1. (25 points) Graph search and topological sorting
   a. (10 points) Consider a breadth-first search of the following directed graph, starting at vertex 0. Draw the breadth-first tree and the time stamps in which the vertices are visited. Iterate through the neighbors of v in increasing order. Did BFS eventually visit all vertices in the graph?

   b. (10 points) Consider a depth-first search of the following directed graph, starting at vertex 0. Draw the depth-first tree, the time stamps in which the vertices are first visited, and the time stamps in which the vertices are finished. (Iterate through the neighbors of v in increasing order.) Did DFS eventually visit all vertices in the graph?

   c. (5 points) Show the topologically sorted order of the vertices of the above graph, using the results you obtained above in 1(b).
2. (15 points) **P and NP**
   Determine whether the following statement is true or false. Briefly justify your answers.
   
   a. **P** is the class of all problems that can be solved in polynomial time.

   b. **NP** is the class of all decision problems that cannot be solved in polynomial time.

   c. A problem is **NP-complete** if it is both **NP-hard** and in **NP**.

   d. If SAT can be solved in polynomial time, all problems in **NP** can be solved in polynomial time.

   e. Suppose \( \Pi_1 \) and \( \Pi_2 \) are two decision problems and \( \Pi_1 \) is polynomial time reducible to \( \Pi_2 \), i.e., \( \Pi_1 \leq_p \Pi_2 \). If \( \Pi_1 \) is in **NP**, then \( \Pi_2 \) is also in **NP**.

3. (Extra credit: 15 points) **Suffix Tree**
   
   a. Draw a suffix tree for the string *taataataaa*. Label the edges and terminal nodes explicitly.
b. **Shortest nonrepeated substring.** Design an efficient algorithm for finding the shortest substring that appears in a text only once.


c. **Shortest signature substrings.** Design an efficient algorithm to find the minimum $l$ for a set of strings $T_1, T_2, \ldots, T_k$, such that there exist a unique “signature” substring of length $l$ for each string. For example, if $T_1 = \text{ACGACGTA}$, $T_2 = \text{ACTATGAC}$, and $T_3 = \text{GATAGTA}$, the smallest $l = 2$, since a signature of length 2 can be found for each string: CG only appears in $T_1$, CT only in $T_2$ and AG only in $T_3$.

4. (Extra credit - 10 points) Please provide any comments/suggestions about the lecture, recitation, and homework. Use additional page if necessary.