Name: Harshit Jain
User ID: hmj5262

Problem 1

1. (aa)* b (bb)*?
2. ε | a | b | (a | b) (ab | ba | bb)
3. (b | ab)*a?
4. (ab*c) | (ba*c) | (ac*b) | (bc*a) | (cb*a) | (ca*b)
5. It can not be constructed because regex cannot do storage.
6. [a-z, A-Z, 0-9]{13,18} @ [a-z, A-Z] {4} (.edu)
7. .* ((( ) .*

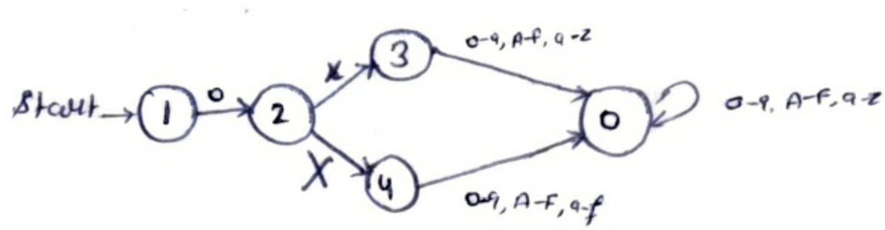
Problem 2

1. Java is both interpreted and compiled. The Java source code is first compiled into bytecode, which is a machine-independent code that runs on the Java Virtual Machine (JVM). The JVM then interprets the bytecode and executes the corresponding machine code.

   So, in a sense, Java is compiled into an intermediate form (bytecode) and then interpreted by the JVM. However, the JVM can also use just-in-time (JIT) compilation to dynamically compile the bytecode into machine code for improved performance at runtime.

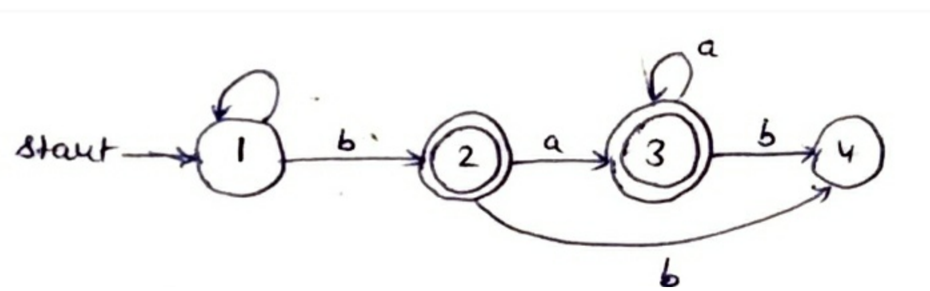
   Therefore, in a broader sense, Java can be considered both compiled and interpreted, depending on the stage of the execution process and the specific implementation of the JVM.

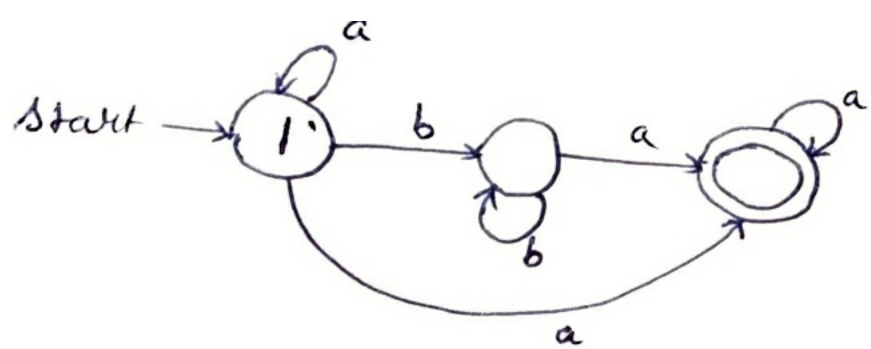
2. It would not be a DFA if arrows are inverted.



3. DFAs are subsets of NFAs, therefore no conversion needed.

4. It is not possible because DFA has no storage.

5. 

6. 

Problem 3

1. $S \rightarrow aXb \mid bXa$
   $X \rightarrow aX \mid bX \mid \varepsilon$

2. $S \rightarrow aSb \mid bSa \mid \varepsilon$

3. Yes, the given grammar is ambiguous because it does not specify a unique parse tree for any string in the language. The unambiguous grammar is:
   $< binary - string > \rightarrow < b > | < binary - string > < b >$
   $< b > \rightarrow 0 \mid 1$

Problem 4

1. $S \rightarrow S - S$

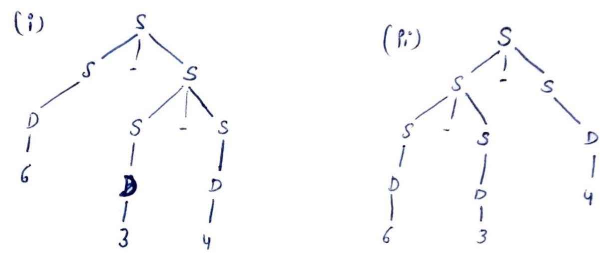
   $S \rightarrow D - S$

   $S \rightarrow 6 - S - S$

   $S \rightarrow 6 - D - S$

   $S \rightarrow 6 - 3 - D$

   $S \rightarrow 6 - 3 - 4$

2. 

