1. Some people believe that _____'s shoulder hit in game 2 of the Go match against _____ marks the end of an era, because **(circle answer)**

   a) this unusual move caused the computer to fall behind, but it recovered and won the game.

   b) a strong human would never make this move, yet this move turned out to be strong.

   c) after this strong move, the human did not win another game in the match.

   d) the computer found the move quickly, and a thorough post-game analysis showed that all other moves were losing.

2.

4	1	3
7	2	5
8		6

For this position, the number of misplaced tiles is _____, and a tile slide that decreases this quantity is **(circle answer) up down left right**. From the new position, a sequence of tile slides that solves the puzzle is _____

For sliding tile puzzles, A* with misplaced tile heuristic is usually preferable to bfs because **(circle answer)**

a) A*'s guided search finds a shortest solution; bfs's solution is not always shortest.

b) A* always find the solution more quickly than bfs.

c) A*'s guided search is usually faster than bfs on larger dimension problems.

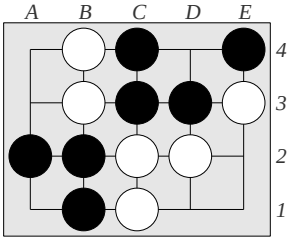
d) A* is usually faster than bfs and easier to implement than bfs.

3.

	B	C	D
cost	75	140	118
heur	374	253	329

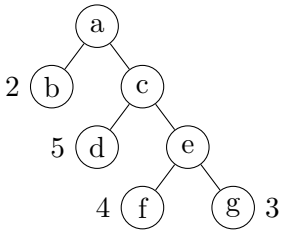
show your work This is A*: shortest path from A to K, use straight-line distance heuristic. A's neighbours are B,C,D. `cost` is current distance from A, and `heur` is _____. The next node selected will be _____, because _____.

4.



If this Go game ends now, the Tromp-Taylor score is _____ points for Black and _____ points for White. From this position, White has _____ legal moves and Black has _____ legal moves. If this game continues, the best move for White is to point _____ .

5. $\alpha\beta$ search executes on this graph in the usual order **(circle one):**
a) left-right reverse dfs b) left-right bfs c) top-down bfs d) left-right dfs. After backing up to node _____ from node _____ , $\alpha\beta$ cuts off the branch from node _____ to _____ because it sees that the value of node _____ will not change the minimax value of the tree, which is _____.



6. Computers achieved superhuman strength in chess in 1997 and in Go in _____.
This took longer for Go mainly because **(circle one)**
a) computer scientists were studying the game of chess longer than they studied the game of Go.
b) chess has an easily computed and relatively accurate heuristic evaluation
c) chess simplifies as players are captured, so the end result can be computed with endgame databases
d) computers can evaluate all endgame positions of the 8x8 chess board but not the 19x19 Go board

7. Right: for this nim(3 3 3) dp solver partial trace, give the missing data for the last 3 lines.

000	loss	update 001 002 003 win
001	win	
002	win	
011	loss	update 012 013 111 112 113 win
003	win	
012	win	
111	win	
013		
022		
112		

For nim(7 10 11), a winning move is to remove _____ stones from the pile with _____.

8. Left: label the root with the minimax value for *Max*, the first player, who tries to maximize her score. Leaf scores are for *Max*. Show your work. Right: `O` moves next.show the next 2 layers of the tic-tac-toe game tree, and give the minimax value: _____

```
        *
     /  |  \
    *   6   *
  / | \    / \
 1  2  3  4   5
```

```
. X .
X O X
O O .
```

1. answers in lecture prologue: AlphaGo, end of an era (this move was so unexpected, Michael Redmond did a triple take when he saw this move)

2. only tile 3 of tiles 1-8 is in the right place; after 8 slides R, D D L U L U. bfs always finds shortest solution, as does A* with not-overestimating heuristic. lucky bfs can be as fast as A*. A* not easier to implement.

3. priority is cost + heur, heur is st-line dist to K. whichever of current nodes under consideration has highest priority (so here, smallest sum, so C)

4. Black 7 stones plus 2 territory points, so 9. White 6 stones plus 3 territory points, so 9. Black legal moves: every empty point, except D4 (suicide), so 6 (or 7 if you include pass). White legal moves: every empty point, except A1 (suicide), so 6 (or 7 if you include pass). Black's best move: E2 (capture E3). White's best move: D4 (capture C3 C4 D3 E4).

5. any form of minimax (including $\alpha\beta$) must proceed in bottom up fashion. here, consider left-right bfs.

   Due to a typo in the labelling of the tree, this particular example has no $\alpha\beta$ cutoffs. So everyone received full marks for this part of the question. You still needed to answer the multiple choice, and find the minimax value.

   Note: this example is t3.in in simple/alphabeta/ ; run `python3 alphabeta.py < t3.in` to see output.

```
dfs(a)
  dfs(b)
    minimax(b) = 2
  after backing up to a, can we cutoff?
  if all remaining nodes score 1,
    max's best root move: to b
  if all remaining nodes score 3,
    max's best root move: to c
  *** so no cutoffs yet ***
  dfs(c)
    dfs(d)
      minimax(d) = 5
    after backing up to c, can we cutoff?
    if all remaining nodes score 3,
       max best root move: c, then min best move: e
    if all remaining nodes score 6
       max best root move: c, then min best move: d
    *** no cutoffs yet ***
    dfs(e)
      dfs(f)
        minimax(f) = 4
      after backing up to e, can we cutoff?
```

```
      if remaining node g has score 6,
        max best root move c, min best move d
      if remaining node g has score 4,
        max best root move c, min best move g
      *** no cutoffs yet ***
      dfs(g)
        minimax(g) = 3
      in dfs(e), max's best move is to f
      minimax(e) = 4
    in dfs(c), min's best move is to e
    minimax(c) = 4
  in dfs(a), max's best move is to c
  minimax(a) = 4
```

6. 2015 (if superhuman means *stronger than some professional*) or 2016 (if superhuman means *stronger than (probably) all humans*) best answer (4 marks): chess's heuristic evaluation; next best answer (2 marks): chess simplifies (but not nearly enough to solve it with endgame databases, there is more that has to be done)

7. answer in webnotes (nim section)

```
 7   1 1 1        leftmost column with 1-sum has a 1 in 7 row,
10 1 0 1 0          so remove from 7-pile, must leave
11 1 0 1 1          total of xorsum of other piles,
                    so leave 1 0 1 0 +x 1 0 1 1 = 1,
              so remove 6 stones from 7-pile is only winning move
```

8. left: minimax value of left subtree 1, minimax value of right subtree 4, so minimax value at root is max(1, 6, 4) = 6

   right: answer as in webnotes (ttt section). minimax value: win for O