CFG

$$E \rightarrow E + E \mid E - E \mid E * E \mid E / E \mid (E) \mid id$$

$\boxed{id + id * id}$

$\equiv$

$$E \rightarrow E + E$$

Nonterminals $= \{ E \}$

$$E \rightarrow E - E$$

Terminals $= \{ id, +,$

$$E \rightarrow - -$$

$$-, *, /, (,) \}$$

Initial symbol $= E$

We like this! $\longrightarrow$
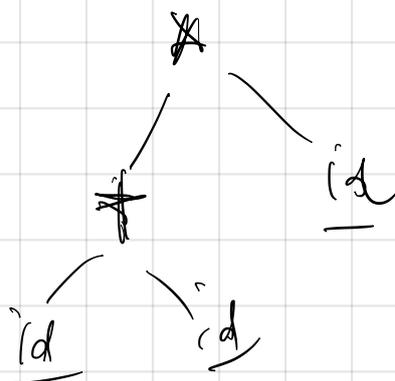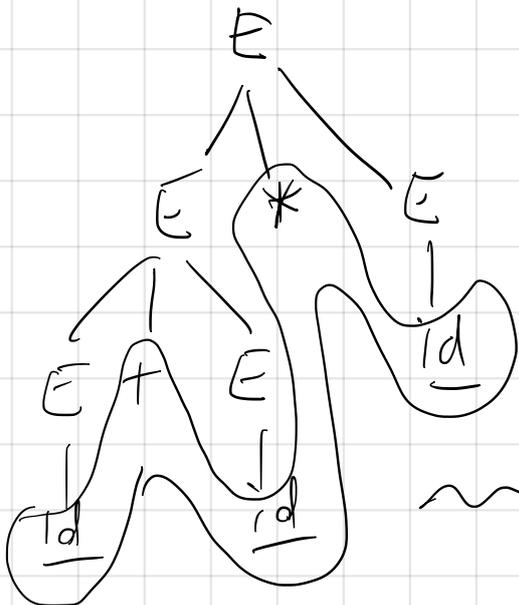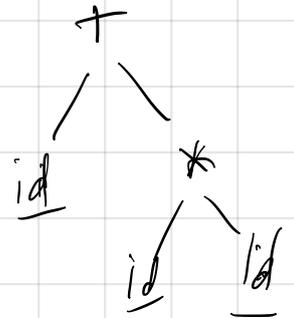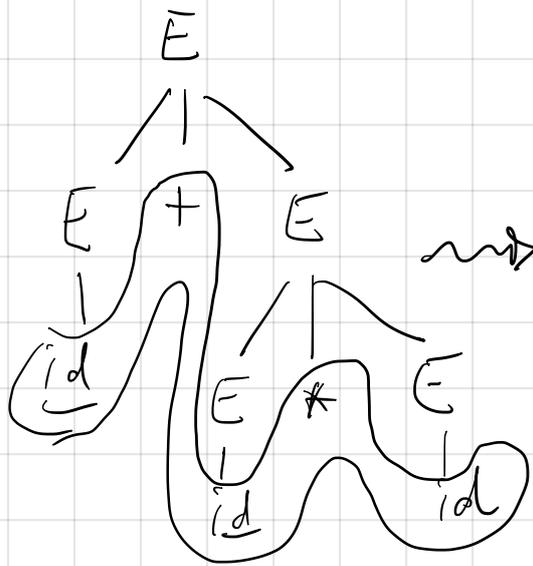
Abstract Syntax Tree

id + id + id

E
├─ E
│ ├─ E
│ │ ├─ E
│ │ │ └─ id
│ │ ├─ +
│ │ └─ E
│ │   └─ id
│ ├─ +
│ └─ E
│   └─ id

