

**CS/AI 2203**  
**ARTIFICIAL & COMPUTATIONAL INTELLIGENCE**  
**ASSIGNMENT-2 Report**

**Index:**

- [\*\*1\)Differential Evolution\*\*](#)
- [\*\*2\)Egg Holder function Differential Evolution\*\*](#)
- [\*\*3\)Holder table function Differential Evolution\*\*](#)
- [\*\*4\)Particle Swarm Optimization \(Bonus\)\*\*](#)
- [\*\*5\)EggHolder function Particle Swarm Optimization\*\*](#)
- [\*\*6\)Holder table function Particle Swarm Optimization\*\*](#)

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## Differential Evolution

Keeping in mind the pros and cons of classical GA, alternate approaches founded on the evolutionary principle have been developed. One such approach is Differential Evolution.

It has 3 major steps:

1. Mutation
2. Crossover
3. Selection/Elitism

The parameters for Differential Evolution are:

1. Population size
2. Number of generations
3. Crossover probability

## Egg Holder function Differential Evolution:

Original value of Egg holder function is

$$f(512, 404.2319) = -959.6407$$

Population=20, Generation=50, Global\_Minimum=-916.062876549

Population=20, Generation=100, Global\_Minimum=-945.0404200013

Population=20, Generation=200, Global\_Minimum=-955.84017855962

Population=50, Generation=50, Global\_Minimum=-952.2266838685

Population=50, Generation=100, Global\_Minimum=-955.2273804224

Population=50, Generation=200, Global\_Minimum=-946.9203083913

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Population=100, Generation=100, Global\_Minimum=-945.752779665

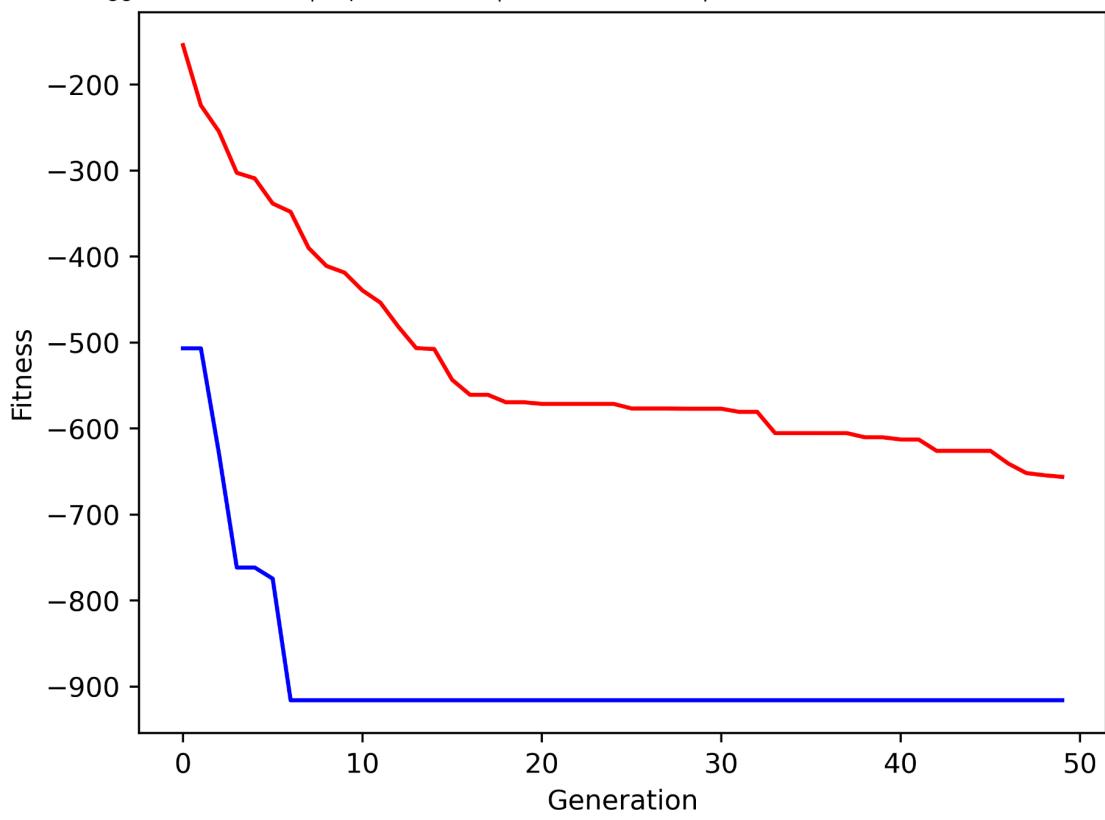
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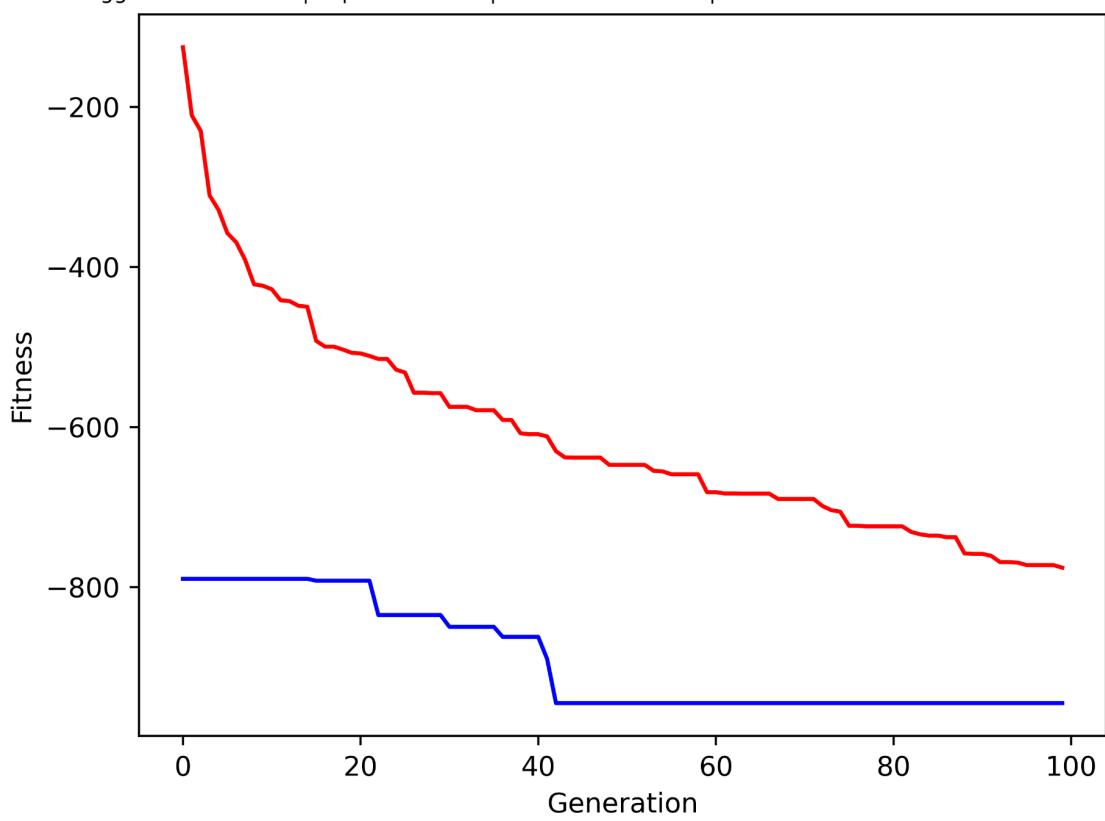
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Population=200, Generation=200, Global\_Minimum=-955.7742005799

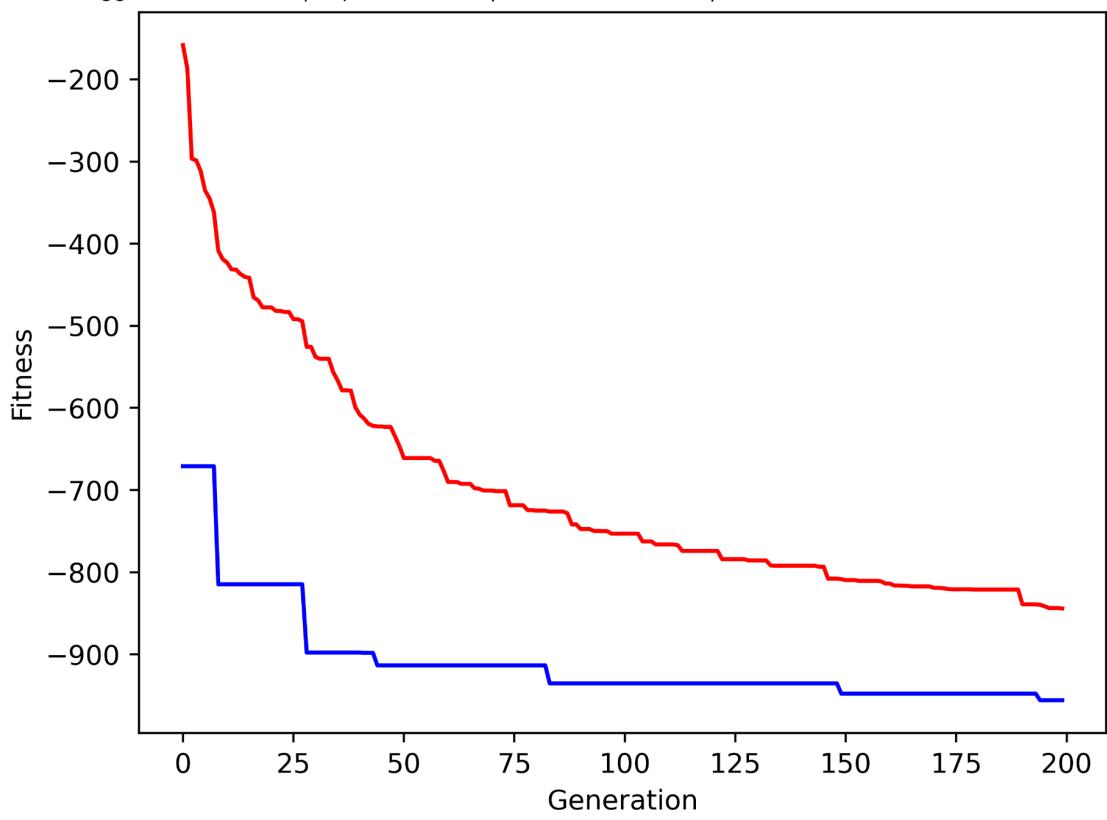
Eggholder Function | Population= 20 | Generations= 50 | Global Minimum= -916.0628765491167



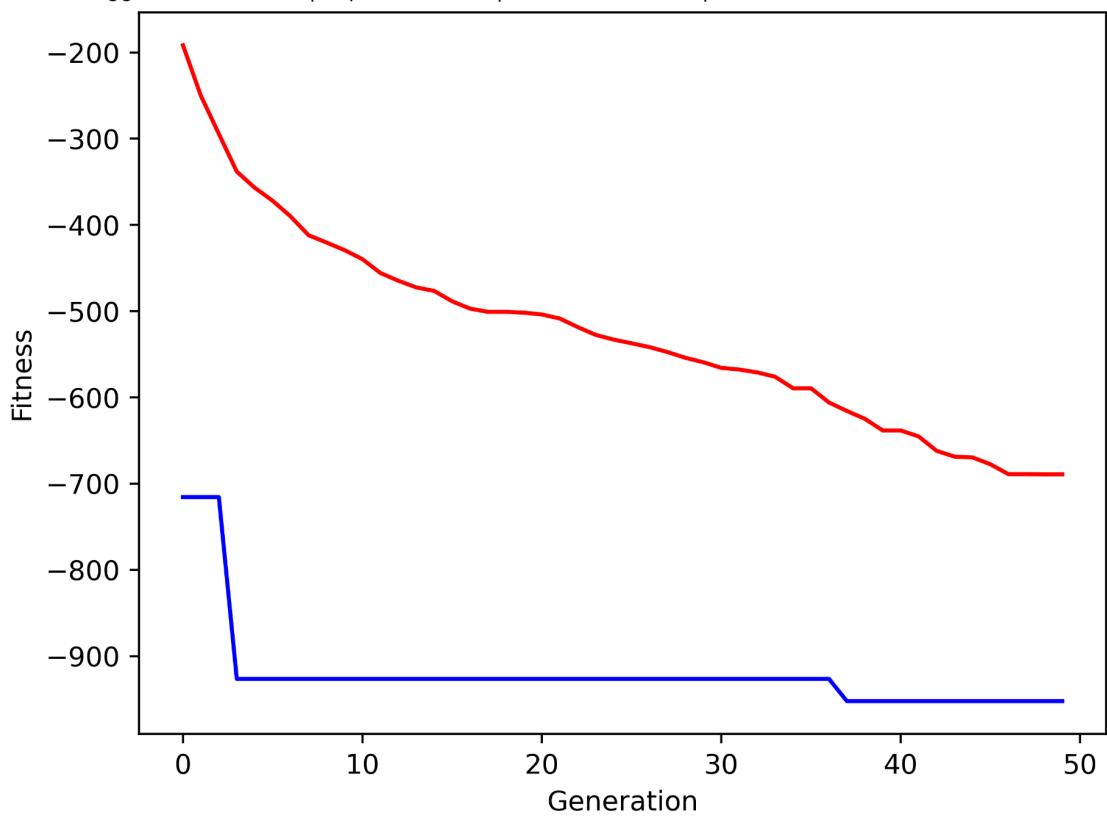
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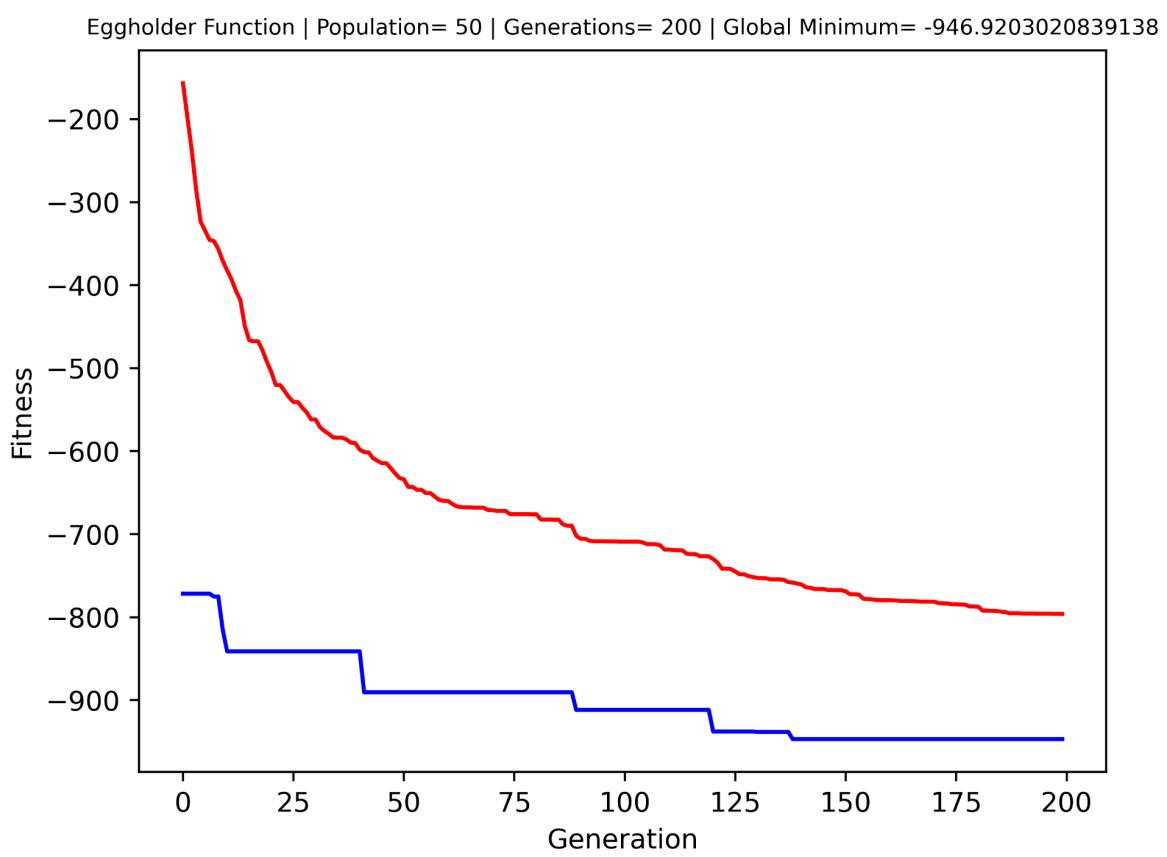
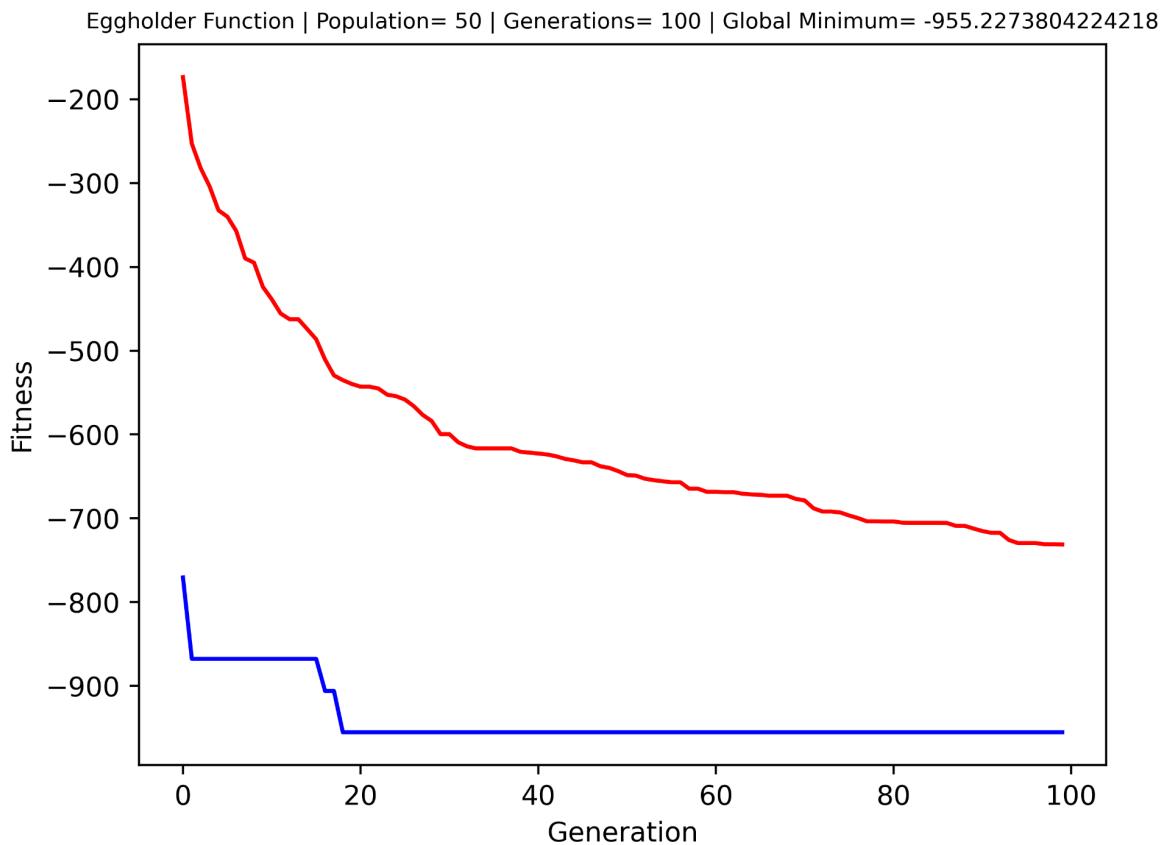


