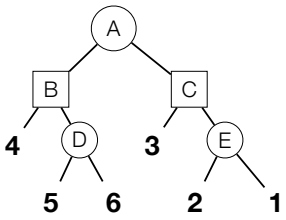
Name: Solution Guide **CCID:** _____

1. **[6 points]** This alpha-beta search has just reached B. In table (a) below, list the new values of `so_far`, `alpha`, and `beta` in order, every time at least one of them changes. In table (b) below, give the value that alpha-beta search returns for each nonterminal node, or `n/a` if alpha-beta was not be called on that nonterminal. Leaf nodes are labelled with player 1's score (the MAX player).



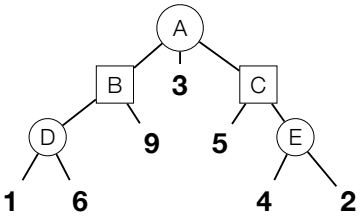
(a) Since I accidentally gave space only for 4 new rows instead of 5, I will give one bonus mark for this question.

chg	node	so_far	alpha	beta
1	A	$-\infty$	$-\infty$	∞
2	B	∞	$-\infty$	∞
3	B	4	$-\infty$	4
4	D	$-\infty$	$-\infty$	4
5	D	5	5	4
6	A	4	4	∞
7	C	∞	4	∞
8	C	3	4	3

(b)

node	returns
A	4
B	4
C	3
D	5
E	n/a

2. **[5 points]** Give the value that negamax returns for each nonterminal of the tree below in the table below. Leaf nodes are labelled with scores for the player to move.



node	A	B	C	D	E
negamax	-1	1	2	-1	-2

3. **[3 points]** Consider the follow code from `abeta/negamax.py`, with three missing expressions:

```
# leaf scores are for player-to-move
def negamax(d, T, V, v):
    if isTerminalNode(v,V):
        val = V[v]
        return val
    val = _____expression_(A)_____
    for c in T[v]: # for each child c of v
        nmx = negamax(d+1, T, V, c)
        val = max(_____expression_(B)_____,
                  _____expression_(C)_____)
    return val
```

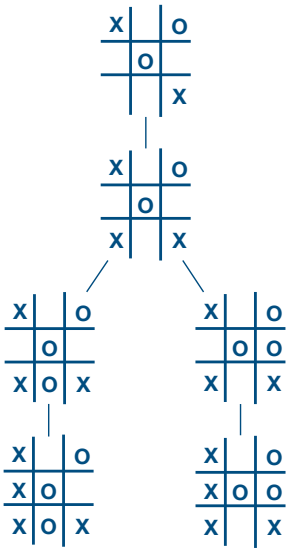
(a) What should expression (A) be?

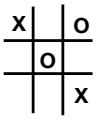
`-inf` or `-float('inf')` or `NEGINF` or anything that indicates negative infinity.

(b) What should expression (B) be? `-nmx`

(c) What should expression (C) be? `val`

4. **[4 points]** Give a proof tree that proves that the following position is a win for X. You may prune isomorphic children, and you need not use any particular canonical representation.





5. **[3 points]** Consider the Nim position `(2,3,3,3)`:
   (a) How many children does this position have?
   There is no need to list the children. $2 + 3 + 3 + 3 = 11$

   (b) How many *non-isomorphic* children does this position have? List them all in canonical form. $2 + 3 = 5$: $\{(1,3,3,3), (0,3,3,3), (2,2,3,3), (1,2,3,3), (0,2,3,3)\}$