECT S.sid, sum(C.units)
FROM Student S, Takes T, Course C
GROUP BY S.sid
HAVING S.sid = T.sid AND T.cno = C.cno;
```

B)
```
SELECT S.sid, sum(C.units)
FROM Student S, Takes T, Course C
Where S.sid = T.sid AND T.cno = C.cno;
GROUP BY S.sid
```

C)
```
SELECT S.sid, Temp.Sum1
FROM Student S, (SELECT sum(C.units) AS Sum1
        FROM Takes T, Course C
        WHERE T.sid = S.sid AND T.cno = C.cno) AS Temp;
```

D)
```
SELECT S.sid, sum(C.units)
FROM Student S, Takes T, Course C
WHERE S.sid = T.sid AND T.cno = C.cno;
```

E) None of the above

e) [3 points] For the following schema: Athletes(name, country, sport, age, height, weight)

Which of the following SQL queries reflects the English query statement: "For each country, find the average height of weightlifters, qualifying only those countries that have weightlifters with minimum weight of 160 pounds." **More than one choice may be correct.**

A)
```
SELECT country, avg(height)
FROM Atheletes
WHERE sport = "weightlifting"
GROUP BY country, height, weight  HAVING min(weight) >= 160;
```

B)
```
SELECT country, avg(height)
FROM Atheletes
GROUP BY country, sport  HAVING min(weight) >= 160 AND sport = "weightlifting";
```

C)
```
SELECT country, avg(height)
FROM Atheletes
WHERE sport ="weightlifting"
GROUP BY country  HAVING min(weight) >= 160;
```

D)
```
SELECT country, avg(height)
FROM Atheletes
WHERE sport = "weightlifting" AND min(weight) >= 160
GROUP BY country, weight;
```

E)
```
SELECT country, avg(height)
FROM Atheletes
WHERE sport ="weightlifting"
GROUP BY country, height  HAVING min(weight) >= 160;
```

f) [8 points] For the schema in part (e), write a SQL query that returns for each sport, the name of the sport, the country that has the most athletes who play that sport, and the number of athletes of that country that play that sport. **(note: you should do scratch work elsewhere and just put your final answer here!)**

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Question 2 – Join Costs [3parts, 9 points total]

For this question, you will consider the I/O cost of operations on two tables of a database. The database has the following schema (note, this schema is slightly different than the schema used in question 1).

Students(sid, name, address, GPA)

EnrolledIn(sid, classid, semester, year)

Assume that tuples are of fixed size. There are 10 Students tuples per page and 200 EnrolledIn tuples per page. Also assume that there are 1000 pages in the Students relation, and 500 pages in the EnrolledIn relation. The data is unsorted, and tuples are distributed evenly throughout the database.

For the following join strategies, give the I/O cost. Assume 52 pages in the buffer, and that no pages are currently in the buffer when the join begins. If multiple variants of an algorithm have been discussed in class, section, or in the book, use the most efficient one unless otherwise noted. **Be sure to state any assumptions you are making and be sure to clearly indicate your final answer.**

a) [3 points] Hash Join (not hybrid):

b) [3 points] Sort Merge (note, both relations can be sorted in two passes):

c) [3 points] Block Nested Loops:

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Question 3 – Query Optimization [7 parts, 24 points]

Consider a database containing information about all the car accidents between 1967 and 1975, including the cars involved and their owners. The database has the following tables:

```
Car(license, year, company, model);
Accident(license, accident date, damage_amount, zipcode);
        // zipcode in Accident is the place where accident took place
    // assume that the same car does not get into an accident twice in a day
Owner(SSN, license, name, street, city, zipcode);
                        // assume each owner has only one licensed car
```

The statistics and other catalog information for the database are as follows:

- NTuples(Car) = 10,000, NTuples(Accident) = 10,000, NTuples(Owner) = 10,000
- NPages(Car) = 100, NPages(Accident) = 1000, NPages(Owner) = 500
- NDistinct(Car.company) = 50
- Min(Accident.damage_amount) = 1000, Max(Accident.damage_amount) = 16,000.