Eggholder Function | Population= 20 | Generations= 200 | Global Minimum= -955.8401785596267

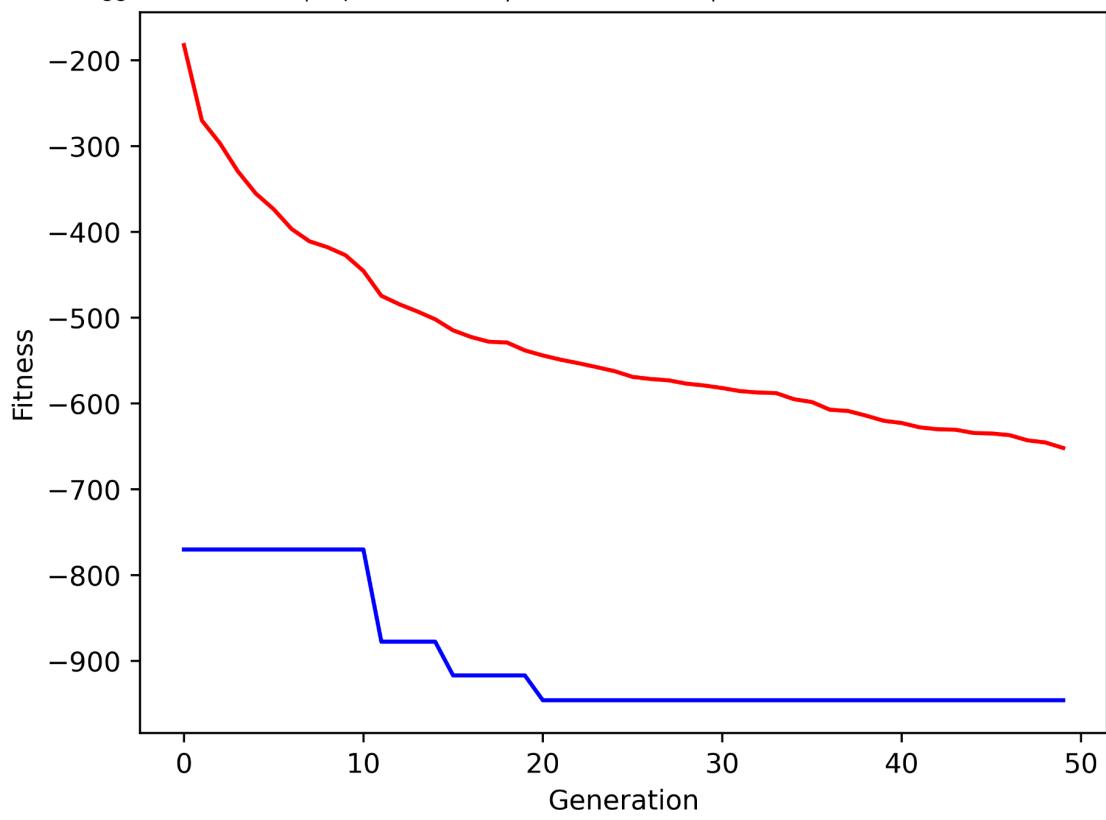


Eggholder Function | Population= 50 | Generations= 50 | Global Minimum= -952.2266838695457

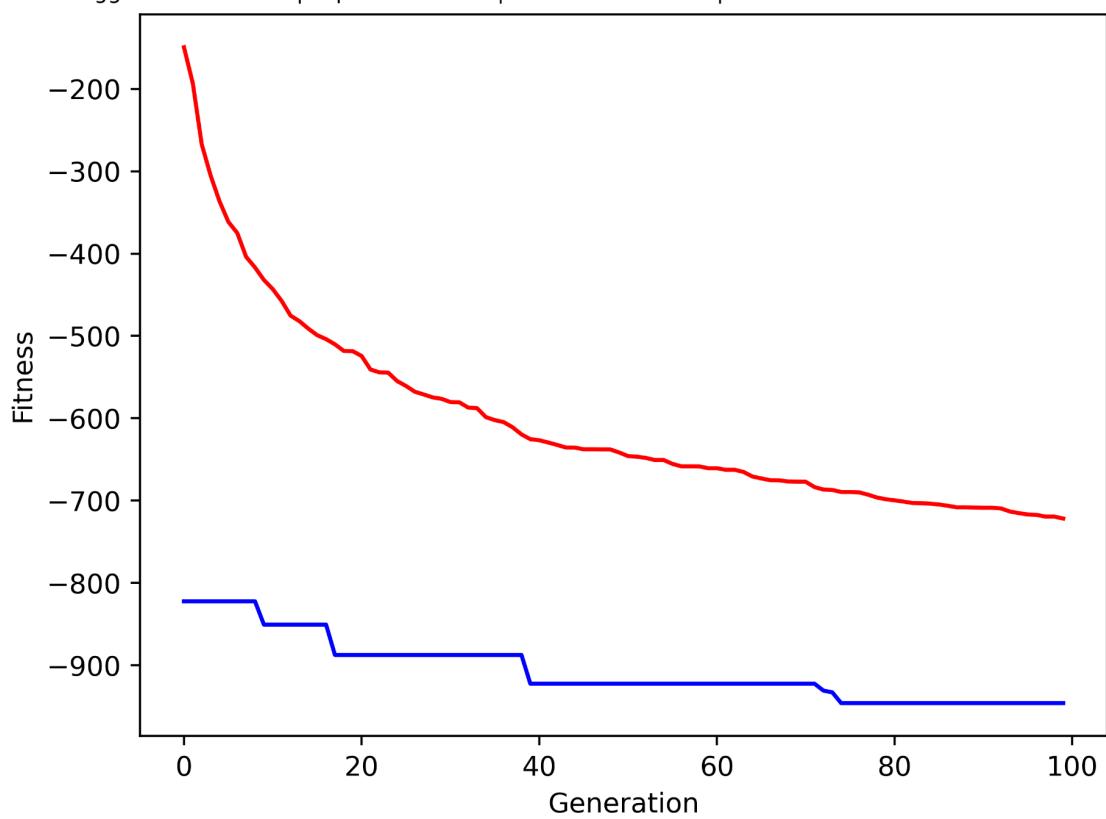




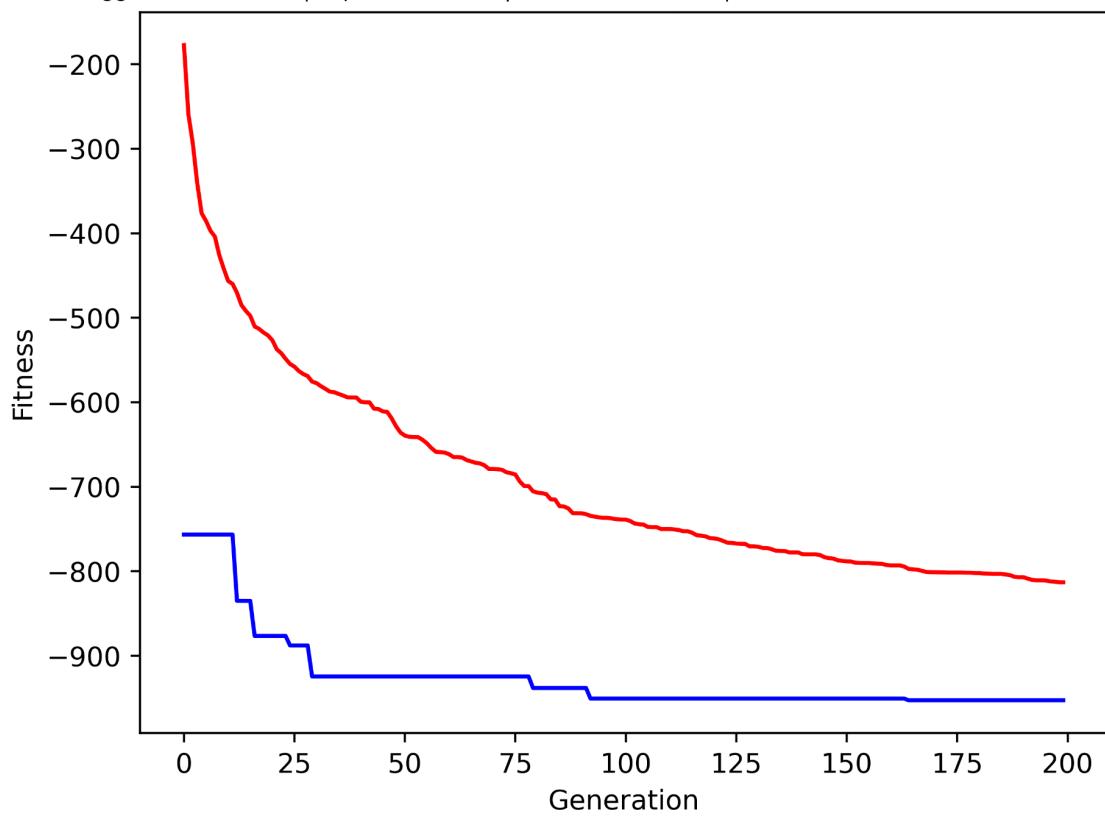
Eggholder Function | Population= 100 | Generations= 50 | Global Minimum= -945.8203401608553



