

TOA Assignment # 2 / Ahmad Sadeed Khan  
211-7584.

Q1

a)  $(ab+ba)^* . bba$

$$S \rightarrow Abba.$$

$$A \rightarrow abA \mid baA \mid \epsilon$$

b)  $L = \{a^n b^m c^n d^n ; n, m \geq 2\}$

$$S \rightarrow aaA dd$$

$$A \rightarrow aAd \mid B$$

$$B \rightarrow bbC cc$$

$$C \rightarrow bCc \mid \epsilon.$$

c) A language with words that have equal of as and bs.

$$S \rightarrow aSb \mid bSa \mid SS \mid \epsilon.$$



d)  $\{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } i=j \text{ or } i=k\}$

$$S \rightarrow AB|c$$

$$A \rightarrow aAb|\epsilon$$

$$B \rightarrow cB|\epsilon$$

$$C \rightarrow aCc|D$$

$$D \rightarrow bD|\epsilon$$

e)  $\{x \in \{0,1\}^* \mid \text{the length of } w \text{ is odd and middle symbol is } 1\}$

$$S \rightarrow 0S1 \mid 1S0 \mid 0S0 \mid 1S1 \mid 1$$

f)

$$S \rightarrow iSk \mid A$$

$$A \rightarrow jAk \mid \epsilon$$

g)

$$S \rightarrow A|00B|11c|100 \leftarrow \epsilon$$

$$A \rightarrow 01D|10E|D010|E101$$

$$B \rightarrow 0B|\epsilon$$

$$C \rightarrow 1C|\epsilon$$

$$D \rightarrow 01D|\epsilon$$

$$E \rightarrow 10E|\epsilon$$



h)  $L = \{a^i b^j c^k ; j = i + k ; i \geq 0 ; k \geq 0\}$   
 $S \rightarrow AB$   
 $A \rightarrow aAb \mid \epsilon$   
 $B \rightarrow bBc \mid \epsilon.$

i)  $L = \{a^i b^j c^k ; i \leq 2j ; i \geq 0 ; k \geq 0\}.$   
 $S \rightarrow ABC$   
 $A \rightarrow aAb \mid aAb \mid \epsilon$   
 $B \rightarrow bB \mid \epsilon$   
 $C \rightarrow cC \mid \epsilon$

j)  $L = \{a^i b^j c^k ; i \geq 2j ; i \geq 0 ; k \geq 0\}$   
 $S \rightarrow ABC$   
 $A \rightarrow aA \mid \epsilon$   
 $B \rightarrow aAb \mid \epsilon.$   
 $C \rightarrow cC \mid \epsilon.$