## **Abstract**

This project was intended to lay the foundation for later evolutionary algorithmic work. In this project, we simply created a population consisting of 100 8-entry arrays, filled with a permutation of the numbers 0 through 7, which represented not only the number of the queen to be placed, but both its position vertically via the number, and horizontally via the column position. In addition, we had to provide fitness scores for each of the arrays. That is, the number of times the queens are in conflict with one another. My solution for that will be discussed in a later section.

## Algorithm

By nature of permutations, we didn't have to worry about any vertical or horizontal conflicts between queens. That only left diagonal conflicts, which I determined were calculable by adding or subtracting the number of the column a queen was in to its value (which represented its horizontal position). By checking if any of these values matched in a given array, I was able to determine if there were any conflicts, and if there were, how many. Adding up these conflicts is what determines the fitness of a particular individual. The closer the score is to 0, the better the board state.

## Output

[2 1 7 0 6 3 4 5] - 12	[6 5 3 0 2 1 4 7] - 14	[3 5 0 2 6 7 4 1] - 6
[2 0 5 6 4 3 7 1] - 8	[0 4 3 5 7 2 1 6] - 6	[4 6 3 0 7 2 5 1] - 6
[0 3 4 7 2 5 1 6] - 8	[40572361] - 6	[0 3 4 1 5 6 7 2] - 12
[2 0 4 6 3 1 5 7] - 10	[1 6 5 4 0 7 2 3] - 14	$[1\ 4\ 5\ 3\ 7\ 6\ 0\ 2]\ -\ 12$
[45706213] - 8	[1 4 2 5 7 6 0 3] - 6	[0 7 5 2 4 3 6 1] - 18
[47106253] - 8	[1 6 5 3 7 0 2 4] - 6	[7 3 2 0 1 4 5 6] - 10
[7 3 1 5 4 0 2 6] - 10	[7 6 2 0 4 5 1 3] - 14	[3 1 7 6 2 5 0 4] - 8
[4 3 0 1 7 6 5 2] - 14	[1 0 7 2 3 6 5 4] - 22	[4 5 7 2 0 6 1 3] - 6
[4 1 5 2 0 7 3 6] - 4	[3 0 7 2 1 6 4 5] - 6	[5 3 7 0 2 1 4 6] - 6
[5 0 2 7 1 4 3 6] - 12	[7 6 0 1 4 2 3 5] - 14	[1 5 0 7 6 4 2 3] - 10

[3 6 5 0 1 7 2 4] - 12	[5 7 1 4 3 2 6 0] - 14	[6 5 7 0 1 4 2 3] - 8
[7 5 4 0 1 6 3 2] - 10	[0 6 4 3 2 7 1 5] - 16	[7 4 2 1 6 0 3 5] - 6
[7 2 1 4 0 5 3 6] - 8	[70251634] - 8	[27164035] - 4
[0 4 2 7 3 5 6 1] - 14	[1 0 5 7 3 2 4 6] - 16	[4 1 6 3 5 2 7 0] - 8
[5 6 3 7 4 2 1 0] - 16	[2 4 7 3 5 6 1 0] - 6	[5 1 6 3 7 2 0 4] - 8
[7 3 5 0 6 1 4 2] - 6	[3 1 5 6 2 7 0 4] - 8	[1 0 2 5 7 4 3 6] - 10
[4 3 7 6 2 5 1 0] - 6	[17045263] - 8	[7 1 2 5 0 4 3 6] - 8
[2 5 7 6 0 3 1 4] - 2	[0 6 3 2 4 5 1 7] - 16	[5 4 3 7 1 6 2 0] - 14
[0 7 2 4 3 1 5 6] - 10	[0 5 4 7 6 2 1 3] - 14	[5 2 1 4 6 3 0 7] - 4
[6 5 7 1 4 3 0 2] - 12	[2 6 4 5 1 0 7 3] - 8	[5 3 6 4 1 2 7 0] - 12
[2 1 6 0 5 4 3 7] - 12	[17032456] - 10	[1 5 3 7 6 4 0 2] - 10
[2 1 0 3 4 5 7 6] - 20	[5 3 1 2 4 6 7 0] - 6	[3 2 7 0 1 5 4 6] - 10
[	F	[
[3 6 7 5 1 0 4 2] - 8	[2 4 1 7 5 3 6 0] - 0	[1 2 0 5 6 7 3 4] - 10
-		-
[3 6 7 5 1 0 4 2] - 8	[2 4 1 7 5 3 6 0] - 0	[1 2 0 5 6 7 3 4] - 10
[3 6 7 5 1 0 4 2] - 8 [7 5 2 0 6 4 1 3] - 4	[2 4 1 7 5 3 6 0] - 0 [7 0 3 1 5 4 2 6] - 10	[1 2 0 5 6 7 3 4] - 10 [3 1 6 5 2 7 0 4] - 6
[3 6 7 5 1 0 4 2] - 8 [7 5 2 0 6 4 1 3] - 4 [2 4 0 1 7 3 5 6] - 14	[2 4 1 7 5 3 6 0] - 0 [7 0 3 1 5 4 2 6] - 10 [3 2 5 7 1 0 4 6] - 8	[1 2 0 5 6 7 3 4] - 10 [3 1 6 5 2 7 0 4] - 6 [3 7 4 6 1 0 2 5] - 6
[3 6 7 5 1 0 4 2] - 8 [7 5 2 0 6 4 1 3] - 4 [2 4 0 1 7 3 5 6] - 14 [7 1 5 0 4 3 2 6] - 10	[2 4 1 7 5 3 6 0] - 0 [7 0 3 1 5 4 2 6] - 10 [3 2 5 7 1 0 4 6] - 8 [6 0 7 4 1 2 5 3] - 6	[1 2 0 5 6 7 3 4] - 10 [3 1 6 5 2 7 0 4] - 6 [3 7 4 6 1 0 2 5] - 6 [5 2 0 4 1 3 7 6] - 12
[3 6 7 5 1 0 4 2] - 8 [7 5 2 0 6 4 1 3] - 4 [2 4 0 1 7 3 5 6] - 14 [7 1 5 0 4 3 2 6] - 10 [7 4 3 5 1 6 2 0] - 12	[2 4 1 7 5 3 6 0] - 0 [7 0 3 1 5 4 2 6] - 10 [3 2 5 7 1 0 4 6] - 8 [6 0 7 4 1 2 5 3] - 6 [5 2 7 6 1 3 0 4] - 8	[1 2 0 5 6 7 3 4] - 10 [3 1 6 5 2 7 0 4] - 6 [3 7 4 6 1 0 2 5] - 6 [5 2 0 4 1 3 7 6] - 12 [1 7 0 5 6 2 4 3] - 12
[3 6 7 5 1 0 4 2] - 8 [7 5 2 0 6 4 1 3] - 4 [2 4 0 1 7 3 5 6] - 14 [7 1 5 0 4 3 2 6] - 10 [7 4 3 5 1 6 2 0] - 12 [3 2 4 6 5 1 7 0] - 14	[2 4 1 7 5 3 6 0] - 0 [7 0 3 1 5 4 2 6] - 10 [3 2 5 7 1 0 4 6] - 8 [6 0 7 4 1 2 5 3] - 6 [5 2 7 6 1 3 0 4] - 8 [7 6 3 4 5 1 2 0] - 20	[1 2 0 5 6 7 3 4] - 10 [3 1 6 5 2 7 0 4] - 6 [3 7 4 6 1 0 2 5] - 6 [5 2 0 4 1 3 7 6] - 12 [1 7 0 5 6 2 4 3] - 12 [6 3 4 0 5 7 2 1] - 10
[3 6 7 5 1 0 4 2] - 8 [7 5 2 0 6 4 1 3] - 4 [2 4 0 1 7 3 5 6] - 14 [7 1 5 0 4 3 2 6] - 10 [7 4 3 5 1 6 2 0] - 12 [3 2 4 6 5 1 7 0] - 14 [7 2 1 0 5 3 4 6] - 12	[2 4 1 7 5 3 6 0] - 0 [7 0 3 1 5 4 2 6] - 10 [3 2 5 7 1 0 4 6] - 8 [6 0 7 4 1 2 5 3] - 6 [5 2 7 6 1 3 0 4] - 8 [7 6 3 4 5 1 2 0] - 20 [3 7 6 4 1 5 2 0] - 8	[1 2 0 5 6 7 3 4] - 10 [3 1 6 5 2 7 0 4] - 6 [3 7 4 6 1 0 2 5] - 6 [5 2 0 4 1 3 7 6] - 12 [1 7 0 5 6 2 4 3] - 12 [6 3 4 0 5 7 2 1] - 10 [0 3 5 1 4 7 2 6] - 8
[3 6 7 5 1 0 4 2] - 8 [7 5 2 0 6 4 1 3] - 4 [2 4 0 1 7 3 5 6] - 14 [7 1 5 0 4 3 2 6] - 10 [7 4 3 5 1 6 2 0] - 12 [3 2 4 6 5 1 7 0] - 14 [7 2 1 0 5 3 4 6] - 12 [4 3 5 2 7 0 1 6] - 12	[2 4 1 7 5 3 6 0] - 0 [7 0 3 1 5 4 2 6] - 10 [3 2 5 7 1 0 4 6] - 8 [6 0 7 4 1 2 5 3] - 6 [5 2 7 6 1 3 0 4] - 8 [7 6 3 4 5 1 2 0] - 20 [3 7 6 4 1 5 2 0] - 8 [7 5 6 2 1 3 4 0] - 10	[1 2 0 5 6 7 3 4] - 10 [3 1 6 5 2 7 0 4] - 6 [3 7 4 6 1 0 2 5] - 6 [5 2 0 4 1 3 7 6] - 12 [1 7 0 5 6 2 4 3] - 12 [6 3 4 0 5 7 2 1] - 10 [0 3 5 1 4 7 2 6] - 8 [4 2 1 3 5 6 7 0] - 14
[3 6 7 5 1 0 4 2] - 8 [7 5 2 0 6 4 1 3] - 4 [2 4 0 1 7 3 5 6] - 14 [7 1 5 0 4 3 2 6] - 10 [7 4 3 5 1 6 2 0] - 12 [3 2 4 6 5 1 7 0] - 14 [7 2 1 0 5 3 4 6] - 12 [4 3 5 2 7 0 1 6] - 12 [1 7 5 2 4 0 6 3] - 6	[2 4 1 7 5 3 6 0] - 0 [7 0 3 1 5 4 2 6] - 10 [3 2 5 7 1 0 4 6] - 8 [6 0 7 4 1 2 5 3] - 6 [5 2 7 6 1 3 0 4] - 8 [7 6 3 4 5 1 2 0] - 20 [3 7 6 4 1 5 2 0] - 8 [7 5 6 2 1 3 4 0] - 10 [5 0 6 7 1 2 3 4] - 16	[1 2 0 5 6 7 3 4] - 10 [3 1 6 5 2 7 0 4] - 6 [3 7 4 6 1 0 2 5] - 6 [5 2 0 4 1 3 7 6] - 12 [1 7 0 5 6 2 4 3] - 12 [6 3 4 0 5 7 2 1] - 10 [0 3 5 1 4 7 2 6] - 8 [4 2 1 3 5 6 7 0] - 14 [2 7 6 5 0 3 1 4] - 14

```
12
                                [4 3 5 2 7 0 1 6]
                                                         12
     7
       0634