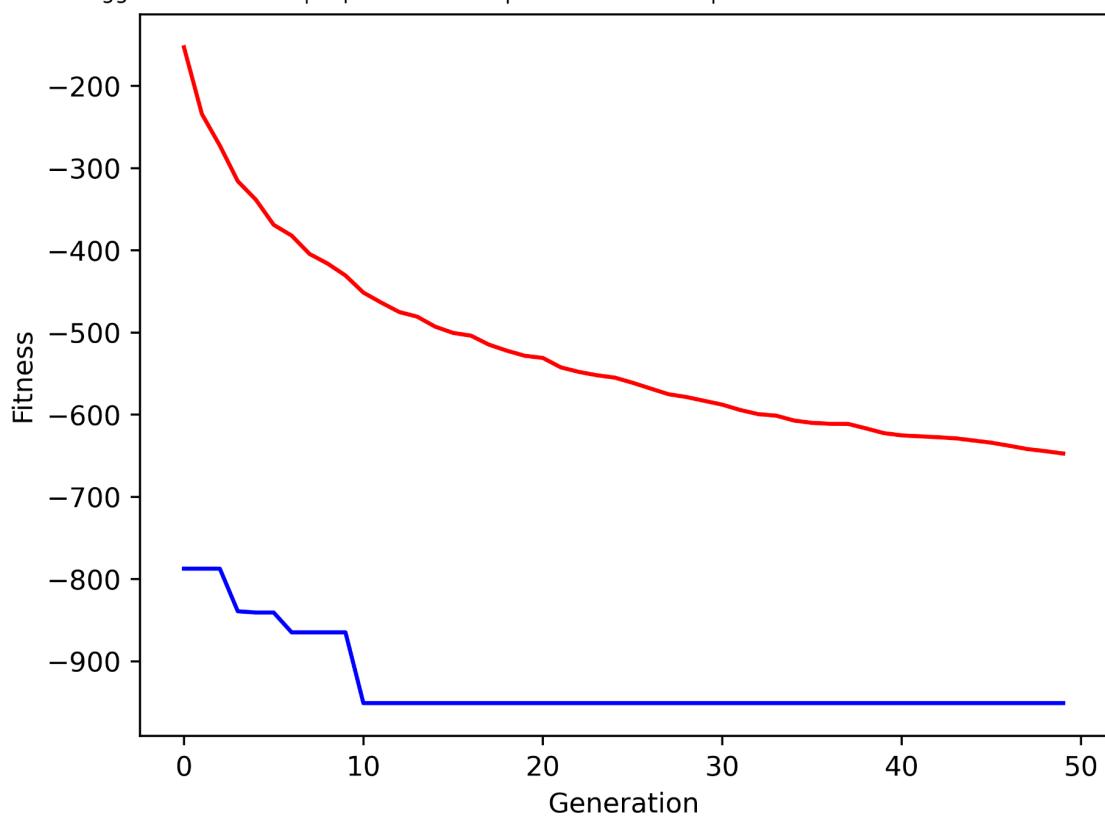
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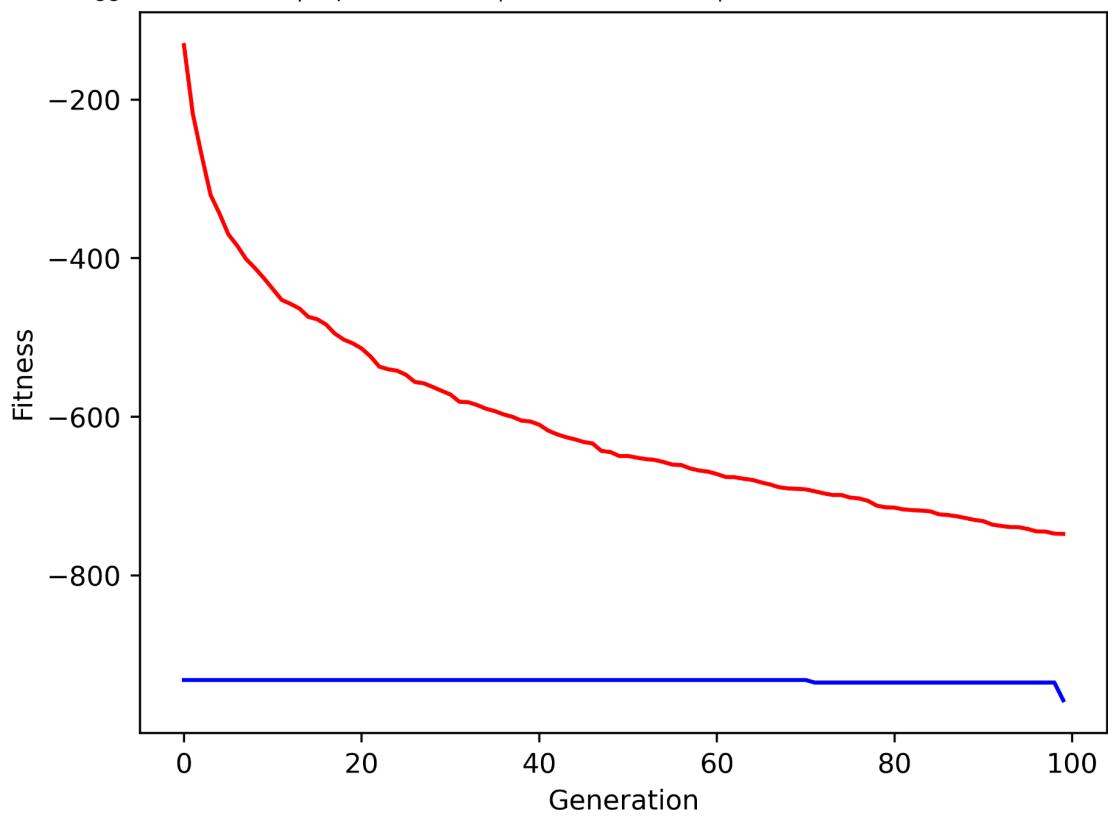
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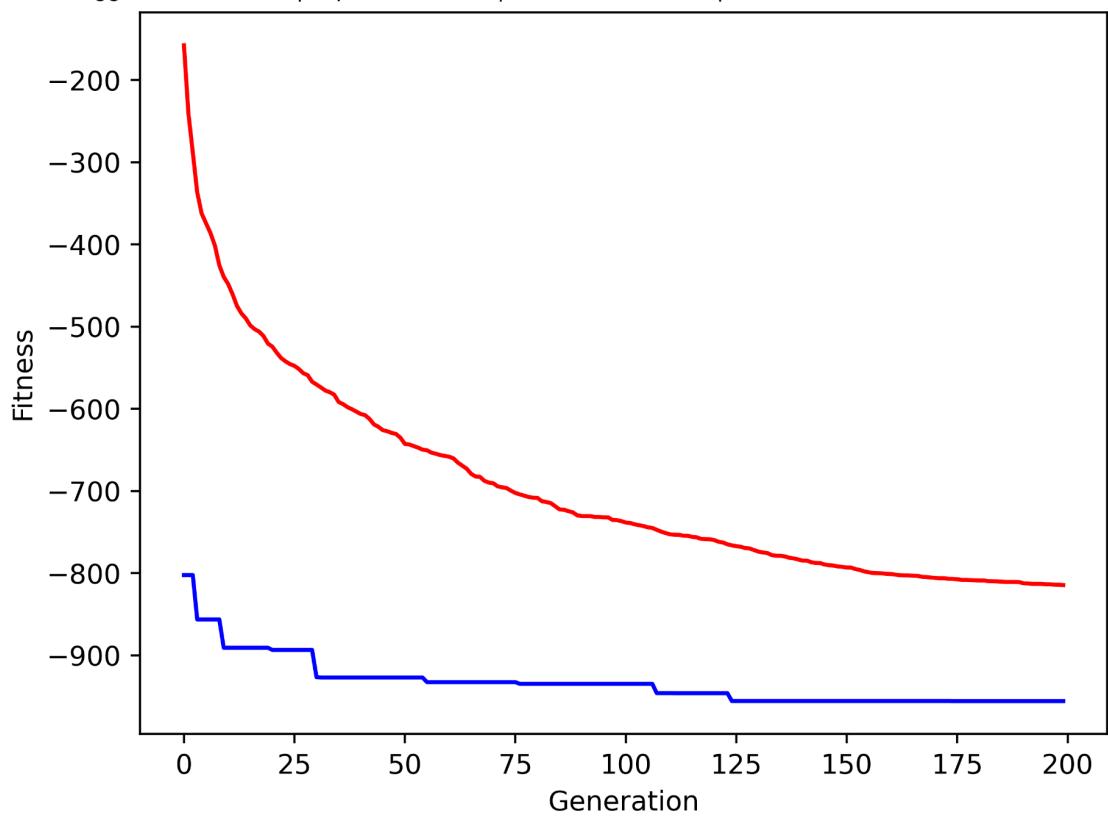
Eggholder Function | Population= 200 | Generations= 50 | Global Minimum= -950.8405900820095



Eggholder Function | Population= 200 | Generations= 100 | Global Minimum= -957.3748759274808



Eggholder Function | Population= 200 | Generations= 200 | Global Minimum= -955.7742005799024



## Holder table function Differential Evolution:

Original value of holder table function is

$$\text{Min} = \begin{cases} f(8.05502, 9.66459) & = -19.2085 \\ f(-8.05502, 9.66459) & = -19.2085 \\ f(8.05502, -9.66459) & = -19.2085 \\ f(-8.05502, -9.66459) & = -19.2085 \end{cases}$$

Population=20, Generation=50, Global\_Minimum=-19.14809884298

Population=20, Generation=100, Global\_Minimum=-19.20848251930

Population=20, Generation=200, Global\_Minimum=-19.208502460589

Population=50, Generation=50, Global\_Minimum=-19.20557715219

Population=50, Generation=100, Global\_Minimum=-19.20749091234

Population=50, Generation=200, Global\_Minimum=-19.20850213213

Population=100, Generation=50, Global\_Minimum=-18.202839653357

Population=100, Generation=100, Global\_Minimum=-19.2084083820

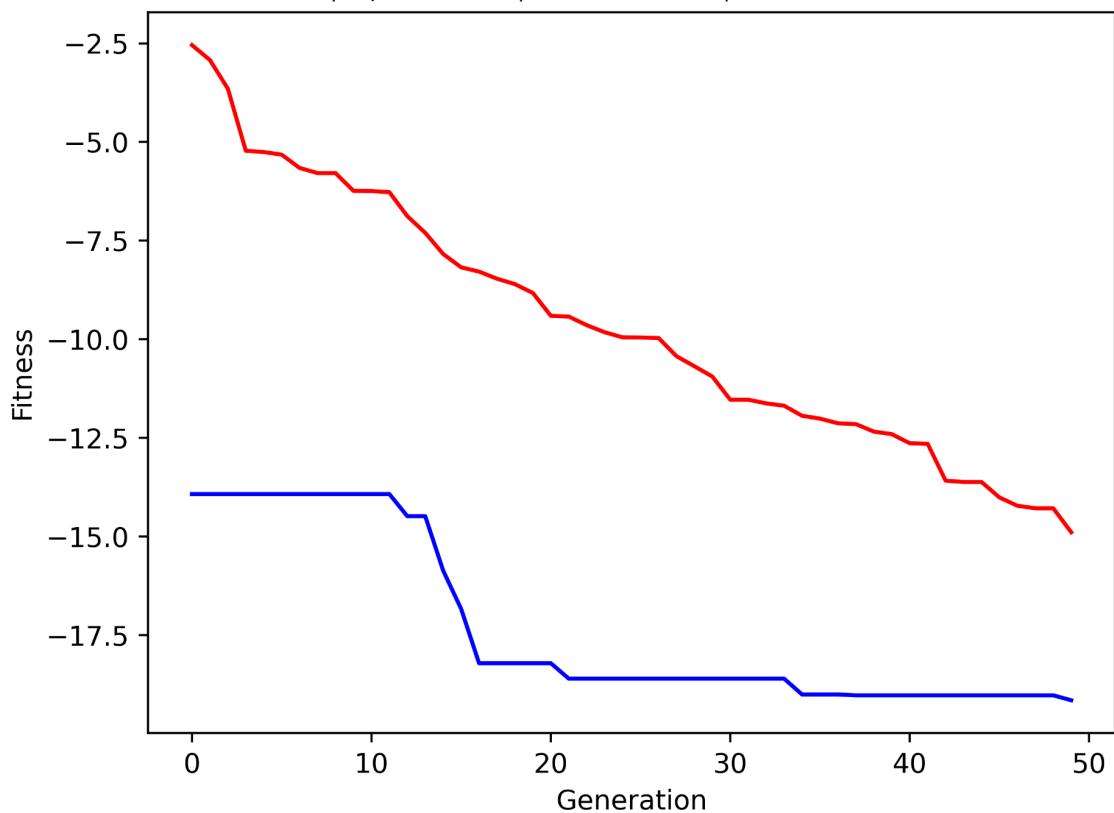
Population=100, Generation=200, Global\_Minimum=-19.2085024979

Population=200, Generation=50, Global\_Minimum=-19.202806524481

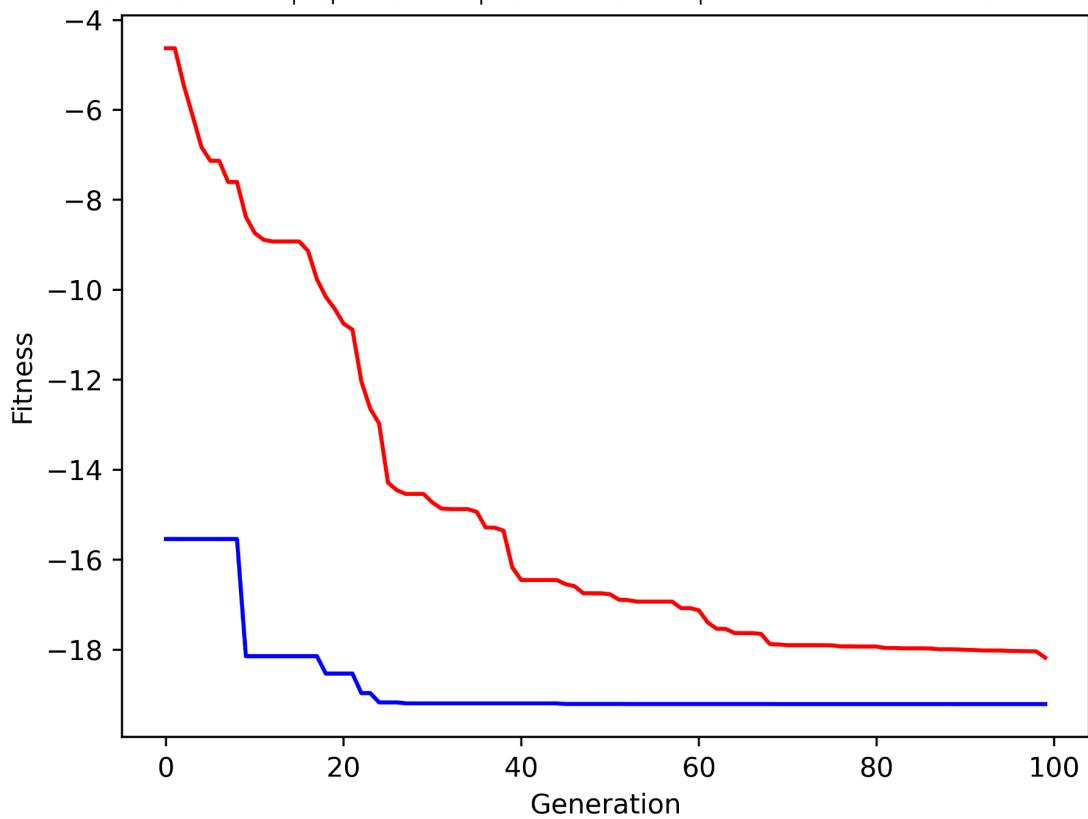
Population=200, Generation=100, Global\_Minimum=-19.20849843553

Population=200, Generation=200, Global\_Minimum=-19.20850211653

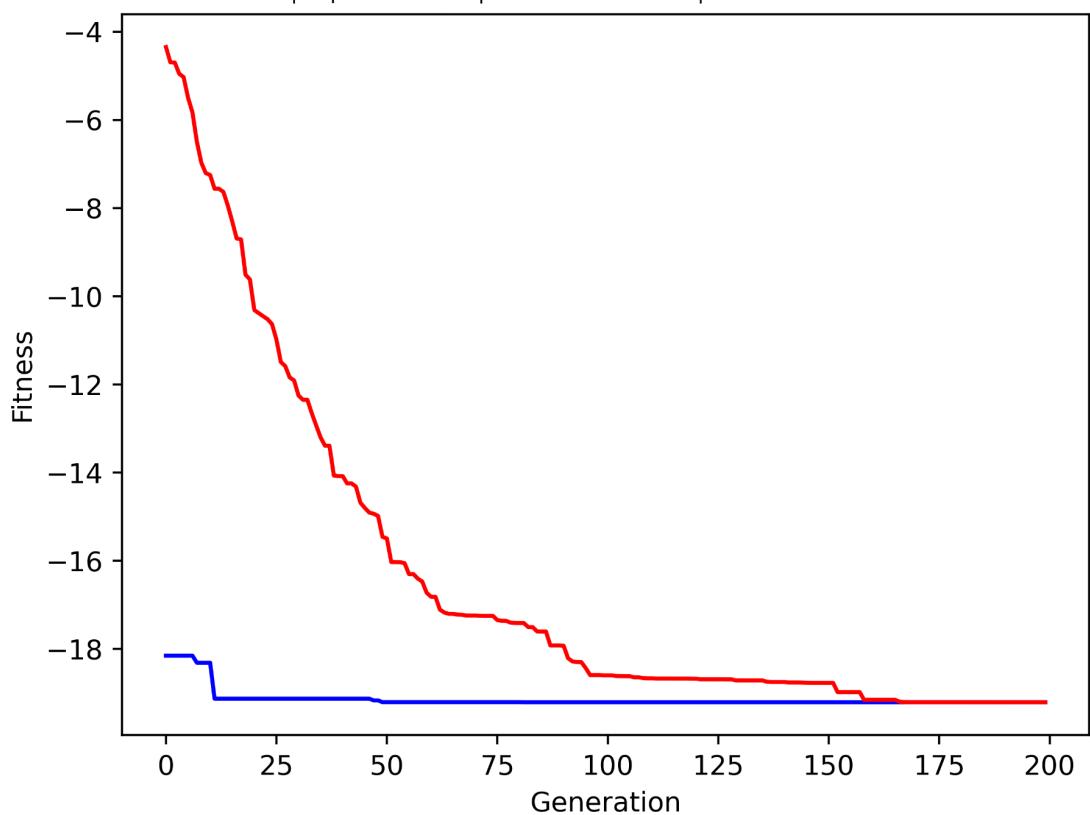
Holder Table Function | Population= 20 | Generations= 50 | Global Minimum= -19.14809884298681



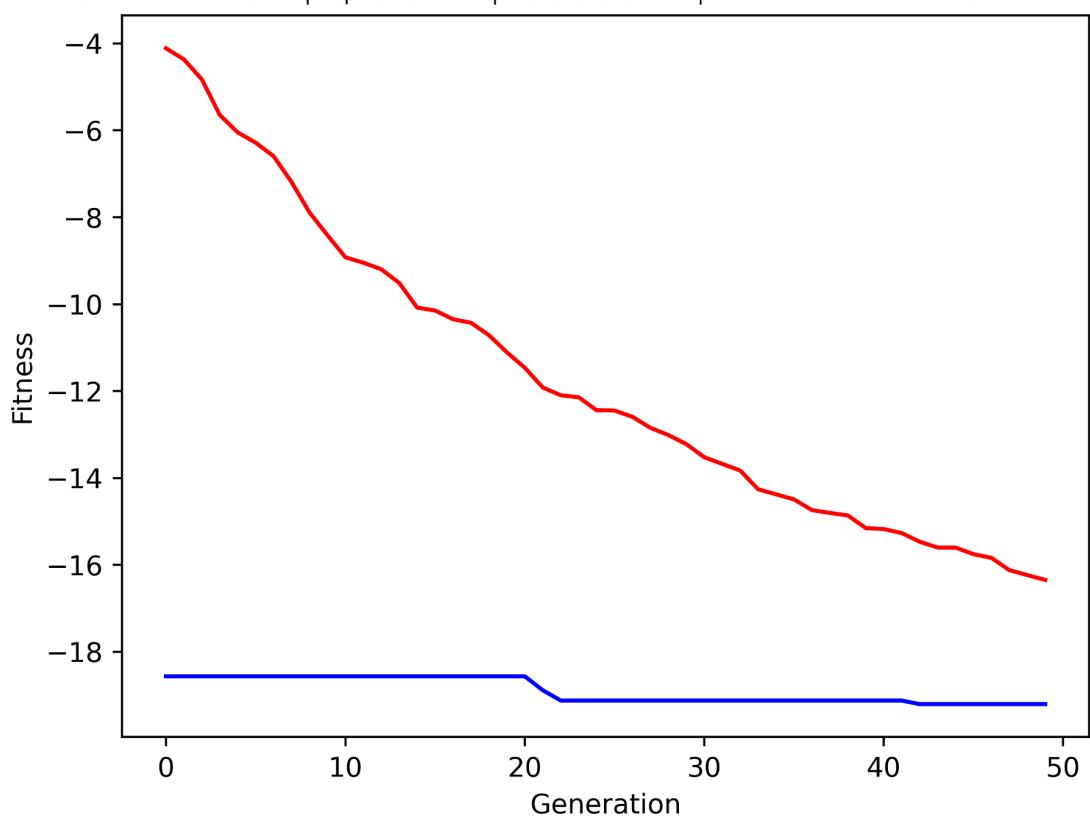
Holder Table Function | Population= 20 | Generations= 100 | Global Minimum= -19.208482519309307



