UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
School of Computer Science & Applied Mathematics

Advanced Analysis of Algorithms
2021 Assignment: Part 3

1 Introduction

In the previous part, we generated the valid moves at a given state. We will now need to implement functionality so that one of these moves can actually be played. This means we must take in the initial position (as a FEN string), and the move to be executed. The program will then output the resulting board position once that move has been played (again as a FEN string).

2 Move Representations

For every submission, we will represent a move as a string `<start_square><end_square>` specifying the starting location of the piece to move and then square the piece ends up on. For example, the move `e3e4` represents a piece moving from `e3` to `e4`.

3 Executing Moves

Each move specifies the square that a piece moves from and the square it moves to. To update the board, we must simply remove the piece from its starting square and place it at the target square (if there is an opposing piece at that square, that piece is "captured" and so is removed from the board). There are three other considerations:

1. After a move has been played, the side to move switches. If Black moved, it is then White's turn (and vice versa).
2. The move counter in the FEN string counts the number of moves made, but is only incremented after Black plays their turn.
3. One other consideration is that of drowning pieces. If a piece of the moving player begins in the river, and after the move is executed it remains in the river, then it too must be removed from the board.

4 Input Hint

Hint: a reminder not to be careful when mixing `cin` with `getline`. An example of doing so is below:

```
int N;
cin >> N;
cin.ignore(); //NB!
for (int i = 0; i < N; ++i) {
    string fen;
    getline(cin, fen);
}
```

Submission: Execute Moves

Write a C++ program that accepts a FEN string and a move to be executed and stores the piece location information in appropriate data structures. It should then output the FEN string of the position that results when the move is executed, as well as whether the game has been won by either side.

Input

The first line of input is N, the number of input positions given as FEN strings. $2N$ lines follow consisting of FEN strings and the move to be executed. You may assume that each FEN string is a valid position, and that the move to play is a valid one.

Output

For each FEN string and move, output two lines. The first line of output should be the resulting position as a FEN string. The second line should specify whether the game is over. If the game is not over, print `Continue`. If the move was made by White and resulted in it winning the game, output `White wins`. Otherwise if Black has just won, output `Black wins`.

Example Input-Output

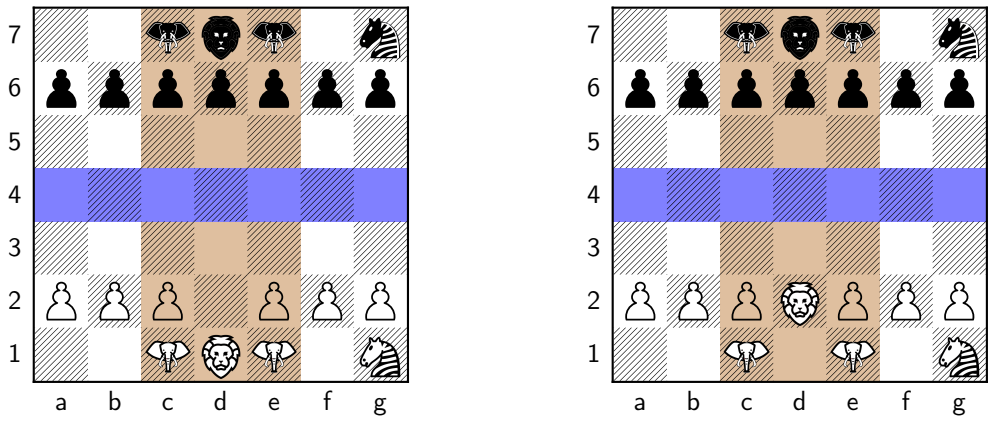
Sample Input

```
3
2ele1z/ppppppp/7/7/7/PPP1PPP/2ELE1Z w 4
d1d2
1z5/pPp1lP1/5ep/4P1e/4L1p/2p2pP/7 b 35
f5f7
1z5/pPp1lP1/5ep/4P1e/4L1p/2p2pP/7 b 12
g4e4
```

Sample Output

```
2ele1z/ppppppp/7/7/7/PPPLPPP/2E1E1Z b 4
Continue
1z3e1/pPp1lP1/6p/4P2/4L1p/2p2pP/7 w 36
Continue
1z5/pPp1lP1/5ep/7/4L1p/2p2pP/7 w 13
Continue
```

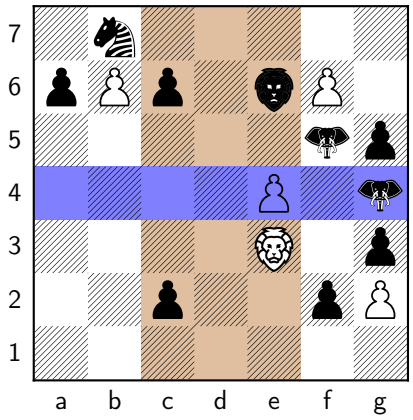
Visualisation of Above Test Cases



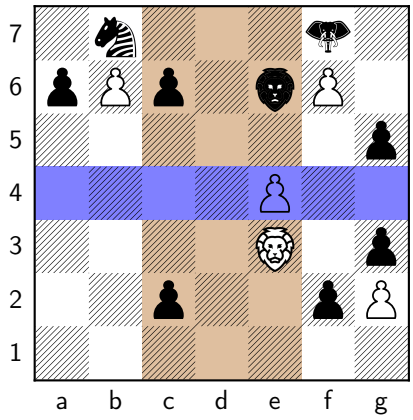
(a) `2ele1z/ppppppp/7/7/7/PPP1PPP/2ELE1Z w 4`

(b) `2ele1z/ppppppp/7/7/7/PPPLPPP/2E1E1Z b 4`

Figure 1: Initial and next positions after the move `d1d2`. The White lion moves one square forward.

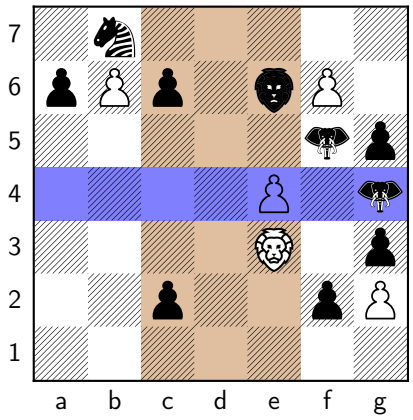


(a) `1z5/pPp1lP1/5ep/4P1e/4L1p/2p2pP/7 b 35`

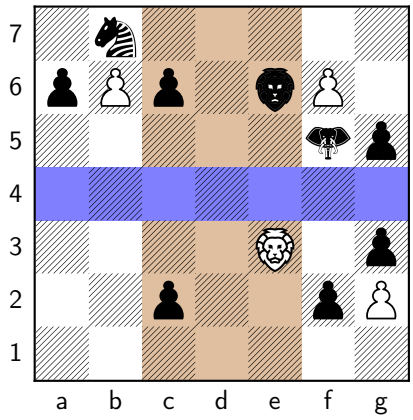


(b) `1z3e1/pPp1lP1/6p/4P2/4L1p/2p2pP/7 w 36`

Figure 2: Initial and next positions after the move `f5f7`. The Black elephant moves to f7, but the elephant in g4 drowns at the end of the move and is removed. The move count is incremented.



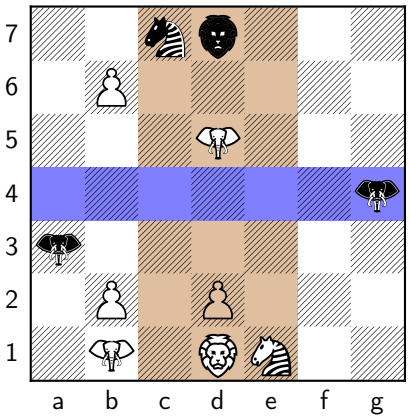
(a) `1z5/pPp1lP1/5ep/4P1e/4L1p/2p2pP/7 b 35`



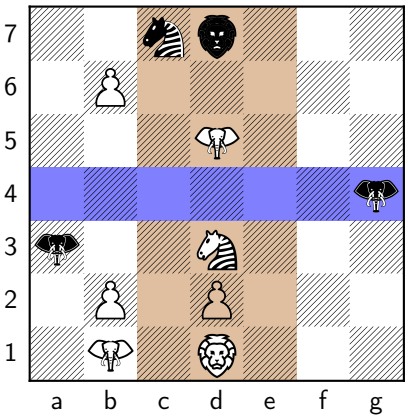
(b) `1z5/pPp1lP1/5ep/7/4L1p/2p2pP/7 w 13`

Figure 3: Initial and next positions after the move `g4e4`. The Black elephant on g4 captures the White pawn on e4. However, it started and ended in the river (although on different squares) and so after moving, it too drowns and is removed from the board.

