

Q#01:

$$\Rightarrow L_1 = \{a^n b^m c^n \mid n, m \geq 0\}$$

$$\begin{aligned} S &\rightarrow OS1 \mid A \\ A &\rightarrow 1SO \mid \Lambda \end{aligned}$$

$$\Rightarrow L_2 = \{a^n b^m c^k d^l \mid n, m, k, l \geq 0, n = m + k\}$$

$$\begin{aligned} S &\rightarrow AD \\ A &\rightarrow aAb \mid aAc \mid \Lambda \\ D &\rightarrow dD \mid \Lambda \end{aligned}$$

$$\begin{aligned} S &\rightarrow AD \\ A &\rightarrow aAb \mid \Lambda \\ C &\rightarrow aCc \mid \Lambda \\ D &\rightarrow dD \mid \Lambda \end{aligned}$$

$$\Rightarrow L_6 = \{a^n b^m \mid 2n \leq 2m \leq 3n, n \geq 0\}$$

$$\begin{aligned} S &\rightarrow aA \\ A &\rightarrow aAB_1 \mid B_2 \\ B_1 &\rightarrow b \mid bb \\ B_2 &\rightarrow b \mid bB_2 \end{aligned}$$

$$\Rightarrow L_7 = \{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } i = j + k\}$$

$$\begin{aligned} S &\rightarrow aSc \mid B \\ B &\rightarrow aBb \mid \Lambda \end{aligned}$$

$$\Rightarrow L_3 = \{a^n b^m c^k \mid n, m, k \geq 0 \text{ and } n = 2m + 3k\} \Rightarrow L_8 = \{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } k = i + j\}$$

$$S \rightarrow aaSb \mid aaaS \mid \Lambda$$

$$\begin{aligned} S &\rightarrow aSc \mid B \\ B &\rightarrow bBc \mid \Lambda \end{aligned}$$

$$\Rightarrow L_4 = \{a^n b^m \mid 0 \leq n \leq m \leq 2n\}$$

$$S \rightarrow aSb \mid aSbb \mid \Lambda$$

$$\Rightarrow L_9 = \{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } i \neq j + k\}$$

$$\begin{aligned} S_1 &\rightarrow Ab \mid Ac \\ A &\rightarrow aAB \mid \Lambda \\ B &\rightarrow b \mid c \end{aligned}$$

$$\Rightarrow L_5 = \{a^n b^m \mid m \geq 2n\}$$

$$\begin{aligned} S &\rightarrow aSbb \mid B \\ B &\rightarrow bB \mid \Lambda \end{aligned}$$

$$\begin{aligned} S_2 &\rightarrow aS \mid X \\ X &\rightarrow aXB \mid \Lambda \\ B &\rightarrow b \mid c \end{aligned}$$

$$S \rightarrow S_1 \mid S_2$$

$$\Rightarrow L_0 = \{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } k \neq i+k\}$$

$$\begin{aligned} S_1 &\rightarrow aA \\ A &\rightarrow aA \mid B \\ B &\rightarrow bB \mid C \\ C &\rightarrow cC \mid \Lambda \end{aligned}$$

∴ In other word

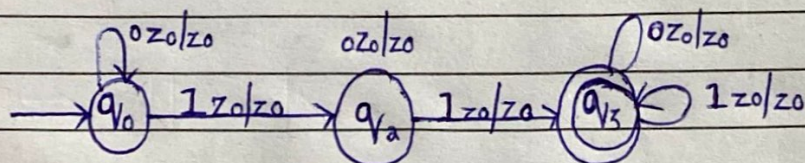
$$k \neq i+k$$

$0 = i$ i cannot be zero

Q#02:

1. $L = \{w \in \{0,1\}^* \mid w \text{ contains at least three 1's}\}$

$$\begin{aligned} S &\rightarrow X1X1X1X \\ X &\rightarrow 0X \mid 1X \mid \Lambda \end{aligned}$$

