Programming Assignment: Local Search NQueens
ITCS 6150/8150

Solving N-queens problem using Genetic Algorithm

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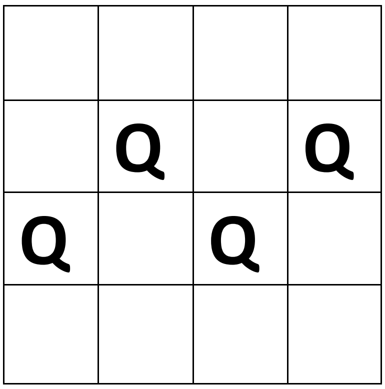
Problem Formulation

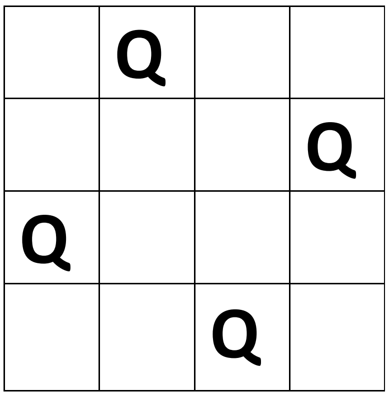
The N-queens problem is a typical programming problem in which we must find a solution to placing ‘n’ queens on ‘n*n’ board such that no two queens can attack each other. Attack means that no 2 queens can be placed in the same row, same column, or same diagonal. Though it seems to be a trivial problem, a wide range of programming algorithms can be applied to solve this. Here I have implemented Genetic Search Algorithm to solve the n-queens problem. The problem formulation for the n-queens problem can be described as below:

1.) Initial State:

- Incremental Formulation: This method starts with placing the n queens one by one on the board.
- Complete-State Formulation: This method starts with placing all the n queens placed randomly on the board at once.
- We choose the Complete-State formulation and hence the initial state is all the queens placed randomly.



Initial State



Goal State

2.) Goal State: n queens on the board with no two queens in the same row, column, or the diagonal.

3.) States: Any arrangement of 0 to n queens on the board is a state.

4.) Actions: Adding a queen to an empty square of the board.

5.) Transition Model: A board with the chosen queen added to the specified square

Genetic Algorithm to solve NQueens Problem:

Genetic Algorithms are a family of algorithms whose purpose is to solve problems more efficiently than usual standard algorithms by using natural science metaphors with parts of the algorithm being strongly inspired by natural evolutionary behavior, such as the concept of **mutation**, **crossover,** and **natural selection**.

The Genetic Algorithm for the NQueens problem can be described as below:

1. A random population of candidate solutions is created and the fitness scores of the individuals are calculated, and the chromosomes are sorted in the population and ranked according to the fitness values.
2. Certain number of chromosomes will pass onto the next generation depending on a selection operator, favoring the better individuals based on their ranking in the population.
3. Selected chromosomes acting as parents will take part in crossover operation to create children whose fitness values are to be calculated simultaneously. Crossover probability is generally kept high, because it is seen to give better children in terms of fitness values.
4. Then based on a mutation probability, a mutation operator is applied on new individuals which randomly changes few chromosomes. Mutation probability is generally kept low.
5. Evaluated off-springs, together with their parents form the population for the next generation.

Steps 2-5 are repeated until a given number of iterations, that is, generations have been evaluated or solution improvement rate falls below some threshold, that is, the difference between two best solutions from consecutive generations is below a certain tolerance limit. The population initialization, the fitness function and the crossover and mutation operators are used.

- **Population Initialization:** Firstly, we initialize a random population of chromosome of length 1000. Every chromosome here is a vector of length N, which is a random permutation of (1, 2, 3… N).
- **Fitness Function:** We design the Fitness of each chromosome in such a way that k number of queens on the same diagonal situation will accumulate k-1 points to the fitness value. All these points are summed which obtains the fitness value.
- **Crossover Function:** For obtaining global optimum for a non-convex function the cross over function performs a very important role for obtaining better offspring. As we are considering each of the chromosomes actually a random permutation of (1, 2, 3… N), so it was needed to design a permutation crossover.

Let's take the N x N chess board arrangement (c1, c2, c3… cN). We'll first check whether more than one Queen is on the same (↗) directed diagonals. This happens if,

$$\text{For } i \in \{1,2 \ldots N\} \text{ and } j \in \{1, 2 \ldots N\} \text{ and } i \neq j;$$

$$(ci - i) == (cj - j)$$

Similarly, for our next checking whether more than one Queen is on the same (↖) directed diagonals, this happens if,

$$\text{For } i \in \{1,2 \ldots N\} \text{ and } j \in \{1, 2 \ldots N\} \text{ and } i \neq j;$$

$$(ci + i) == (cj + j)$$

Thus we amass the fitness value if any of the above situation occurs. Which clearly shows that the fittest chromosome is signified as 0 fitness value.