5 Generated Positions

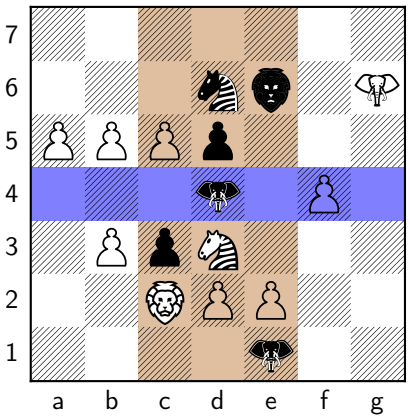


(a) `2zl3/1P5/3E3/6e/e6/1P1P3/1E1LZ2 w 0`

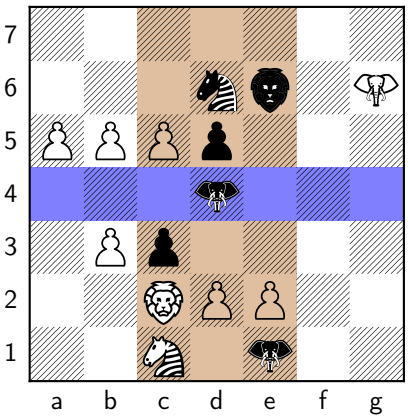


(b) `2zl3/1P5/3E3/6e/e2Z3/1P1P3/1E1L3 b 0`

Figure 4: Initial and next positions after the move `e1d3`

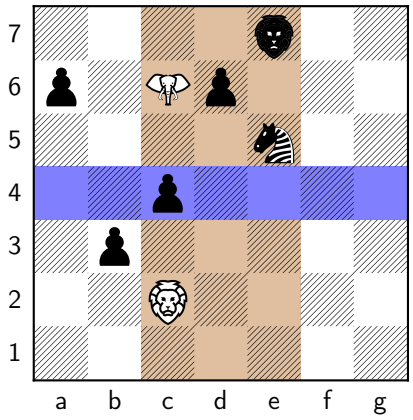


(a) `7/3zl1E/PPPp3/3e1P1/1PpZ3/2LPP2/4e2 w 42`

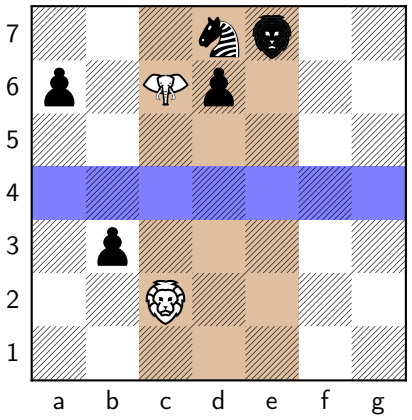


(b) `7/3zl1E/PPPp3/3e3/1Pp4/2LPP2/2Z1e2 b 42`

Figure 5: Initial and next positions after the move `d3c1`

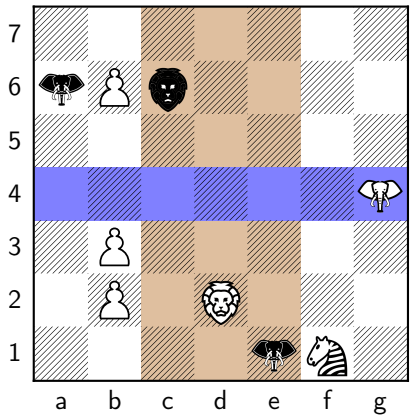


(a) `4l2/p1Ep3/4z2/2p4/1p5/2L4/7 b 4`

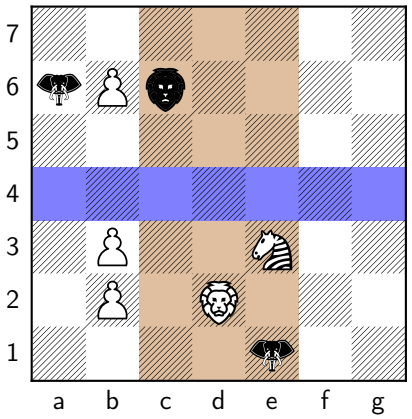


(b) `3zl2/p1Ep3/7/7/1p5/2L4/7 w 5`

Figure 6: Initial and next positions after the move `e5d7`

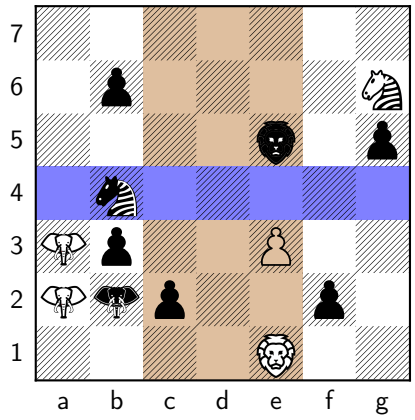


(a) `7/eP14/7/6E/1P5/1P1L3/4eZ1 w 10`

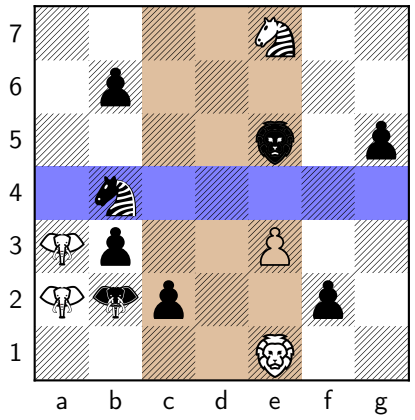


(b) `7/eP14/7/7/1P2Z2/1P1L3/4e2 b 10`

Figure 7: Initial and next positions after the move `f1e3`

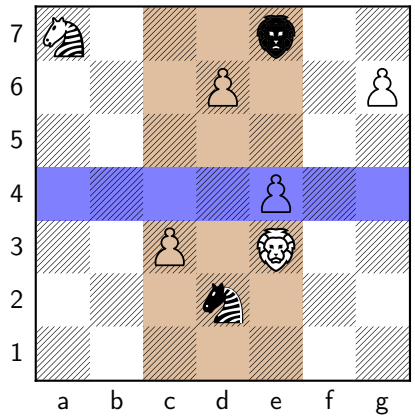


(a) `7/1p4Z/4l1p/1z5/Ep2P2/Eep2p1/4L2 w 10`

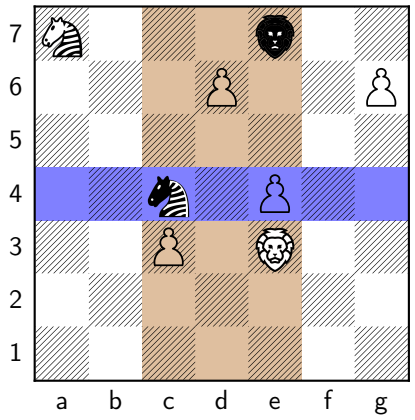


(b) `4Z2/1p5/4l1p/1z5/Ep2P2/Eep2p1/4L2 b 10`

Figure 8: Initial and next positions after the move `g6e7`

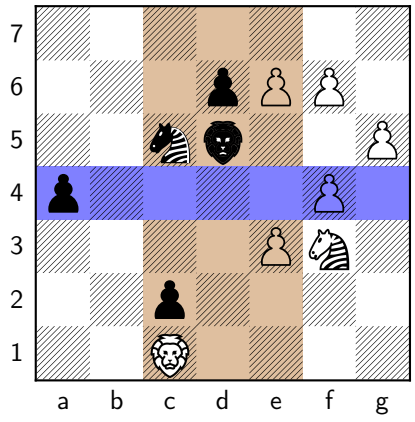


(a) `Z3l2/3P2P/7/4P2/2P1L2/3z3/7 b 9`

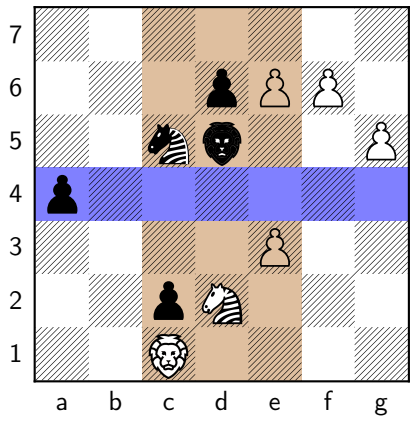


(b) `Z3l2/3P2P/7/2z1P2/2P1L2/7/7 w 10`

Figure 9: Initial and next positions after the move `d2c4`

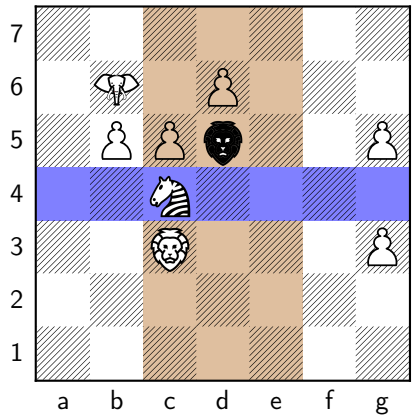


(a) `7/3pPP1/2zl2P/p4P1/4PZ1/2p4/2L4 w 17`

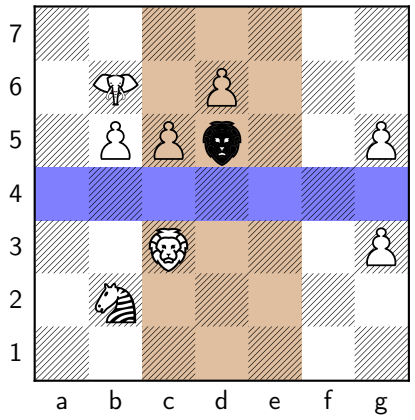


(b) `7/3pPP1/2zl2P/p6/4P2/2pZ3/2L4 b 17`