                 51
                                     5
                                       2
                                  7
[2
   0
     5
        6
          4
               7
                         8
                                [1
                                          4
                                            Ø
                                              6
                                                 3]
                                                         6
            3
                 1]
                                  1
                                       7
     4
          2
                                     3
                                          5
                                            2
                                                 4]
                                                         10
  3
        7
            5
               1
                 6]
                         8
                                ſØ
                                              6
ſΘ
          3
                                         1
                                  3
                                     2
                                       Ø
                                            5
                                              4
                                                 7]
            1
               5
                                [6
                                                         12
[2
   04
       6
                         10
                                       7
                                          2
        06
            2
              1
                                [5
                                   3
                                     1
                                            Ø
                                              6
                                                         2
   5
     7
                         8
                                                 41
                 31
                                     1 4
                                          3
                                            2
                               [5
                                  7
                                              6
                                                         14
   7
       Ø
          6
            2
              5
                         8
     1
                 3]
                                                 0]
                                          2
                                            7
                                       3
        5
          4
            Ø
               2
                 6]
                         10
                                [0 6
                                     4
                                              1
                                                 5]
                                                         16
   3
       1
          7
                                     2
                                       5
                                         1
                                  Ø
                                            6
                                              3
     Ø
               5
                 2]
                                                         8
   3
            6
                         14
                                [7
                                       7
       2
7
                                            2
               3
                                [1 0
                                     5
                                                 6]
                 61
                         4
                                              4
                                                         16
     5
          Ø
            7
     2
              3
                                     7
                                       3
                                            6
                                [2 4
                                          5
                                              1
          1
                                                 0]
                                                         6
  0
            4
                 6]
                         12
                                          2
                                       6
                                  1
                                            7
                                              Ø
     3
          2
                                [3
                                     5
                                                 4]
                                                         8
   5
       Ø
            1
               4
                 71
                         14
     3
          7
              1
                                       4
       5
            2
                                          5
                                            2
                         6
                                  7
                                     0
                                                         8
  4
                 6]
                                [1
                                              6
                                                 3]
       7
              6
                         6
                                     3
                                       2
                                         4 5
                                              1
                                                 7]
     5
          2
            3
                                [0 6
                                                         16
   0
                 1]
         0
       4
              2
                                     4
                                       7
