CSC242: Homework 1.3
AIMA Chapter 5.0–5.2.2

1. Define the following terms briefly:

   (a) Zero-sum game

   ANSWER: Utility values at the end of the game are always equal and opposite. Equivalently, total payoff to all players is the same for every instance of the game. In other words, a win for one player is a loss for the other.

   (b) Perfect information

   ANSWER: All information about the state of the game is visible to all players. Chess is a perfect information game because the pieces on the chess board are all state there is. Card games are imperfect information games since some of the cards are hidden from some of the players.

   (c) Terminal state

   ANSWER: A state in which the game has ended. These correspond to "goal states" in standard state-space search.

   (d) Utility function

   ANSWER: A function that returns the numeric utility of a terminal state for each player. Note that the utility function is only defined on terminal states!

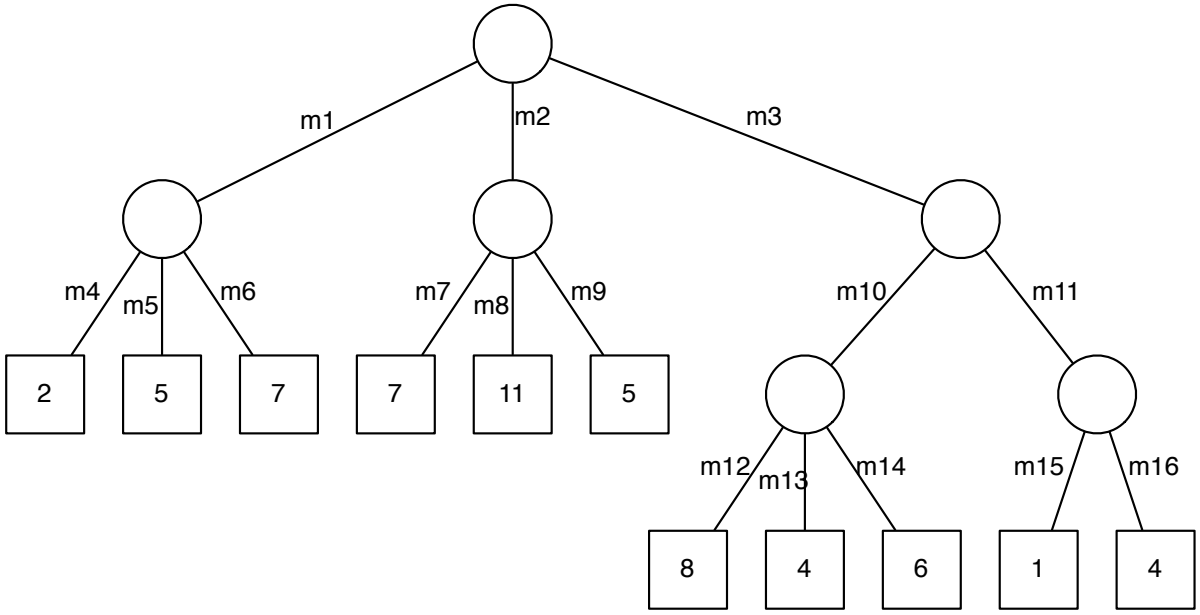
   (e) Game tree

   ANSWER: Nodes are game states. Edges are moves. The root node is the current state of the game (*i.e.*, the initial state for the first move). Levels of the tree alternate between players (*e.g.*, first my moves, then your moves, then my moves, *etc.*).

2. Where does the name "MINIMAX" come from?

   ANSWER: For a two-player game, I label the levels of the game which involve a choice of a move for me as "MAX" since I'm trying to *maximize* my utility. I label the levels with my opponent's moves as "MIN" because they will be trying to maximize their utility which, *in a zero-sum game*, is the same as minimizing my utility. In general, the player whose turn it is to move is MAX since they are trying to maximize their utility with the next move.