Figure 10: Initial and next positions after the move `f3d2`

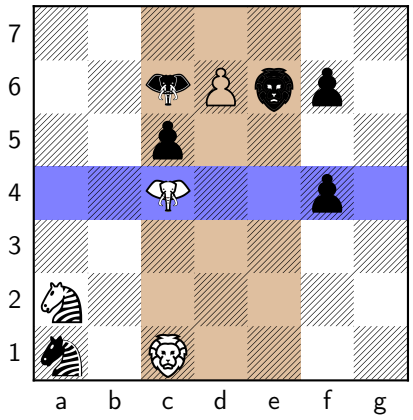


(a) `7/1E1P3/1PPl2P/2Z4/2L3P/7/7 w 27`

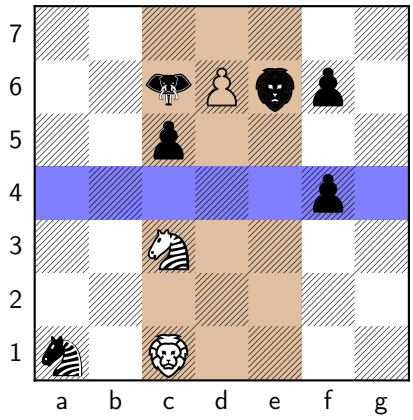


(b) `7/1E1P3/1PPl2P/7/2L3P/1Z5/7 b 27`

Figure 11: Initial and next positions after the move `c4b2`

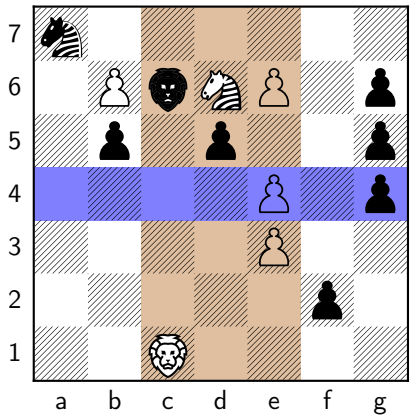


(a) `7/2ePlp1/2p4/2E2p1/7/Z6/z1L4 w 5`

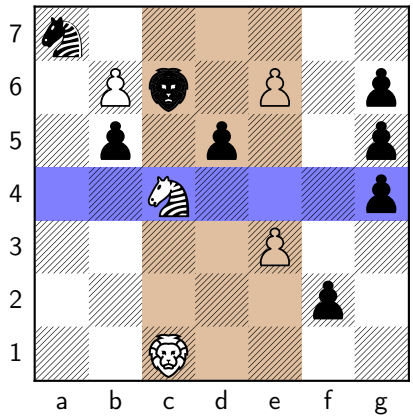


(b) `7/2ePlp1/2p4/5p1/2Z4/7/z1L4 b 5`

Figure 12: Initial and next positions after the move `a2c3`

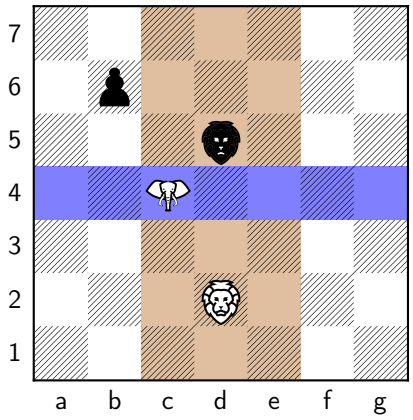


(a) `z6/1PlZP1p/1p1p2p/4P1p/4P2/5p1/2L4 w 39`

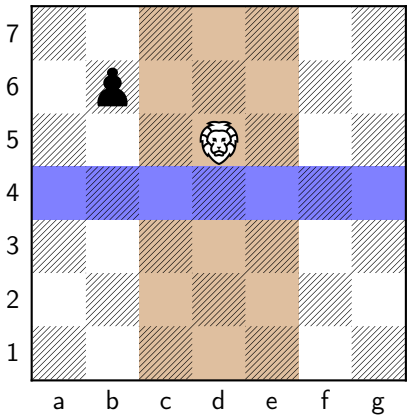


(b) `z6/1Pl1P1p/1p1p2p/2Z3p/4P2/5p1/2L4 b 39`

Figure 13: Initial and next positions after the move `d6c4`

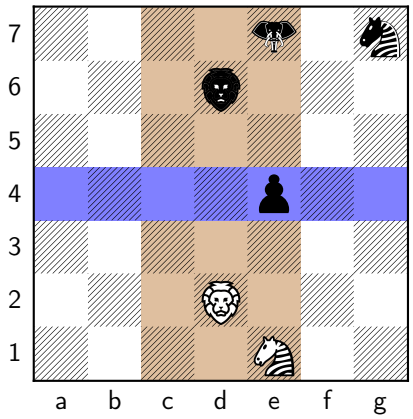


(a) `7/1p5/3l3/2E4/7/3L3/7 w 10`

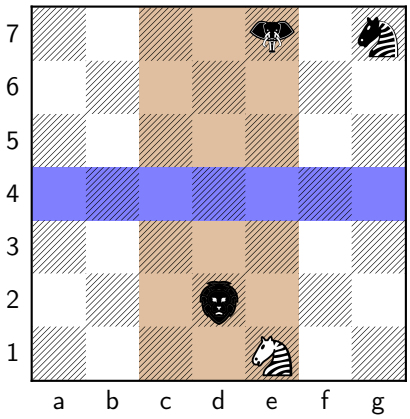


(b) `7/1p5/3L3/7/7/7/7 b 10`

Figure 14: Initial and next positions after the move `d2d5`

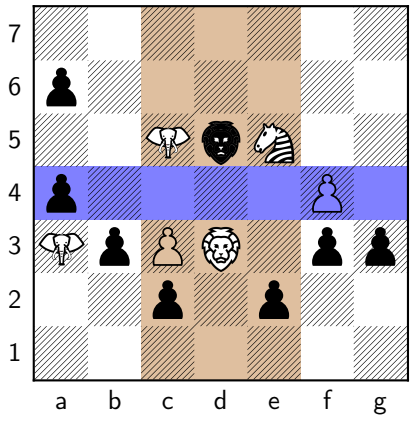


(a) `4e1z/3l3/7/4p2/7/3L3/4Z2 b 9`

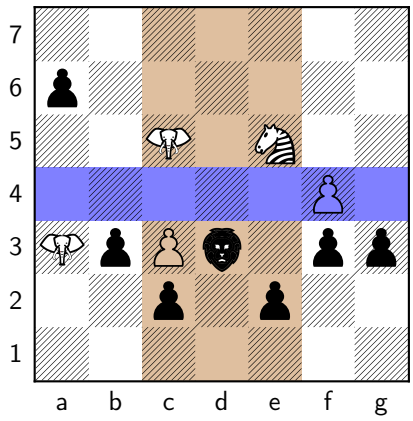


(b) `4e1z/7/7/7/7/3l3/4Z2 w 10`

Figure 15: Initial and next positions after the move `d6d2`

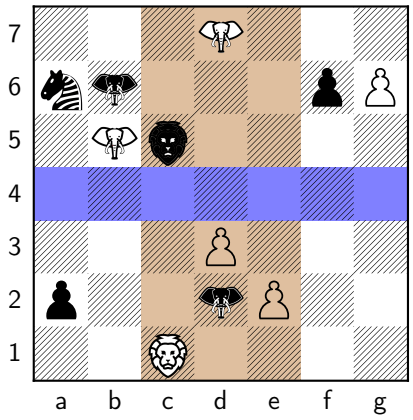


(a) `7/p6/2E1Z2/p4P1/EpPL1pp/2p1p2/7 b 27`

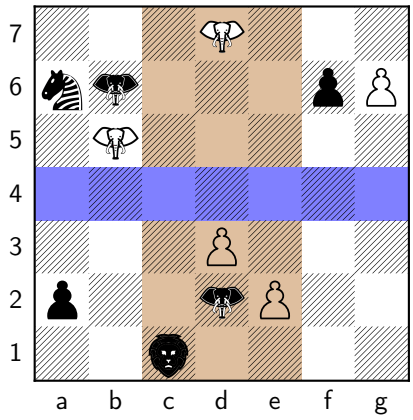


(b) `7/p6/2E1Z2/5P1/EpPl1pp/2p1p2/7 w 28`

Figure 16: Initial and next positions after the move `d5d3`

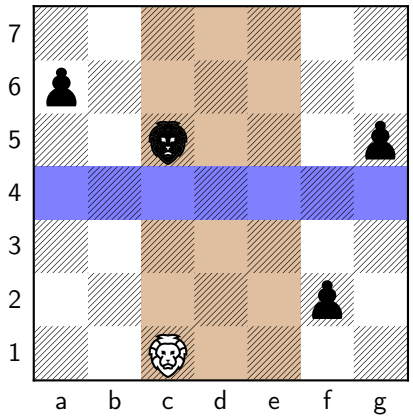


(a) `3E3/ze3pP/1El4/7/3P3/p2eP2/2L4 b 32`

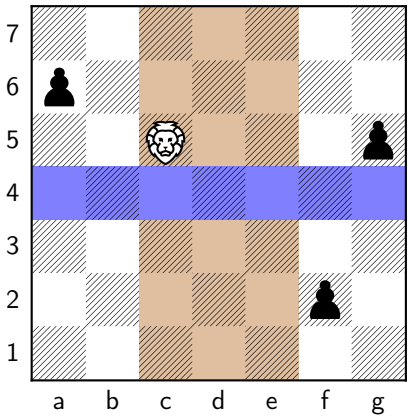


(b) `3E3/ze3pP/1E5/7/3P3/p2eP2/2l4 w 33`

Figure 17: Initial and next positions after the move `c5c1`