                                          6
                                            2
  65
            7
                                [0 5
                                              1
                                                         14
                 3]
                         14
                                                 3]
     2
       5
                                [2
                                  6
                                     4
                                       5
                                          1
                                            Ø
                                              7
                                                 3]
                                                         8
              0
                         6
          7
            6
                 31
  4
                                       3
       3
                                            4
     5
              2
                                     Ø
                                          2
                                                         10
                         6
                                [1
                                   7
                                              5
                                                 61
[1
   6
          7
            0
                 4]
                                       2
                                            6
     2
              1
                               į5
                                     1
                                         4
                                              7
                                                 0]
       Ø
                                  3
                                                         6
   6
          4
            5
                 31
                         14
                                       7
                                          5
     7
       2
          3
              5
                               [2
                                  4
                                     1
                                            3
                                                         0
                         22
                                              6
                                                 01
  Ø
            6
                 4]
                                  Ø
       2
              4
                               [7
                                     3
                                       1
                                          5
                         6
                                            4
                                              2
                                                 61
                                                         10
     7
          1
  Ø
            6
                 51
                                     5
7
       1
                                       7
                               [3
          4
            2
              3
                         14
                                   2
                                            0
                                                 6]
                                                         8
   6
     Ø
                 51
                                       4
         6
                                            2
       2
                                Ī6
                                  Ø
                                          1
                                              5
                                                 31
                                                         6
            7
               4
                 1]
                         6
     Ø
   5
                                         1
5
       ø
                                       6
          7
              5
     3
                         6
                                [5
                                   2
                                     7
                                                 4]
                                                         8
  6
            2
                 1]
              7
                                [7
                                  6
                                     3
                                       4
                                            1
                                              2
                                                 0]
                                                         20
        1
            6
                         12
[0
          5
                 21
  3 4
                                       4
2
                                              2
                                     6
                                          1
                                            5
     5
        3
          7
                                [3
                                   7
                                                 01
                                                         8
   4
            6
              0
                 2]
                         12
                                            3
       2
                               [7
                                     6
                                          1
                                              4
[0
     5
               6
                         18
                                  5
                                                 0]
                                                         10
   7
          4
            3
                 1]
                                      7
                                     6 7
5 1
                                         1
       Ø
                                            2
                                              3
     2
                                  Ø