E
├─ E
│ └─ id
├─ +
└─ E
   ├─ E
   │ └─ id
   ├─ +
   └─ E
      └─ id
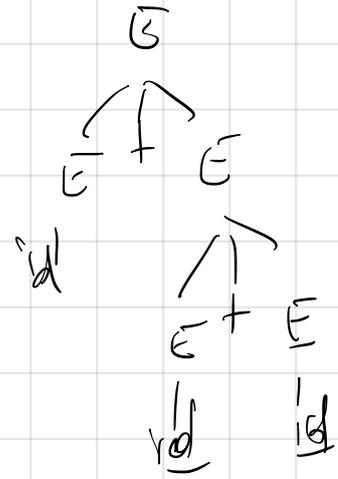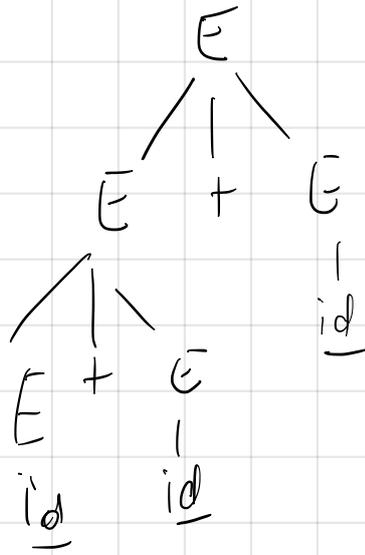
$$E \rightarrow E + T \mid T \mid E - T$$
$$T \rightarrow T * F \mid T / F \mid F$$
$$F \rightarrow id \mid (E)$$

$$id + id * id$$

A parse tree with root E, expanding $E + T$, where $E \to T \to F \to id$ and $T \to T * F$, $T \to F \to id$, $F \to id$.

$\leadsto$ tree with root $+$, left id, right $*$ with children id id.

$$\underline{id}_1 + \underline{id}_2 + \underline{id}_3 + \underline{id}_4 * \underline{id}_5 + \underline{id}_6$$

A large parse tree rooted at $E \to E + T$, expanding repeatedly through $E + T$, $T * F$, down to the id leaves.

$\leadsto$ tree rooted at $+$ with left subtree $+$ (children $+$ and id_6), further nesting $+$, $*$ with id_3, id_4, id_5, and leftmost $+$ over id_1, id_2.

$$L = \{ a^m b^m \mid m \geq 0 \} \not\approx \{ c^m \jmath^n \mid m \geq 0 \}$$

$\{ a, b \}^* \supseteq L$

$\not\subseteq$

NO

$L' \neq L$

INFINITE STATES!

