Department of Computer Science
Core Graduate Comprehensive Exam
Spring 2013

- Answer the questions on the paper supplied.
- Answer question 1 or Answer question 2. Answer question 3 or 4. Answer question 5 or 6 or 7 or 8. Answer question 9 or 10. You should answer a total of four questions.
- Start each question on a new page. Write on only one side of the paper.
- Write your SIX-DIGIT Texas State ID in the top right corner of each page of your answer. Do NOT put your name anywhere on the answers.
- Put the number of the question being answered in the top left corner of each answer page. Put the CORRECT question number to avoid missing your answer.
- If the answer to a question is written on more than one page, number the pages consecutively.

Group 1

1. CS 5329 Algorithm Design and Analysis
   - Define mathematically the asymptotic upper bound big \( O \) notation: \( f(n) = O(g(n)) \)
     \[
     O(g(n)) = \{ \\
     \}
     \]
   - Use recursion tree and log algebra to derive the maxima total running time of the recurrence function: \( T(n) = T(n/3) + cn \)

2. CS 5329 Algorithm Design and Analysis
   Give definition and an example of a double hashing scheme for building a hash table. Insert entries with keys 1, 21, 4, 13 and 34 in a hash table of size five (i.e., \( N = 5 \)) using the double hashing scheme you defined. Draw final table and show the calculations for full credit.

Group 2

3. CS 5346 Advanced Artificial Intelligence
   (a) In the following cryptarithmetic problem, each letter stands for a distinct digit. The aim is to find a substitution of digits for letters such that the resulting sum is arithmetically correct, with the added restriction that no leading zeros are allowed.
      \[
      \begin{array}{c}
      \text{O N E} \\
      + \text{F O U R} \\
      \hline \\
      \text{F I V E}
      \end{array}
      \]
      Write a set of constraints which must be satisfied to solve this problem.
   (b) Convert the following English sentences into predicate logic sentences. Then convert predicate logic sentences into Atomic and Horn sentences.
      i. Horses are mammals.
      ii. Cows are mammals.
      iii. Pigs are mammals.
      iv. An offspring of a horse is a horse.
      v. Bluebeard is a horse.
      vi. Bluebeard is Charlie’s parent.
      vii. Offspring and parent are inverse relations.
      viii. Every mammal has a parent.
      Using Backward Chaining method, draw the proof tree to prove Horse (Charlie).
4. **CS 5391 Survey of Software Engineering**

Describe the pros and cons of the following models and point out their applications.

(a) linear sequential
(b) incremental
(c) spiral

**Group 3**

5. **CS 5306 Advanced Operating Systems**

There are two main approaches to organizing a server daemon such as a Web server:

(a) Create a new kernel thread for each client (for each Web browser connection);
(b) Use a single process responding to all clients, usually based on the select() system call. Compare and contract these two approaches.

6. **CS 5310 Network and Communication Systems**

(a) Why Internet is a connectionless packet switched network?
(b) Explain the meaning of TCP connection. Does the notion of TCP connection contradict the fact the Internet is a connectionless packet switched network?
(c) If a user tries to send an email message from one of the Linux workstations in the CS lab to a friend, describe all the protocols and sequence of actions involved in sending the email message.

7. **CS 5332 Data Base Theory and Design**

Construct an E/R diagram for a database system for the following problem. You must specify the PK’s, FK’s, and relationships for each entity. Your relations (entities) must be normalized up to 3NF or BCNF. (Prefer you use crow feet notation for E/R model. If you use other notations, you must specify the relationships clearly.)

The problem: Design a database for Ray. He is interested in movies and wants to keep information on movies, actors, and directors in a database. The only user is Ray and he needs to produce the following reports:

(a) For each director, list his or her number, name, and the year he or she was born. If the director is deceased, list the year of death.
(b) For each movie, list its number, title, the year the movie was made, and its type (for example, Comedy, Drama, Science Fiction, and so on).
(c) For each movie, list its number, title, the number and name of its director, the critics’ rating, the MPAA rating (G, PG, PG-13, or R), the number of awards for which the movie was nominated, and the number of awards the movie won. (The critics rate the movie with a number of “stars.” Four stars is the top rating possible. Zero stars is the worst possible rating.)
(d) For each actor, list his or her number, name, birthplace, and the year he or she was born. If the actor is deceased, list the year of death.
(e) For each movie, list its number and title, along with the number and name of the actors who appeared in it.
(f) For each actor, list his or her number and name, along with the number and name of the movies in which the actor starred.
8. **CS 5332 Data Base Theory and Design**

Consider the following schema:

- Suppliers (sid: integer, sname: string, address: string)
- Parts (pid: integer, pname: string, color: string)
- Catalog (sid: integer, pid: integer, cost: real)

Write each of the following queries in relational algebra and SQL.

(a) Find the names of suppliers who supply some red part.

(b) Find the sids of suppliers who supply every red part.

---

9. **CS 5318 Design of Programming Languages**

(a) A number consists of digits from 0 to 9. For example, 123 is a number. Give two different grammars to define a number, one using a left-recursive rule and the other using a right-recursive rule.

(b) A decimal number can be defined as a number followed by a decimal point (.) and another number. For example, 123.045 is a decimal number. Define attributes and write an attribute grammar to carry out the following tasks:
   i. Restrict the number of digits after the decimal point to no more than 6;
   ii. Compute the decimal value of any decimal number with no more than 6 digits after the decimal point.

(c) Decorate the parse tree for 123.045 to show how its value is computed.

---

10. **CS 5338 Formal Languages**

(a) Draw an FSM $M$ for language $L(M) = \{w \in \{a, b\}^* : w \text{ has } aab \text{ as a substring}\}$

(b) Draw a PDA $M$ for language $L(M) = \{w \in \{a, b\}^* : \#_a(w) = \#_b(w)\}$. Note that $\#_a(w)$ denotes the number of $a$’s in $w$. 

---