1. Is the Nim position `(43, 7, 7, 43)` a winning or a losing position? Why?

2. Is the Nim position `(43, 7, 7, 43, 107)` a winning or a losing position? Why?

3. List all the winning moves from the Nim position `(11, 4, 2)`.

4. List all the winning moves from the Nim position `(45, 43, 7)`.

5. Does the extra-stone argument apply to tic-tac-toe? That is, is it true that adding an X to a position (without changing whose turn it is) can never make X worse off? Why or why not?

6. Why does the strategy-stealing argument *not* prove that tic-tac-toe is a win for X the first player?

7. Does the extra-stone argument apply to Go? That is, is it true that adding a Black stone to a position (without changing whose turn it is) can never make Black worse off? Why or why not?

8. Use a strategy-stealing argument to prove that White does not have a winning strategy from an empty Go board.

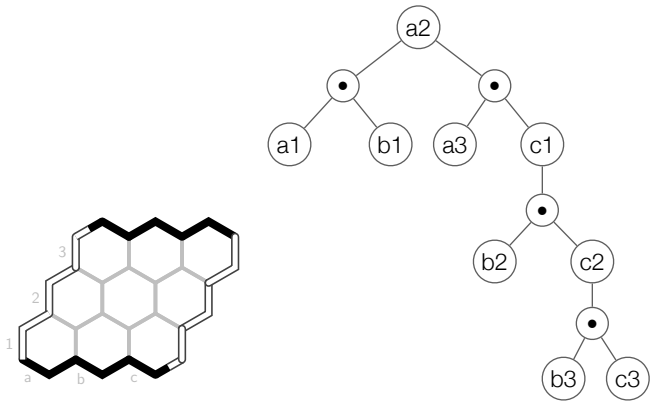
9. Consider the following pairing strategy for Black: $(\{a3, b3\}, \{b1, c1\})$

   (a) Where can Black play after `1.B[b2] 2.W[b3]`?

   (b) Where can Black play after `1.B[b2] 2.W[a3]`?

10. Consider the following AND/OR strategy on an empty 3×3 Hex board:

$$a2 \wedge (a1 \vee b1) \wedge (a3 \vee (c1 \wedge (b2 \vee (c2 \wedge (b3 \vee c3)))))$$



(a) What must Black's first move be? Why?

(b) What are this strategy's *cell sets*?

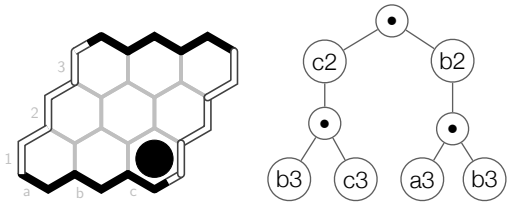
(c) Is this a winning strategy for Black from this position? Why or why not?

(d) Where must Black play after `1.B[a2] 2.W[b1]`?

(e) Where must Black play after `1.B[a2] 2.W[a3] 3.B[c1] 4.W[c3]`?

11. Consider the following AND/OR strategy after `1.B[c1]` on the 3×3 Hex board:

$$(c2 \wedge (b3 \vee c3)) \vee (b2 \wedge (a3 \vee b3))$$

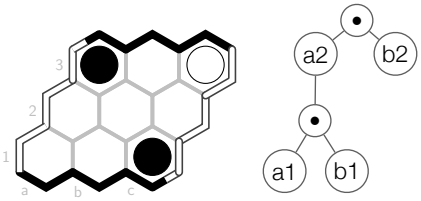


(a) What are this strategy's *cell sets*?

(b) Is this a winning strategy for Black from this position? Why or why not?

12. Consider the following AND/OR strategy after `1.B[c1] 2.W[c3] 3.B[a3]` on the 3×3 Hex board:

$$(a2 \wedge (a1 \vee b1)) \vee b2$$

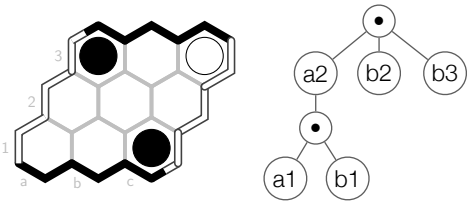


(a) What are this strategy's *cell sets*?

(b) Is this a winning strategy for Black from this position? Why or why not?

13. Consider the following AND/OR strategy after `1.B[c1] 2.W[c3] 3.B[a3]` on the 3×3 Hex board:

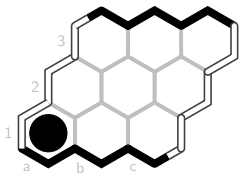
$$(a2 \wedge (a1 \vee b1)) \vee b2 \vee b3$$



(a) What are this strategy's *cell sets*?

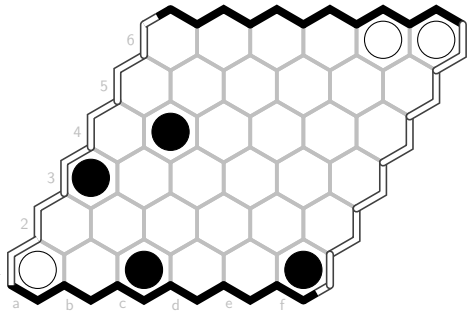
(b) Is this a winning strategy for Black from this position? Why or why not?

14. Construct a winning AND/OR strategy for White from the position after Black plays on $a1$, or explain why this is impossible.



15. Consider the following 6×6 Hex position. For each pair of nodes below, indicate whether they are **F**ully connected, **S**emi-connected, or **N**ot virtually connected:

node 1	**node 2**	**virtually connected?**
$a3$	$b4$	
$a3$	$c1$	
$c1$	$f1$	
$c1$	$b4$	
$b4$	$f1$	



16. Consider the `go/tromp.py` implementation in the example code github.

    (a) How would you modify `go/tromp.py` to try pass moves last instead of first?

    (b) Is `go/tromp.py` still able to solve 2×2 Go after this change? How long does it take?

    (c) Why do `go/tromp.py` (and `go/tromp.c`) rely on bit manipulation instead of something more readable?

    (d) How would you modify `go/tromp.py` to solve 3×3 Go instead of 2×2 Go?

17. (a) What is the minimax value of 1×2 Go? Prove your answer.

    (b) What is the minimax value of 2×2 Go? You need not prove this answer.

    (c) What is the minimax value of 2×2 Go after the move `1.B[pass]`? Explain your answer.