32002: Artificial Intelligence Assignment # 3
(For Self-test)

1. Consider the standard Towers of Hanoi problem with 3-pegs, and 4 number of disks (d_1, d_2, d_3, d_4, with d_1 at top). The disks are to be transferred from start-peg to end-peg, using intermediate peg, one at a time such that at no time larger disk comes over the smaller. The disk d_1 is smallest and d_4 is largest. Make use of only 3-predicates: unary predicate: *clear*, and binary predicates: *on* and *smaller*, and only one action: $puton(x, y)$ needs to be used.

   Write the domain of the problem, and make use of *forward planning* to plan the solution to move all the 4 disks from start-peg to end-peg.

2. Given the 3-SAT problem:

$$(\neg p_1 \vee p_2 \vee p_3) \wedge (p_1 \vee \neg p_2 \vee p_3) \wedge (p_1 \vee p_2 \vee \neg p_3)$$

   Solve it using *forward planning.* (Hint: you need to assume some *operators* (i.e., actions) to assign the values to variables $p_1 \ldots p_3$.)

3. Given the Table T, and blocks A, B, C, D, apply the STRIPS to plan the solution of following problem:

   Initial state **I** :

$$clear(A), clear(B), clear(C), clear(D), on(A, T),$$
$$on(B, T), on(C, T), on(D, T)$$

   i.e., the blocks $A \ldots D$ are on table, and their tops are clear.

   Final State **F** :
   $on(A, T), on(A, B), on(B, C), on(C, D), on(D, T), clear(A).$

   Use the action $puton(X, Y)$, where X is a block $A \ldots D$ and Y is either table T or block $A \ldots D$. Give the forward planning to reach state **G** starting from state **I**.

4. Demonstrate the min-max search for tic-tac-toe puzzle (10 steps).

5. Demonstrate the alpha-beta search for tic-tac-toe puzzle.

6. A game *nim* is played as follows: there are two players who remove one, two, or three coins, alternately from a stack of five coins. Represent this game playing as a search tree. Suggest any suitable strategy for winning this game?

7. Given the tree in figure 1, explore this tree using the alpha-beta procedure. Indicate all parts of this tree that are cut off. Also, indicate the winning path(s), and strike out all the values that are not required to be computed.

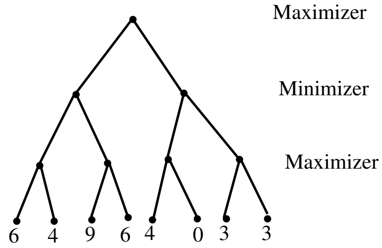

Figure 1: Alpha-beta search.

8. The Minimal Bandwidth Ordering Problem (CSP) is explained as follows: Given a graph (V, E), where V is a set of vertices and E is a set of edges $(x, y); x, y \in V$, if we order the vertices, the bandwidth of a vertex x is the maximum distance between x and a vertex y that is adjacent to it. The bandwidth of the ordering is the *maximum bandwidth* of all the nodes under that ordering. The *minimal bandwidth* ordering problem is to find an ordering with the minimum bandwidth.

   (a) Formulate the Minimal Bandwidth Ordering Problem as a constraint satisfaction problem. Clearly state the variables, domains and constraints. Ignore the minimization requirement.

   (b) Given your formulation in (a), describe the topology of the constraint graph.

   (c) Given your formulation in (a), what is the size of the search space?

   (d) Extend your formulation in (a) to a constraint optimization problem. Describe the objective function by reference to your variable assignments.

   (e) Are there any constraint satisfaction techniques effective for solving the optimization problem that you formulated above? If yes, name one such technique and evaluate how effective it is. If no, justify your answer carefully.

9. What algorithms or heuristics are relevant to solving some constraint satisfaction problems under the following situations. Justify your answers carefully.

   (a) The domain sizes vary significantly: some variables have very large domains (over 1,000 values) and some have very small domains (with fewer than 10 values).

   (b) The problem is so tightly constrained that it is highly unlikely that solutions exist.

10. There is a fixed number of Professors, to whom a list of courses are to be offered, and there is a list of possible time slots for the classes to be held. Each professor has a corresponding set of courses that he or she can teach. Assume that there are abundant number of class rooms, hence no constraint over the class-rooms. Give a precise formulation for the above as a CSP (constraint satisfaction problem).