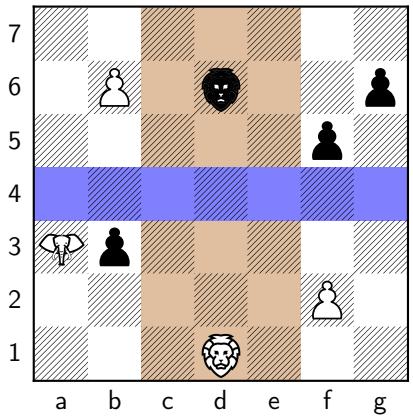


(a) `7/p6/2l3p/7/7/5p1/2L4 w 4`

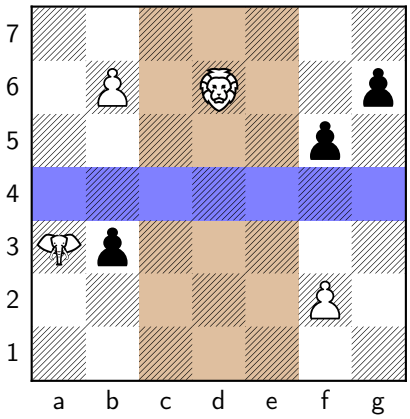


(b) `7/p6/2L3p/7/7/5p1/7 b 4`

Figure 18: Initial and next positions after the move `c1c5`

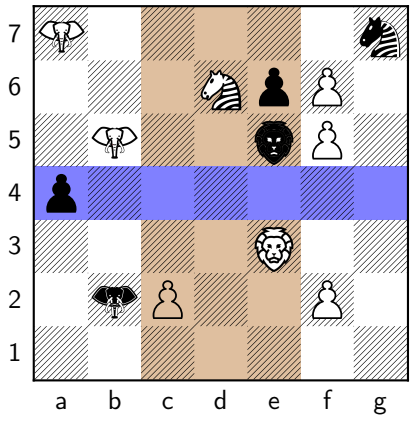


(a) `7/1P1l2p/5p1/7/Ep5/5P1/3L3 w 1`

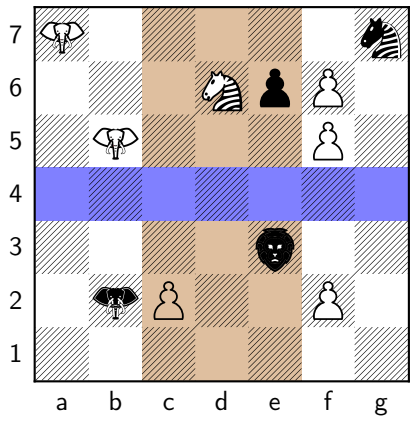


(b) `7/1P1L2p/5p1/7/Ep5/5P1/7 b 1`

Figure 19: Initial and next positions after the move `d1d6`

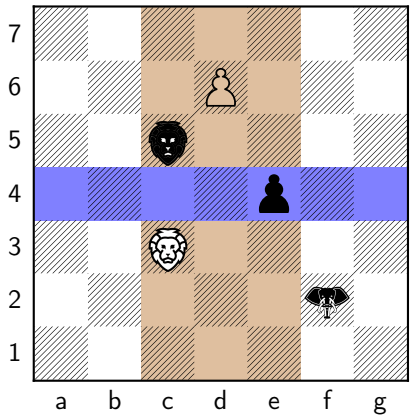


(a) `E5z/3ZpP1/1E2lP1/p6/4L2/1eP2P1/7 b 30`

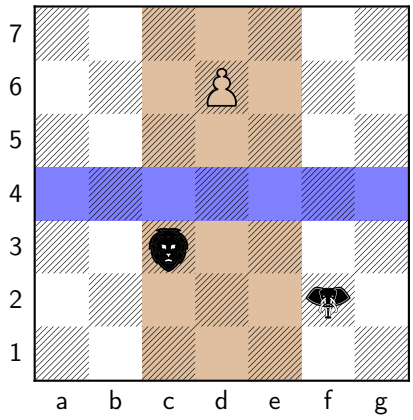


(b) `E5z/3ZpP1/1E3P1/7/4l2/1eP2P1/7 w 31`

Figure 20: Initial and next positions after the move `e5e3`

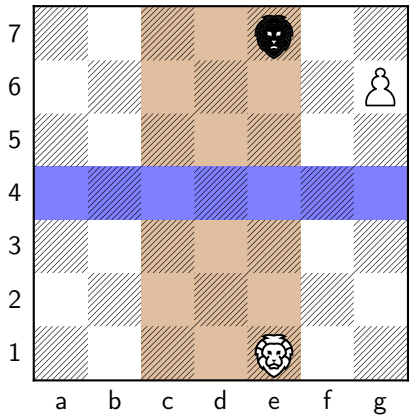


(a) `7/3P3/2l4/4p2/2L4/5e1/7 b 49`

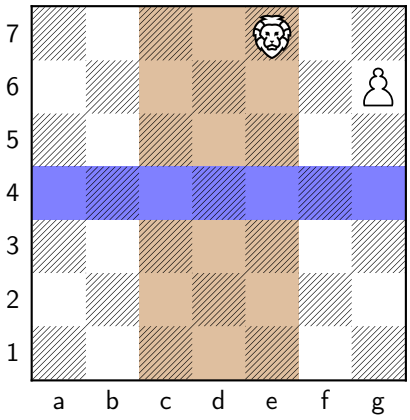


(b) `7/3P3/7/7/2l4/5e1/7 w 50`

Figure 21: Initial and next positions after the move `c5c3`

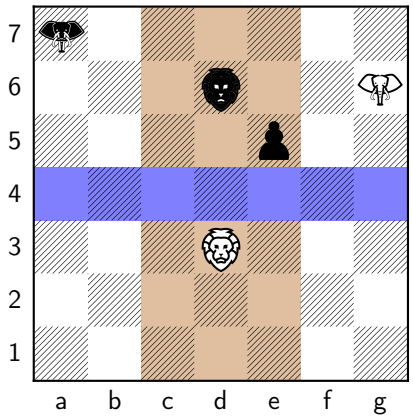


(a) `4l2/6P/7/7/7/7/4L2 w 18`

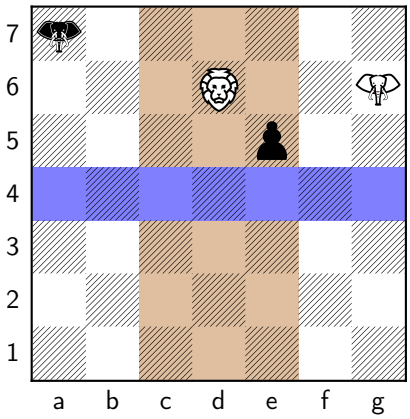


(b) `4L2/6P/7/7/7/7/7 b 18`

Figure 22: Initial and next positions after the move `e1e7`

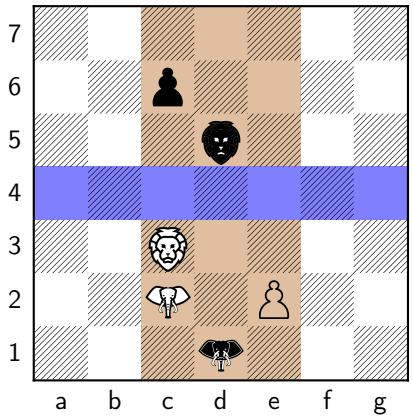


(a) `e6/3l2E/4p2/7/3L3/7/7 w 1`

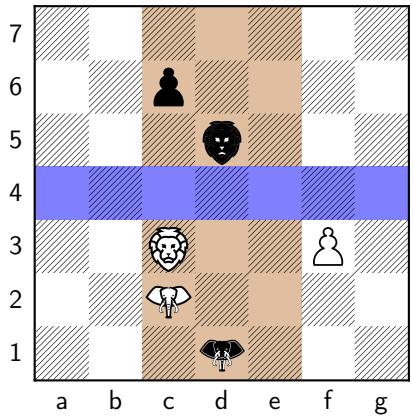


(b) `e6/3L2E/4p2/7/7/7/7 b 1`

Figure 23: Initial and next positions after the move `d3d6`

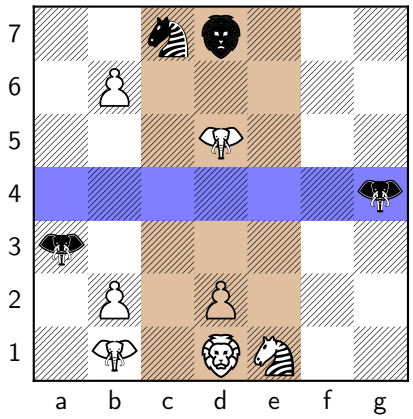


(a) `7/2p4/3l3/7/2L4/2E1P2/3e3 w 25`

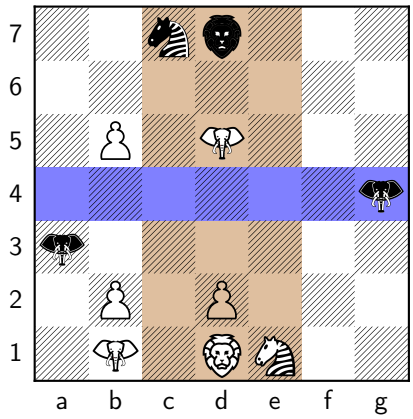


(b) `7/2p4/3l3/7/2L2P1/2E4/3e3 b 25`

Figure 24: Initial and next positions after the move `e2f3`

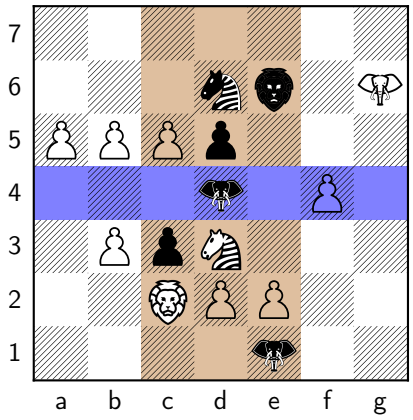