3. Consider the following game tree:



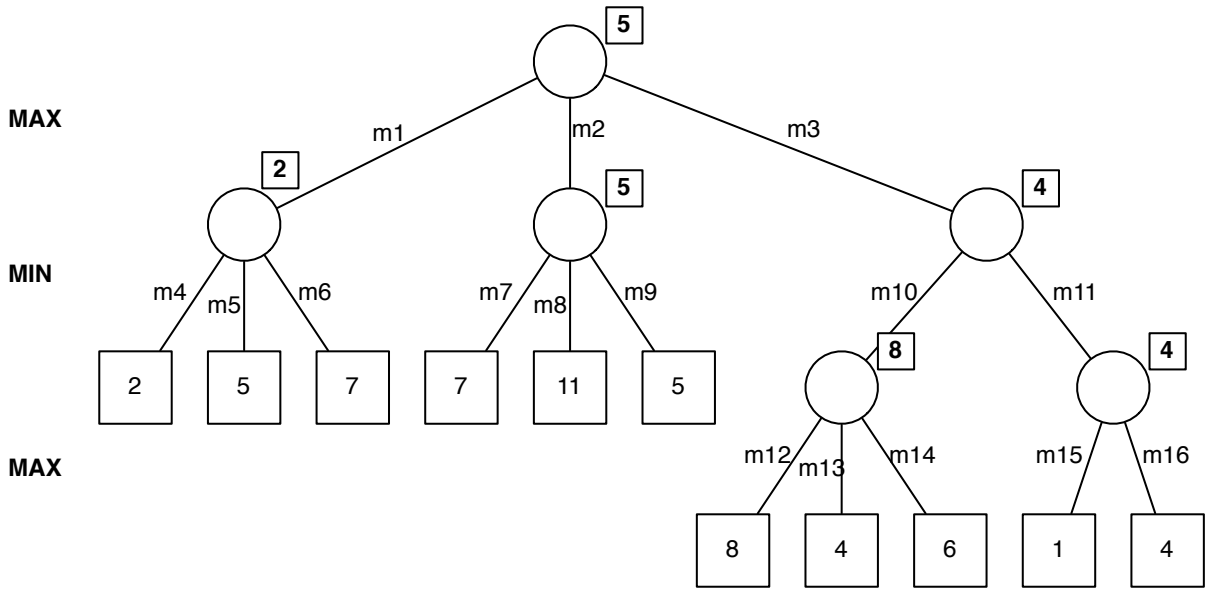
Terminal states are squares and are labelled with their utility for MAX. Non-terminals are circles. Edges are labeled with moves.

(a) Label the levels of the tree with MAX and MIN.

(b) Compute the minimax values of the non-terminal nodes.

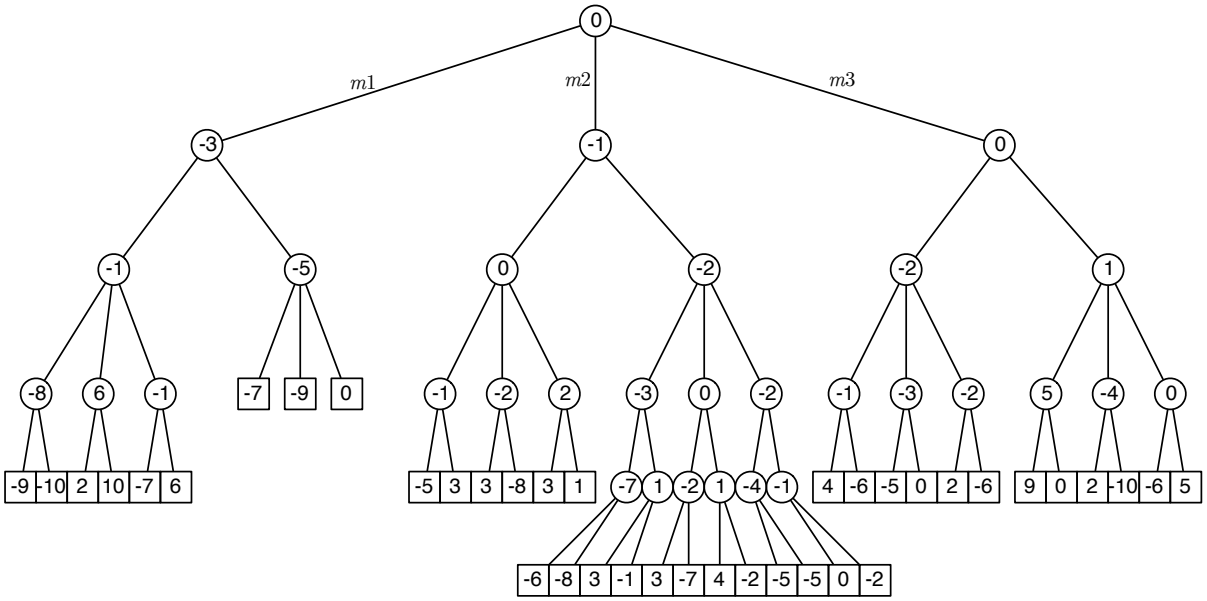
(c) What is the optimal move for the first player? What is the second player's optimal response?

