CSE 105
Individual Homework 5
Due: Tuesday February 20, 2018 at 11:00PM (on Gradescope)

INSTRUCTIONS
This **Individual HW5** must be completed without any collaboration with other students in this class. The only allowed sources of help for this homework are the class textbook, notes, and podcast, and the instructional team. Two of the questions on this homework will be graded for fair effort completeness; one will be graded for correctness. Your homework **must be typed**.

READING Sipser Sections 3.1, 3.2

KEY CONCEPTS Formal definitions of Turing machines, computations of Turing machines, halting computations, implementation-level descriptions of Turing machines, recognizable languages, decidable languages.

1. (**10 points**) Consider the Turing Machine

$$(\{q_0, q_1, q_2, q_3, q_4, q_5, q_6, q_{acc}, q_{rej}\}, \{a, b\}, \{a, b, X, \sqcup\}, \delta, q_0, q_{acc}, q_{rej})$$

where δ is defined as:

(q,s)	$\delta((q,s))$	(q,s)	$\delta((q,s))$	(q,s)	$\delta((q,s))$	(q,s)	$\delta((q,s))$
(q_0, a)	$(q_1, \sqcup, R)$	(q_2, a)	$(q_{rej}, \sqcup, R)$	(q_4, a)	(q_4, a, L)	(q_6, a)	$(q_{rej}, \sqcup, R)$
(q_0, b)	$(q_{rej}, \sqcup, R)$	(q_2, b)	(q_3, b, L)	(q_4, b)	$(q_{rej}, \sqcup, R)$	(q_6, b)	$(q_{rej}, \sqcup, R)$
(q_0, X)	$(q_{rej}, \sqcup, R)$	(q_2, X)	$(q_{rej}, \sqcup, R)$	(q_4, X)	(q_5, X, R)	(q_6, X)	(q_6, X, L)
$(q_0, \sqcup)$	$(q_{rej}, \sqcup, R)$	$(q_2, \sqcup)$	$(q_6, \sqcup, L)$	$(q_4, \sqcup)$	$(q_5, \sqcup, R)$	$(q_6, \sqcup)$	$(q_{acc}, \sqcup, R)$
(q_1, a)	(q_1, a, R)	(q_3, a)	(q_4, a, L)	(q_5, a)	(q_1, X, R)		
(q_1, b)	(q_2, X, R)	(q_3, b)	$(q_{rej}, \sqcup, R)$	(q_5, b)	$(q_{rej}, \sqcup, R)$		
(q_1, X)	(q_1, X, R)	(q_3, X)	(q_3, X, L)	(q_5, X)	$(q_{rej}, \sqcup, R)$		
$(q_1, \sqcup)$	$(q_{rej}, \sqcup, R)$	$(q_3, \sqcup)$	$(q_{rej}, \sqcup, R)$	$(q_5, \sqcup)$	$(q_{rej}, \sqcup, R)$		

and

$$\delta((q_{acc}, s)) = (q_{acc}, \sqcup, L) \quad \textit{and} \quad \delta((q_{rej}, s)) = (q_{rej}, \sqcup, L) \qquad \text{for each } s \in \{a, b, X, \sqcup\}$$

a) Draw the state diagram of this Turing machine. For clarity, in your diagram you may leave out all outgoing transitions from q_{acc} and q_{rej} and all incoming transitions to q_{rej}.

(Hint: q_1, q_2, q_3, q_4, q_5 form a pentagon so draw that first.)

b) Trace through the computation of this machine on input $aabb$ by listing each configuration of the machine in turn.

c) Will this machine always halt? Why or why not?

Extra practice; not for credit: is ε accepted by this machine? is the language of this machine infinite?

2. (**10 points**) Give an implementation level description of a Turing machine that recognizes the language

$$\{a^n b^n \mid n > 0\}$$

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3. (**10 points**) Suppose $M = (Q, \Sigma, \Gamma, \delta, q_0, q_{acc}, q_{rej})$ is a Turing machine. Define a new Turing machine

$$M_{new} = (Q, \Sigma, \Gamma, \delta, q_0, q_{rej}, q_{acc})$$

Answer Yes or No and give a brief justification:

a) If M is a decider, is $L(M_{new}) = \overline{L(M)}$?

b) If M is not a decider, is $L(M_{new}) = \overline{L(M)}$?

Extra practice; not for credit
Answer Yes or No and give a brief justification.

a) Can the tape of a Turing machine have a symbol in Σ between two blanks before the machine starts?

b) Can the tape of a Turing machine start with a blank?

c) Can a Turing machine accept an input without reading its last symbol?

d) Are there non-context-free languages that are Turing recognizable?