(a) `2zl3/1P5/3E3/6e/e6/1P1P3/1E1LZ2 w 0`

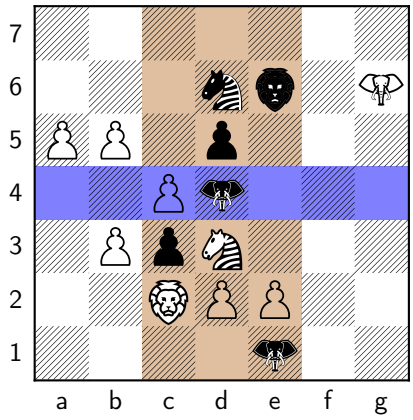


(b) `2zl3/7/1P1E3/6e/e6/1P1P3/1E1LZ2 b 0`

Figure 25: Initial and next positions after the move `b6b5`

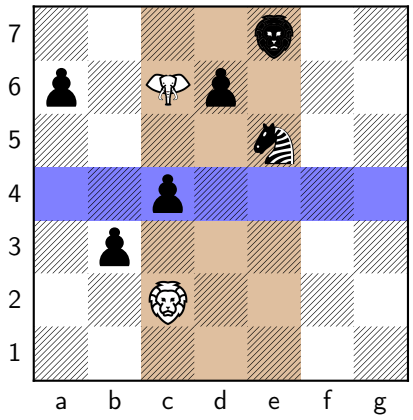


(a) `7/3zl1E/PPPp3/3e1P1/1PpZ3/2LPP2/4e2 w 42`

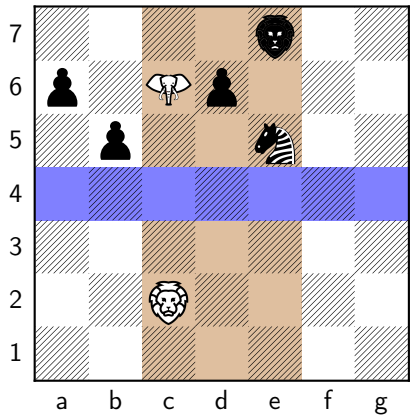


(b) `7/3zl1E/PP1p3/2Pe3/1PpZ3/2LPP2/4e2 b 42`

Figure 26: Initial and next positions after the move `c5c4`

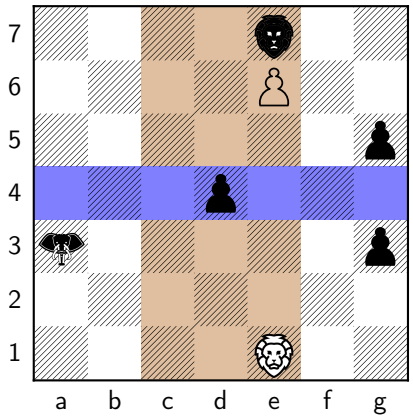


(a) `4l2/p1Ep3/4z2/2p4/1p5/2L4/7 b 4`

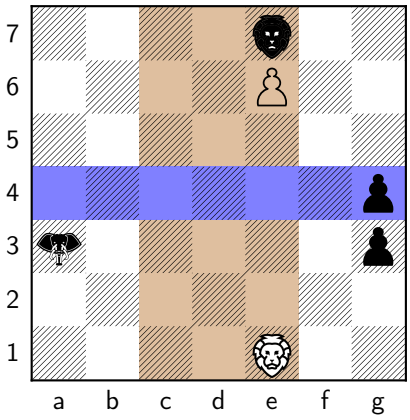


(b) `4l2/p1Ep3/1p2z2/7/7/2L4/7 w 5`

Figure 27: Initial and next positions after the move `b3b5`

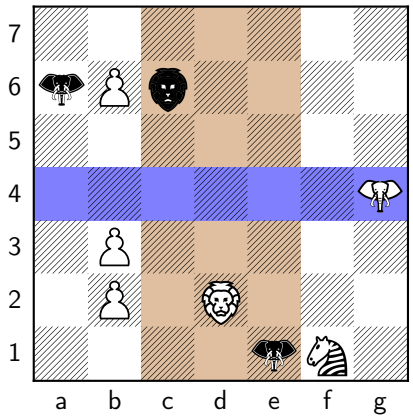


(a) `4l2/4P2/6p/3p3/e5p/7/4L2 b 2`

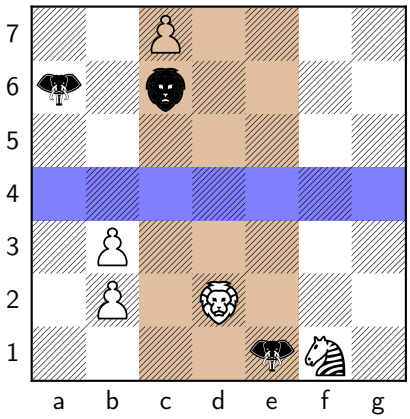


(b) `4l2/4P2/7/6p/e5p/7/4L2 w 3`

Figure 28: Initial and next positions after the move g5g4

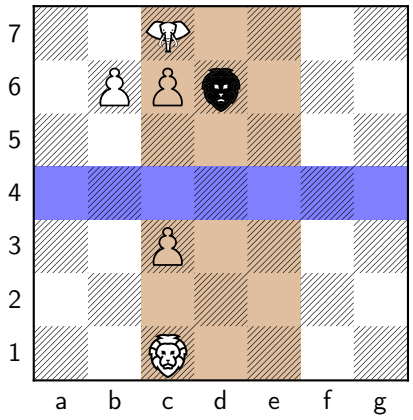


(a) `7/eP14/7/6E/1P5/1P1L3/4eZ1 w 10`

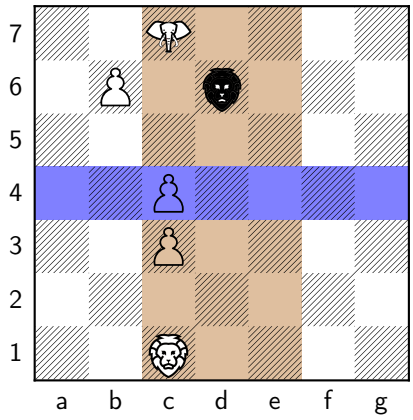


(b) `2P4/e1l4/7/7/1P5/1P1L3/4eZ1 b 10`

Figure 29: Initial and next positions after the move b6c7

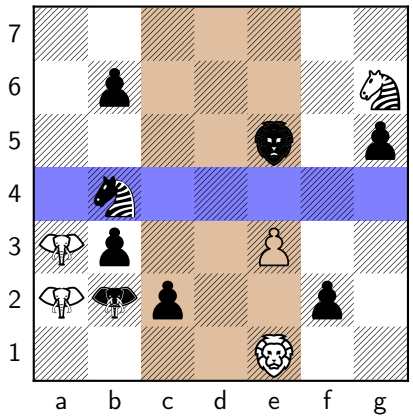


(a) `2E4/1PP13/7/7/2P4/7/2L4 w 25`

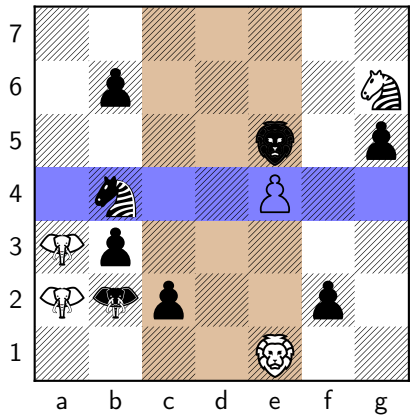


(b) `2E4/1P113/7/2P4/2P4/7/2L4 b 25`

Figure 30: Initial and next positions after the move `c6c4`

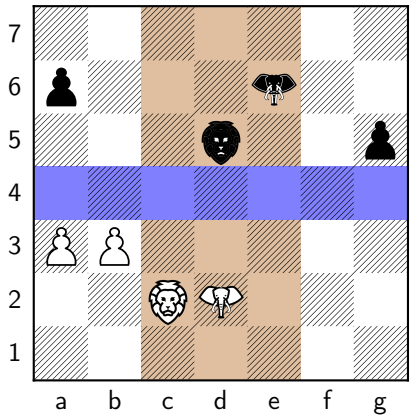


(a) `7/1p4Z/4l1p/1z5/Ep2P2/Eep2p1/4L2 w 10`

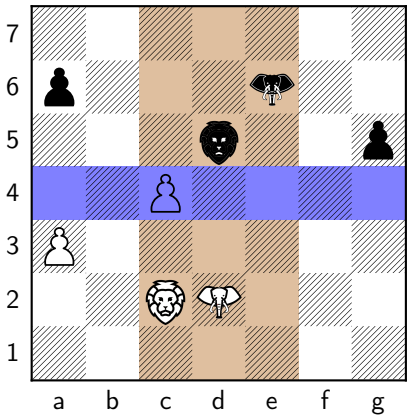


(b) `7/1p4Z/4l1p/1z2P2/Ep5/Eep2p1/4L2 b 10`

Figure 31: Initial and next positions after the move `e3e4`

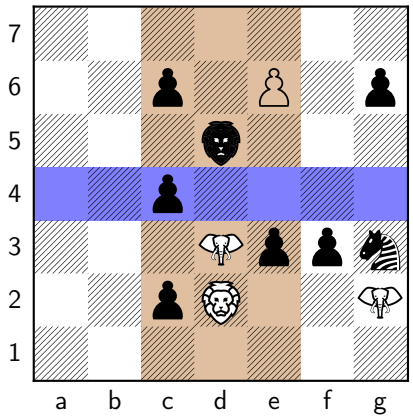