CFG $\{ a^m b^m \mid m \geq 0 \} = L$

$S \rightarrow a S b \mid \varepsilon$
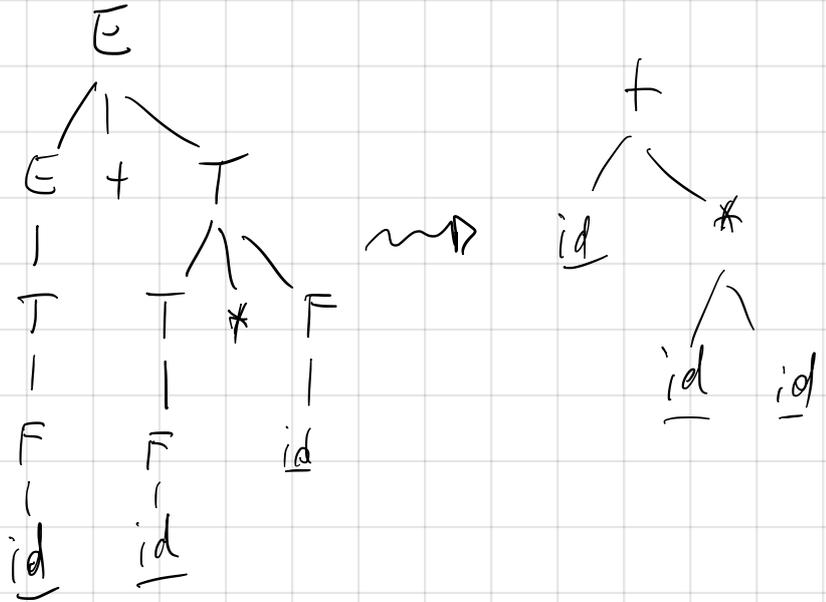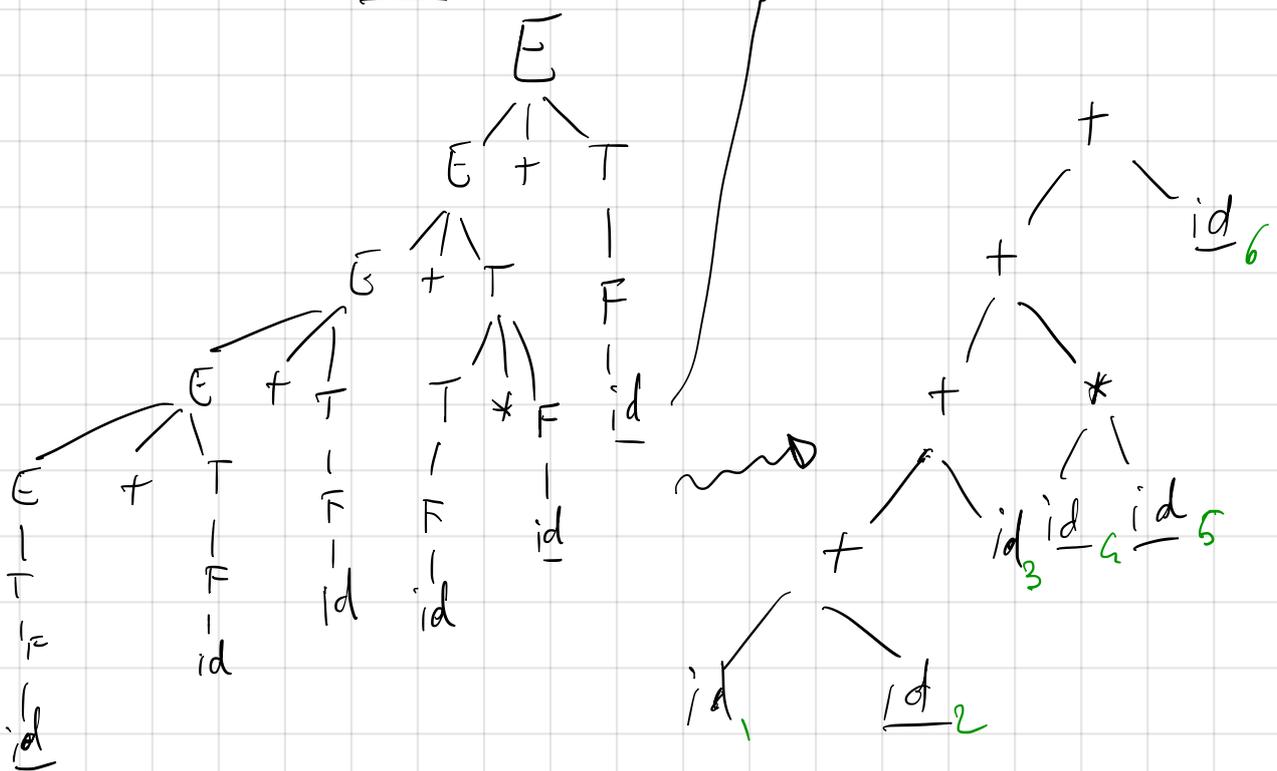
$$L = \{ x \, c \, x^R \mid x \in \{a,b\}^* \} \qquad \Sigma = \{a,b,c\}$$

e.g

$abb \, c \, bba \in L$

$ababbba \, c \, abbbba \in L$

$abcab \notin L$

$$\Gamma = \{Z, A, B\} \qquad S = \{s_0, s_1\}$$

	a	b	c
Z	s_0, ZA	s_0, ZB	s_1, ε
A			
B			

State s_0 initial

acceptance by empty stack

(no final states)

$\rightarrow$ state s_1

	a	b	c
Z			
A	s_1, ε		
B		s_1, ε	

Simulation

a b b c b b a $

STACK

| Z | a → [S₀] ⟶ □⟶▷ | Z A | ← [S₀]

| B B B A | ← [S₁] ⟶ □⟶ | Z B B A | ← | S₀ | ⟶ □⟶ | Z B A | ⟶ [Sₐ]