         1
              5
                                [5
                                                 4]
                                                         16
  3
            4
                 6]
                         10
       6
          2
                                  2
                                          4
                                            0
                                              3
                                                 61
                                                         2
     7
              Ø
                                [7
                         8
  1
            5
                 4]
                                         2
     7
       2
          Ø
              1
                         6
                                [1
                                   3
                                     45
                                            Ø
                                              6
                                                 71
                                                         10
            6
                 31
  5
                                       4
       02
                                [5
                                   2
                                     Ø
                                          3
                                            6
                                              7
     7
                         6
                                                 1]
                                                         14
               4
   3
            1
                 6]
       7 6
              2
                                [6
                                  5
                                     7
                                       Ø
                                         1
                                            4
                                              2
                                                 31
                                                         8
   5
     Ø
            4
                 3]
                         10
                                       1
               2
                                [7
                                  4
                                     2
                                          6
                                            Ø
                                              3
                                                 51
                                                         6
     5
       0 1
                         12
  6
            7
                 4]
              3
                                [2
                                   7
                                     16
                                          4
                                            0
                                              3
                                                 51
                                                         4
     4
       0
          1
                         10
   5
            6
                 2]
                                       3
    1
                               [4
                                            2
                                     6
                                          5
                                              7
       4 0 5
                                  1
                                                 0]
                                                         8
   2
                 61
                         8
                                         7 2
7 4
                                       3
                                Ī5
                                     6
     2
                                  1
                                              Ø
                                                 4]
                                                         8
  4
               6
                         14
            5
                 1]
                                       5
                                     2
                               [1 0
                                              3
     3
                                                 6]
                                                         10
   6
        7
            2
               1
                         16
          4
                 0]
                                     25
                                   1
                                          Ø
     5
          6
                                [7
                                            4
                                              3
                                                 6]
                                                         8
   3
       Ø
            1
               4
                 2]
                         6
                                       7
                                          1
                                  4
                                     3
     7
                                            6
                                              2
                                                         14
       6
          2
                                [5
                                                 0]
              1
                 0]
                         6
            5
   3
                                [5
                                     1 4
                                          6
                                            3
                                   2
                                              Ø
                                                 7]
                                                         4
     7
       6
          Ø
            3
              1
                          2
  5
                 4]
                                            2
