CS 205M :
Theoretical Foundations of Computer Science.

Khushraj Nanik Madnani

Lecture 1: Instructor and Teaching Assistants

- Khushraj Nanik Madnani (instructors):

- Teaching Assistants (yet to be decided):
  - Ritu Kumari (Ph.D. candidate),
  - Archana K R. (Ph.D. candidate),
  - Kethireddy Mahendranath Reddy (M.Tech. I),
  - Vishwa Pranav Reddy Bobbala (M. Tech. I).

About the Course

Discrete Mathematics 50%

+

Formal Languages and Automata Theory 50%

Discrete Mathematics (first half)

- Sets, Functions, Relations, Partial Orders, Recurrences, Summations;
- Counting, Generating functions, asymptotics;
- Elementary Logic and Proof Techniques.
- Graphs: basic concepts
- Group Theory, symmetries (if time permits).

Formal Languages and Automata Theory

- Alphabets, Languages;
- Regular Languages:
  Finite State Automata, Regular Expressions;
- Context Free Languages:
  Pushdown Automata, Context Free Grammars;
- Recursively Enumerable Languages: Turing Machines;
- Introduction to Computability and Complexity (if time permits).

Exam Schedule

- 5% lecture attendance, 95% exams;
- Quiz 1 (within a week before midsem);
- Mid Sem;
- Quiz 2;
- Quiz 3 (within a week before endsem);
- End Sem.
- 25% will be evaluated externally.

Course Evaluation

- 5% lecture attendance;25% quizzes (best of 2 out of 3),
  5% research presentation;
- 20% midsem; 45% endsem.
- Potluck grading 15%.
  - Group of 5 will be formed after quiz 1 scores. Let the individual marks after endssems be A,B,C,D,E.
  - A' = A – 0.15*A, . . . , E' = E – 0.15* E.
  - X = 0.15*(A+B+C+D+E)/5
  - A_new = A'+X, B_new = B'+X,. . . , E_new =E' + X.

Conclusion

So its in your interest that your group members are also performing well and attending classes regularly.

Grading

Partially Relative Grading. The absolute component as follows:

- Anyone getting 90% or above will get an AA or above.
- Anyone getting 80% or above will get AB or above.
- Anyone getting 36% or above will get CC or above.

Sets – revision.

- Intersection, Union, subset, superset, powerset.
- Relations – introduction.
- Functions.
- Cardinality of Sets, Finite vs. Infinite sets.
- Sequences and Summation.
- Will be revisited next week.

Lecture 2: Introduction to Sets.

- A set is a collection of distinct objects.
- Denoted using curly braces: $A = \{1, 2, 3\}$
- Elements are unordered and no duplicates.
- Membership notation: $x \in A$, $y \notin A$

Application of Set Theory

- Databases (SQL uses set operations).
- Programming (Python sets, Java HashSet).
- Logic and proof theory.
- Relations and functions.

How to Define a Set?

- Roster Method: Explicit listing: issues with this?
  - $A = \{1, 2, 3, 4\}$
- Set-builder Notation: More precise, and unambiguous.
  - $B = \{x \mid x \text{ is an even number}, x < 10\}$

Types of Sets

- Finite and Infinite Sets
    - $A = \{1, 2, 3\}$ (finite), $\mathbb{N} = \{0, 1, 2, 3, \ldots\}$ (infinite)
- Empty Set: $\emptyset = \{\}$, Subset: $A \subseteq B$ – every element of A is included in B, Superset $B \supseteq A$: vice versa. Universal Sets?
- Proper/Strict Subset: $A \subset B$ means $A \subseteq B$ and $A \neq B$, Proper/Strict Superset $A \supset B$ means $A \supseteq B$ and $A \neq B$

Elementary Set Opertations.

- Union: $A \cup B = \{x \mid x \in A \text{ or } x \in B\}$
- Intersection: $A \cap B = \{x \mid x \in A \text{ and } x \in B\}$
- Difference: $A - B = \{x \mid x \in A \text{ and } x \notin B\}$
- Complement: $A' = \{x \mid x \notin A\}$ (w.r.t. a universal set)

Venn Diagram

- Visual Representation of sets and its operations: On board.

Properties of Set Operations

- Commutative: $A \cup B = B \cup A$, $A \cap B = B \cap A$
- Associative: $(A \cup B) \cup C = A \cup (B \cup C)$
- Distributive: $A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$
- De Morgan's Laws:

$$\neg(A \cup B) = \neg A \cap \neg B, \quad \neg(A \cap B) = \neg A \cup \neg B$$

Cartesian Product.

- $A \times B = \{(a, b) \mid a \in A \text{ and } b \in B\}$
- Example:
- $A = \{1, 2\}, B = \{x, y\}$
- $A \times B = \{(1, x), (1, y), (2, x), (2, y)\}$

Some Interesting Puzzles/Observations.

- Russel's paradox – issues with existing set theory – on board.
- Comparing infinities.
- Behind which door is the treasure. A lair and a truthful person.
- Paradox examples – escaping punishment.
- The Hydra.

Elementary Logic

- Propositional Logic: Logical Operators, truth table, equivalence, rules of inference.
- First Order Logic.