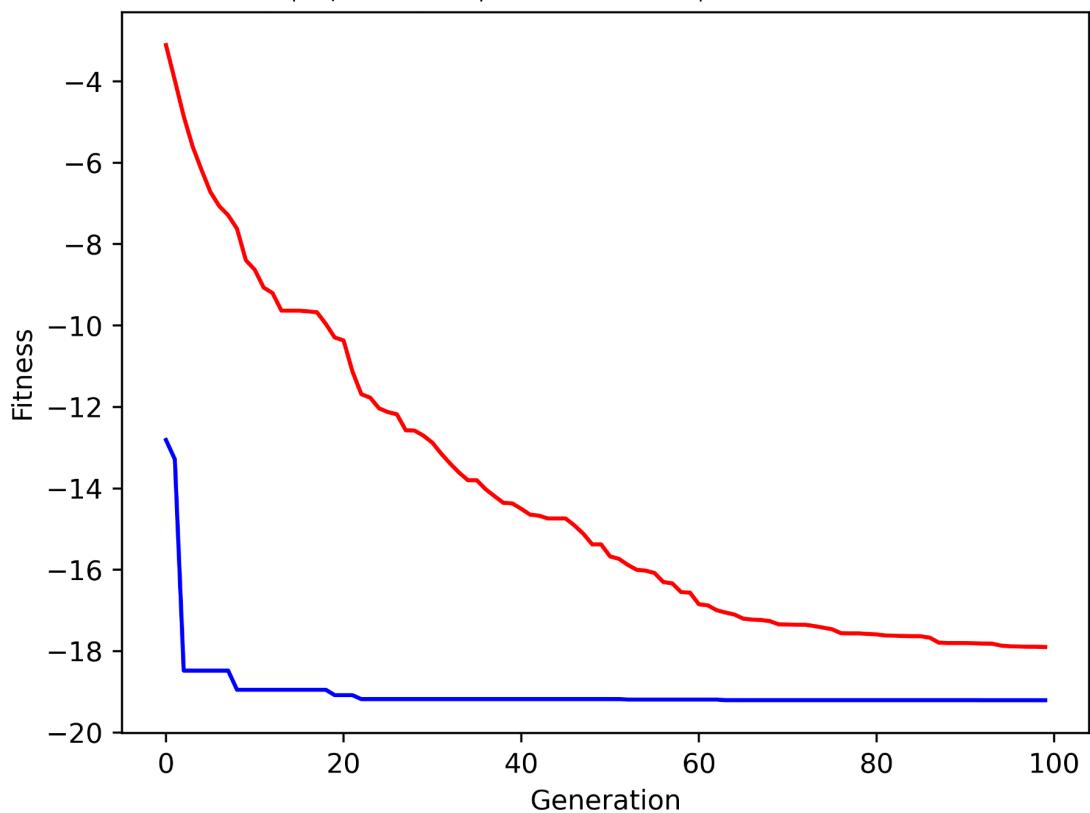
Holder Table Function | Population= 20 | Generations= 200 | Global Minimum= -19.208502460589138



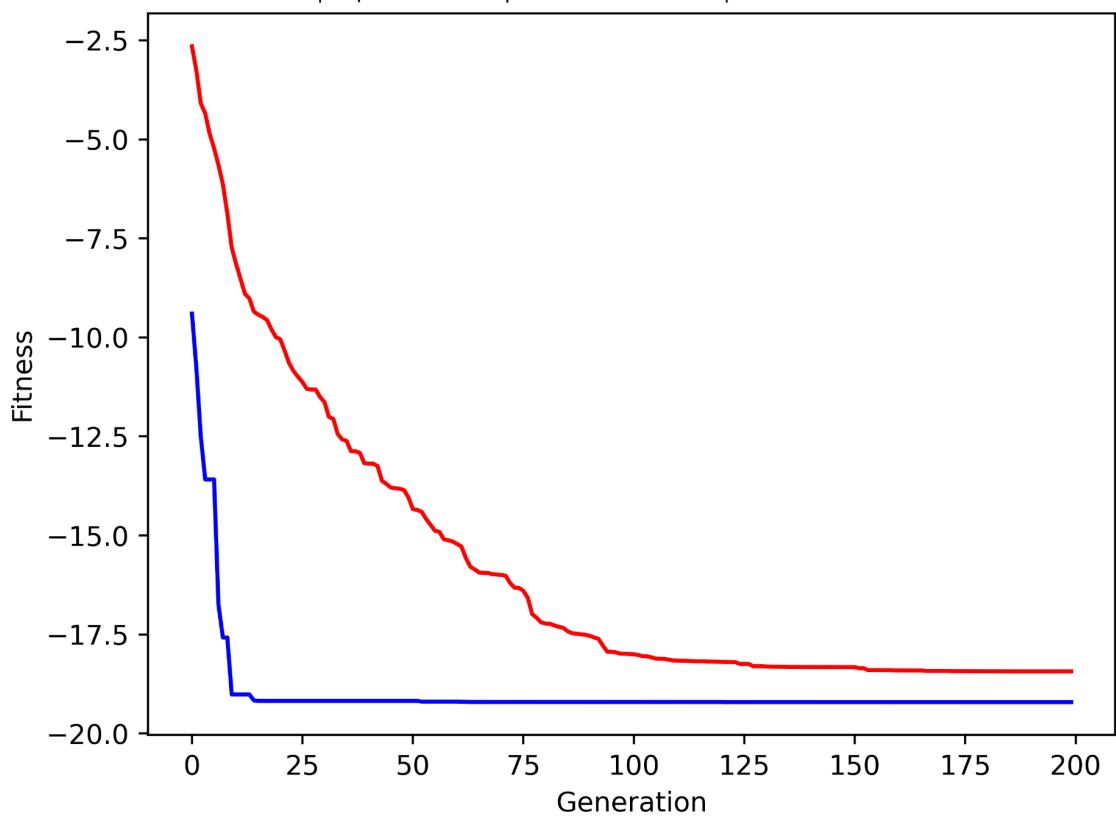
Holder Table Function | Population= 50 | Generations= 50 | Global Minimum= -19.20557715219586



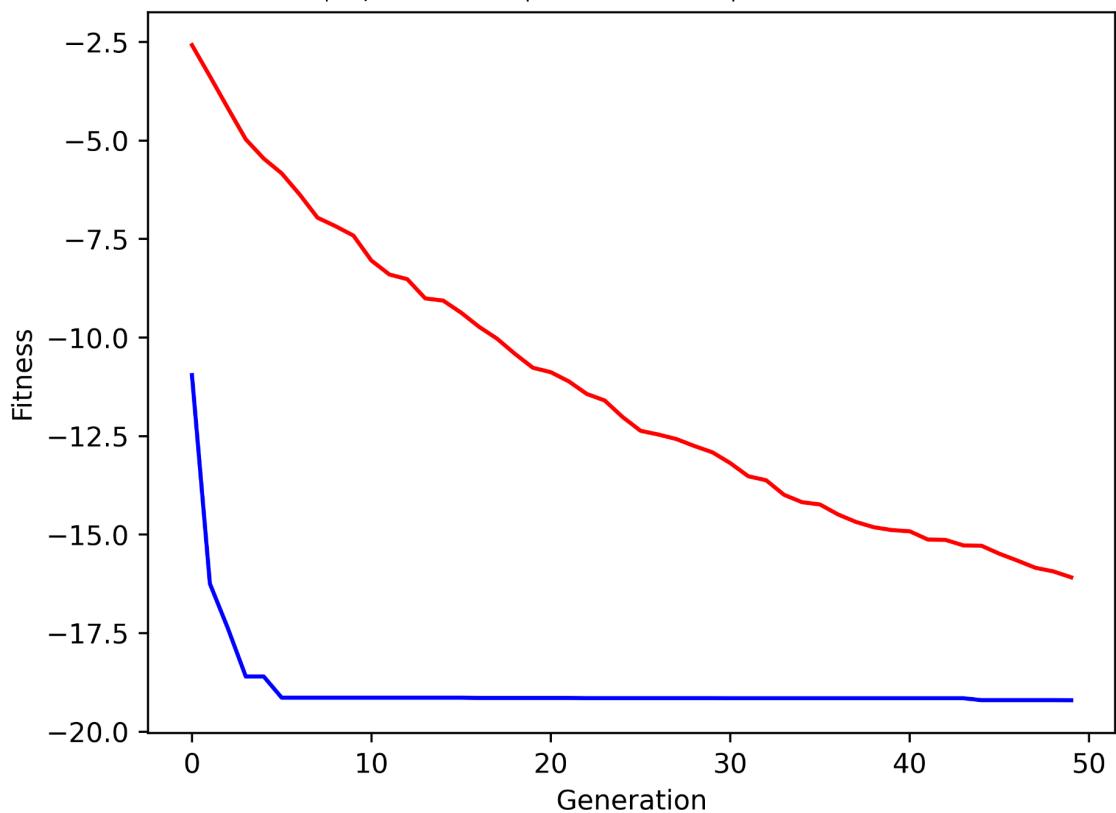
Holder Table Function | Population= 50 | Generations= 100 | Global Minimum= -19.207490912340255



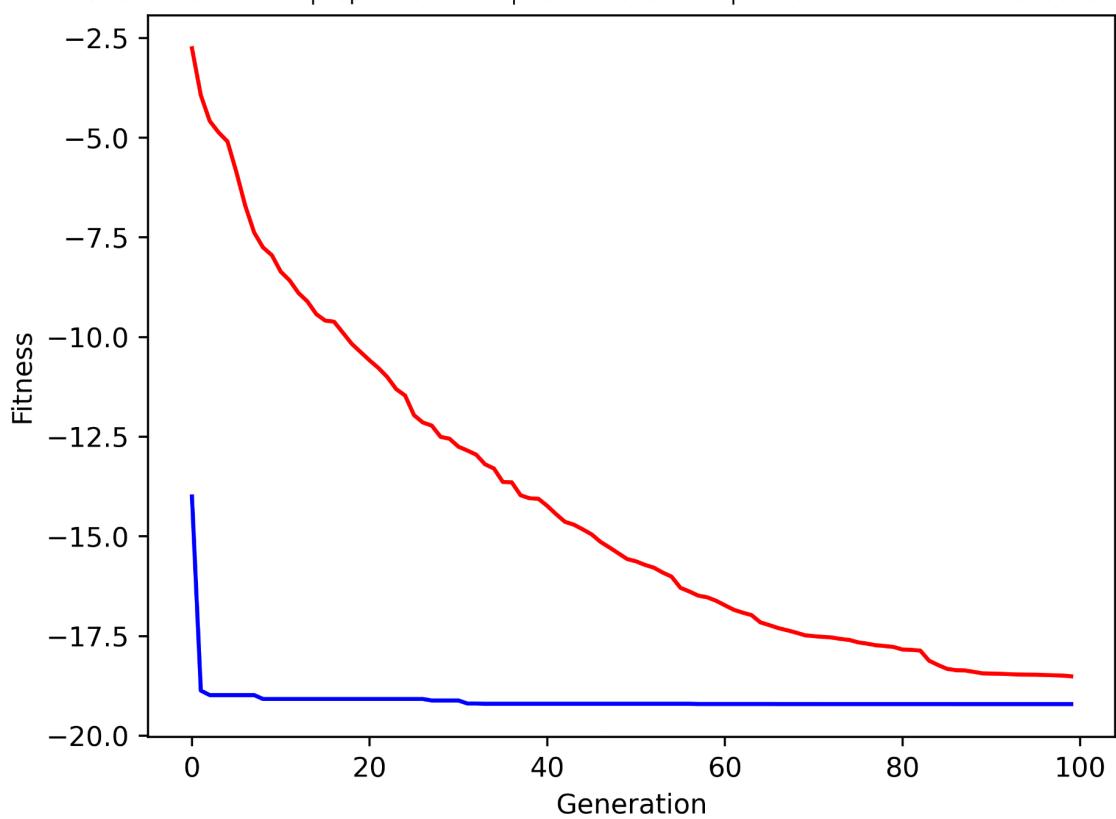
Holder Table Function | Population= 50 | Generations= 200 | Global Minimum= -19.208502132314848



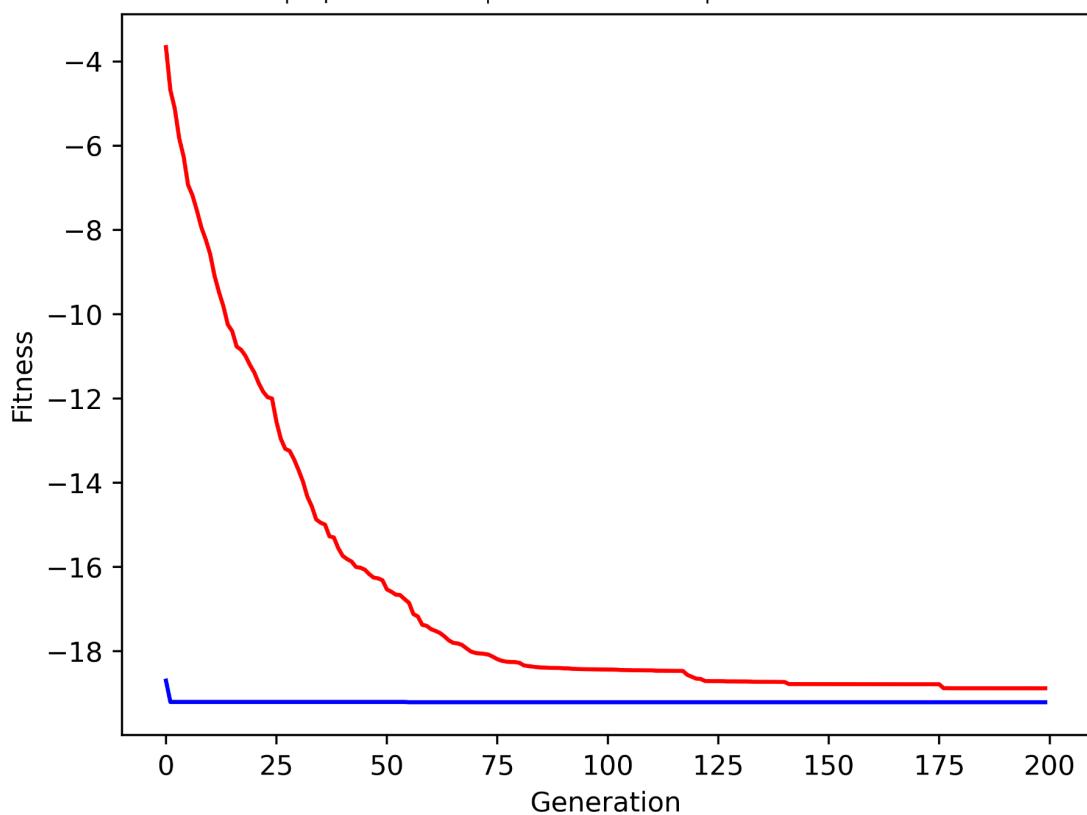
Holder Table Function | Population= 100 | Generations= 50 | Global Minimum= -19.20283965336707



