Answer all questions.

1. "Anti-tic-tac-toe" is a two-player, zero-sum game played using a 4×4 grid. Player X places a cross on an empty square, and player O places a circle on an empty square. The two players play in succession (as in regular tic-tac-toe), we may assume X plays first. Player O wins if three crosses are placed in adjacent squares in the same "loss line" (any of the four rows, four columns, or six "diagonal" lines with slope 1 or -1). Similarly, player X wins if three circles are placed in adjacent squares in the same loss line. For instance, the following states indicate wins for player X, dashes indicate empty squares.

```
--OX    OOOX    -O-X    -O-X    ---X    O--X ---- ---X
-OX-    --X-    -OX-    -XO-    OX-- -O-X --OX ---O
O-X-    --X-    -OX-    --XO    -OX-    --O- -OX- X-OX
----    ----    ----    ----    --O-    XX-- O--X -O--
```

   (a) Execute alpha-beta search using the following heuristic evaluation function:

   $$10(\text{number of loss lines with 3 X's} - \text{number of loss lines with 3 O's})$$

   $$+(\text{number of loss lines with exactly 2 X's} - \text{number of loss lines with exactly 2 O's}),$$

   assuming that you (player O) must move next, from the following position:

```
X-XX
OO--
O-XX
-OOX
```

   [Note that the board evaluation function yields $10(3-0)+(2-7)=25$.]
   Examine precisely three levels of the tree: your current move, X's next possible move, and your next possible move. You may assume that the game terminates when a win or lose position is reached, so that the game tree cannot be elaborated below that position.

   (b) Compare the heuristic function given above to the following one:

   $$\begin{cases} 100 \text{ if there is a line with 3 adjacent X's} \\ -100 \text{ if there is a line with 3 adjacent O's} \\ (\text{number of lines with 2 adjacent X's} - \text{number of lines with 2 adjacent O's}), \text{ otherwise.} \end{cases}$$

   Which of the two heuristic functions is likely to yield better results, and why?

2. **Given:** Landrew is a thinking being. Landrew has tape drives. No machine is a thinking being. Only machines have tape drives. No machine has tape worms.
   Prove, using resolution and the refutation theorem-proving method, that:

   Landrew has tape worms.

   Note: Clearly translate the above English sentences into formulas, identifying the intended meaning of each symbol used.

3. Using the AI techniques you have learnt, design a tour planner for a group of people traveling together in Europe for a two-week vacation. Each city has several possible locations that can be visited. Obviously, not every possible location can be visited in the limited time available. With each possible location that can be visited, there is a certain activity that can be performed. Each member of the group has his own preferences among various activities, but would also like to indulge in more than one activity; for instance, John Doe likes art museums, but wouldn't want to spend the entire trip in museums. Due to cost constraints, all in the group must drive together everywhere in the same car. Note that it takes time to travel from city to city. Also, different locations may have different levels of attraction to the tourists even if they correspond to the same activity, e.g., the Louvre museum is preferable to an unknown museum in Stuttgart.

4. Let $B = \{(0,0),\ (0,1)\}$. Describe the effects of the following operations:

   (a) Dilation by B

   (b) Dilation by B, followed by dilation of the result by B

   (c) Dilation by B, followed by erosion of the result by B

5. Answer one of the following parts:

   (a) Discuss whether one can develop a neural network whose output is "1" if the input supplied is a grammatical sequence of words (according to a given, arbitrary grammar), and "0" otherwise.

   (b) Discuss whether a rule-based expert system can be developed to determine whether a given sequence of words is a grammatical sentence (according to a given, arbitrary grammar).