Pseudo Code:

Pseudo code:

```
Function fitness (chromosome) {

t1 = 0;   //number of repetitive queens in one diagonal while seen from left corner
t2 = 0;   //number of repetitive queens in one diagonal while seen from right corner
size = length (chromosome);
for i= 1 to size:
   f1 (i) = (chromosome (i)-i);
   f2 (i) = ((1+size)-chromosome (i)-i);
end
f1=sort (f1);
f2=sort (f2);
for i=2 to size:
   if(f1 (i) == f1 (i-1)) //checks whether two Queens are in same diagonals seeing from left corner or not
      t1 = t1+1;
   end
   if(f2 (i) == f2(i-1)) //checks whether two Queens are in same diagonals seeing from right corner or not
      t2 = t2+1;
   end
end
fitness_value = t1 + t2;
return  fitness_value;
}
```

Overall Program Structure

I have implemented the n queens' algorithm to solve this problem using **python.**

Functions and Procedures

Function Name	Description
`genetic`	Performs genetic algorithm
`initPopulation`	Produces the initial population
`parent_Selection`	Creates a new population from the parents
`crossover`	Selects a random point to merge both configurations
`mutation`	Mutates child using probability
`quickSort`	Performs quicksort algorithm
`fitness`	Calculates the cost/fitness by counting the number of queen conflicts
`printBoard`	Prints the board to the console

Input/Output:

Enter the number of queens:

8

[[0, 5, 7, 6, 5, 3, 7, 0], [0, 0, 1, 3, 3, 6, 0, 6], [0, 6, 5, 3, 4, 4, 0, 1], [7, 5, 2, 1, 6, 4, 4, 6], [0, 7, 6, 7, 4, 4, 0, 2], [4, 1, 0, 5, 7, 4, 0, 4], [4, 2, 3, 2, 5, 7, 3, 7], [7, 7, 3, 4, 4, 1, 2, 0], [3, 2, 7, 5, 5, 2, 2, 1], [0, 4, 6, 5, 1, 6, 5, 5], [6, 5, 5, 6, 7, 7, 2, 0], [4, 5, 4, 0, 6, 2, 3, 6], [7, 7, 1, 7, 1, 4, 6, 2]]

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Generation: 263 cost: 0 [1, 7, 5, 0, 2, 4, 6, 3]

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Runtime: 0.12300586700439453 (seconds)

Enter the number of queens:

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[[4, 1, 4, 18, 5, 2, 10, 6, 17, 0, 18, 3, 15, 14, 19, 3, 5, 18, 6, 15], [2, 14, 14, 9, 0, 4, 18, 7, 19, 4, 14, 16, 11, 3, 19, 12, 9, 8, 14, 3], [15, 1, 2, 0, 11, 7, 1, 14, 10, 0, 15, 16, 18, 7, 8, 16, 10, 7, 7, 8], [12, 14, 0, 14, 16, 2, 5, 18, 9, 1, 5, 14, 12, 14, 1, 16, 10, 0, 1, 9], [12, 12, 10, 11, 4, 14, 5, 5, 14, 11, 6, 8, 6, 15, 15, 13, 19, 0, 16, 12], [12, 13, 9, 10, 6, 9, 12, 14, 10, 4, 7, 3, 0, 7, 7, 1, 16, 18, 7, 8], [0, 7, 18, 1, 19, 11, 6, 14, 10, 16, 12, 3, 9, 16, 12, 5, 14, 3, 12, 19], [3, 14, 5, 8, 13, 2, 11, 19, 15, 3, 12, 17, 3, 12, 3, 3, 18, 2, 2, 2], [5, 11, 11, 5, 6, 5, 9, 17, 12, 9, 17, 16, 13, 3, 2, 13, 4, 5, 2, 8], [11, 11, 11, 3, 9, 3, 19, 2, 11, 18, 7, 10, 13, 13, 18, 11, 11, 11, 12, 8], [3, 3, 19, 5, 1, 8, 8, 3, 16, 8, 18, 8, 14, 10, 5, 9, 1, 6, 15, 17], [1, 4, 14, 19, 1, 7, 2, 8, 17, 3, 14, 7, 12, 0, 5, 4, 15, 9, 1, 6], [4, 6, 9, 15, 12, 11, 11, 18, 16, 1, 18, 5, 12, 11, 2, 15, 0, 2, 17, 4], [19, 5, 19, 3, 16, 8, 11, 13, 12, 14, 7, 13, 0, 17, 9, 17, 18, 0, 4, 5], [8, 15, 7, 1, 10, 1, 10, 10, 14, 3, 1, 0, 15, 8, 1, 5, 16, 10, 12, 0], [7, 14, 13, 8, 3, 4, 0, 1, 9, 4, 4, 7, 12, 17, 17, 2, 6, 1, 10, 0], [11, 10, 17, 1, 15, 18, 15, 9, 8, 18, 0, 17, 7, 1, 1, 17, 18, 9, 19, 2], [0, 11, 7, 7, 17, 15, 3, 7, 11, 0, 9, 1, 8, 0, 8, 12, 8, 3, 1, 15], [9, 5, 11, 18, 5, 9, 17, 12, 15, 1, 6, 5, 10, 7, 10, 13, 11, 13, 1, 8], [1, 3, 14, 17, 1, 8, 18, 16, 9, 9, 12, 17, 0, 13, 14, 17, 1, 0, 14, 4], [10, 1, 16, 19, 1, 2, 4, 13, 4, 16, 13, 17, 14, 15, 18, 12, 14, 0, 1, 0], [12, 8, 7, 14, 6, 11, 8, 3, 4, 1, 17, 12, 10, 4, 12, 9, 5, 8, 6, 14], [8, 9, 3, 16, 7, 9, 4, 13, 18, 0, 3, 10, 17, 13, 7, 2, 1, 7, 11, 7], [6, 11, 4, 3, 10, 7, 15, 8, 19, 16, 7, 17, 19, 14, 17, 4, 19, 0, 4, 6], [1, 5, 0, 13, 13, 18, 8, 6, 3, 9, 4, 11, 3, 0, 3, 16, 6, 14, 18, 12], [13, 16, 2, 6, 18, 0, 5, 11, 7, 14, 0, 18, 15, 11, 5, 11, 3, 7, 18, 6], [3, 1, 10, 10, 19, 0, 19, 4, 12, 6, 4, 3, 7, 2, 18, 17, 15, 12, 4, 17], [10, 9, 15, 0, 8, 10, 12, 13, 4, 16, 19, 8, 7, 2, 14, 2, 4, 12, 9, 18], [4, 0, 9, 2, 6, 10, 5, 11, 9, 8, 8, 18, 15, 2, 0, 4, 1, 1, 7, 4], [17, 1, 12, 17, 10, 6, 3, 1, 8, 1, 0, 17, 17, 18, 14, 16, 15, 19, 9, 16], [18, 5, 0, 4, 5, 7, 15, 4, 0, 9, 3, 18, 12, 5, 16, 12, 11, 1, 19, 5]]

