CS 138: Section-1

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1. Convert to CNF.
   \[ E \rightarrow E + T \]
   \[ E \rightarrow T \]
   \[ T \rightarrow T \ast F \]
   \[ T \rightarrow F \]
   \[ F \rightarrow (E) \]
   \[ F \rightarrow id \]

2. CYK algorithm: For the given grammar \( G \), decide if \( w = aabba \in L(G) \).
   \[ S \rightarrow AB \]
   \[ S \rightarrow BB | a \]
   \[ S \rightarrow AB | b \]

3. PDA: definition and few basic operations:
   \[ M = (Q, \Sigma, T, \delta, q_0, z, F) \] be a non-deterministic PDA where
   \( T \) is the stack alphabet
   \( z \) is the initial stack symbol
   \[ \delta : Q \times (\Sigma \cup \{\lambda\}) \times T \rightarrow 2^{Q \times T^*} \]
   
   Pushing \( a \) onto the stack: \( (p, u, \lambda) \rightarrow (q, a) \)
   
   Popping \( a \) from the stack: \( (p, u, a) \rightarrow (q, \lambda) \)
   
   Replacing TOS with \( a \): \( (p, u, v) \rightarrow (q, a) \)

4. Construct PDAs for the following languages
   (a) \( L = \{wcw^R \text{ such that } w \in \{a,b\}^* \} \)
   (b) \( L = \{ww^R \text{ such that } w \in \{a,b\}^* \} \)
   (c) \( L = \{w \text{ such that } w \in \{a,b\}^* \text{ and } n_a w = n_b (w) \} \)

5. Is PDA with a queue strictly stronger than PDA with a stack?
   (a) Does there exist a language that can be accepted by a PDA with a queue but not by PDAs with a stack?
   (b) What about \( L = \{ww \text{ such that } w \in \{a,b\}^* \} \)?
   (c) Is the converse true?