1. (20p) A partial search tree for a two player game is given below.

a) (10p) Find the best move for the MAX player using the minimax procedure.

b) (10p) Using alpha-beta pruning show which parts of the tree do not need to be searched. Indicate where the cutoffs occur.
2. (30p) The sliding-tile puzzle consists of three black tiles, three white tiles and an empty space in the configuration shown below

```
| B | B | B | W | W | W |
```

The puzzle has two legal moves with associate costs:

- A tile may move into an adjacent empty location. This has a cost of 1. A tile can move over one or two other tiles into the empty position. This has a cost equal to the number of tiles jumped over.

The goal is to have all the white tiles to the left of all the black tiles. The position of the blank is not important.

a) (10p) Choose a representation for this problem so that the best-first search procedure can be applied to find a solution.

b) (10p) Propose two heuristics for solving this problem.

c) (10p) Show all states that can be reached from the start and compute their $g$ and $h$ values for one of your heuristics.
3. (12p) Answer briefly:

   a) (3p) What is the major difference between blind and heuristic search methods.
   b) (3p) Enumerate and define three major blind search methods.
   c) (6p) How is the hill-climbing method different from the best-first search method? For what classes of problems are the hill-climbing and the best-first search methods equivalent?
4. (30p) Consider the sentence “Heads I win; tails you lose”. We can represent this sentence plus associated domain knowledge in the propositional logic using the following proper axioms, where Heads, Tails, WinMe, and LoseYou are propositional variables:

\[
\begin{align*}
    Heads & \supset WinMe \\
    Tails & \supset LoseYou \\
    \neg Heads & \supset Tails \\
    LoseYou & \supset WinMe
\end{align*}
\]

a) (10p) Determine if it is possible to prove WinMe using just the rule of inference modus ponens and these four axioms.

b) (5p) Convert each of the four axioms to a disjunction of literals.

c) (5p) For each of the resulting disjunctions, specify if it is a Horn clause.

d) (10p) Determine if it is possible to prove WinMe using just the resolution rule of inference and the four axioms written as disjunctions of literals.
5. (8p) What do these functions do?

a) (4p) (defun enigma (x)
     (and (not (null x))
         (or (null (car x))
             (enigma (cdr x))))

b) (4p) (defun mystery (x y)
     (if (null y)
         nil
         (if (eql (car y) x)
             0
             (let ((z (mystery x (cdr y))))
                 (and z (+ z 1))))))
6. (10p) A friend is trying to write a function that returns the sum of all the non-nil elements in a list. He has written two versions of this function, and neither of them work. Explain what’s wrong with each, and give a correct version:

a) (5p) `(defun summit (lst)
       (remove nil lst)
       (apply #'+ lst))`

b) (5p) `(defun summit (lst)
       (let ((x (car lst)))
       (if (null x)
           (summit (cdr lst))
           (+ x (summit (cdr lst))))))`
7. (10p) Write a version of *union* that preserves the order of the elements in the original lists:

```plaintext
> (my-union '(a b c) '(b a d))
(A B C D)
```