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Generation: 1746 cost: 0 [12, 16, 1, 13, 11, 19, 14, 7, 2, 0, 3, 8, 17, 9, 4, 18, 5, 15, 10, 6]]

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Runtime: 11.050851106643677 (seconds)

Enter the number of queens:

30
[[26, 29, 20, 20, 5, 15, 3, 9, 12, 23, 6, 13, 22, 10, 0, 26, 14, 1, 6, 12, 11, 11, 18, 8, 5, 16, 7, 9, 28, 21], [17, 20, 28, 10, 6, 1, 5, 8, 2, 29, 17, 25, 29, 4, 13, 20, 5, 9, 8, 0, 21, 28, 11, 14, 13, 11, 11, 17, 0, 1], [22, 16, 29, 27, 16, 27, 0, 5, 10, 16, 26, 8, 22, 29, 20, 0, 14, 13, 19, 19, 20, 23, 9, 8, 25, 21, 14, 12, 22, 0], [13, 16, 28, 25, 4, 3, 6, 21, 18, 15, 12, 17, 5, 23, 19, 22, 28, 9, 8, 6, 23, 17, 29, 21, 28, 0, 5, 14, 8, 2], [12, 3, 26, 10, 24, 7, 23, 17, 27, 22, 9, 19, 26, 8, 15, 10, 24, 15, 21, 23, 26, 17, 27, 4, 9, 2, 8, 18, 11, 22], [29, 11, 15, 3, 12, 6, 10, 13, 8, 4, 27, 4, 17, 10, 25, 8, 1, 16, 16, 26, 15, 13, 2, 13, 13, 0, 3, 16, 9, 19], [12, 17, 7, 17, 24, 7, 25, 2, 27, 8, 10, 22, 22, 17, 11, 18, 1, 7, 7, 5, 26, 23, 24, 24, 17, 3, 13, 14, 2, 20], [28, 2, 24, 4, 7, 26, 26, 29, 22, 22, 9, 21, 6, 7, 19, 28, 8, 11, 20, 0, 15, 5, 13, 13, 6, 1, 29, 18, 17, 14], [16, 29, 10, 19, 13, 6, 12, 21, 23, 7, 12, 3, 24, 18, 23, 14, 16, 16, 1, 10, 3, 14, 12, 13, 0, 4, 12, 23, 11, 0], [12, 25, 2, 27, 22, 14, 16, 13, 5, 26, 23, 24, 13, 27, 9, 27, 5, 18, 27, 6, 12, 21, 1, 1, 10, 14, 15, 20, 24, 15], [17, 6, 19, 17, 19, 18, 25, 11, 8, 12, 27, 11, 16, 11, 28, 8, 25, 27, 26, 12, 26, 3, 24, 25, 3, 23, 19, 1, 15, 8], [13, 13, 4, 11, 23, 29, 5, 29, 23, 11, 12, 16, 6, 11, 3, 0, 23, 1, 23, 11, 10, 11, 7, 0, 18, 24, 11, 5, 23, 27], [15, 19, 28, 9, 7, 22, 8, 19, 22, 25, 29, 2, 24, 9, 4, 2, 0, 23, 4, 24, 13, 21, 7, 22, 14, 0, 1, 20, 12, 19], [29, 27, 16, 1, 23, 15, 7, 4, 13, 22, 6, 8, 3, 3, 23, 22, 13, 7, 17, 25, 24, 1, 1, 7, 12, 21, 7, 3, 18, 29], [19, 4, 20, 10, 7, 13, 21, 14, 1, 10, 27, 24, 24, 29, 12, 17, 25, 18, 9, 6, 2, 19, 5, 11, 0, 23, 29, 28, 13, 22], [1, 21, 25, 14, 20, 29, 22, 27, 16, 29, 18, 27, 26, 10, 4, 16, 5, 14, 18, 28, 8, 28, 13, 27, 8, 11, 12, 5, 19, 1], [4, 11, 8, 23, 7, 24, 27, 16, 14, 28, 23, 8, 26, 13, 6, 19, 26, 16, 17, 14, 13, 6, 10, 1, 22, 20, 6, 5, 26, 26], [15, 7, 2, 16, 7, 1, 27, 13, 27, 20, 5, 19, 16, 21, 12, 29, 19, 2, 19, 19, 18, 2, 1, 10, 3, 25, 9, 19, 15, 20], [15, 27, 24, 22, 28, 27, 13, 22, 12, 4, 21, 2, 28, 24, 19, 26, 21, 26, 3, 11, 28, 18, 7, 28, 10, 17, 9, 10, 15, 0], [22, 6, 22, 16, 18, 15, 26, 11, 23, 11, 11, 0, 4, 2, 14, 13, 0, 28, 7, 15, 4, 24, 2, 10, 16, 5, 27, 1, 24, 6], [3, 18, 17, 4, 9, 21, 28, 10, 16, 15, 17, 19, 26, 16, 23, 27, 7, 29, 22, 11, 6, 7, 13, 20, 27, 14, 16, 8, 0, 15], [21, 22, 19, 29, 29, 7, 12, 29, 14, 19, 16, 8, 16, 9, 14, 26, 14, 15, 9, 19, 17, 19, 20, 13, 12, 1, 29, 6, 26, 4], [29, 17, 7, 22, 29, 2, 14, 9, 7, 3, 1, 26, 16, 8, 12, 22, 29, 12, 3, 29, 9, 15, 22, 24, 22, 3, 6, 20, 15, 17], [12, 25, 25, 18, 21, 20, 14, 28, 9, 6, 27, 10, 5, 21, 20, 29, 27, 3, 12, 13, 18, 13, 18, 20, 14, 19, 20, 15, 11, 13], [2, 1, 14, 19, 10, 4, 6, 1, 25, 25, 29, 19, 28, 4, 20, 15, 8, 25, 25, 9, 14, 0, 17, 0, 21, 1, 9, 26, 23, 15], [21, 4, 11, 7, 27, 14, 12, 6, 8, 29, 13, 24, 11, 27, 5, 14, 0, 22, 3, 27, 13, 4, 26, 12, 1, 16, 11, 12, 13, 8], [13, 27, 17, 1, 19, 18, 15, 0, 9, 15, 11, 24, 5, 9, 16, 5, 5, 21, 29,