(a) `7/p3e2/3l2p/7/PP5/2LE3/7 w 1`

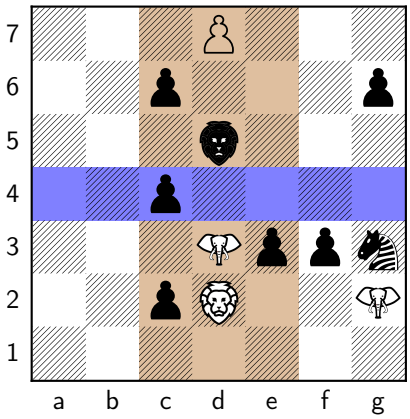


(b) `7/p3e2/3l2p/2P4/P6/2LE3/7 b 1`

Figure 32: Initial and next positions after the move `b3c4`

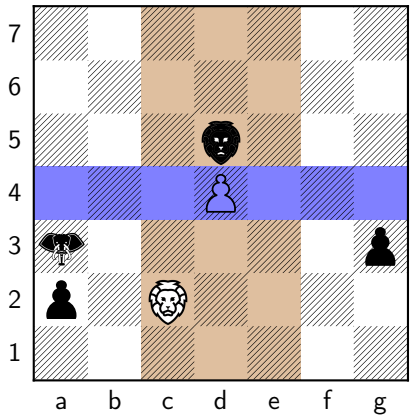


(a) `7/2p1P1p/3l3/2p4/3Eppz/2pL2E/7 w 19`

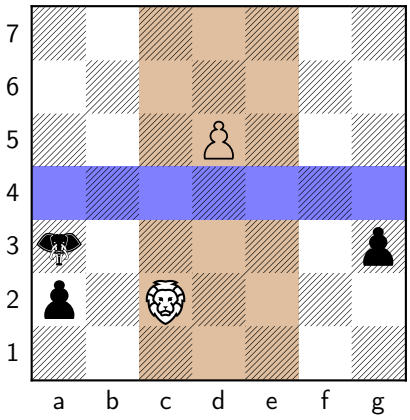


(b) `3P3/2p3p/3l3/2p4/3Eppz/2pL2E/7 b 19`

Figure 33: Initial and next positions after the move `e6d7`

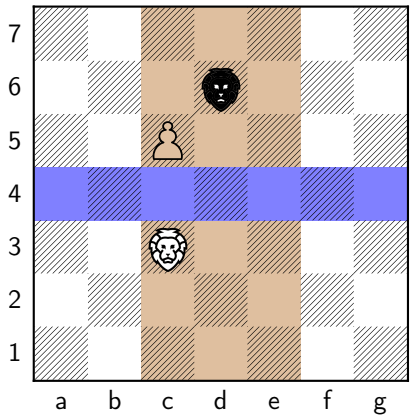


(a) `7/7/3l3/3P3/e5p/p1L4/7 w 48`

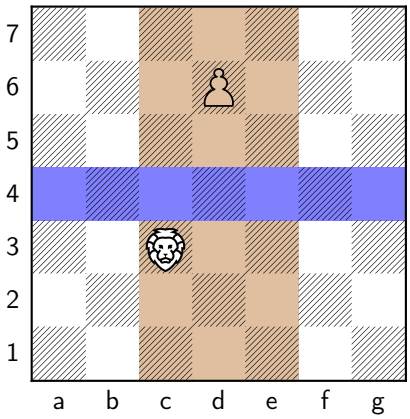


(b) `7/7/3P3/7/e5p/p1L4/7 b 48`

Figure 34: Initial and next positions after the move `d4d5`

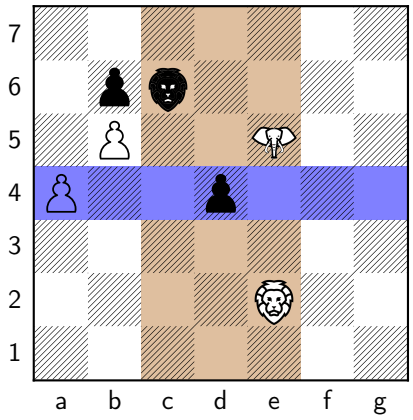


(a) `7/3l3/2P4/7/2L4/7/7 w 45`

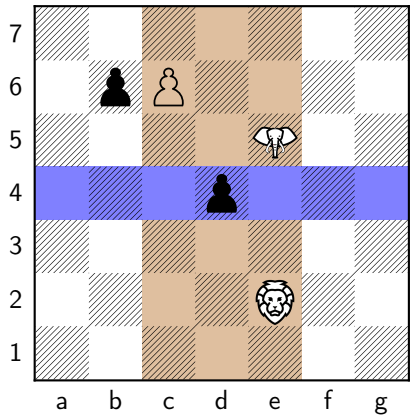


(b) `7/3P3/7/7/2L4/7/7 b 45`

Figure 35: Initial and next positions after the move `c5d6`

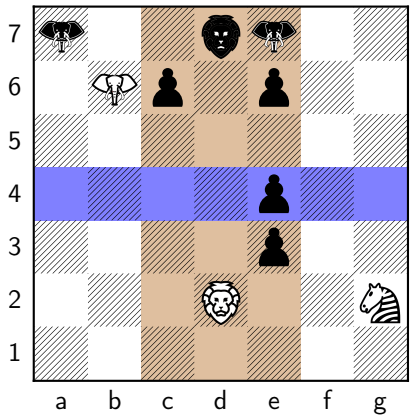


(a) `7/1pl4/1P2E2/P2p3/7/4L2/7 w 39`

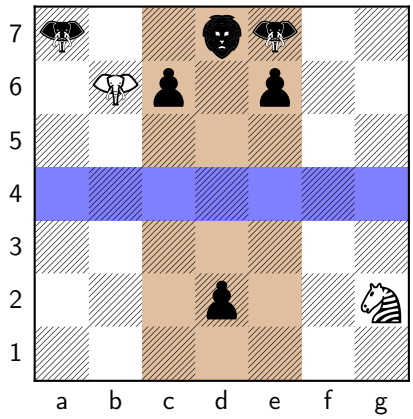


(b) `7/1pP4/4E2/3p3/7/4L2/7 b 39`

Figure 36: Initial and next positions after the move `b5c6`

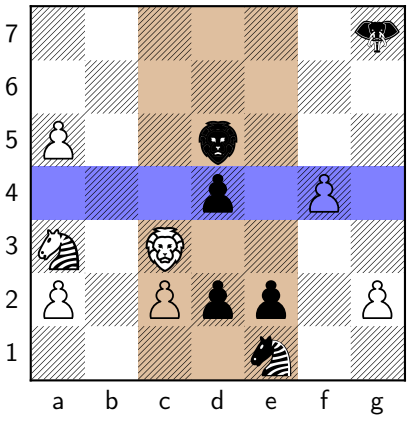


(a) `e2le2/1Ep1p2/7/4p2/4p2/3L2Z/7 b 8`

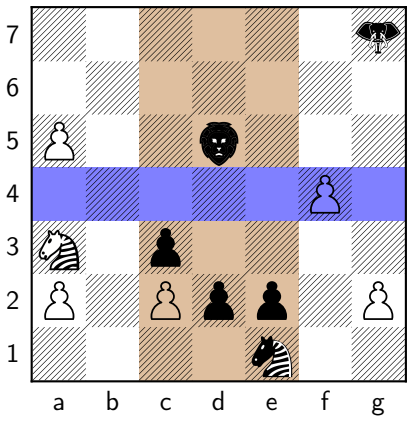


(b) `e2le2/1Ep1p2/7/7/7/3p2Z/7 w 9`

Figure 37: Initial and next positions after the move `e3d2`

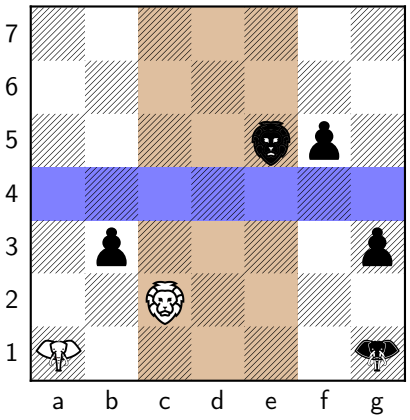


(a) `6e/7/P2l3/3p1P1/Z1L4/P1Ppp1P/4z2 b 17`

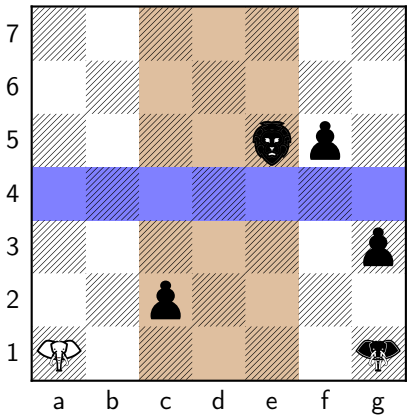


(b) `6e/7/P2l3/5P1/Z1p4/P1Ppp1P/4z2 w 18`

Figure 38: Initial and next positions after the move `d4c3`

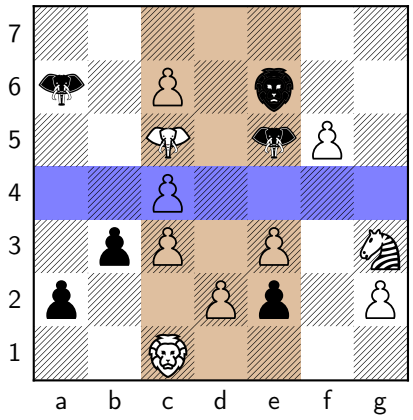


(a) `7/7/4lp1/7/1p4p/2L4/E5e b 37`

