$$S \rightarrow C \cdot S \mid \varepsilon$$
$$C \rightarrow A \cdot B$$
$$A \rightarrow 0 A 1 \mid 01$$
$$B \rightarrow 1 B \mid \varepsilon$$

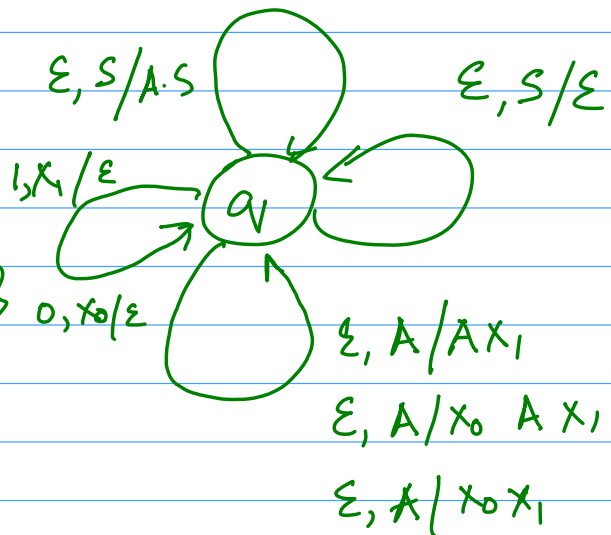$$S \rightarrow A \mid B$$

$$\underline{S} \rightarrow A \cdot S \mid \varepsilon$$
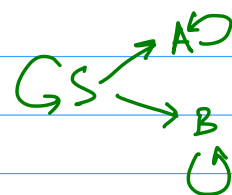$$A \rightarrow A 1 \mid 0 A 1 \mid 01$$

$$\Sigma = \{0, 1\}$$
$$\Gamma = \{S, A, X_0, X_1\}$$

$$\varepsilon, S / A \cdot S$$
$$\varepsilon, S / \varepsilon$$
$$1, X_1 / \varepsilon$$
$$0, X_0 / \varepsilon$$
$$\varepsilon, A / A X_1$$
$$\varepsilon, A / X_0 A X_1$$
$$\varepsilon, A / X_0 X_1$$

$$\underline{S} \rightarrow$$
$$\checkmark A \rightarrow 01 \mid 1A0 \mid \qquad \mid 10$$
$$\quad \begin{array}{l} 0S1 \\ 0D1 \end{array} \qquad \mid 0A1 / 01$$
$$\quad \begin{array}{l} 1D0 \\ 1S0 \end{array}$$

$$G S \rightarrow A \circlearrowright$$
$$\quad \rightarrow B$$
$$\quad \circlearrowleft$$
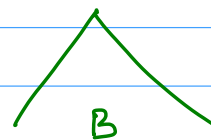
$$S \rightarrow X_0 S_1$$
$$S_1 \rightarrow S X_1$$

$$D \rightarrow \mid 0 A D / 0 A S$$

B

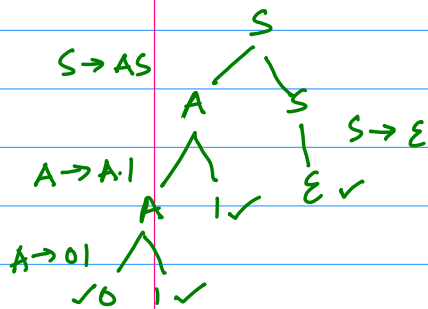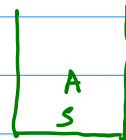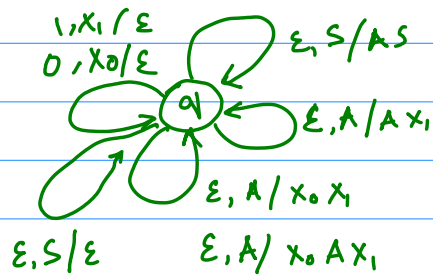$$S \rightarrow X_0 S X_1 \mid X_0 D X_1 \mid X_0 A X_1 \mid X_0 X_1$$
$$\checkmark X_0 \rightarrow 0$$
$$\checkmark X_1 \rightarrow 1$$
$$A \rightarrow X_0 X_1 \mid X_1 A X_0 \mid X_1 D X_0 \mid X_1 S X_0 \mid X_1 X_0$$
$$D \rightarrow X_0 A D \mid X_0 A S \text{----} D \rightarrow X_0 D_1 \quad D_1 \rightarrow A S$$

