

**CS 310T-31 - TPCS: Theory of Computation**  
**Quiz 5 Answer Key**  
 December 2, 2004

1. Give context-free grammars that generate the following languages. The alphabet  $\Sigma$  is  $\{0, 1\}$

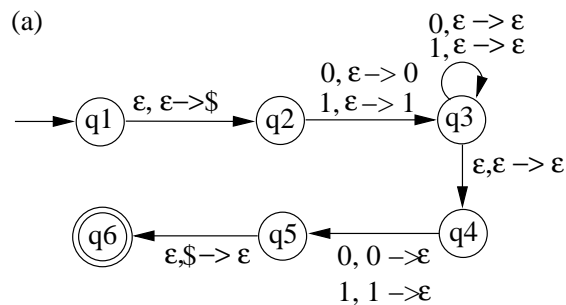
(a)  $\{w \mid w \text{ starts and ends with different symbols}\}$

$A = (V, \Sigma, R, S)$  where,  
 $V = \{S, M\}$ ,  
 $\Sigma = \{0, 1\}$ , and  
 $R = \{S \rightarrow 0M1 \mid 1M0,$   
 $M \rightarrow 0M \mid 1M \mid \epsilon\}$

(b) The set of strings with three times as many 1's than 0's

$B = (V, \Sigma, R, S)$  where,  
 $V = \{S\}$ ,  
 $\Sigma = \{0, 1\}$ , and  
 $R = \{S \rightarrow S0111 \mid S1011 \mid S1101 \mid S1110 \mid$   
 $0S111 \mid 1S011 \mid 1S101 \mid 1S110 \mid$   
 $01S11 \mid 10S11 \mid 11S01 \mid 11S10 \mid$   
 $011S1 \mid 101S1 \mid 110S1 \mid 111S0 \mid$   
 $0111S \mid 1011S \mid 1101S \mid 1110S \mid \epsilon\}$

2. Give state diagrams of PDA for the languages described above.



(b)