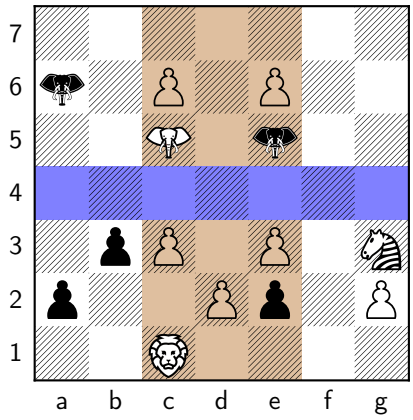


(b) `7/7/4lp1/7/6p/2p4/E5e w 38`

Figure 39: Initial and next positions after the move `b3c2`

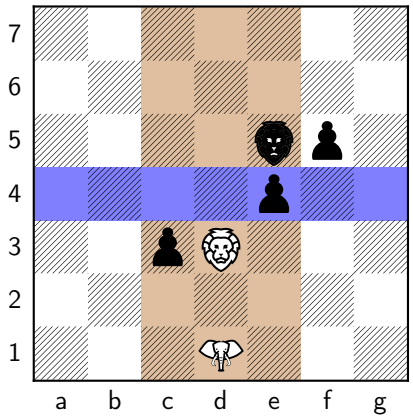


(a) `7/e1P1l2/2E1eP1/2P4/1pP1P1Z/p2Pp1P/2L4 w 37`

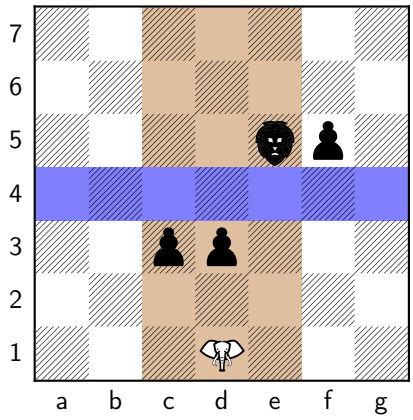


(b) `7/e1P1P2/2E1e2/7/1pP1P1Z/p2Pp1P/2L4 b 37`

Figure 40: Initial and next positions after the move `f5e6`

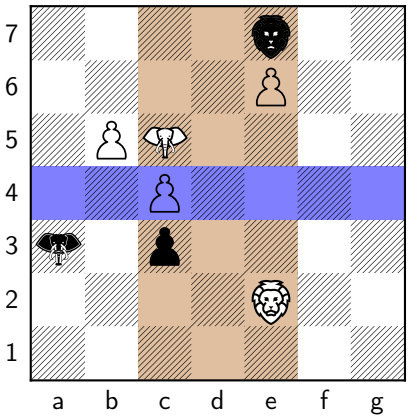


(a) `7/7/4l1p1/4p2/2pL3/7/3E3 b 48`

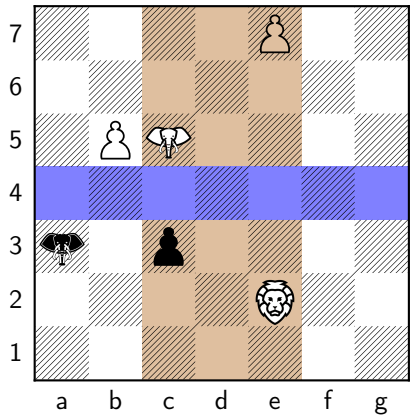


(b) `7/7/4l1p1/7/2pp3/7/3E3 w 49`

Figure 41: Initial and next positions after the move `e4d3`

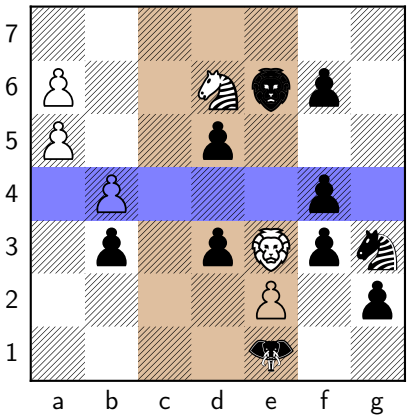


(a) `4l2/4P2/1PE4/2P4/e1p4/4L2/7 w 40`

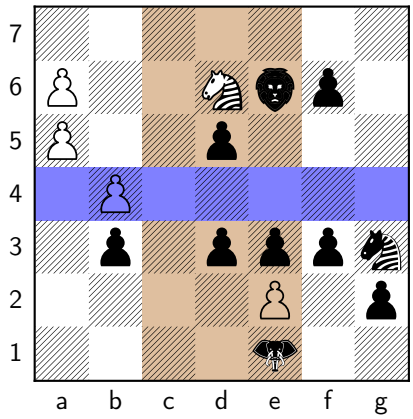


(b) `4P2/7/1PE4/7/e1p4/4L2/7 b 40`

Figure 42: Initial and next positions after the move `e6e7`

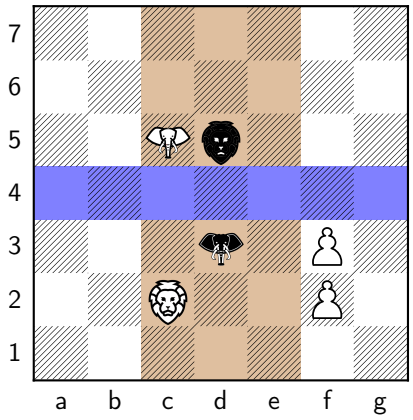


(a) `7/P2Zlp1/P2p3/1P3p1/1p1pLpz/4P1p/4e2 b 9`

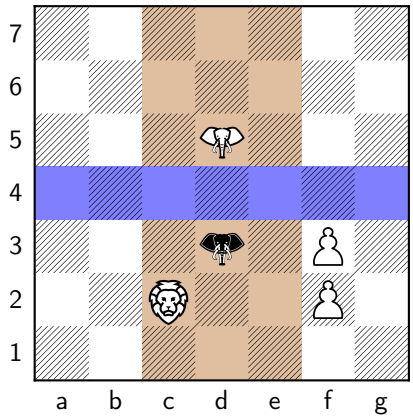


(b) `7/P2Zlp1/P2p3/1P5/1p1pppz/4P1p/4e2 w 10`

Figure 43: Initial and next positions after the move `f4e3`

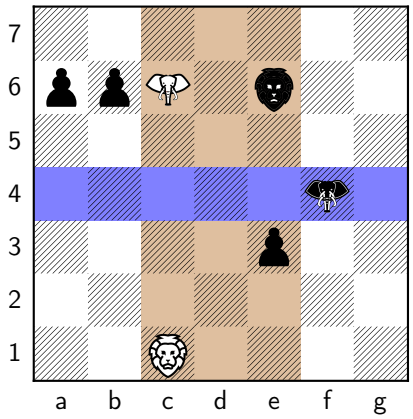


(a) `7/7/2El3/7/3e1P1/2L2P1/7 w 4`

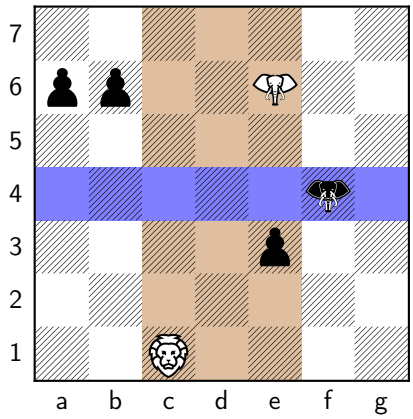


(b) `7/7/3E3/7/3e1P1/2L2P1/7 b 4`

Figure 44: Initial and next positions after the move `c5d5`

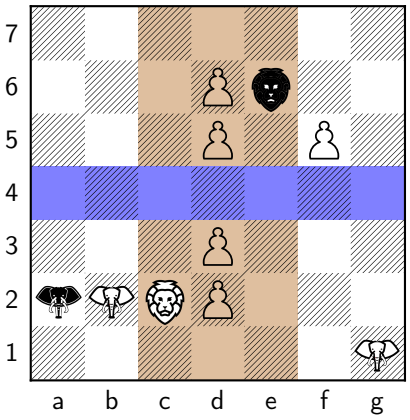


(a) `7/ppE1l2/7/5e1/4p2/7/2L4 w 18`

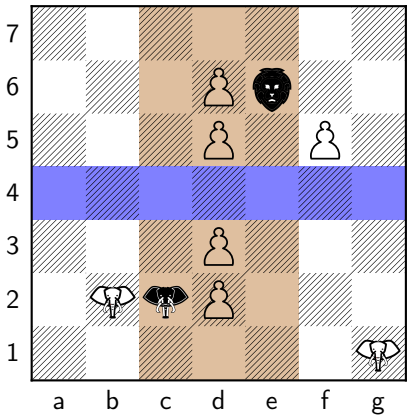


(b) `7/pp2E2/7/5e1/4p2/7/2L4 b 18`

Figure 45: Initial and next positions after the move `c6e6`

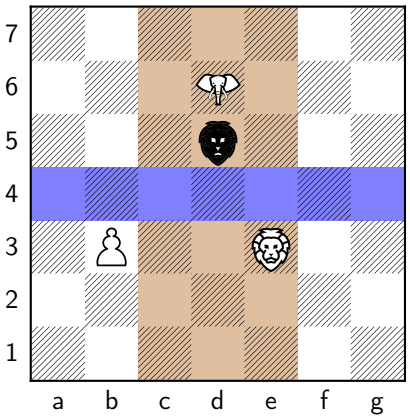


(a) `7/3Pl2/3P1P1/7/3P3/eELP3/6E b 40`

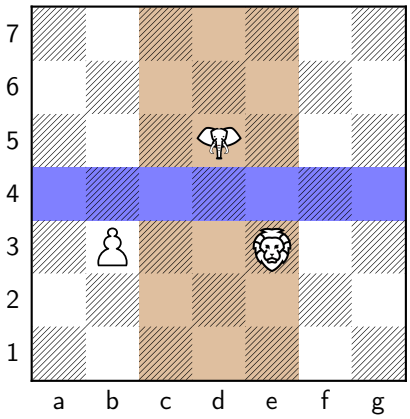