ANSWER:



(c) Best move for MAX is $m2$, then best move for MIN is $m9$.

4. Consider the following game tree:



Terminal states are squares and are labelled with their utility for MAX. Non-terminals are circles and are labelled with a heuristic estimate of the value of the state. Some edges are labeled with moves.

(a) What is the MINIMAX value of the root and what move should MAX make?

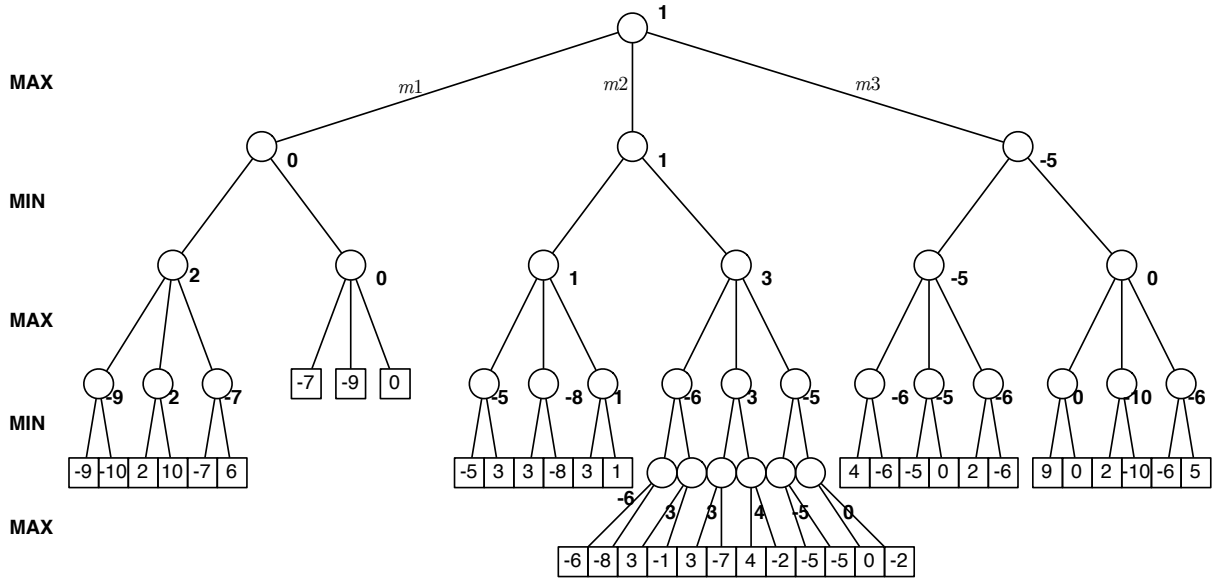
(b) Suppose you can only search to depth 2 (two moves or *ply*). What is the H-MINIMAX value of the root and what move should MAX make?