2, 18, 12, 26, 14, 21, 23, 11, 15, 29, 6], [4, 2, 1, 6, 2, 7, 16, 21, 19, 10, 16, 26, 25, 14, 3, 27, 13, 3, 6, 13, 19, 17, 21, 22, 15, 1, 9, 17, 18, 7], [18, 23, 10, 18, 17, 28, 14, 20, 15, 0, 22, 2, 18, 13, 13, 26, 28, 3, 7, 23, 10, 16, 13, 9, 13, 26, 7, 28, 1, 28], [20, 21, 11, 15, 28, 2, 24, 18, 14, 20, 3, 3, 10, 24, 24, 6, 10, 28, 19, 19, 15, 18, 23, 7, 29, 20, 28, 10, 15, 16], [2, 14, 6, 22, 26, 25, 3, 19, 18, 24, 4, 27, 2, 20, 2, 12, 29, 4, 25, 11, 21, 10, 12, 27, 17, 11, 4, 27, 11, 17], [15, 9, 4, 28, 17, 24, 19, 24, 24, 13, 27, 2, 27, 27, 11, 22, 3, 9, 1, 26, 23, 25, 17, 19, 1, 17, 17, 14, 15, 10], [29, 5, 21, 17, 0, 14, 20, 28, 6, 3, 17, 22, 8, 4, 10, 16, 11, 26, 12, 11, 5, 1, 23, 25, 24, 21, 2, 17, 22, 8], [3, 14, 9, 17, 8, 16, 0, 6, 6, 8, 17, 7, 11, 16, 18, 7, 7, 16, 8, 24, 15, 13, 23, 18, 24, 21, 22, 18, 25, 17], [17, 19, 20, 8, 5, 3, 13, 10, 18, 18, 26, 29, 9, 26, 3, 1, 16, 8, 21, 28, 16, 0, 7, 9, 6, 9, 10, 26, 20, 29], [15, 7, 0, 3, 2, 2, 2, 2, 27, 3, 17, 21, 27, 12, 12, 21, 7, 23, 22, 26, 10, 0, 14, 7, 4, 8, 6, 6, 13, 17], [28, 17, 8, 8, 10, 12, 16, 17, 15, 11, 5, 9, 17, 27, 7, 2, 19, 0, 15, 11, 7, 17, 22, 7, 21, 25, 9, 3, 1, 22], [9, 22, 23, 7, 12, 22, 23, 28, 2, 11, 24, 18, 16, 9, 7, 7, 18, 29, 19, 12, 15, 1, 2, 5, 21, 28, 9, 21, 28, 12], [4, 14, 0, 1, 17, 16, 20, 3, 12, 16, 23, 9, 23, 5, 4, 24, 12, 11, 1, 11, 28, 1, 22, 6, 3, 17, 24, 22, 24, 23], [20, 24, 15, 12, 9, 25, 24, 12, 0, 23, 5, 9, 15, 28, 11, 13, 1, 21, 16, 2, 9, 6, 20, 8, 18, 9, 6, 15, 9, 4], [14, 28, 8, 4, 3, 25, 7, 4, 14, 3, 10, 7, 15, 28, 9, 22, 14, 16, 0, 8, 8, 15, 29, 16, 10, 26, 10, 12, 26, 18], [10, 8, 5, 3, 2, 27, 24, 23, 23, 3, 28, 14, 24, 3, 13, 8, 21, 3, 6, 1, 9, 7, 1, 6, 0, 19, 15, 16, 16, 23], [4, 17, 19, 25, 18, 10, 5, 1, 25, 8, 25, 2, 6, 20, 25, 27, 19, 17, 21, 24, 27, 19, 17, 17, 21, 19, 22, 21, 5, 9], [28, 19, 3, 6, 20, 7, 9, 13, 26, 27, 9, 22, 20, 21, 2, 20, 25, 7, 18, 7, 16, 4, 2, 12, 0, 29, 24, 7, 28, 7], [0, 17, 1, 19, 29, 3, 20, 13, 3, 4, 23, 20, 25, 14, 0, 2, 29, 5, 11, 7, 18, 26, 25, 7, 16, 29, 19, 6, 27, 26], [26, 15, 25, 19, 16, 28, 14, 6, 29, 8, 8, 2, 5, 19, 9, 23, 0, 19, 15, 27, 7, 16, 15, 18, 21, 20, 22, 24, 0, 12]]

