Consider the 8-puzzle game (you can move the empty tile around, thereby changing the position of the numbers).

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Start State
1 2 8
5 6
4 3 7

Goal State
1 2
3 4 5
6 7 8
```

Do the following:

1. Representing the game, with the start and goal states as depicted in the above picture, as a planning problem. Use the following vocabularies:
   a. \text{At}(X,I,J): the tile number X is at the I\textsuperscript{th} column and J\textsuperscript{th} row where (0,0) is the lower left corner and (3,3) is the top right corner; Use 0 for the empty tile;
   b. \text{Left}: the empty tile moves to the left;
   c. \text{Right}: the empty tile moves to the right;
   d. \text{Up}: the empty tile moves up;
   e. \text{Down}: the empty tile moves down;
   f. Additional ones if you need.

2. A frequently used heuristic function for solving this problem – as search problem – is called the \textbf{Manhattan distance} function. Let us denote this function by \( h \). It is the sum of the distances of the tiles from their goal positions. The distance of a tile to its goal position is the sum of the horizontal and vertical distances. For example, the distance of the tile number 1 to its goal is 1; 4 is 2; 3 is 2; etc. The value of \( h \) for the start state is \( 1 + 1 + 2 + 2 + 3 + 2 + 2 + 1 = 15 \).

   Construct the search tree for this problem after 8 expansions. In your construction, us the Manhattan distance heuristic function and A* algorithm.

3. Suppose that you were told that a good way to solve the problem is to select the move that reduces the function \( h \) at every step. Represent this knowledge as a temporal logic formula. You might introduce \textit{defined formulas} to make the representation easier.

   Demonstrate the use of this formula by the TLPlan system by executing the loop in the TLPlan algorithm three times.

4. Let \( \alpha \) be the formula that you develop in question 3. Do you think that \( \alpha \) is a good control formula in that it helps us to select the action that needs to be done at every step?
5. What is the difference between using $\alpha$ (question 3 & 4) and using $h$ (question 2) in solving the problem?

The following question is not related to the above four problems.

6. Write a paragraph detailing the difficulties you meet while working on the project. How did you overcome them?