(c) What if you can search to depth 3?

(d) What if you can search to depth 4?

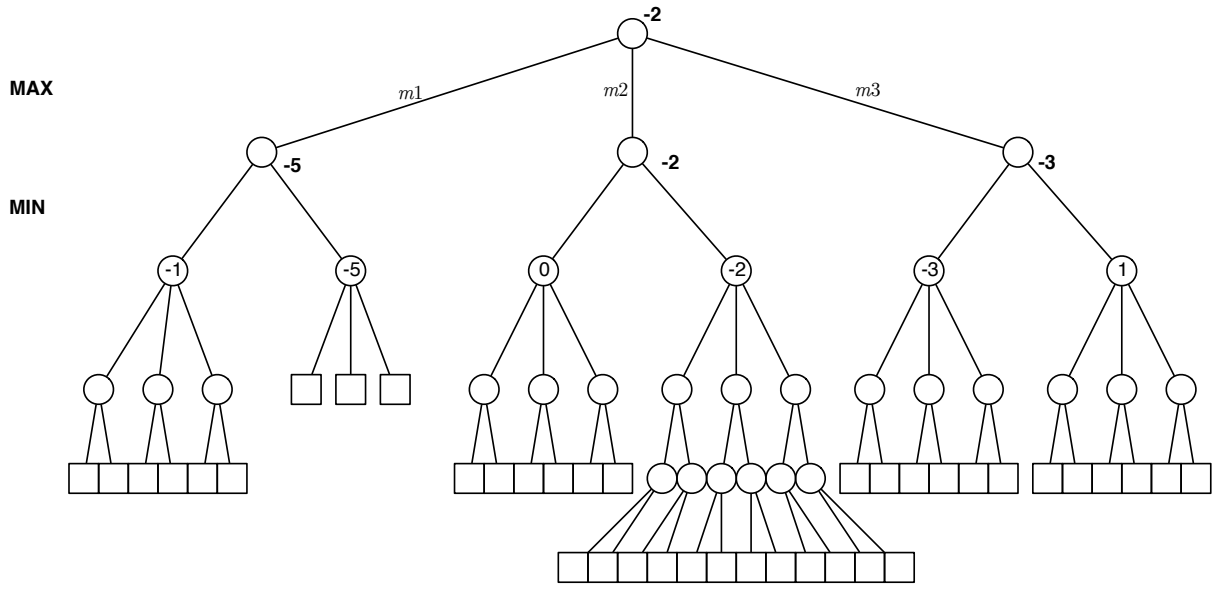
ANSWER:

(a) Full MINIMAX: Ignore heuristic estimates:



