CS 692: Capstone Exam
Theory Exam

Spring 2025, April 25, 2025 3:00-4:30pm

Instructions:

1. You can write your answers on **both sides of the paper**. If you run out of space as you answer the questions on the front pages, continue your answer on the back of the page. Please do not ask the instructor whether you can write on the back side of the paper. The answer is YES YOU CAN.

2. You may use the last paper sheet (front and back) as scratch paper. It is also marked as scratch paper. Please note that the instructor will NOT grade the scratch paper. The scratch sheet stays with the instructor. Please do not detach it.

3. Do NOT detach the exam sheets. If at any point the papers got detached, raise your hand and request for them to be stapled immediately.

4. You are NOT allowed to use Calculator.

5. You are NOT allowed to have your cell phone, e-watch, or other electronic devices nearby (on the desk or inside your pocket). They should be turned off and stay inside your bag or backpack which will be placed in the front or back of the room.

6. Exam duration: 3:00 to 4:30 pm.

Name	
NetID	

Check which TWO problems you are submitting:

☐	Problem 1
☐	Problem 2
☐	Problem 3

Problem 1. [Category: Design] Consider the language $L = \{w | w$ has odd length, or w begins with 0 and ends in 1$\}$ over $\Sigma = \{0, 1\}$.

(a) Give the state diagram of the NFA that recognizes the language L, and this NFA must use ϵ-transition(s) to differentiate from a DFA that is asked in part (b). You do NOT need to justify your answer. [**10 points**]

(b) Give the state diagram of the DFA that recognizes the language L. You do NOT need to justify your answer. [**10 points**]

Problem 2. [Category: Design] Consider the language that contains **all palindrome strings that have odd length** over $\Sigma = \{0, 1\}$.

(a) Give the Context-Free Grammar for this language. You only need to write out the grammar's rules with **S** as the starting symbol. You do NOT need to give the formal full definition of the grammar. You do NOT need to justify your answer. **[8 points]**

(b) Write one difference between Pushdown Automata and Turing machines. **[2 points]**

(c) Give the state diagram of the Deterministic One-tape Turing Machine that decides this language. You do NOT need to justify your answer.

For the Turing Machine, please ONLY use ⊔ to denote the blank symbol, and transitions are labeled as shown in the Figure below where α, β can be the blank symbol ⊔, : **[10 points]**
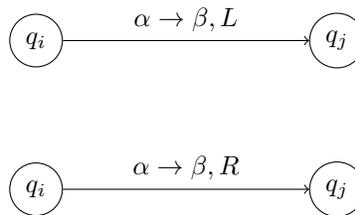

Figure 1: Notation format for Turing Machine: read symbol α, write symbol β, move to left (L) or right (R)

Problem 3. [Category: Proof]

A **Hamiltonian path** in a directed graph G is a directed path that goes through each node exactly once. Let

$$HAMPATH = \{\langle G, s, t \rangle \mid G \text{ is a directed graph with a Hamiltonian path from } s \text{ to } t\}.$$

(a) Show that $HAMPATH$ is in NP. **[15 points]**

(b) $HAMPATH$ is NP-complete, give the definition of NP-complete. **[5 points]**