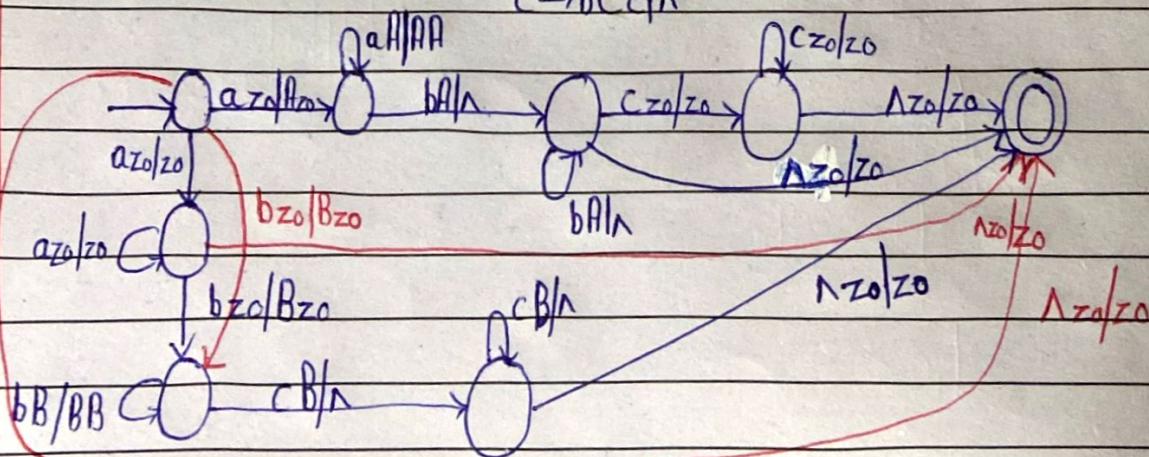


2. $L = \{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } i=j \text{ or } j=k\}$

$$\begin{aligned} S_1 &= aS_1 \mid C \\ C &= cC \mid \Lambda \end{aligned}$$

$$\begin{aligned} S_2 &= AC \\ A &= aA \mid \Lambda \\ C &= bC \mid \Lambda \end{aligned}$$

$$S \rightarrow S_1 \mid S_2$$

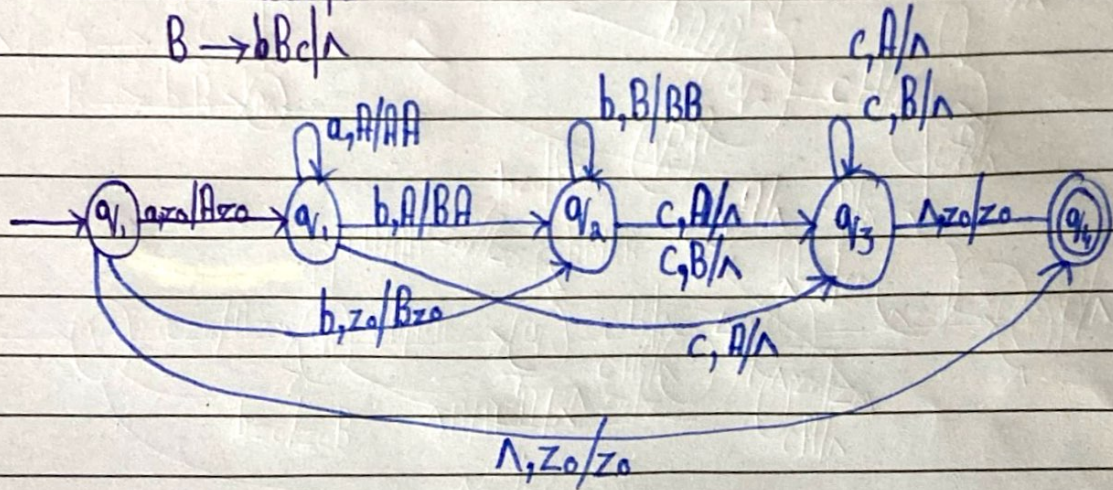


3.