(b) `7/3Pl2/3P1P1/7/3P3/1EeP3/6E w 41`

Figure 46: Initial and next positions after the move `a2c2`

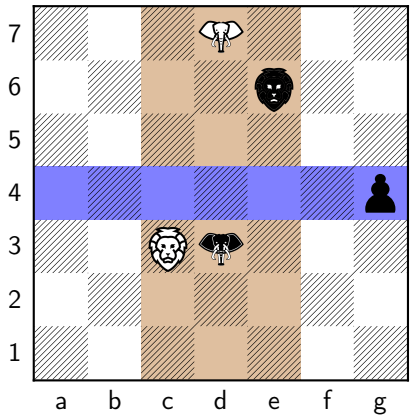


(a) `7/3E3/3l3/7/1P2L2/7/7 w 8`

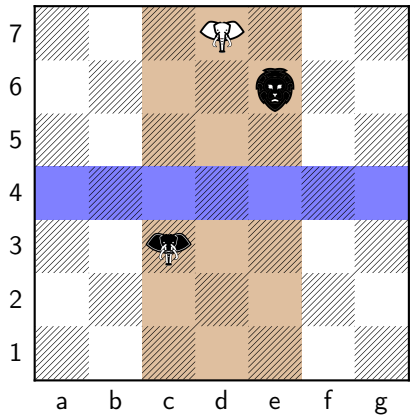


(b) `7/7/3E3/7/1P2L2/7/7 b 8`

Figure 47: Initial and next positions after the move `d6d5`

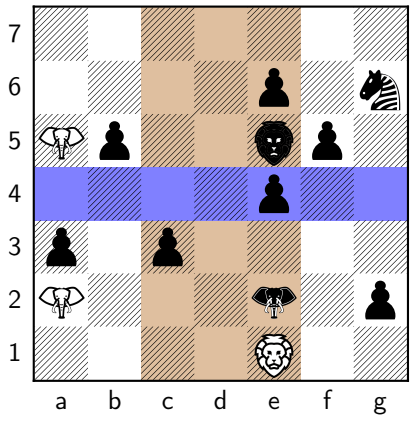


(a) `3E3/4l2/7/6p/2Le3/7/7 b 0`

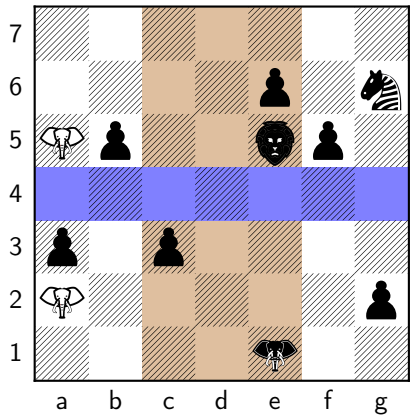


(b) `3E3/4l2/7/7/2e4/7/7 w 1`

Figure 48: Initial and next positions after the move `d3c3`

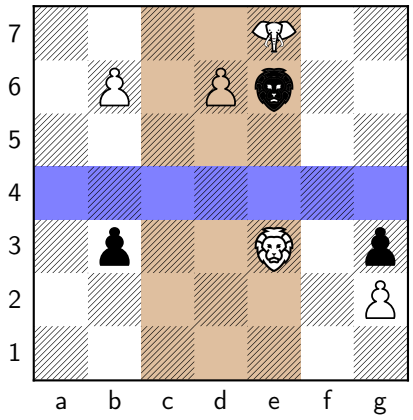


(a) `7/4p1z/Ep2lp1/4p2/p1p4/E3e1p/4L2 b 48`

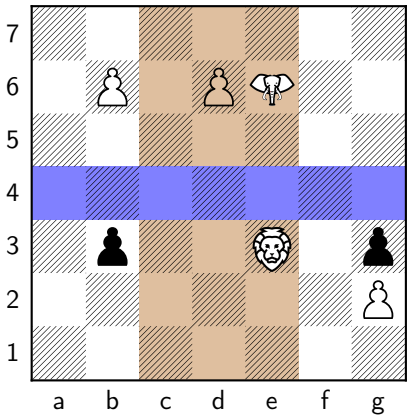


(b) `7/4p1z/Ep2lp1/7/p1p4/E5p/4e2 w 49`

Figure 49: Initial and next positions after the move `e2e1`

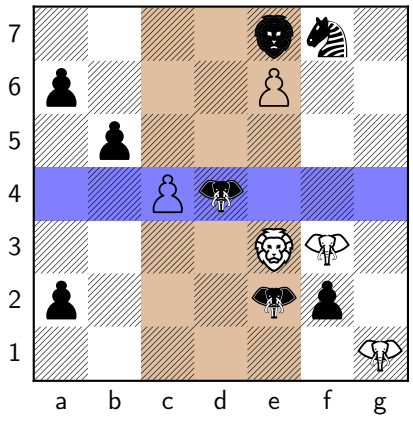


(a) `4E2/1P1Pl2/7/7/1p2L1p/6P/7 w 27`

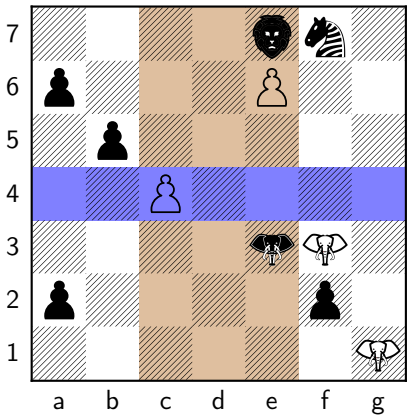


(b) `7/1P1PE2/7/7/1p2L1p/6P/7 b 27`

Figure 50: Initial and next positions after the move `e7e6`

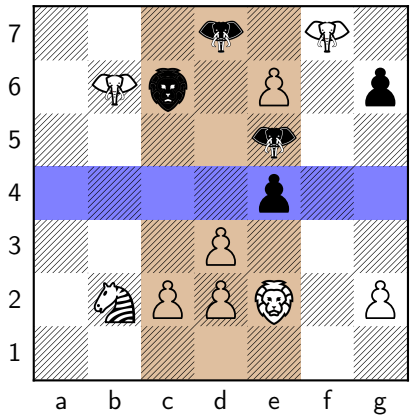


(a) `4lz1/p3P2/1p5/2Pe3/4LE1/p3ep1/6E b 22`

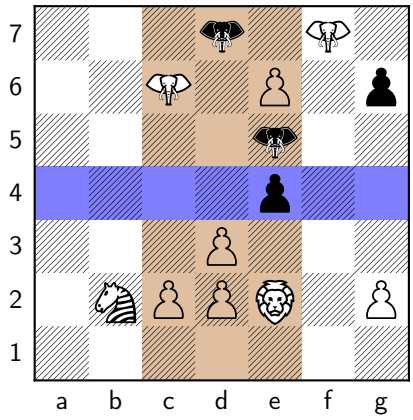


(b) `4lz1/p3P2/1p5/2P4/4eE1/p4p1/6E w 23`

Figure 51: Initial and next positions after the move `e2e3`

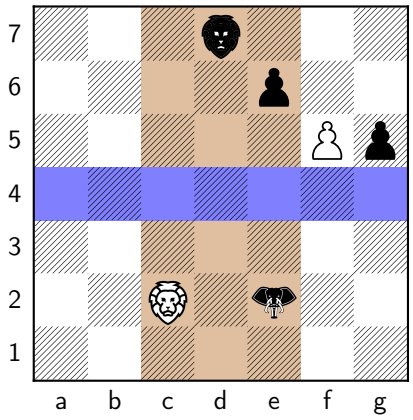


(a) `3e1E1/1El1P1p/4e2/4p2/3P3/1ZPPL1P/7 w 26`

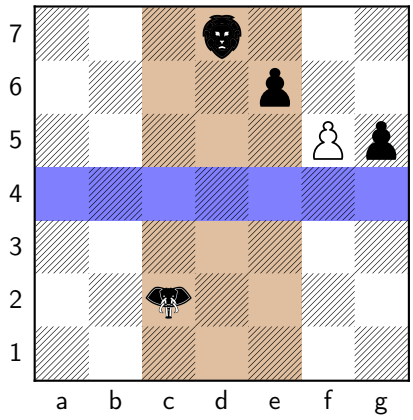


(b) `3e1E1/2E1P1p/4e2/4p2/3P3/1ZPPL1P/7 b 26`

Figure 52: Initial and next positions after the move `b6c6`



(a) `3l3/4p2/5Pp/7/7/2L1e2/7 b 1`



(b) `3l3/4p2/5Pp/7/7/2e4/7 w 2`

Figure 53: Initial and next positions after the move `e2c2`