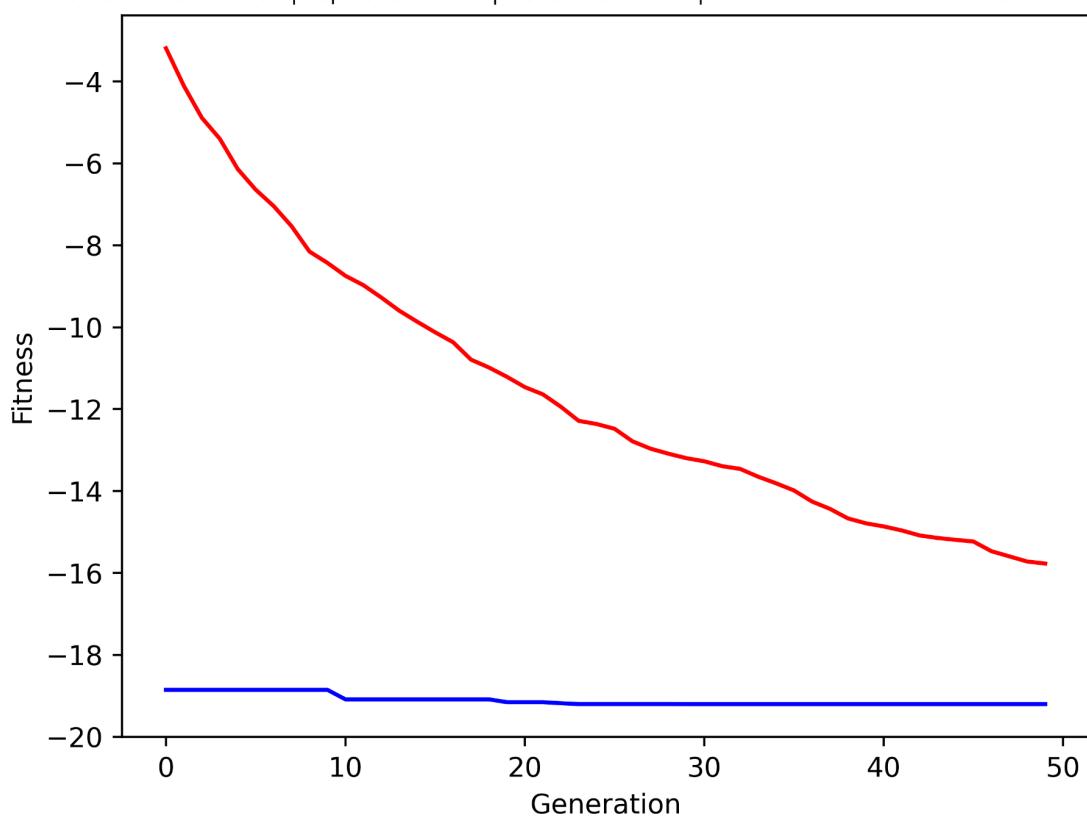
Holder Table Function | Population= 100 | Generations= 100 | Global Minimum= -19.208408382067315



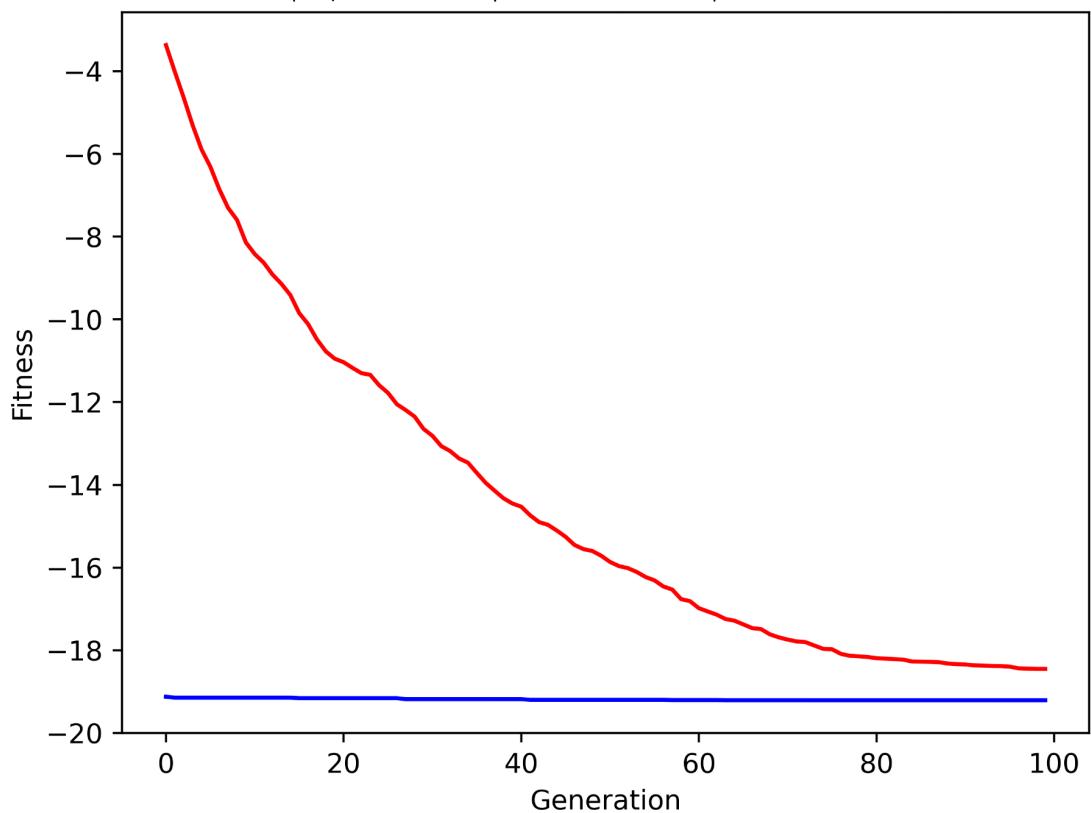
Holder Table Function | Population= 100 | Generations= 200 | Global Minimum= -19.208502497929167



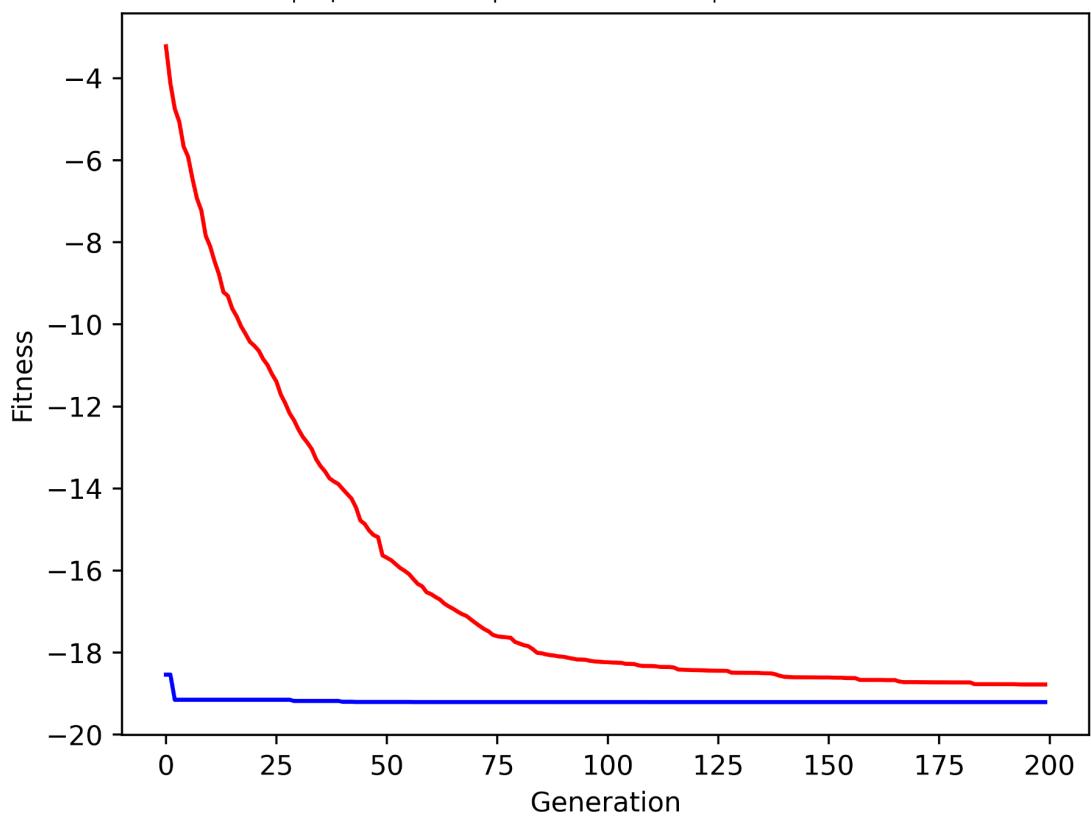
Holder Table Function | Population= 200 | Generations= 50 | Global Minimum= -19.202806524481964



Holder Table Function | Population= 200 | Generations= 100 | Global Minimum= -19.20849843553729



Holder Table Function | Population= 200 | Generations= 200 | Global Minimum= -19.20850211653945



# Particle Swarm Optimization

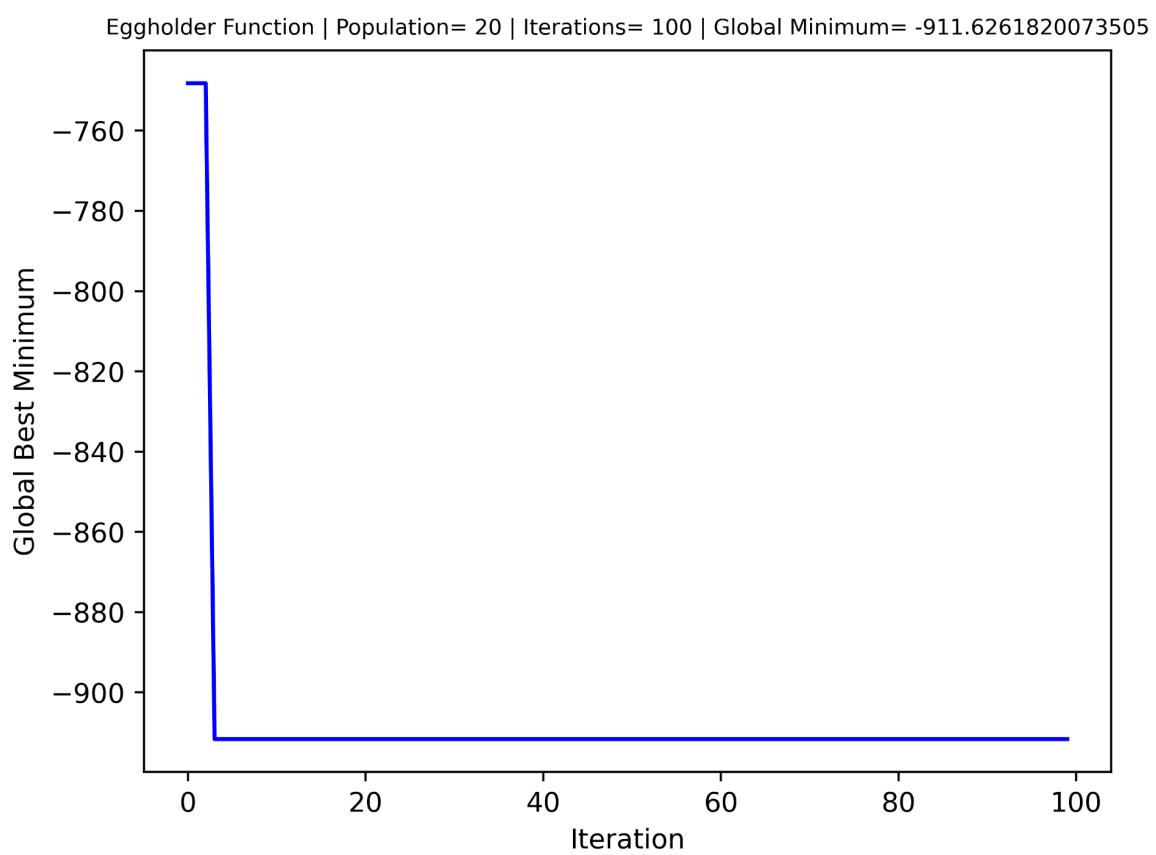
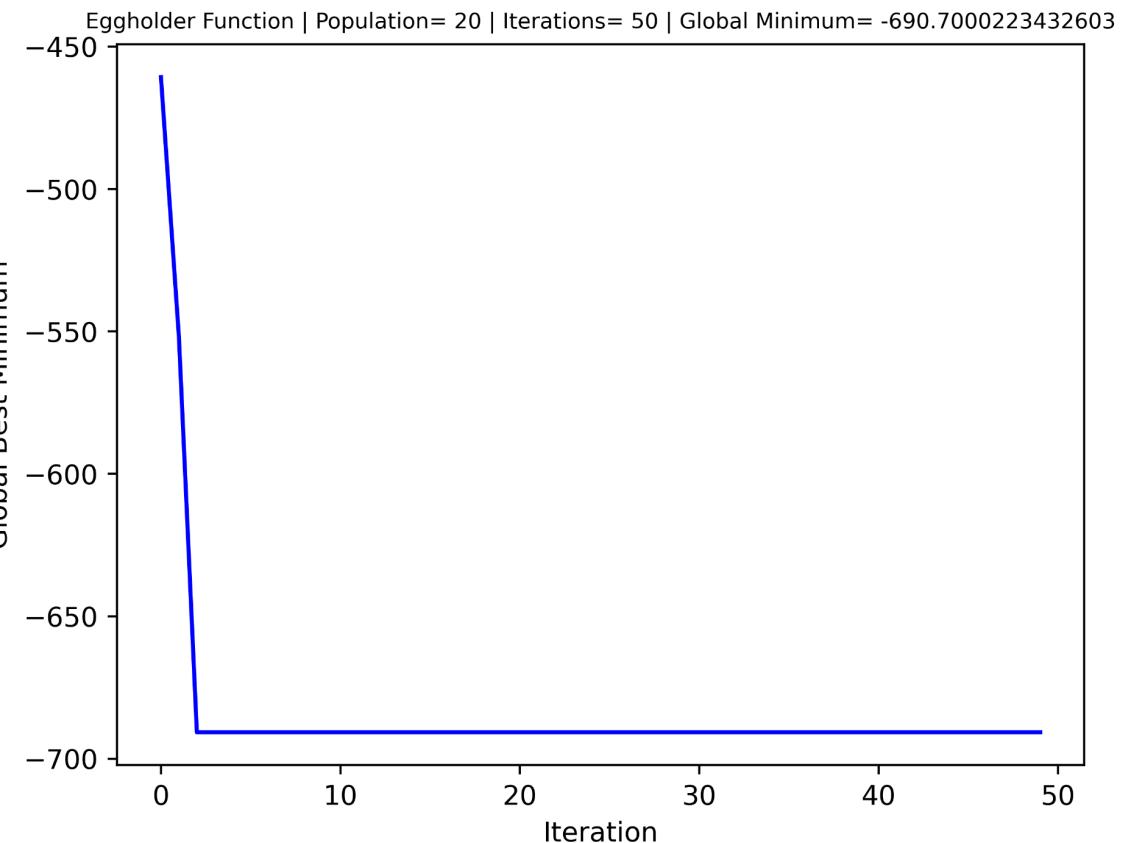
- We can't use particle swarm optimization for the given functions since the given functions are constrained.
- The algorithm discussed in class can be used for unconstrained functions since the new particle generated isn't satisfying the constraints and time complexity is also going high.
- To solve those problems we have to use constraint handling technique(<https://arxiv.org/abs/2101.10933>)
- What we have done in code is if the new particle generated is not satisfying constraints for more than 20 times(we can consider any value) then the new particle will be our old particle.