3. This derivation can continue indefinitely, as there is no rule to reduce the expression to a single number. Therefore, "9 - 1 -" is not a well-formed expression according to this grammar.

4. $S \rightarrow S - S$

   $S \rightarrow S + S - S$

   $S \rightarrow S + D - S$

   $S \rightarrow S + S + 3 - D$

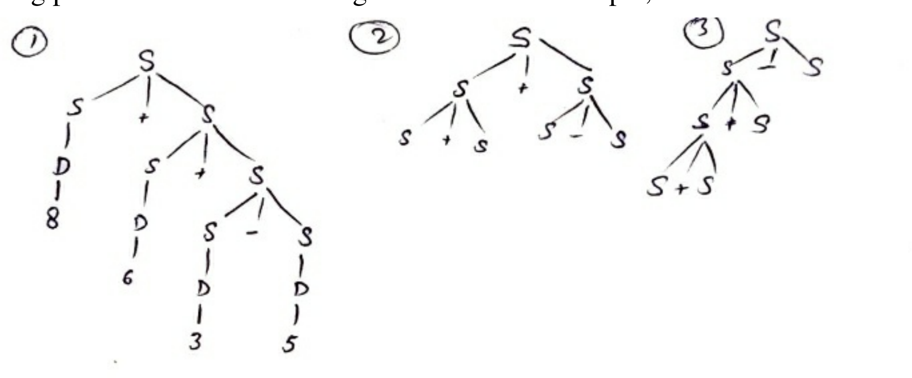
   $S \rightarrow D + D + 3 - 5$

   $S \rightarrow 8 + 6 + 3 - 5$

5. Leftmost derivations are those that start at the root of the parse tree and go down the tree towards the leaves, replacing the leftmost non-terminal symbol with its expansion at each step.

   Rightmost derivations are those that start at the leaves of the parse tree and go up the tree towards the root, replacing the rightmost non-terminal symbol with its expansion at each step.

   There are 3 leftmost & rightmost derivations each (total = 6) for this string because there are 3 potential starting positions and no branching decisions. For example, the 2 leftmost derivations would be:

   All of these trees can be further expanded and can be reached by both right and left most derivations.

Problem 5

1. There are 3 parse trees possible.
2. No, the number of derivations for the string in Q4.4 is not same as the number of parse trees because everytime left/rightmost have to choose a branch where there is another possible route to be picked. Therefore, the derivation to reach the same tree can vary.
3. Yes, the grammar is ambiguous because there are multiple parse trees possible and the structure is not uniquely defined and it has associativity.
4. $S \rightarrow S + T \mid T$

   $T \rightarrow T - F \mid F$

   $F \rightarrow D \mid S$

   D is the mathematical digits.
5. Yes. We can control the precedence of $'+'$ and $'-'$ signs. The grammar in 5.4 gives $'-'$ sign precedence over $'+'$. Other way is to give precedence to $'+'$.

Problem 6

1. $S \to DS \mid ,X \mid \varepsilon$

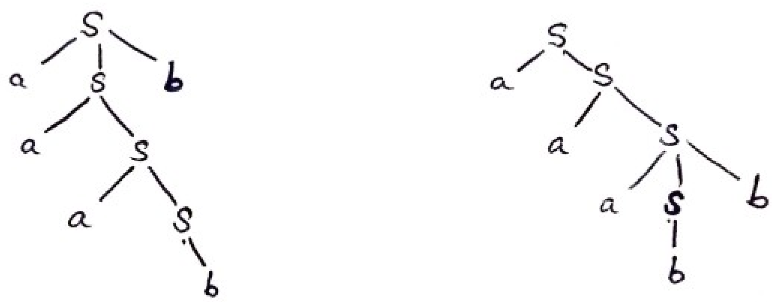
   $X \to DS$

   $D \to 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$

   It is unambiguous because the grammar is right recursive and right associated.

2. Yes, this grammar is ambiguous because there are multiple parse trees possible. Here's is an example:

   S = "aaa bb"

   The unambiguous grammar is:

   $S \to aS \mid T$

   $T \to Tb \mid F$

   $F \to b \mid \varepsilon$

3. $E \to E + T \mid T$

   $T \to T - F \mid F$

   $F \to \neg F \mid D$

   $D \to 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$

4. Yes, context-free grammars can represent all regular languages.

   Yes, because all regular languages can be represented by CFGs.

   No, Context-free grammars cannot represent all possible languages (i.e. non-regular).