| B A | ← [S₁] ⟶ □⟶▷ | A | ← [S₁] ⟶ □⟶▷ | | ← [S₁] ⟶▷ $
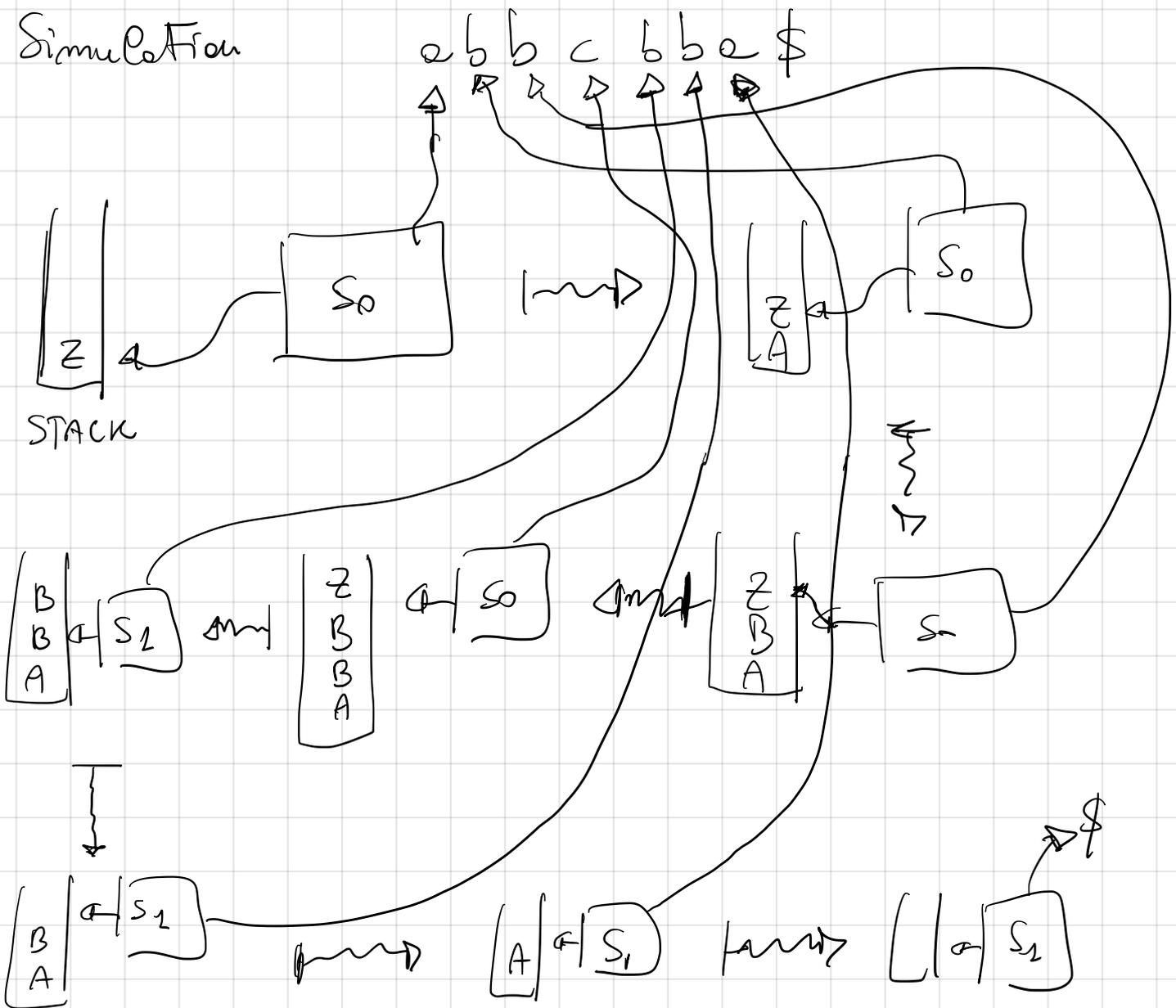
ACCEPT BECAUSE

The stock is empty
and the string is
consumed

$$L = \{ a^n b^m c^{2n} \mid n \geq 0,\ m > 2 \}$$

CFG:

$$S \to a\,S\,cc \mid B$$
$$B \to b \mid Bb$$

$$S = \{ s_0,\ s_1,\ s_2 \}$$

PDA:

$$\Gamma = \{ Z, C, B \} \qquad \Sigma = \{ a, b, c \}$$

s_0	a	b	c
Z	s_0, ZCC	s_1, B	/
C	/	/	/
B	/	/	/

s_1	a	b	c
Z	/	/	/
C	/	/	s_1, ε
B	/	/	/

s_2	a	b	c
Z			
C			
B	/	s_1, B	s_2, ε

Accept by empty stock

Derivation $\qquad E \rightarrow E + E \mid E * E \mid (E) \mid id$

$E \Rightarrow E + E \Rightarrow E * E + E \Rightarrow E * id + E$

$\Rightarrow id * id + E \Rightarrow id * id + id$

Right most derivation

$E \underset{rm}{\Rightarrow} E + E \underset{rm}{\Rightarrow} E + id \underset{rm}{\Rightarrow} E * E + id \underset{rm}{\Rightarrow}$

right most non-terminal symbol

$\underset{rm}{\Rightarrow} E * id + id \underset{rm}{\Rightarrow} id * id + id.$

Left most derivation