## EggHolder function Particle Swarm Optimization:

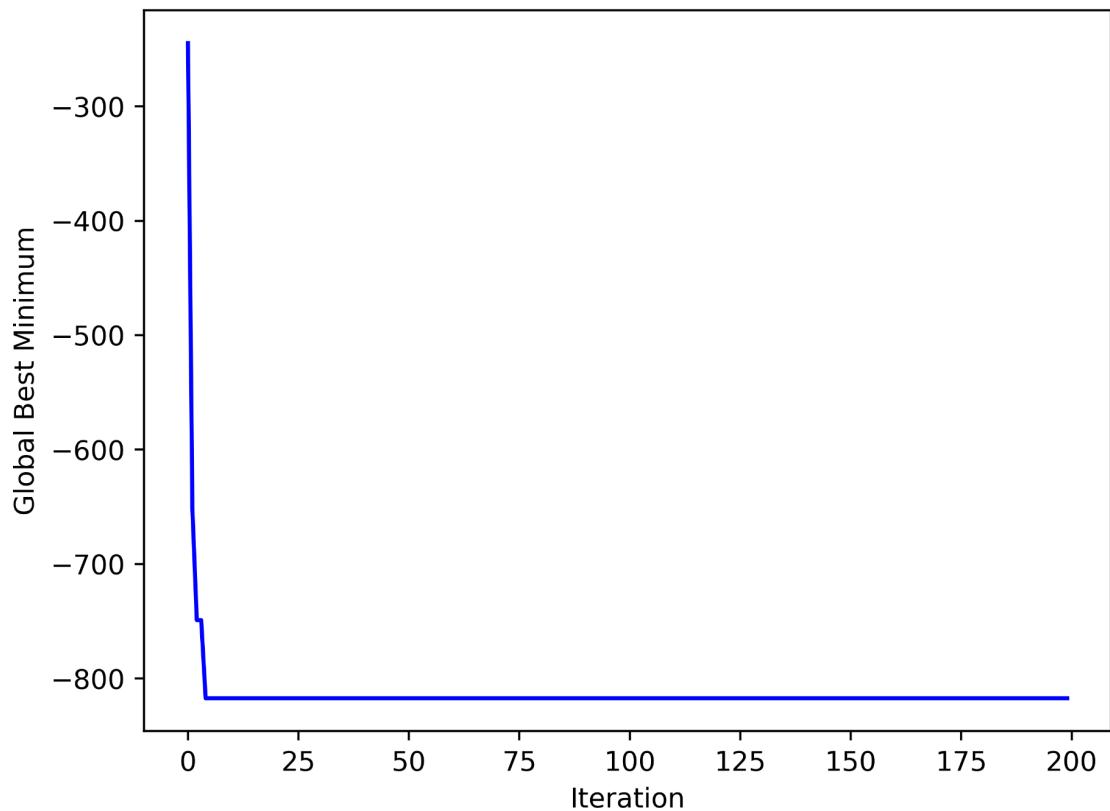
Original value of Egg holder function is

$$f(512, 404.2319) = -959.6407$$

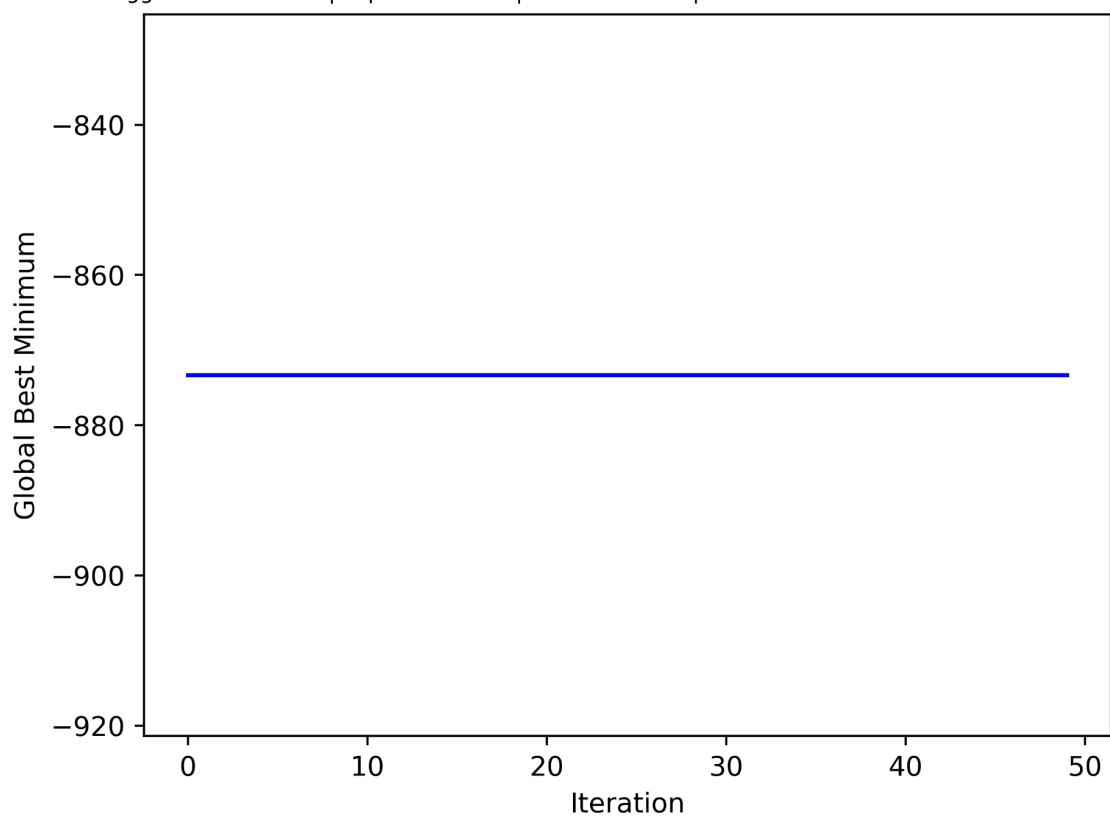
Population=20, Iterations=50, Global\_Minimum=-690.7000223432  
Population=20, Iterations=100, Global\_Minimum=-911.6261820073  
Population=20, Iterations=200, Global\_Minimum=-817.2901775628  
Population=50, Iterations=50, Global\_Minimum=-873.3407625524  
Population=50, Iterations=100, Global\_Minimum=-872.5170287920  
Population=50, Iterations=200, Global\_Minimum=-728.2434000977  
Population=100, Iterations=50, Global\_Minimum=-926.7571348460  
Population=100, Iterations=100, Global\_Minimum=-868.7340704512  
Population=100, Iterations=200, Global\_Minimum=-881.9339408664  
Population=200, Iterations=50, Global\_Minimum=-888.9397958104  
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Population=200, Iterations=200, Global\_Minimum=-939.4178854998

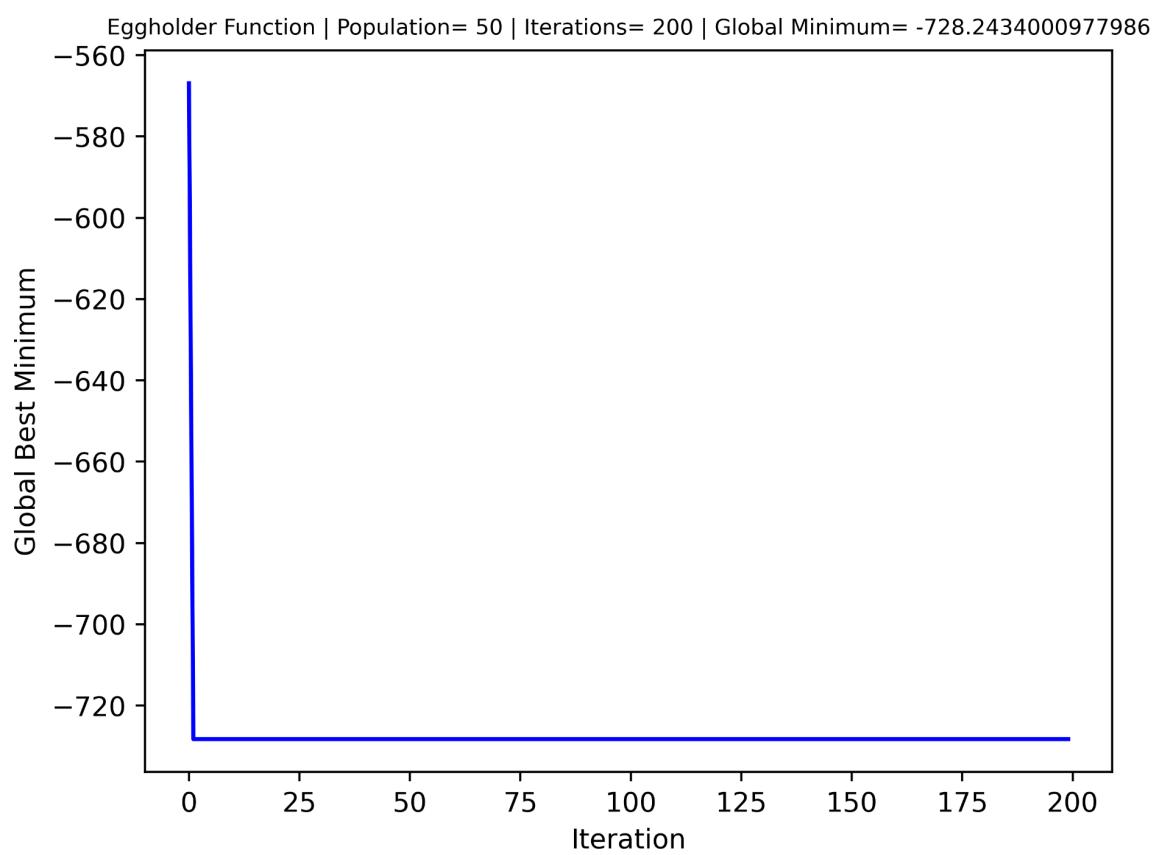
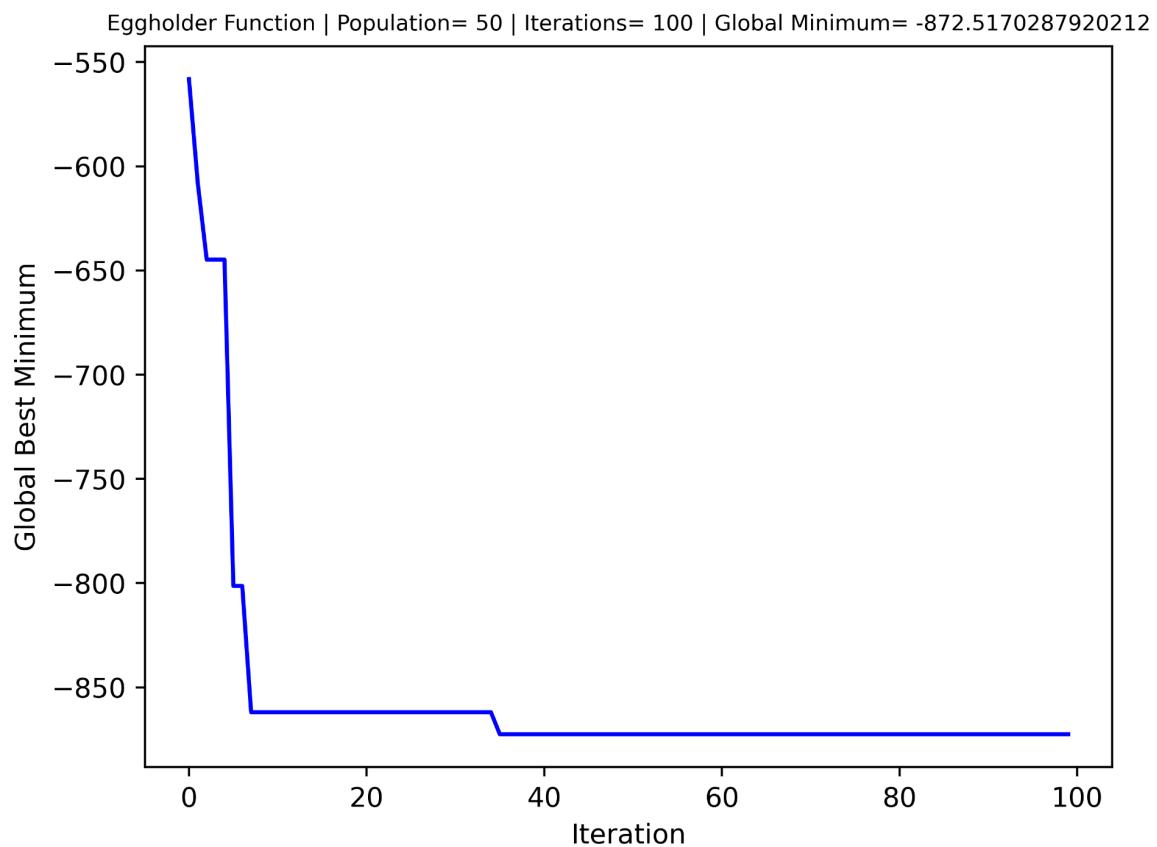


Eggholder Function | Population= 20 | Iterations= 200 | Global Minimum= -817.2901775628013

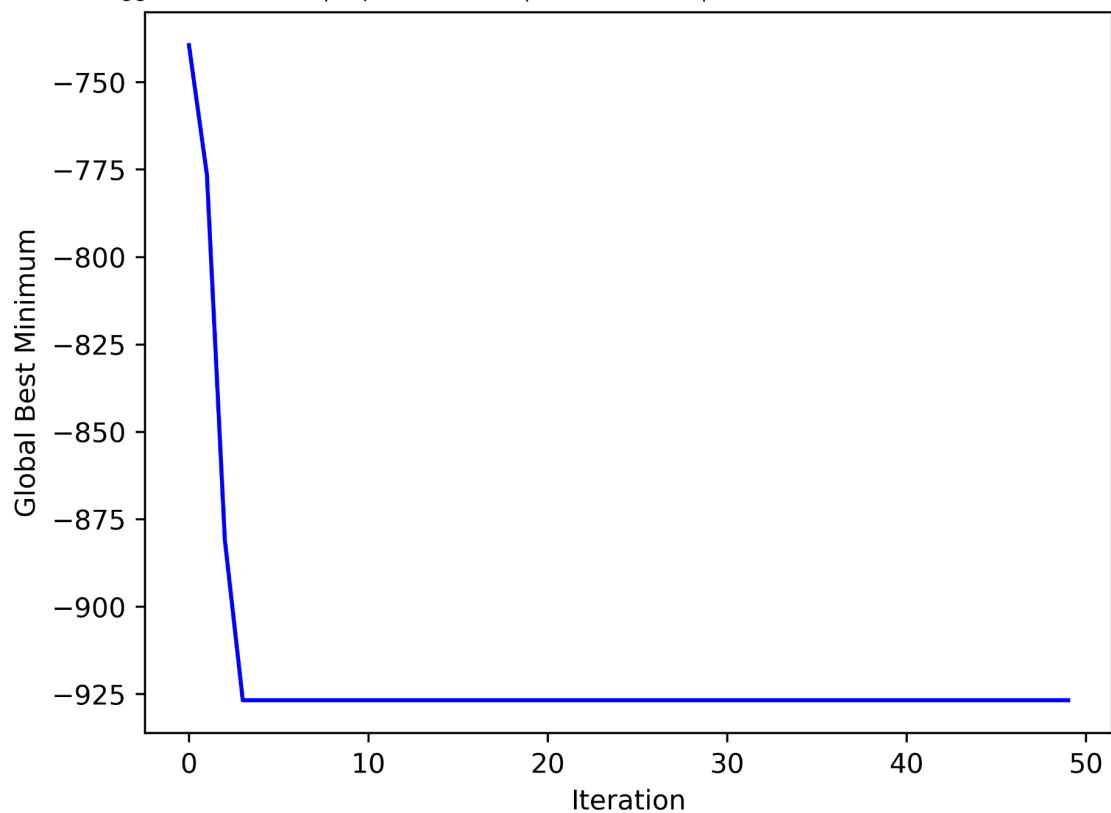


Eggholder Function | Population= 50 | Iterations= 50 | Global Minimum= -873.3407625524499