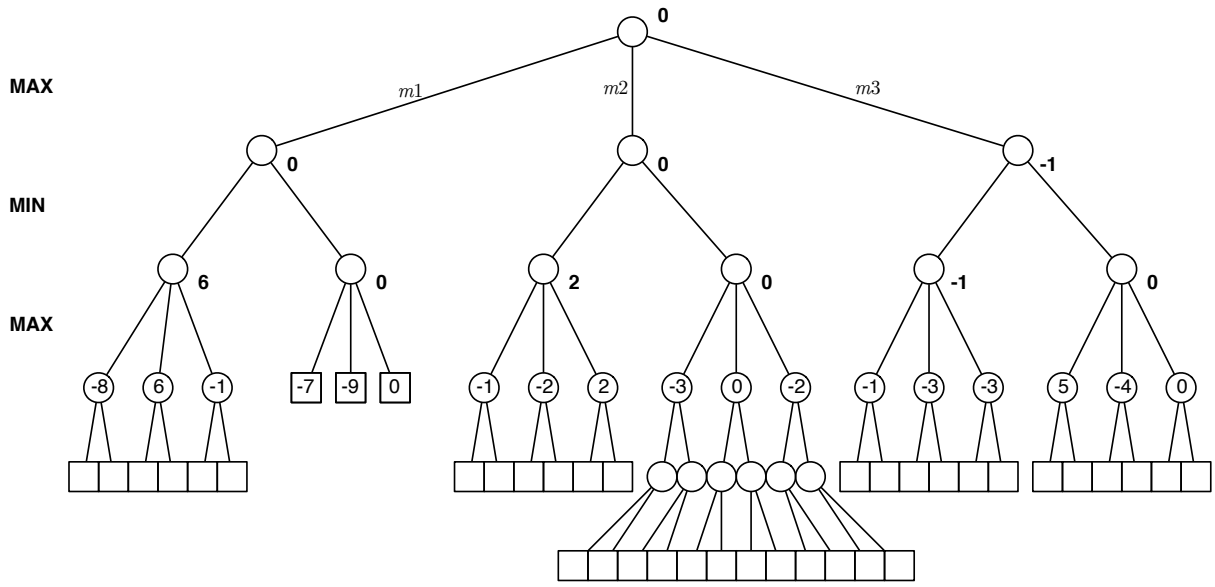
MINIMAX value of the root is 1; best move is $m2$.

(b) H-MINIMAX to depth 2:



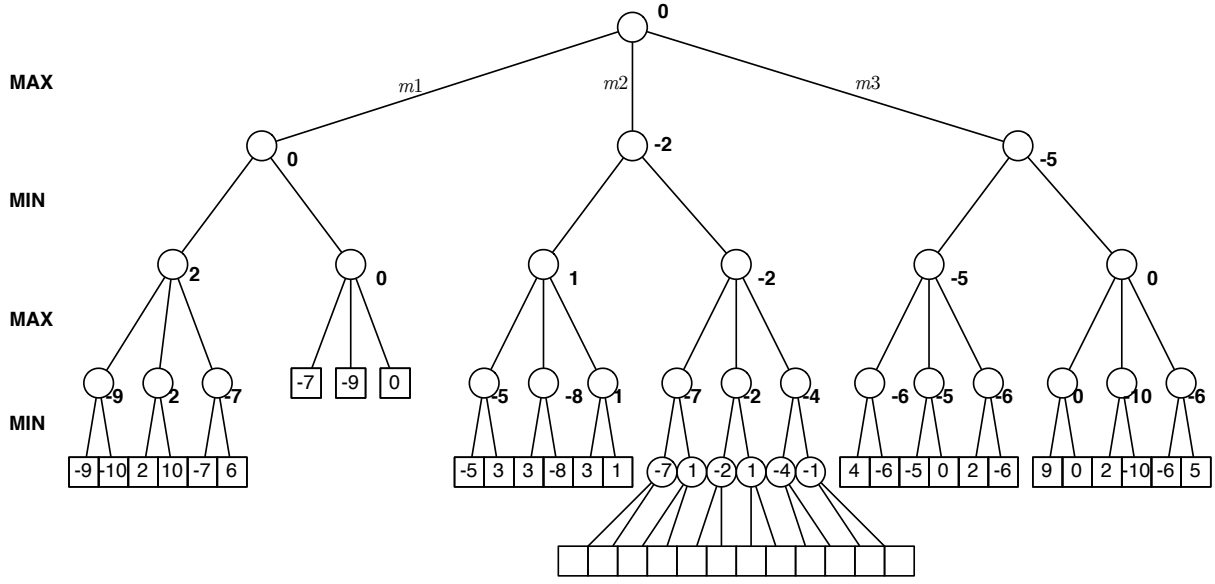
H-MINIMAX value of the root is -2; best move is $m2$.

(c) H-MINIMAX to depth 3:



H-MINIMAX value of the root is 0; best move is either $m1$ or $m2$.

(d) H-MINIMAX to depth 4:



H-MINIMAX value of the root is 0; best move is $m1$.