1. minimax is covered in topic *two-player games*, there was a question like this on the assignment. max score over all opponent strategies. cutoffs avoid having to search the whole space.

2. could be unreachable because winning condition was already reached, or play was not alternating. 9!. transposition table (or memoization, or dynamic programming). the last part is from the assignment: `ttt-classic.py` with transposition table has around 1000 nodes

3. webnotes, topic *nim game*, section *checkers*

   add the line "print(a,b,c)" to foo to see the call parameters in the order they are made. in this question, return values alternate by level: 1, -1, ...

4. negamax, 3-pile nim. To estimate the number of nodes in the call tree, consider a subtree formed by a long path, and estimate subtree size from the bottom up. this will be a lower bound on the total number of nodes.

```
calls    estimated number of nodes in the call
in long
path

333     3(033) 3(133) 3(233),  guess 18000 nodes
233     033 133 2(223) 2(123), guess 6000 nodes
223     2(023) + 2(123) + 222, guess 1500 nodes
222     3(022) + 3(122), guess 300 nodes
122     (022) + 2(112), each 112 at least 30, guess 100 nodes
112     1 + 2(012) + 111, more than 30 nodes
111     16 nodes
011      5 nodes
001      2 nodes
000      1 node

012 subtree?        012             12 nodes
               002       011    010
             001 000  001 010   000
             000      000 000
```

Our estimate is at least 18000 nodes, so we guess 24000 nodes.