$$L = \{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } k = i + j\}$$

$$S \rightarrow aSc \mid B$$

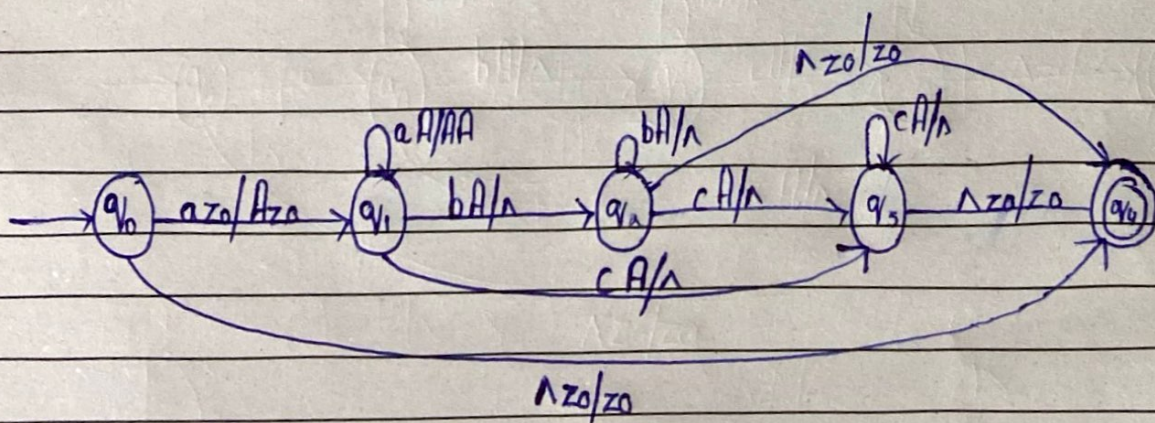
$$B \rightarrow bBc \mid \Lambda$$



$$4. \{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } i = j + k\}$$

$$S \rightarrow aSc \mid B$$

$$B \rightarrow aBb \mid \Lambda$$



5.

$$L = \{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } j = i + k\}$$

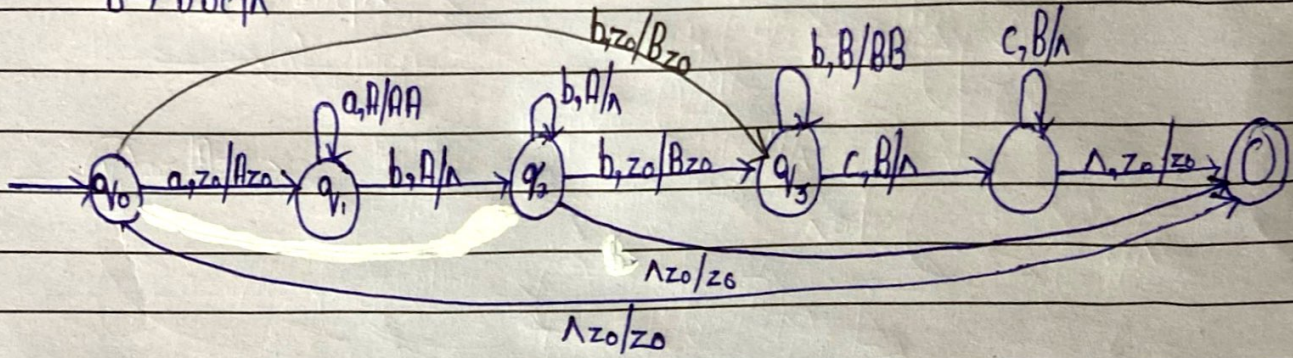
$$S \rightarrow AB$$

$$A \rightarrow aAb \mid \Lambda$$

$$B \rightarrow bBc \mid \Lambda$$

$$S \rightarrow aSbX \mid \Lambda$$

$$X \rightarrow bXc \mid \Lambda$$



6.