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Generation: 260 cost: 0 [19, 24, 16, 2, 5, 15, 22, 1, 13, 17, 12, 26, 4, 0, 3, 27, 14, 21, 29, 25, 23, 11, 18, 8, 10, 20, 7, 9, 28, 6]]]

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Runtime: 6.453503847122192 (seconds)

Enter the number of queens:

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[[11, 0, 14, 18, 17, 31, 8, 28, 8, 43, 5, 13, 17, 8, 48, 29, 13, 28, 32, 33, 27, 33, 48, 47, 20, 3, 16, 31, 5, 27, 11, 17, 11, 31, 36, 6, 29, 31, 22, 15, 1, 25, 34, 1, 17, 46, 18, 0, 0, 1], [9, 3, 41, 1, 39, 33, 24, 42, 25, 24, 10, 41, 16, 18, 49, 38, 15, 30, 39, 32, 36, 29, 10, 15, 6, 34, 12, 2, 23, 9, 26, 24, 28, 37, 37, 35, 26, 29, 29, 21, 15, 7, 21, 39, 26, 49, 44, 37, 34, 39], [29, 3, 15, 38, 25, 47, 34, 31, 46, 39, 49, 13, 2, 23, 5, 14, 22, 39, 43, 18, 36, 18, 45, 8, 3, 45, 27, 8, 32, 26, 39, 49, 4, 17, 31, 25, 42, 12, 44, 42, 33, 27, 9, 15, 44, 8, 39, 46, 2, 6], [15, 0, 19, 16, 34, 26, 27, 29, 2, 21, 44, 21, 17, 14, 40, 22, 31, 30, 46, 11, 25, 31, 32, 29, 39, 12, 14, 13, 14, 23, 46, 9, 22, 25, 40, 38, 10, 44, 15, 29, 31, 34, 34, 0, 3, 10, 44, 29, 33, 38], [26, 4, 40, 39, 32, 43, 26, 18, 42, 8, 2, 11, 49, 6, 30, 39, 29, 32, 9, 36, 44, 40, 23, 41, 45, 40, 39, 2, 35, 30, 42, 45, 0, 9, 19, 33, 3, 29, 22, 33, 27, 6, 6, 23, 12, 6, 46, 46, 4, 6], [31, 31, 39, 25, 26, 33, 40, 34, 37, 22, 11, 28, 25, 41, 25, 32, 46, 11, 12, 27, 45, 38, 27, 46, 21, 11, 35, 9, 48, 0, 23, 44, 29, 10, 3, 32, 21, 44, 42, 10, 8, 22, 26, 17, 41, 31, 4, 19, 11, 41], [24, 18, 29, 37, 27, 14, 43, 20, 25, 35, 36, 41, 25, 31, 43, 26, 31, 25, 27, 42, 3, 2, 32, 33, 46, 16, 19, 46, 47, 23, 48, 47, 24, 37, 44, 17, 2, 44, 32, 21, 22, 29, 41, 44, 29, 42, 35, 6, 34, 40], [48, 45, 4, 19, 47, 5, 45, 24, 49, 22, 33, 0, 25, 1, 6, 33, 29, 6, 2, 27, 40, 46, 8, 29, 34, 36, 7, 21, 10, 33, 20, 24, 21, 34, 9, 4, 27, 37, 22, 49, 27, 11, 5, 1, 32, 2, 14, 13, 31, 25], [7, 4, 29, 21, 11, 4, 30, 18, 17, 11, 7, 44, 17, 13, 37, 33, 15, 14, 22, 31, 36, 15, 4, 10, 36, 9, 30, 16, 32, 32, 21, 34, 22, 26, 1, 14, 5, 42, 32, 48, 31, 17, 1, 33, 24, 7, 25, 31, 5, 17], [32, 18, 38, 38, 20, 17, 12, 12, 0, 2, 45, 49, 13, 46, 49, 27, 17, 33, 41, 42, 29, 26, 12, 18, 48, 18, 5, 25, 45, 38, 46, 17, 45, 37, 20, 35, 43, 9, 26, 20, 13, 44, 23, 47, 46, 43, 40, 16, 39, 19], [23, 26, 2, 25, 48, 44, 5, 46, 1, 33, 45, 19, 6, 8, 24, 33, 7, 21, 35, 44, 26, 17, 10, 47, 0, 49, 32, 15, 13, 0, 27, 20, 28, 26, 8, 18, 44, 2, 12, 15, 34, 24, 15, 15, 25, 21, 33, 2, 15, 40], [26, 49, 34, 0, 48, 39, 27, 2, 11, 30, 14, 14, 21, 39, 1, 45, 32, 25, 17, 2, 17, 17, 23, 2, 19, 13, 45, 36, 10, 2, 40, 39, 37, 30, 20, 37, 5, 34, 32, 34, 15, 48, 46, 14, 33, 37, 29, 17, 4, 16], [23, 27, 14, 1, 16, 16, 46, 34, 21, 6, 36, 45, 33, 30, 23, 7, 24, 27, 25, 46, 5, 11, 37, 22, 16, 6, 3, 9, 44, 25, 21, 1, 42, 48, 27, 7, 18, 27, 28, 47, 32, 43, 42, 21, 28, 23, 6, 9, 40, 29], [0, 26, 32, 36, 47, 12, 15, 47, 16, 39, 33, 43, 16, 1, 47, 43, 15, 27, 17, 31, 42, 33, 24, 42, 32, 34, 1, 1, 6, 37, 6, 25, 27, 32, 46, 4, 22, 19, 28, 36, 48, 17, 35, 49, 27, 31, 39, 1, 5, 43], [11, 41, 12, 43, 5, 23, 5, 46, 49, 11, 17, 5, 48, 3, 17, 11, 45, 17, 15, 20, 19, 44, 17, 45, 20, 32, 34, 5, 24, 13, 25, 49, 28, 4, 5, 38, 37, 22, 41, 7, 26, 8, 4, 17, 17, 40, 4, 16, 32, 20], [48, 48, 11, 3, 13, 47, 3, 20, 37, 42, 30, 37, 32, 33, 32, 8, 1, 33, 1, 47, 30, 45, 26, 11, 8, 4, 0, 20, 6, 29, 31, 35, 5, 3, 35, 10, 33, 38, 14, 48, 8, 18, 21, 29, 28, 16, 44, 25, 22, 35], [42, 32, 6, 10, 44, 18, 8, 28, 44, 27, 49, 41, 37, 33, 3, 1, 24, 42, 21, 32, 44, 35, 26, 48, 32, 