$S \rightarrow A.S \mid \varepsilon$

$A \rightarrow A1 \mid 0 A1 \mid 01$

$1, X_1 / \varepsilon$
$0, X_0 / \varepsilon$

$\varepsilon, S / AS$

$\varepsilon, A / A X_1$

$\varepsilon, A / X_0 X_1$

$\varepsilon, S / \varepsilon$ $\varepsilon, A / X_0 A X_1$

$\begin{array}{c} A \\ S \end{array}$

$S \rightarrow AS$

$A \rightarrow A.1$

$A \rightarrow 01$

S

A S $S \rightarrow \varepsilon$

A $1 \checkmark$ $\varepsilon \checkmark$

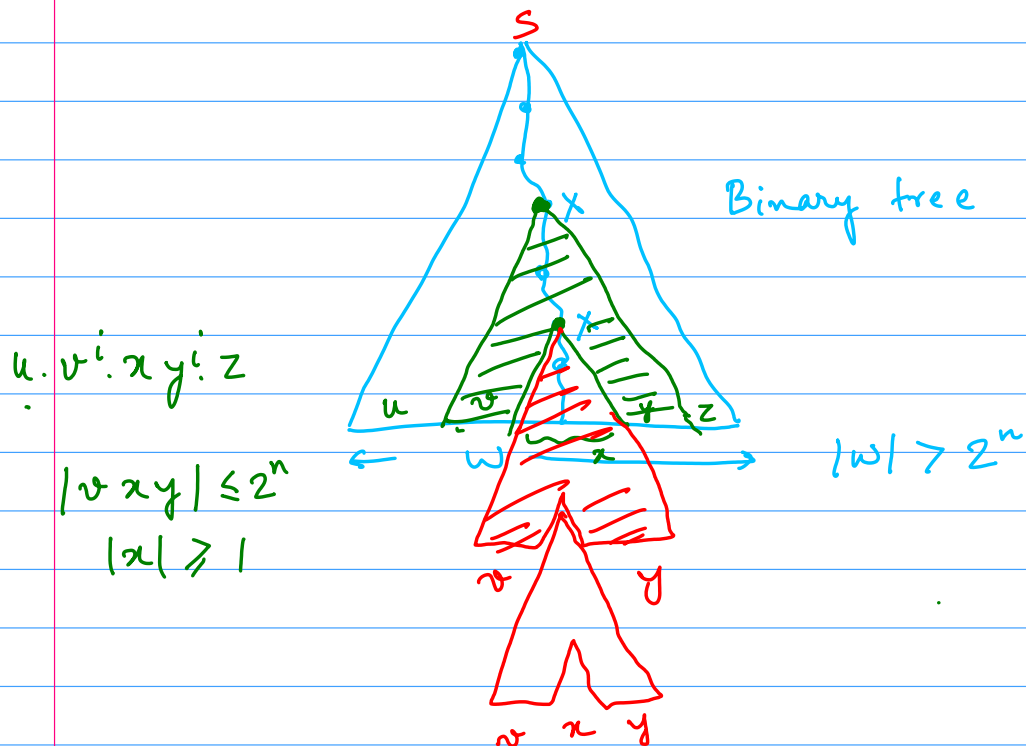$\checkmark 0$ $1 \checkmark$

Chomsky
Normal
Form
(CNF)

{
No useless symbols

No ε production $X \rightarrow \varepsilon$

No unit production $X \rightarrow Y$

All prod. rules : $A \rightarrow BC$

$D \rightarrow 0$

CNF   CFG.   G .... n non-terminals

S

Binary tree

$u.v^i.x y^i.z$

$|v x y| \leq 2^n$

$|x| \geq 1$

$u \quad v \qquad x \; z$

w

$\leftarrow \qquad \qquad \rightarrow \qquad |w| > 2^n$

$v \qquad y$

$v \quad x \quad y$

PL for CFLs

$w = u.v.xy.z.$ $\qquad |w| \geq 2^n$

$\forall i \quad u v^i. x y^i z \in L$

$L = \{ 0^n 1^n 2^n \mid n \geq 0 \}$ $\qquad \Sigma = \{0, 1, 2\}$

$0^{2k} 1^{2k} 2^{2k}$ $\qquad \qquad$ # NT in CNF Grammar

$\qquad \qquad \qquad \qquad \qquad \qquad k = 2$