- Histogram on # of accidents per year (evenly distributed among the 12 months in each year:

Year	1967	1968	1969	1970	1971	1972	1973	1974	1975
N(Accidents)	500	1000	1500	1200	1500	1500	950	1250	500

- All indexes use Alternative #2 for the data entries.
- All BTrees have 100 keys per node, hash indexes have 100 keys per bucket,; assume BTrees are 3 levels deep, and the cost for a hash look up is 1.2 I/Os on average.
- An unclustered Extendible hash index exists on Car(company)
- A clustered B+Tree index on Accident(accident_date)
- An unclustered B+Tree index on Accident(damage_amount)

Consider the following query:

```
SELECT O.name, A.damage_amount
FROM Car C, Accident A, Owner O
WHERE C.license = A.license AND C.license = O.license
  AND A.zipcode = O.zipcode AND C.company = 'Volvo'
  AND A.accident_date < '07/01/1970' AND A.damage_amount > 10000;
```

For question parts **(a)** and **(b)**, begin the process of query optimization, by first pushing down all the non-join predicates. Compute the cardinality of the relations after these selections are applied.

a) [2 points] What is the expected cardinality of the Car relation after the initial selections are applied:

Question 3 – Query Optimization (continued)

b) [4 points] What is the expected cardinality of the Accident relation after initial selections are applied:

Next, estimate the I/O cost for the following access plans in Pass 1. **Be sure to list any assumptions you are making (for example if you are sorting RIDs before accessing data).**

c) [3points] Index scan on Car(company) for the relation Car:

d) [3 points] Index scan on Accident(accident_date) for the relation Accident:

e) [3 points] Index scan on Accident(damage_amount) for the relation Accident:

f) [3 points] List all *join orders* that will be considered in Pass 3 by the System R query optimizer. (ignore the specific join algorithm in this step).

g) [6 points] Suppose page nested loop join algorithm is the only available join algorithm, what is the best join order and what is the total estimated cost?

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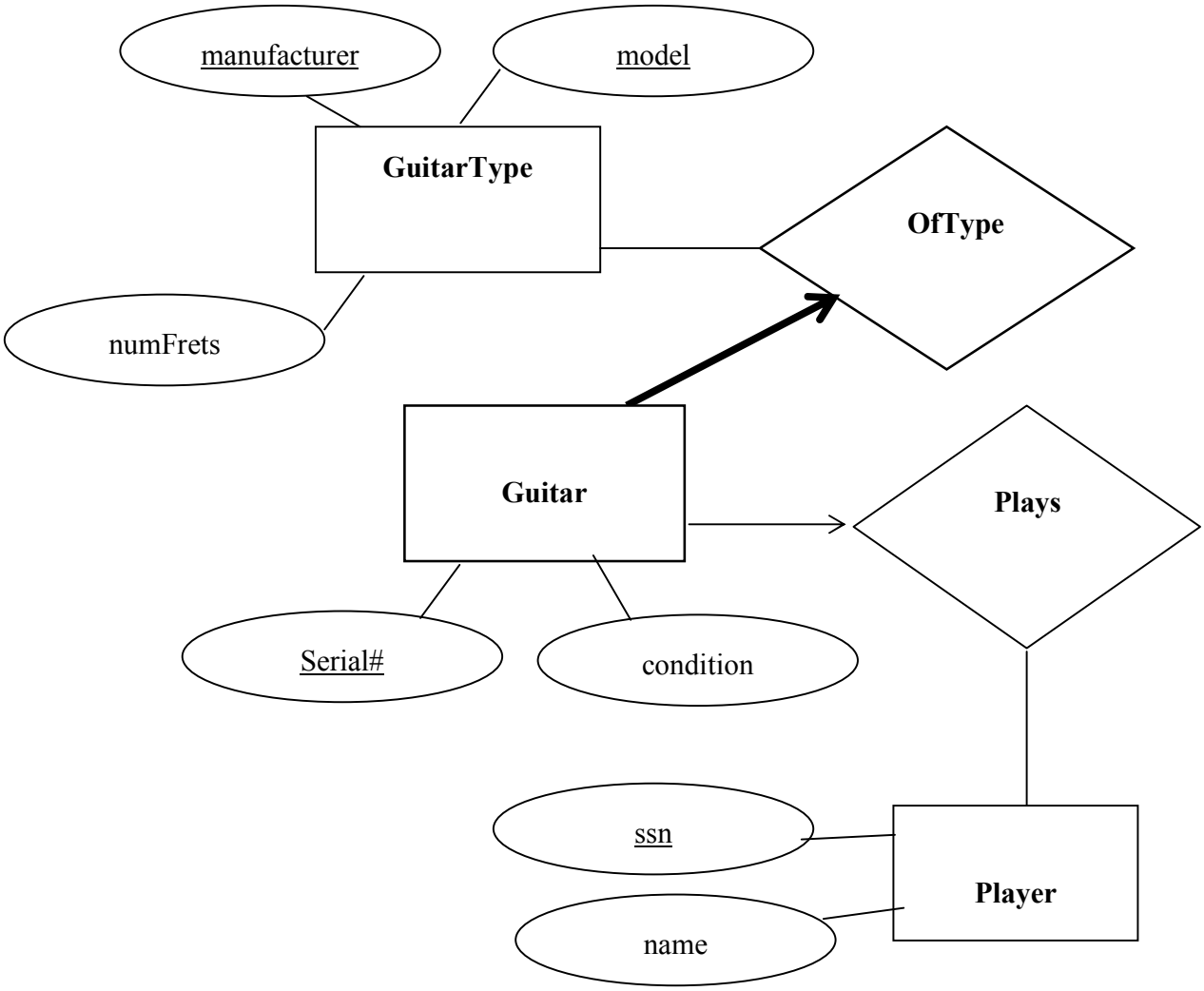
Question 4 – ER models [5 parts, 25 points]

Consider the following ER diagram



Using this diagram, answer the questions that appear on the following pages.

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Question 4 – ER models (continued)