4, 22, 11, 7, 35, 15, 16, 15, 3, 18, 7, 40, 2, 42, 39, 42, 43, 16, 43, 32, 19, 12, 47, 12, 26], [19, 39, 32, 49, 14, 18, 36, 47, 21, 42, 39, 49, 8, 23, 1, 38, 21, 28, 40, 48, 37, 37, 7, 7, 2, 22, 45, 23, 24, 33, 27, 28, 29, 21, 21, 1, 4, 46, 23, 43, 49, 0, 11, 17, 47, 30, 13, 43, 12, 13], [27, 1, 38, 35, 45, 23, 2, 4, 31, 7, 41, 34, 6, 15, 8, 25, 14, 39, 18, 48, 41, 40, 24, 2, 17, 0, 43, 34, 17, 32, 6, 37, 18, 2, 13, 17, 0, 27, 33, 13, 46, 35, 16, 6, 42, 17, 27, 24, 31, 26], [34, 1, 48, 46, 38, 1, 5, 16, 36, 45, 29, 12, 28, 34, 33, 1, 21, 29, 10, 31, 37, 13, 41, 37, 7, 33, 8, 28, 24, 7, 46, 15, 6, 49, 40, 25, 32, 2, 17, 37, 1, 1, 24, 6, 34, 48, 28, 36, 42, 46], [40, 1, 22, 3, 18, 17, 10, 38, 24, 4, 22, 0, 11, 48, 4, 13, 26, 1, 17, 46, 39, 4, 15, 16, 29, 29, 5, 25, 22, 41, 33, 13, 25, 4, 5, 43, 6, 37, 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Generation: 1 cost: 37 [26, 4, 40, 39, 32, 43, 26, 18, 42, 8, 2, 11, 49, 6, 30, 39, 29, 32, 9, 36, 44, 40, 23, 41, 45, 36, 7, 21, 10, 33, 20, 24, 21 Generation: 2 cost: 37 [1, 18, 30, 42, 44, 42, 37, 20, 13, 20, 47, 23, 38, 20, 36, 12, 35, 0, 27, 22, 0, 21, 26, 15, 42, 29, 5, 25, 22, 41, 33, 13, Generation: 3 cost: 38 [31, 27, 48, 35, 5, 2, 33, 19, 10, 29, 21, 20, 15, 13, 33, 30, 34, 17, 3, 36, 41, 46, 28, 49, 11, 18, 5, 25, 45, 38, 46, 17, Generation: 4 cost: 37 [26, 15, 40, 39, 32, 43, 26, 16, 42, 8, 2, 35, 49, 6, 30, 39, 29, 32, 9, 36, 44, 40, 23, 41, 45, 36, 7, 21, 10, 33, 20, 32, 2 Generation: 5 cost: 37 [26, 4, 32, 39, 32, 43, 26, 18, 42, 8, 2, 11, 49, 6, 30, 39, 29, 32, 9, 36, 44, 40, 23, 41, 45, 29, 5, 25, 22, 41, 2, 13, 25, Generation: 6 cost: 37 [26, 15, 40, 39, 32, 43, 26, 16, 42, 8, 2, 11, 49, 6, 30, 39, 29, 32, 9, 36, 44, 40, 23, 41, 45, 36, 7, 21, 10, 33, 20, 32, 2 Generation: 7 cost: 34 [26, 4, 32, 39, 32, 43, 26, 18, 42, 8, 2, 11, 49, 6, 30, 14, 29, 32, 9, 36, 44, 40, 23, 41, 45, 29, 15, 25, 22, 41, 2, 13, 25 Generation: 8 cost: 33 [26, 4, 32, 39, 32, 43, 26, 18, 42, 8, 2, 11, 49, 6, 30, 14, 29, 32, 25, 36, 44, 40, 23, 41, 45, 29, 15, 25, 22, 41, 2, 13, 2 Generation: 9 cost: 31 [26, 4, 40, 15, 32, 43, 26, 16, 42, 8, 2, 11, 49, 6, 30, 42, 29, 32, 9, 36, 44, 40, 44, 41, 45, 29, 15, 25, 22, 41, 2, 13, 25 Generation: 10 cost: 29 [26, 4, 40, 17, 32, 43, 26, 16, 42, 8, 46, 11, 49, 6, 30, 39, 29, 32, 9, 36, 44, 40, 23, 41, 45, 29, 15, 25, 22, 41, 2, 13, Generation: 11 cost: 29 [26, 4, 40, 17, 32, 43, 26, 16, 42, 8, 2, 11, 49, 6, 30, 22, 29, 32, 9, 36, 44, 40, 23, 41, 45, 29, 15, 25, 22, 41, 2, 13, 2 Generation: 12 cost: 28 [26, 4, 32, 39, 32, 46, 26, 18, 42, 8, 2, 11, 49, 6, 30, 39, 29, 32, 9, 36, 10, 40, 23, 41, 45, 29, 15, 25, 22, 41, 44, 13, Generation: 13 cost: 28 [26, 4, 40, 17, 32, 0, 26, 16, 42, 8, 2, 11, 49, 6, 30, 22, 29, 32, 9, 36, 44, 40, 23, 41, 45, 29, 15, 25, 22, 41, 2, 13, 25 Generation: 14 cost: 26 [26, 4, 40, 17, 32, 0, 26, 16, 42, 8, 2, 11, 49, 6, 30, 22, 29, 32, 9, 36, 44, 40, 23, 41, 45, 29, 15, 25, 22, 41, 44, 13, 1 Generation: 15 cost: 24 [26, 4, 40, 17, 32, 0, 26, 16, 42, 8, 2, 11, 49, 6, 30, 22, 29, 32, 9, 36, 44, 40, 23, 41, 45, 29, 15, 25, 22, 41, 8, 13, 25 Generation: 16 cost: 25 [26, 4, 32, 39, 32, 46, 26, 18, 42, 8, 2, 11, 49, 6, 30, 40, 29, 32, 9, 12, 10, 40, 23, 41, 45, 29, 15, 25, 22, 41, 44, 13, Generation: 17 cost: 24 [26, 4, 40, 15, 32, 43, 26, 16, 27, 8, 2, 11, 49, 6, 46, 42, 35, 32, 9, 36, 44, 35, 23, 41, 45, 29, 15, 25, 22, 41, 44, 13, Generation: 18 cost: 23 [26, 3, 40, 17, 32, 0, 26, 16, 42, 8, 2, 11, 49, 6, 30, 22, 29, 12, 9, 36, 44, 40, 23, 41, 45, 29, 15, 25, 22, 41, 8, 13, 25

