

Practice Final Exam

(8:45 AM – 10:45 AM : 120 Minutes)

- This exam will account for 30% of your overall grade.
- There are seven (7) questions, worth 120 points in total. Please answer all of them.
- This is a *closed book, closed notes* exam. *No cheat sheets* are allowed.
- You are allowed to *use scratch papers* for your calculations.
- You are *not allowed to use your own calculator*. A scientific calculator will be available inside the Respondus Lockdown Browser.

GOOD LUCK!

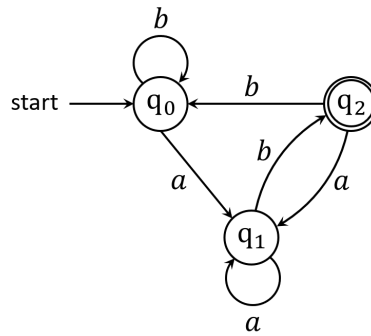
Question	Parts	Points
1. Construct CFG	–	15
2. Construct CFG from DFA	–	10
3. Convert CFG to CNS	–	15
4. Non-CFL	–	20
5. Construct TM	–	20
6. Easy or Hard?	(a)–(b)	$5 + 10 = 15$
7. True or False?	(a)–(e)	$5 \times 5 = 25$
Total		120

QUESTION 1. [15 Points] Construct CFG. Write down a Context-free Grammar (CFG) to accept the following language.

$$L = \{w \mid w \in \Sigma^* \text{ and } n_a(w) = n_b(w) = n_c(w)\}, \quad \Sigma = \{a, b, c\},$$

where, $n_x(w)$ represents the number of occurrences of symbol x in string w .

QUESTION 2. [10 Points] Construct CFG from DFA. Convert the following Deterministic Finite Automata (DFA) to an equivalent CFG assuming $\Sigma = \{a, b\}$.



QUESTION 3. [15 Points] Convert CFG to CNS. Convert the following CFG to Chomsky Normal Form (CNF). Please show the transformation step by step (as shown in the class).

$$\begin{aligned} S &\rightarrow ASA \mid A \mid \epsilon \\ A &\rightarrow AA \mid \epsilon \end{aligned}$$

QUESTION 4. [20 Points] Non-CFL. Use the pumping lemma to show that the following is not a Context-free Language (CFL).

$$L = \{a^{\Delta n} \mid n \geq 0, \Delta n = 1 + 2 + 3 + \dots + n, \Delta 0 = 0\}, \quad \Sigma = \{a\}$$

QUESTION 5. [20 Points] Construct TM. Construct a Turing Machine (TM) for identifying the following language. Write down the TM in the 6-tuple format.

$$L = \{\text{strings containing the substring } baba\}, \quad \Sigma = \{a, b\}$$

You do not need to draw the state transition diagram.

QUESTION 6. [15 Points] Easy or Hard? From a CSE 303 class of n students we want to select the largest possible number of students such that the SBU IDs of no two chosen students have a common substring of length more than three. For example, if 112252235 and 121225703 are the SBU IDs of two students then both of them cannot be chosen simultaneously as their SBU IDs share a substring of length 4 (i.e., 1225).

- (a) [**5 Points**] Which problem that we discussed in the class does this problem remind you of?
- (b) [**10 Points**] Is this problem NP-hard or solvable in polynomial time (**5 points**)? In one or two sentences write down the main idea supporting your answer (**5 points**).

QUESTION 7. [25 Points] True or False? State if the following statements are true or false (**2 points** each). Justify each of your answers in one or two sentences (**3 points** each).

- (a) [**5 Points**] The following language is Turing-decidable: $L = \{\text{programs that do not halt}\}$.
- (b) [**5 Points**] Context-free Grammar is Turing-complete.
- (c) [**5 Points**] A TM never halts when deciding a Turing-semidecidable language.
- (d) [**5 Points**] The set of all algorithms is countable.
- (e) [**5 Points**] At least two problems are known that are in NP but not in P.