a) [10 points] Create a relational schema (with SQL CREATE TABLE statements) for this diagram. Be sure to label all primary and foreign key constraints. The types of the attributes are as follows:

INTEGER: GuitarType.numFrets, Guitar.serial#, Player.ssn

CHAR(20): all others

Note: Your schema for this part should have no more than four tables (solutions with more than four tables will not receive full credit). **NOTE: the solution for question 4 is a sample solution; some minor variations on this could still give you full credit.**

Question 4 – ER models (continued)

b) [2 points] Say that we want to impose an additional constraint that a guitar can be played by at most one player. Indicate this new constraint **on the original diagram** for this question (**Be sure that the change is clearly indicated, there will be no regarding on this part).**

See arrow in dashed ellipse in diagram.

c) [4 points] For the change in part b, indicate (below) how your CREATE TABLE statements would have to be changed to reflect this.

d) [4 points] Now, say that we want to add the fact that some players are teachers that teach other players. Teachers can teach multiple players and players can have multiple teachers. Indicate this new information **on the original diagram** for this question (**Be sure that the change is clearly indicated, there will be no regarding on this part).**

e) [5 points] Write the CREATE TABLE statement(s) that capture this information. Note, this may cause you to change one or more of your original CREATE TABLE statements.

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Question 5 – Functional Dependencies [4 parts, 15 points]

Consider a database table T with attributes ABCDE and a set of functional dependencies

FD ={AE->BC, AC->D, CD->BE, D->E}

a) [6 points] Give three (3) *candidate* keys (if there are more than three, choose any three you want), and explain why they are *candidate* keys (i.e., in addition to being superkeys).

b) [3 points] Is table T already in BCNF? Why or why not?

Now, consider the following table R with attributes ABCD and with the set of functional dependencies FD = {A->B, B->C, C->D}

c) [3 points] Say you decompose it into AB, CD, AC. Is this decomposition lossless? Explain why or why not.

d) [3 points] Give another BCNF decomposition of relation R, which is different from the one in part (c). Your decomposition should be lossless, but need not be dependency preserving.