Generation: 19 cost: 23 [26, 4, 40, 15, 32, 43, 26, 16, 27, 8, 2, 11, 49, 6, 46, 42, 35, 32, 9, 36, 44, 35, 23, 41, 45, 29, 15, 25, 22, 41, 8, 13, 2 Generation: 20 cost: 23 [26, 4, 40, 15, 32, 43, 26, 16, 31, 8, 2, 11, 49, 6, 46, 42, 35, 32, 9, 36, 44, 35, 23, 41, 45, 27, 15, 25, 22, 14, 44, 13, Generation: 21 cost: 23 [26, 4, 40, 15, 32, 43, 26, 16, 31, 8, 2, 11, 49, 6, 46, 42, 35, 32, 9, 36, 44, 35, 23, 41, 45, 27, 15, 25, 22, 14, 44, 13, Generation: 22 cost: 22 [26, 4, 14, 17, 32, 0, 26, 16, 42, 8, 49, 11, 49, 17, 24, 22, 29, 32, 9, 36, 44, 40, 23, 41, 45, 27, 15, 25, 22, 14, 44, 13, Generation: 23 cost: 22 [26, 4, 14, 17, 32, 0, 26, 16, 42, 8, 2, 11, 49, 6, 30, 22, 29, 32, 9, 36, 44, 40, 23, 41, 45, 27, 15, 25, 22, 14, 44, 13, 1 Generation: 24 cost: 20 [26, 4, 40, 15, 17, 43, 26, 16, 31, 8, 2, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 35, 23, 41, 45, 27, 15, 25, 22, 14, 44, 13, Generation: 25 cost: 20 [35, 4, 40, 15, 32, 43, 26, 16, 31, 8, 2, 11, 49, 6, 46, 42, 35, 32, 9, 36, 14, 7, 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32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 22, 14, 44, 7, 10 Generation: 53 cost: 10 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 22, 14, 44, 7, 1, Generation: 54 cost: 9 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 22, 14, 44, 7, 10, Generation: 55 cost: 10 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 22, 14, 44, 7, 10 Generation: 56 cost: 9 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 7, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 1, 0 Generation: 57 cost: 9 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 22, 14, 44, 7, 10, Generation: 58 cost: 8 [26, 4, 40, 15, 17, 9, 29, 16, 4, 8, 17, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10, Generation: 59 cost: 7 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 1, Generation: 60 cost: 8 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 1, Generation: 61 cost: 8 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10, Generation: 62 cost: 8 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 10, 20, 14, 44, 7, 10 Generation: 63 cost: 7 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 64 cost: 7 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 65 cost: 7 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 66 cost: 7 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 67 cost: 7 [26, 4, 40, 15, 28, 9, 29, 16, 2, 8, 17, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10, Generation: 68 cost: 6 [26, 4, 22, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 69 cost: 6 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 70 cost: 7 [26, 4, 40, 15, 28, 9, 29, 16, 2, 8, 17, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 10, 20, 14, 44, 7, 10, Generation: 71 cost: 6 [26, 4, 40, 15, 28, 9, 29, 16, 2, 8, 17, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10, Generation: 72 cost: 6 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 73 cost: 6 [26, 4, 40, 15, 28, 9, 29, 16, 2, 8, 17, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10, Generation: 74 cost: 6 [26, 4, 40, 15, 17, 9, 29, 16, 37, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 1 Generation: 75 cost: 6 [26, 4, 40, 15, 28, 9, 29, 16, 2, 8, 17, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10, Generation: 76 cost: 6 [26, 4, 40, 15, 17, 9, 29, 16, 37, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 1 Generation: 77 cost: 7 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 21, 3, 25, 20, 14, 44, 7, 10 Generation: 78 cost: 6 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 79 cost: 6 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 80 cost: 6 [26, 4, 26, 15, 17, 9, 29, 16, 37, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 1 Generation: 81 cost: 6 [26, 4, 26, 15, 17, 9, 29, 16, 37, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 1 Generation: 82 cost: 6 [26, 4, 40, 15, 28, 9, 29, 16, 8, 22, 17, 11, 49, 6, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 83 cost: 5 [26, 4, 40, 15, 17, 9, 29, 16, 24, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 1 Generation: 84 cost: 5 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 85 cost: 5 [26, 4, 40, 15, 17, 9, 29, 16, 24, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 1 Generation: 86 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27, 3, 25, 20, 14, 44, 7, 10 Generation: 93 cost: 5 [26, 4, 40, 15, 17, 9, 29, 16, 24, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 1 Generation: 94 cost: 5 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 3, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10, Generation: 95 cost: 5 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 3, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10, Generation: 96 cost: 5 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 3, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10, Generation: 97 cost: 5 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 3, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10, Generation: 98 cost: 5 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 99 cost: 5 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 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14, 44, 7, 1

