1. [5 pts] Give the CFG that generates L = {a^i b^j | $i = j$ *or* $i < j$ *and* $i, j \geq 0$}

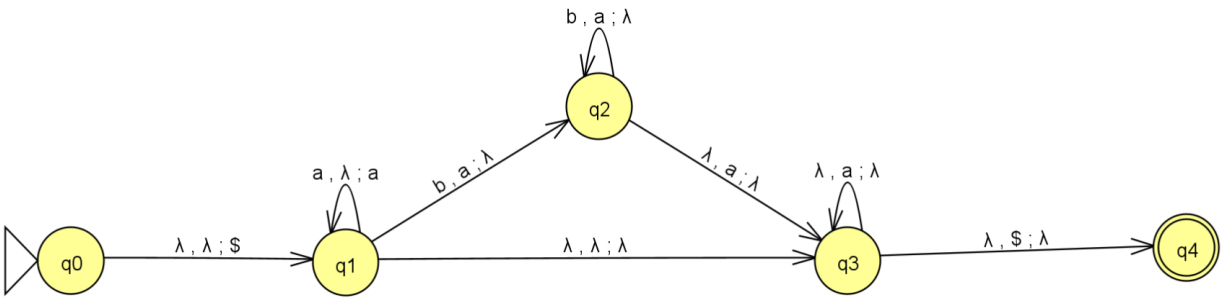
S => aSb | B | ε

B => bB | b | ε

2. Let M be the PDA defined by: Q = {q0, q1, q2, q3, q4}, Σ = {a, b}, Γ = {a, $}, F = {q4} and transition function is defined as below:

$$\delta(q0, \varepsilon, \varepsilon) = (q1, \$)$$
$$\delta(q1, a, \varepsilon) = (q1, a)$$
$$\delta(q1, \varepsilon, \varepsilon) = (q3, \varepsilon)$$
$$\delta(q1, b, a) = (q2, \varepsilon)$$
$$\delta(q2, b, a) = (q2, \varepsilon)$$
$$\delta(q2, \varepsilon, a) = (q3, \varepsilon)$$
$$\delta(q3, \varepsilon, a) = (q3, \varepsilon)$$
$$\delta(q3, \varepsilon, \$) = (q4, \varepsilon)$$

2.1) [3 pts] Use JFLAP (https://www.jflap.org/jflaptmp/, download JFLAP7.1.jar) to draw the state diagram of the PDA.

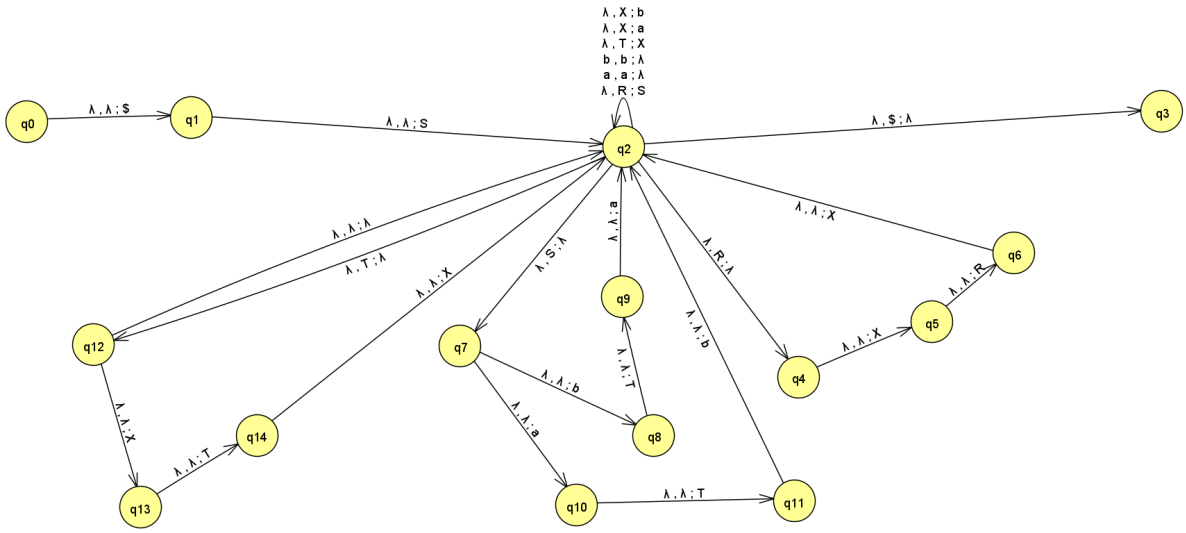


2.2) [2 pts] Use set notation to describe the language accepted by M

L(M) = {a^x b^y | x>y and x≥1, y≥0}

3. [10 pts] Convert the following contest-free grammar into equivalent generalized non-deterministic PDA using algorithm presented in class (Theorem 2.20, pp.136). Draw the PDA's state diagram.

$$R \longrightarrow XRX \mid S$$
$$S \longrightarrow aTb \mid bTa$$
$$T \longrightarrow XTX \mid X \mid \varepsilon$$
$$X \longrightarrow a \mid b$$



Q0 is INITIAL and Q3 is FINAL
Q1 to Q2 should be as follows λ,λ;R