$$L = \{10^n 1^n \mid n > 0\} \cup \{110^n 1^{2n} \mid n > 0\}$$

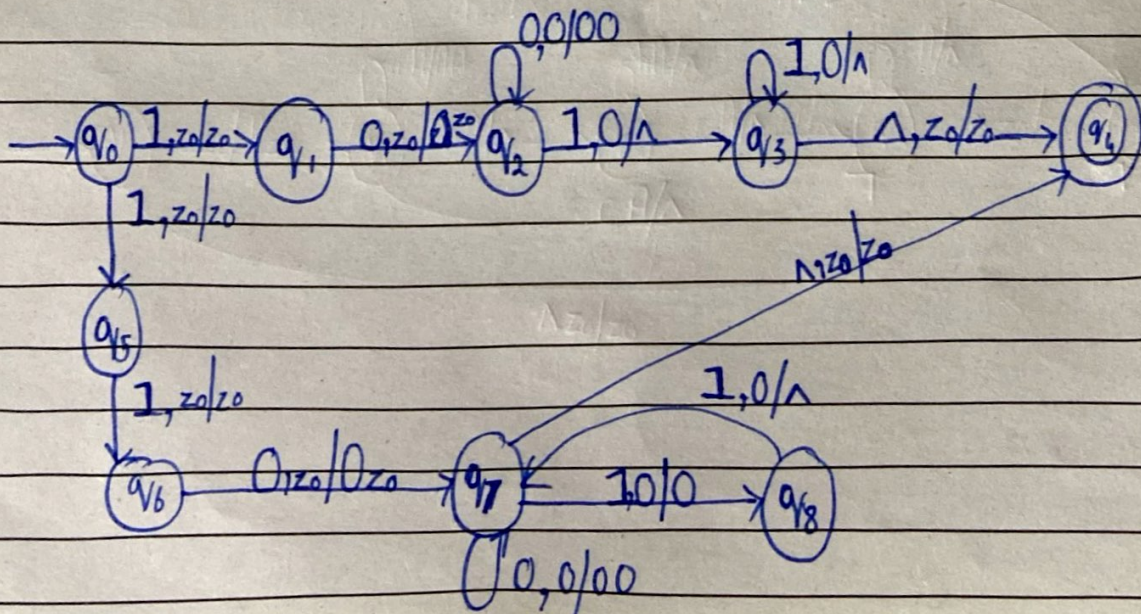
$$S_1 \rightarrow 1X_1$$

$$X_1 \rightarrow 0X_1 1 \mid 01$$

$$S_2 \rightarrow 11X_2$$

$$X_2 \rightarrow 0X_2 11 \mid 011$$

$$S \rightarrow S_1 \mid S_2$$

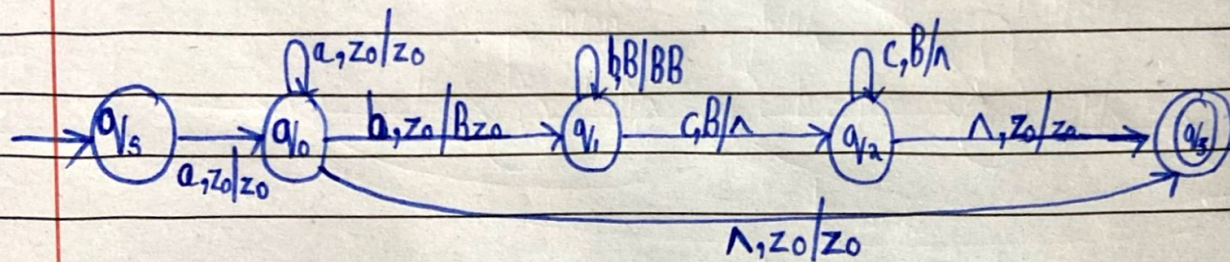


7.