                               į5
                                  3
                                     6
                                       4
                                         1
                                              7
                                                         12
                                                 0]
     2
       4
          3
            1
               5
                         10
   7
                 6]
                                       7
                                          6
                                [1
                                     3
                                   5
                                            4
                                                 2]
                                                         10
     7
       1
          4
            3
               Ø
                 2]
                         12
                                              Ø
[6
                                     7
       05
                                [3
                                  2
                                       Ø
                                         1
                                            5
                                              4
                                                 6]
                                                         10
                         12
   1
            4
               3
                 7]
     6
                                     05
                                         6
                                            7
                                [1 2
                                              3
                                                 4]
                                                         10
          4
              7
  1
     Ø
                          20
            5
                 6]
                                       5
                                  1
                                          2
                                            7
                                     6
                                [3
                                              Ø
                                                 4]
                                                         6
     7
       5
          1
                 2]
                         8
  6
            Ø
              4
                                         1 0
                                     4 6
                                [3
                                   7
                                              2
                                                 51
                                                         6
     2
       Ø
          6
              1
                 3]
                         4
   5
            4
                                         1
                                   2
                                     04
                                            3
                                              7
                                                 6]
                                                         12
                                [5
       1
          7
              5 6]
     Ø
            3
                         14
   4
                               [1
                                         62
                                     05
              2
                                   7
                                              4
                                                 3]
                                                         12
  1
     5
       0 4
                 6]
                         10
            3
                                       Ø
                                         5
                                            7
                                              2
                                                1]
                                [6
                                  3
                                     4
                                                         10
     3
       5
          1
               2 0]
   4
            6
                         12
                                                6]
                                       1
                                         4
                                     5
                                [0 3
                                            7
                                              2
                                                         8
  2
     4
       6
          5
            1
                 0]
                         14
                                [4 2 1 3
                                         56
                                              7
                                                         14
       05346
   2 1
                         12
```

## Code

```
#!/Library/Frameworks/Python.framework/Versions/3.4/bin/python3
# Joel Doumit
# CS472 - Evolutionary Algorithms
# Assignment 1a - 8 Queens
import numpy as np
def initializeBoard():
        return np.random.permutation(8)
def initializePopulation(size):
        return [initializeBoard() for i in range(size)]
def checkMatch(pos):
        counts = (np.unique(pos, return counts=True))[1]
        conflicts = [i * (i-1) \text{ for } i \text{ in counts}]
        return np.sum(conflicts)
def fitness(board):
        score = 0
        posdiag = [0, 1, 2, 3, 4, 5, 6, 7]
        negdiag = [0, -1, -2, -3, -4, -5, -6, -7]
        checkpos = [x + y \text{ for } x, y \text{ in zip(board, posdiag)}]
        checkneg = [x + y \text{ for } x, y \text{ in } zip(board, negdiag)]
```

```
score = (checkMatch(checkpos) + checkMatch(checkneg))

return score

if __name__ == "__main__":
    population = initializePopulation(100)
    for i in population:
        print(i, " - ", fitness(i))
```