Generation: 113 cost: 5 [26, 4, 40, 15, 17, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 41, 45, 27, 3, 25, 20, 14, 44, 7, 1 Generation: 114 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 115 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 116 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 117 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 118 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 119 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 120 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 121 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 122 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 123 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 124 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 125 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 126 cost: 3 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 127 cost: 4 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 27, 3, 25, 20, 14, 44, 7, 10 Generation: 128 cost: 3 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 129 cost: 3 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 130 cost: 3 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 41, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 131 cost: 3 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 132 cost: 3 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 133 cost: 3 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 134 cost: 3 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 135 cost: 2 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 136 cost: 2 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 137 cost: 2 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 138 cost: 2 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 139 cost: 2 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 140 cost: 2 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 141 cost: 2 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 142 cost: 2 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 143 cost: 2 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 144 cost: 2 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 145 cost: 2 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 146 cost: 1 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 147 cost: 1 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 148 cost: 1 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 149 cost: 1 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 150 cost: 1 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 151 cost: 1 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 152 cost: 1 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 153 cost: 1 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 154 cost: 1 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 155 cost: 1 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 156 cost: 1 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 157 cost: 0 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, Generation: 158 cost: 0 [26, 4, 22, 15, 40, 9, 29, 16, 2, 8, 17, 11, 47, 24, 46, 42, 35, 32, 48, 36, 30, 49, 23, 5, 45, 6, 3, 25, 20, 14, 44, 7, 10, 39, 27, 43, 31, 21, 18, 1, 28, 38, 12, 33, 19, 41, 0, 34, 37, 13]

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```

Runtime: 21.947015285491943 (seconds)

Enter the number of queens:

70 (I could solve for 70 queens in 542.3342154026031 seconds.)