$$L = \{a^n b^m c^m \mid n \geq 0, m \geq 0\}$$

$$\begin{aligned} S &\rightarrow aX \mid aS \\ X &\rightarrow bXc \mid \Lambda \end{aligned}$$

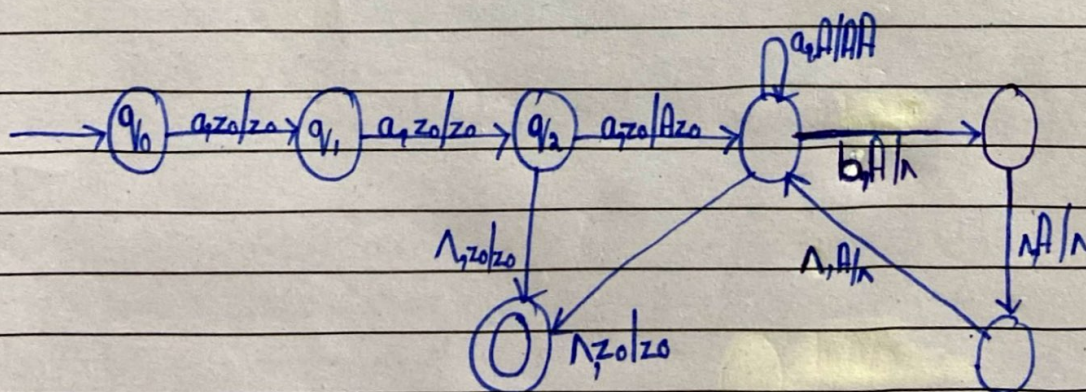
$$\begin{aligned} S &\rightarrow AB \\ A &\rightarrow a \mid aA \\ B &\rightarrow bBc \mid \Lambda \end{aligned}$$



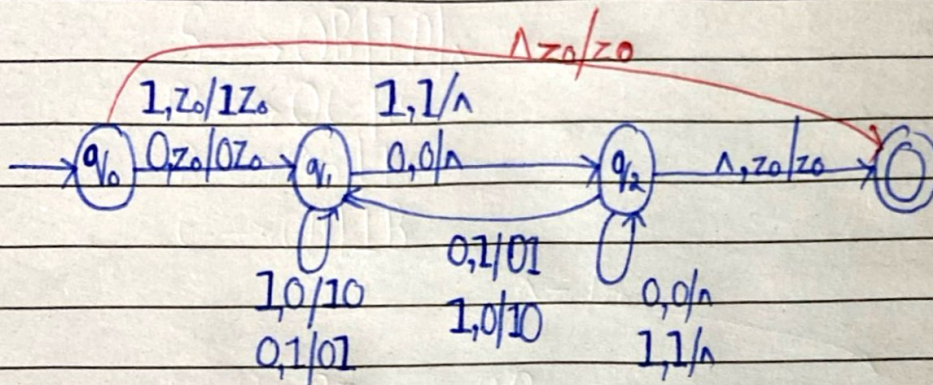
8.

$$L = \{a^i b^j \mid i = 3j + 2\}$$

$$\begin{aligned} S &\rightarrow aaX \\ X &\rightarrow aaaXb \mid \Lambda \end{aligned}$$



9 $\{w \in \{0,1\}^* \mid \text{no of 0's and 1's are even}\}$



$S \rightarrow 0B \mid 1A \mid \wedge$
 $B \rightarrow 0S \mid 1C$
 $A \rightarrow 0C \mid 1S$
 $C \rightarrow 0A \mid 1B$

10 Binary String start and end with same symbol and no of 0's = no of 1's

$S \rightarrow 1X0X0X1 \mid 0X1X1X0$
 $X \rightarrow X1X0X \mid X0X1X \mid \wedge$