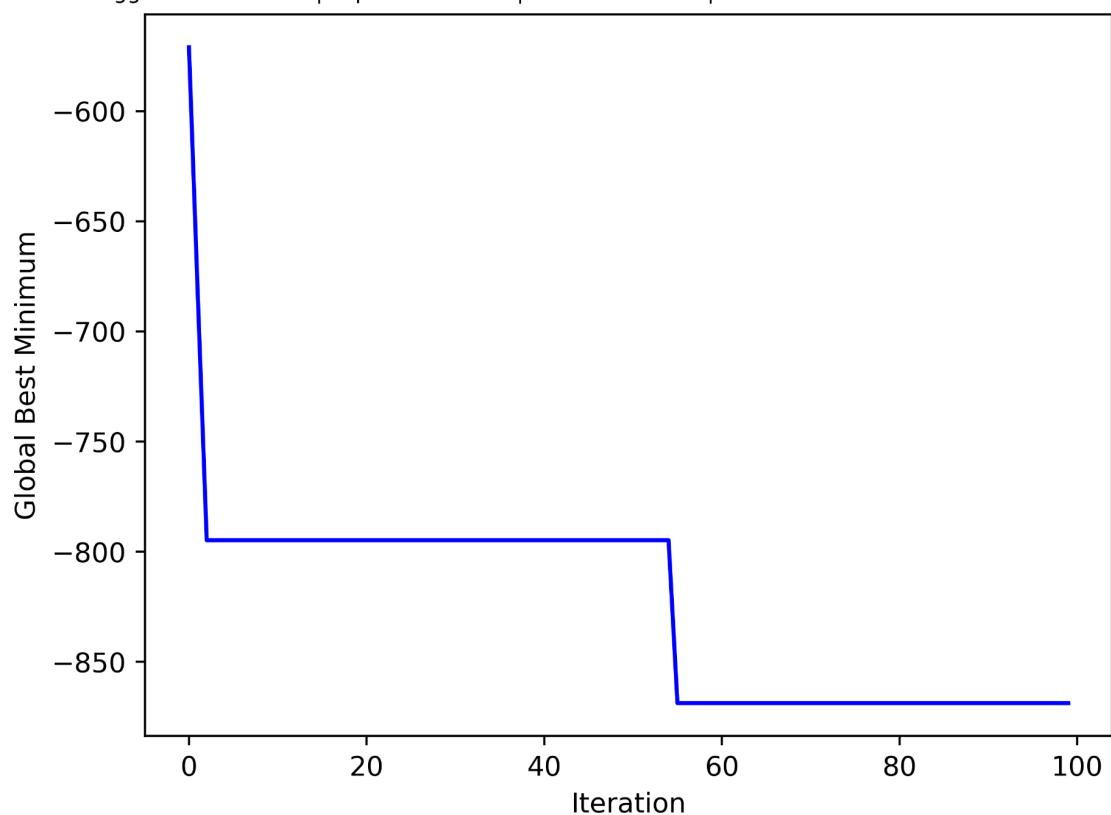


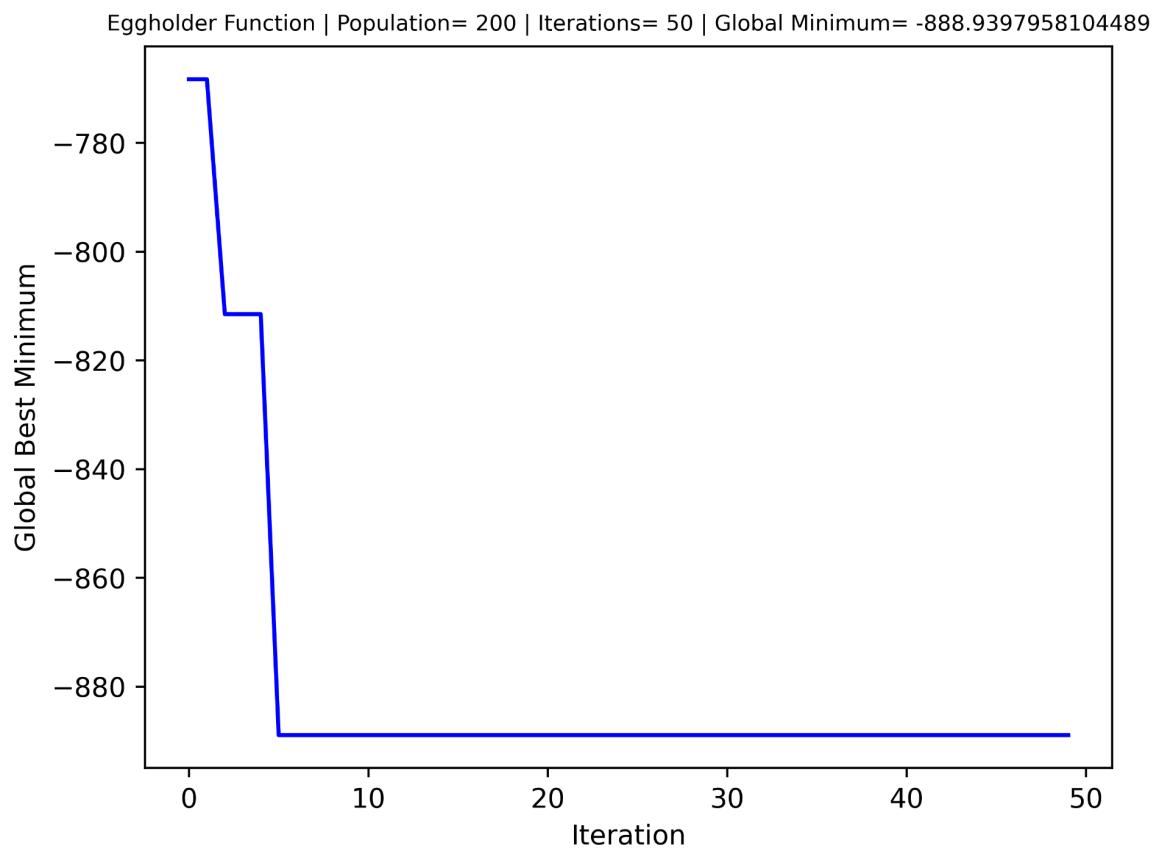
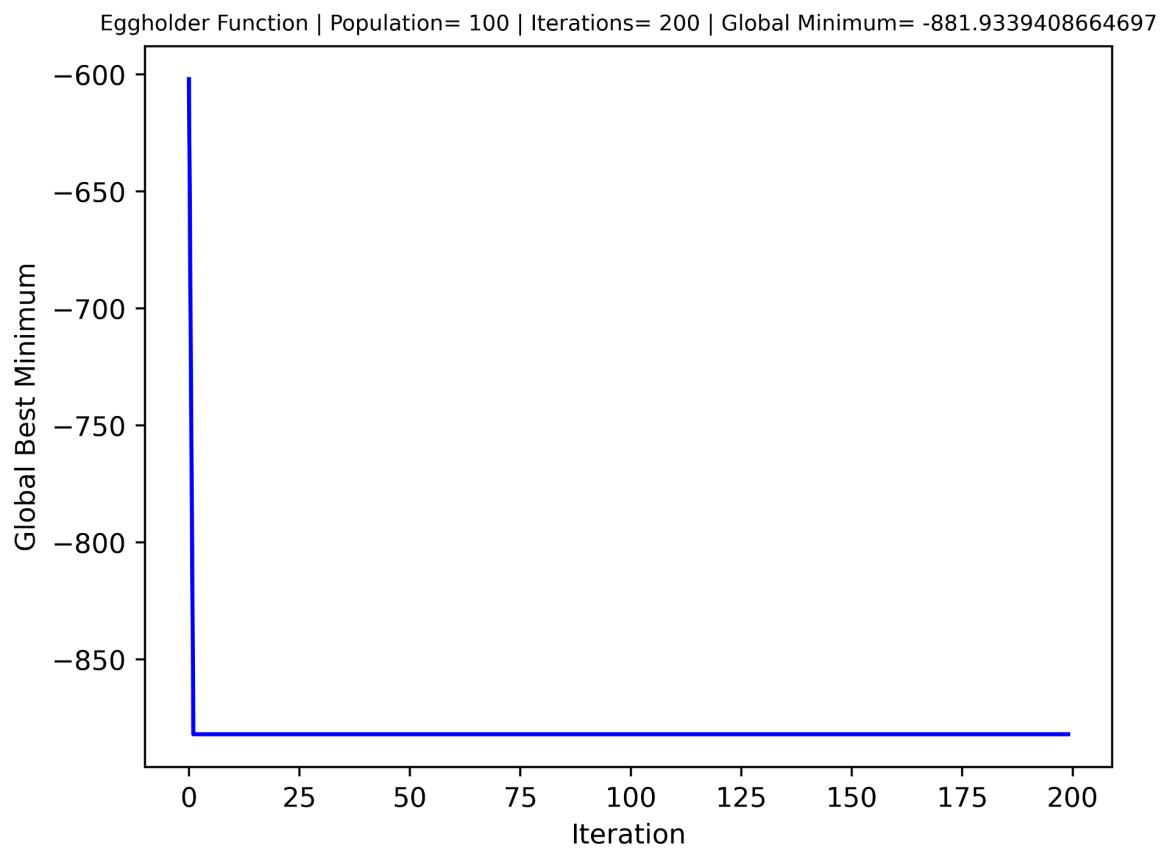


Eggholder Function | Population= 100 | Iterations= 50 | Global Minimum= -926.7571348460123

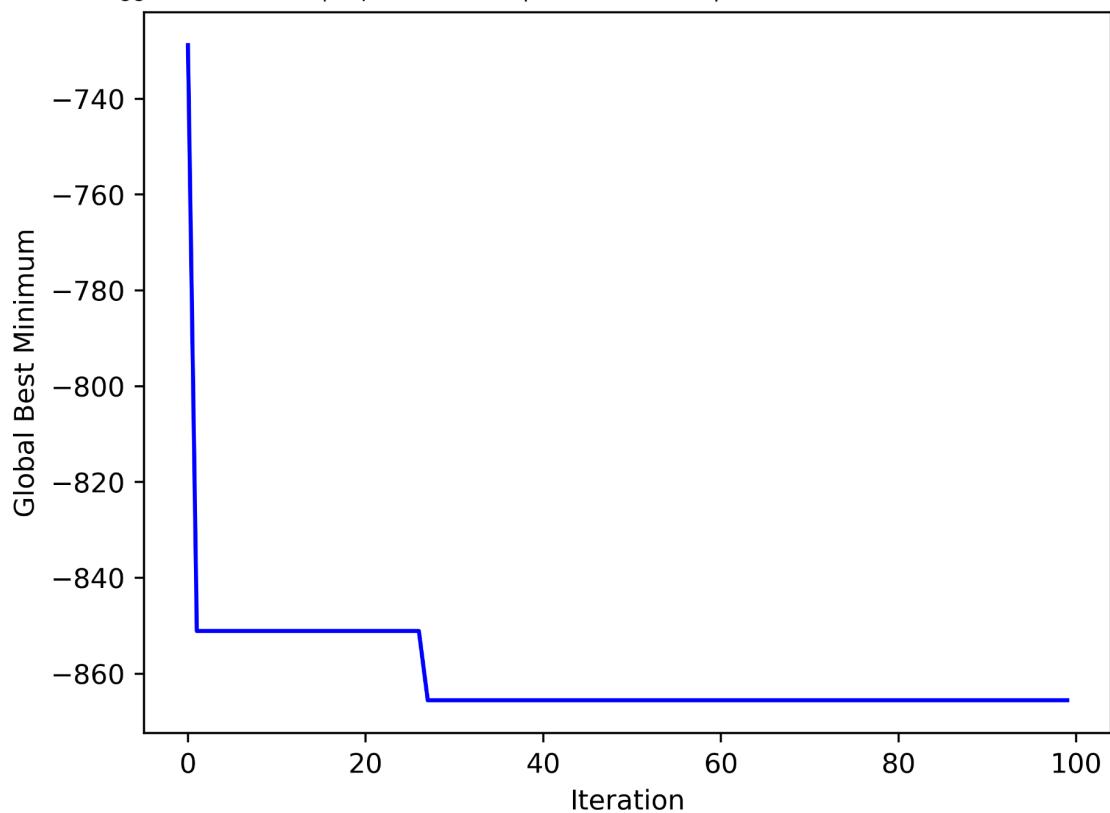


Eggholder Function | Population= 100 | Iterations= 100 | Global Minimum= -868.7340704512912

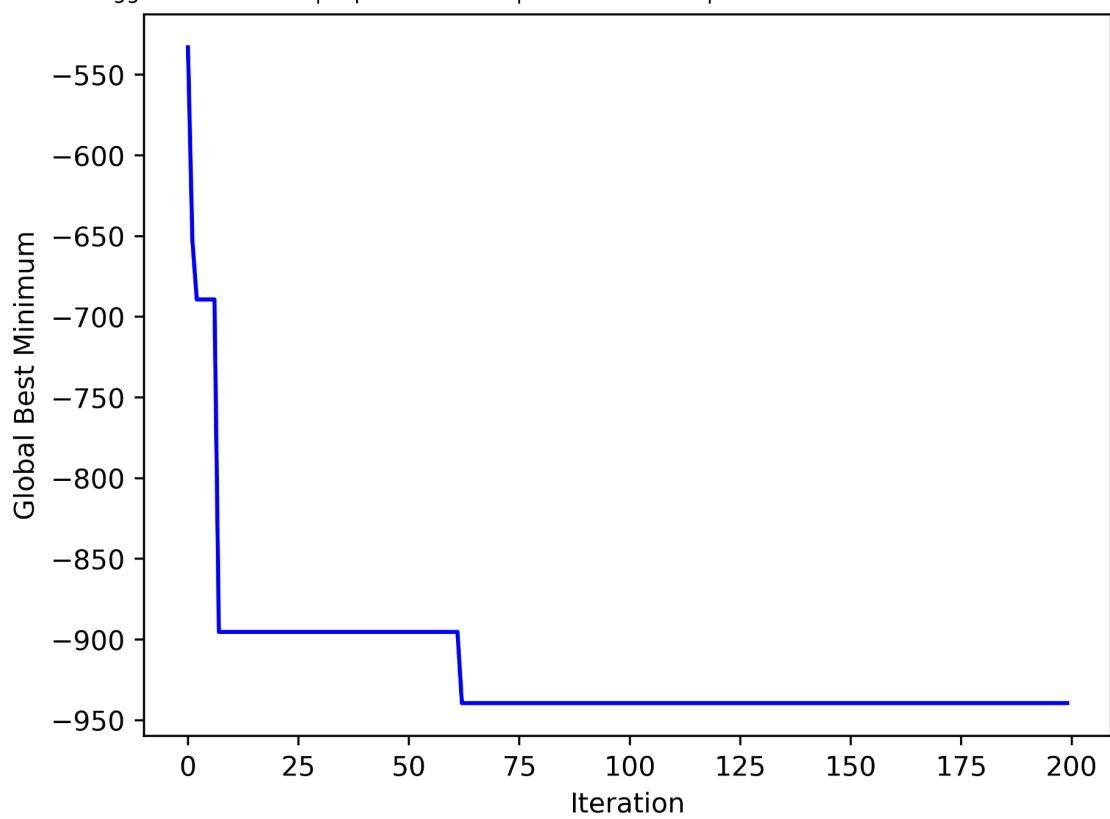




Eggholder Function | Population= 200 | Iterations= 100 | Global Minimum= -865.568354253808



Eggholder Function | Population= 200 | Iterations= 200 | Global Minimum= -939.4178854998252



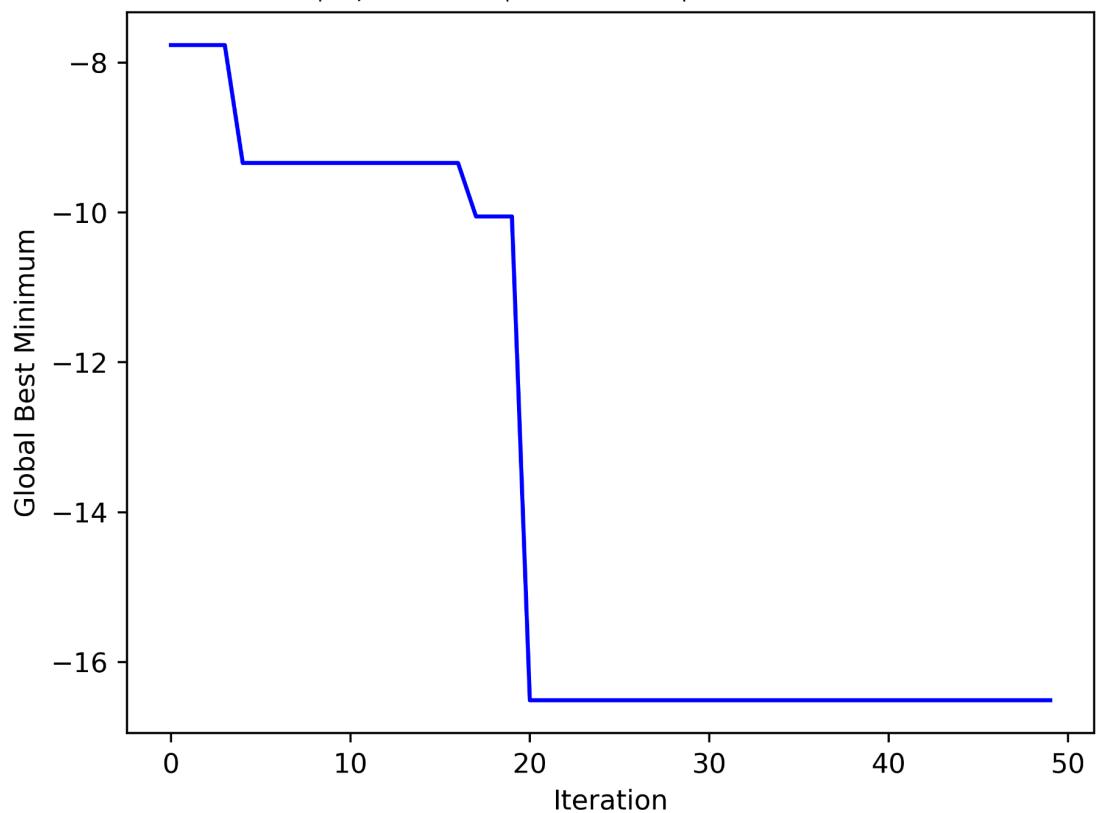
## Holder table function Particle Swarm Optimization:

Original value of holder table function is

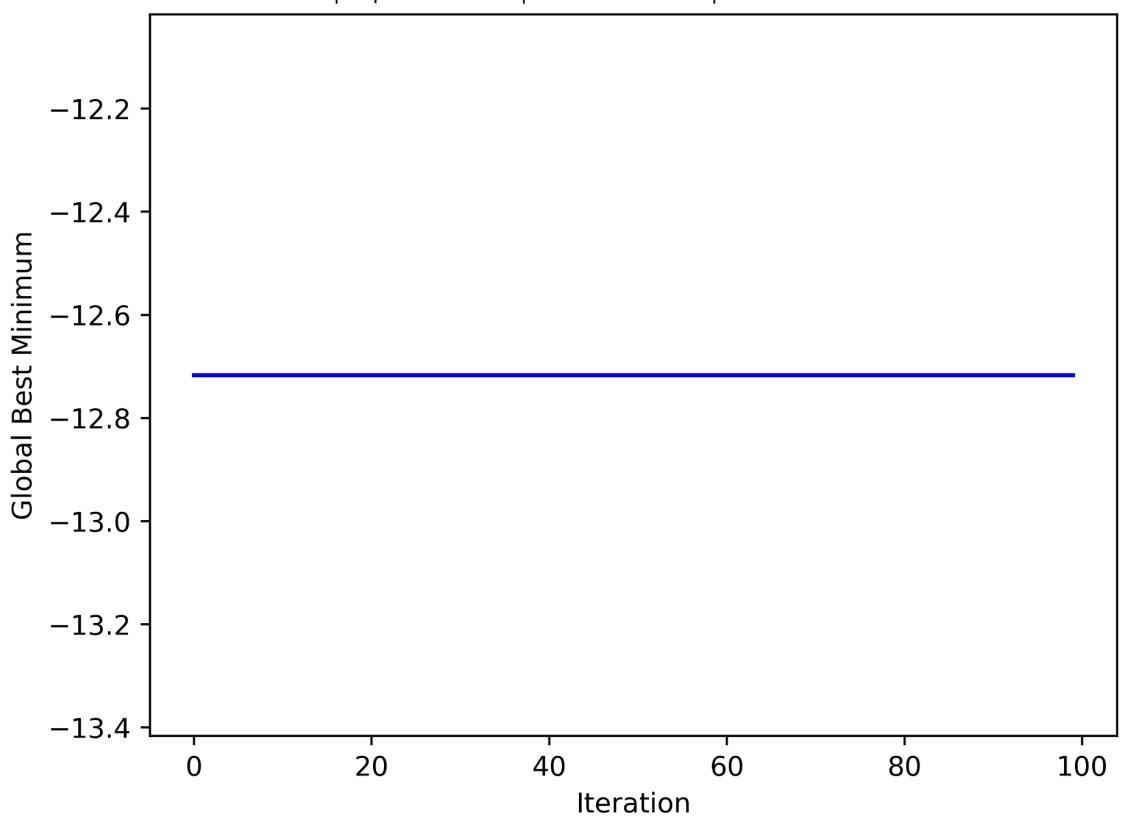
$$\text{Min} = \begin{cases} f(8.05502, 9.66459) & = -19.2085 \\ f(-8.05502, 9.66459) & = -19.2085 \\ f(8.05502, -9.66459) & = -19.2085 \\ f(-8.05502, -9.66459) & = -19.2085 \end{cases}$$

Population=20, Iterations=50, Global\_Minimum=-16.5103554823  
Population=20, Iterations=100, Global\_Minimum=-12.7168889439  
Population=20, Iterations=200, Global\_Minimum=-10.5694771955  
Population=50, Iterations=50, Global\_Minimum=-17.2876732764  
Population=50, Iterations=100, Global\_Minimum=-16.1580357115  
Population=50, Iterations=200, Global\_Minimum=-14.7772288979  
Population=100, Iterations=50, Global\_Minimum=-18.4761600239  
Population=100, Iterations=100, Global\_Minimum=-19.1164244372  
Population=100, Iterations=200, Global\_Minimum=-18.5574348080  
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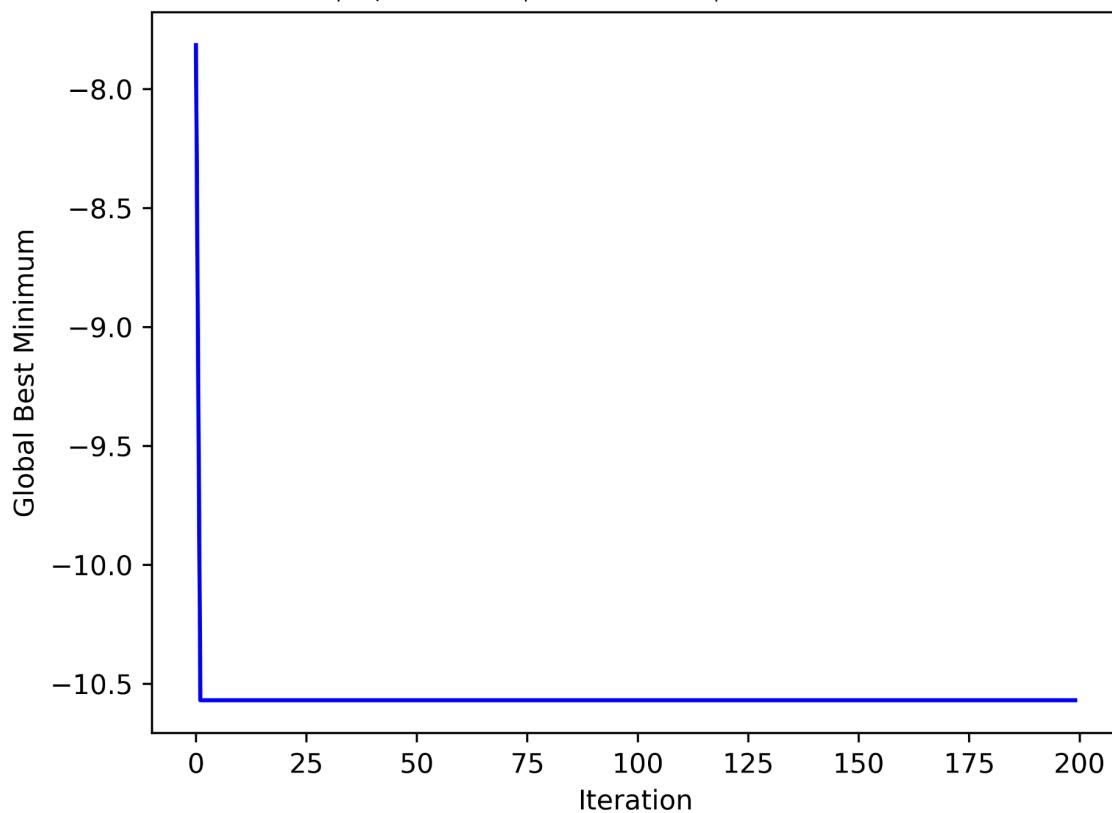
Holder Table Function | Population= 20 | Iterations= 50 | Global Minimum= -16.510355482321362



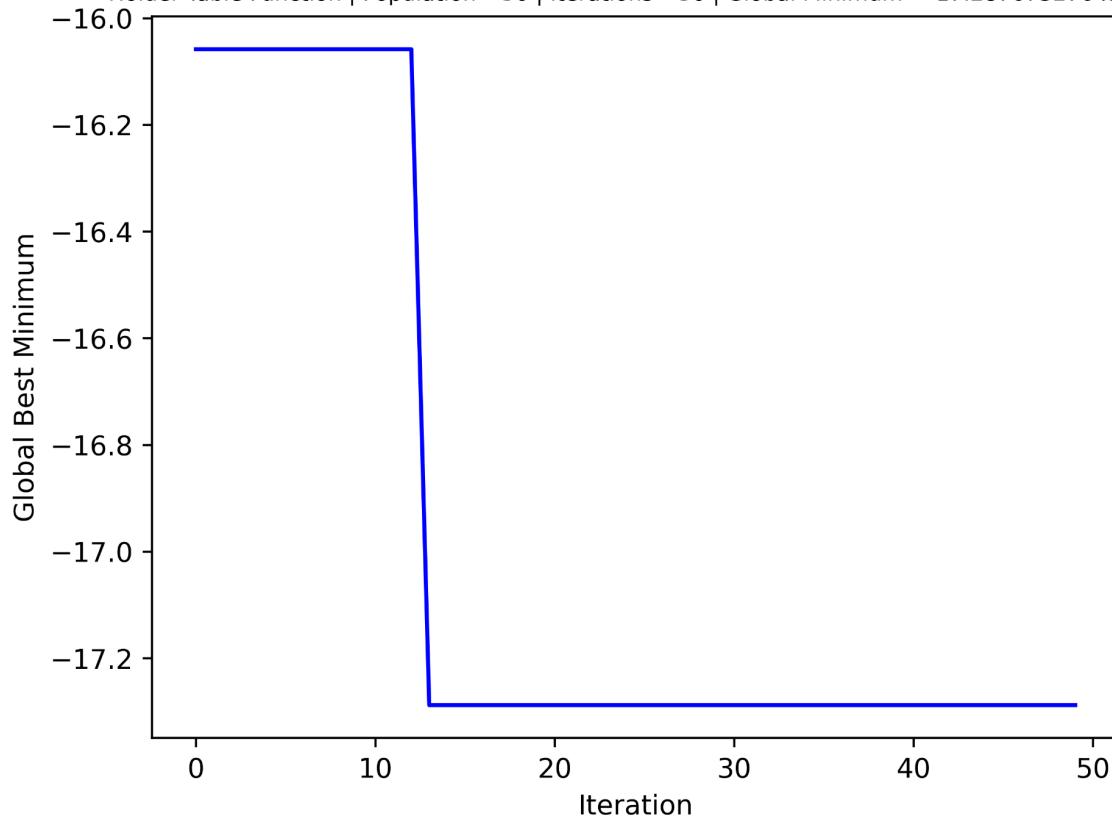
Holder Table Function | Population= 20 | Iterations= 100 | Global Minimum= -12.716888943948229



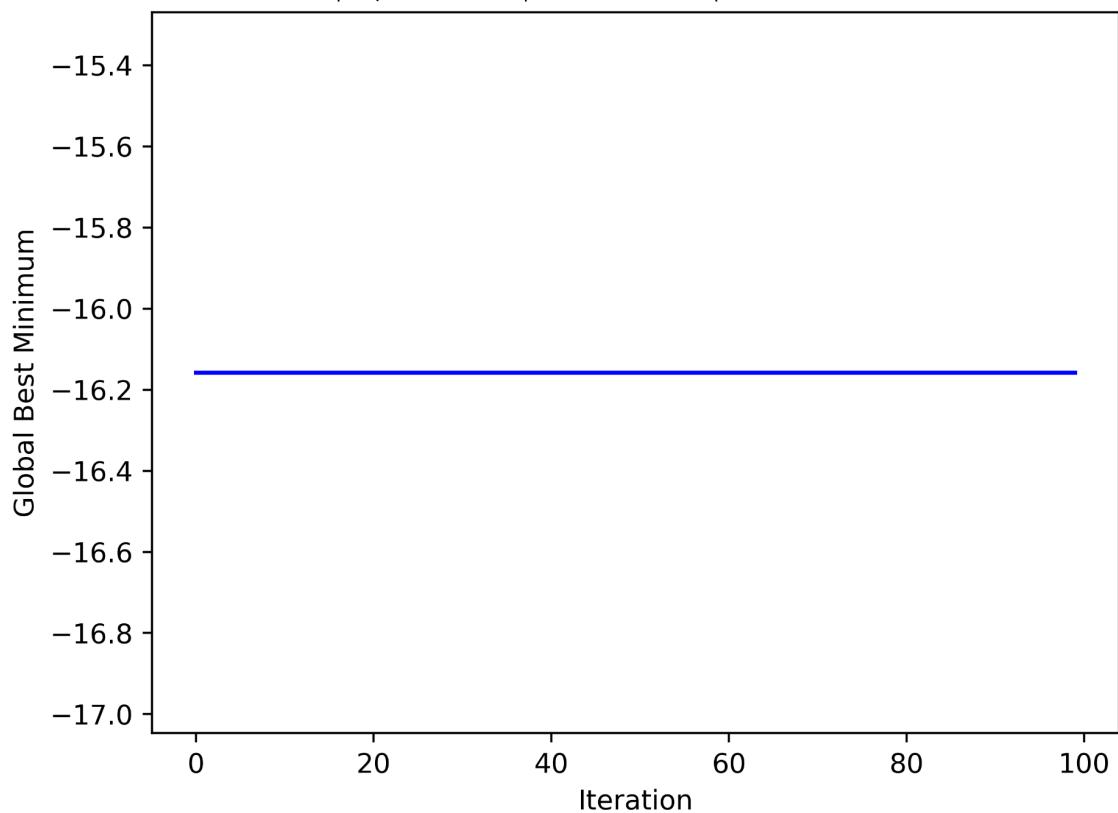
Holder Table Function | Population= 20 | Iterations= 200 | Global Minimum= -10.569477195570185



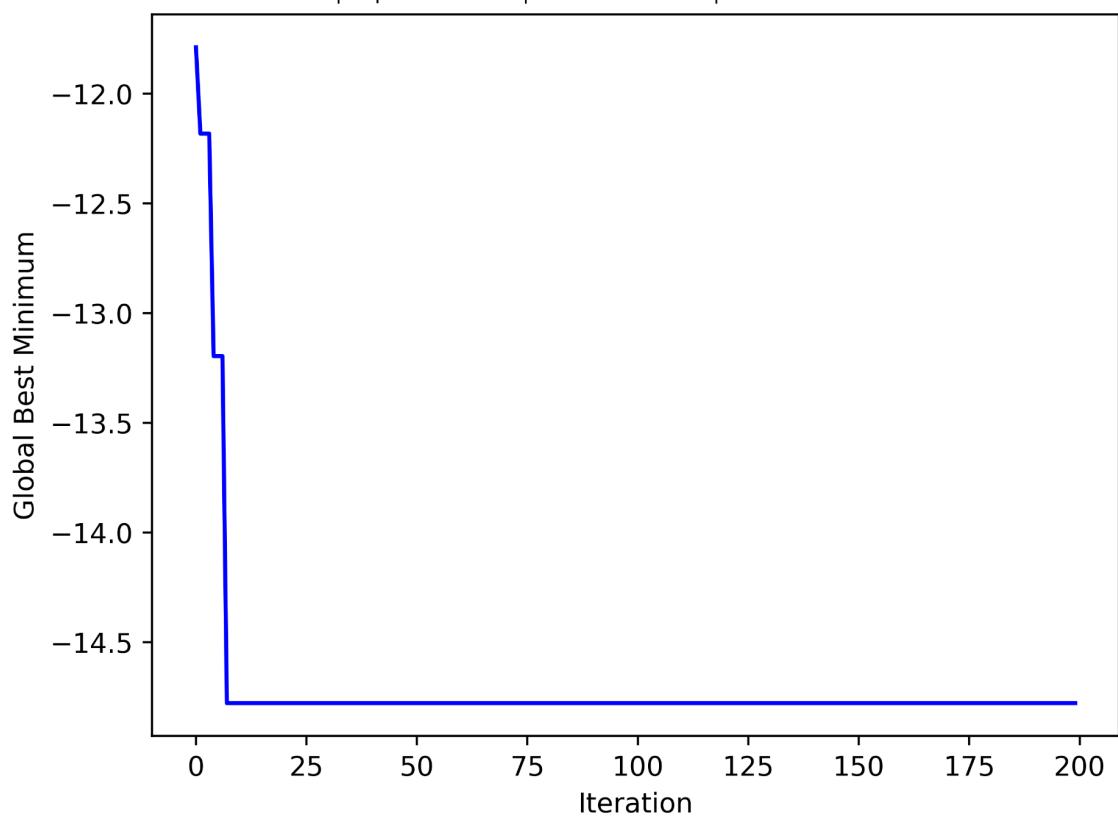
Holder Table Function | Population= 50 | Iterations= 50 | Global Minimum= -17.28767327643431

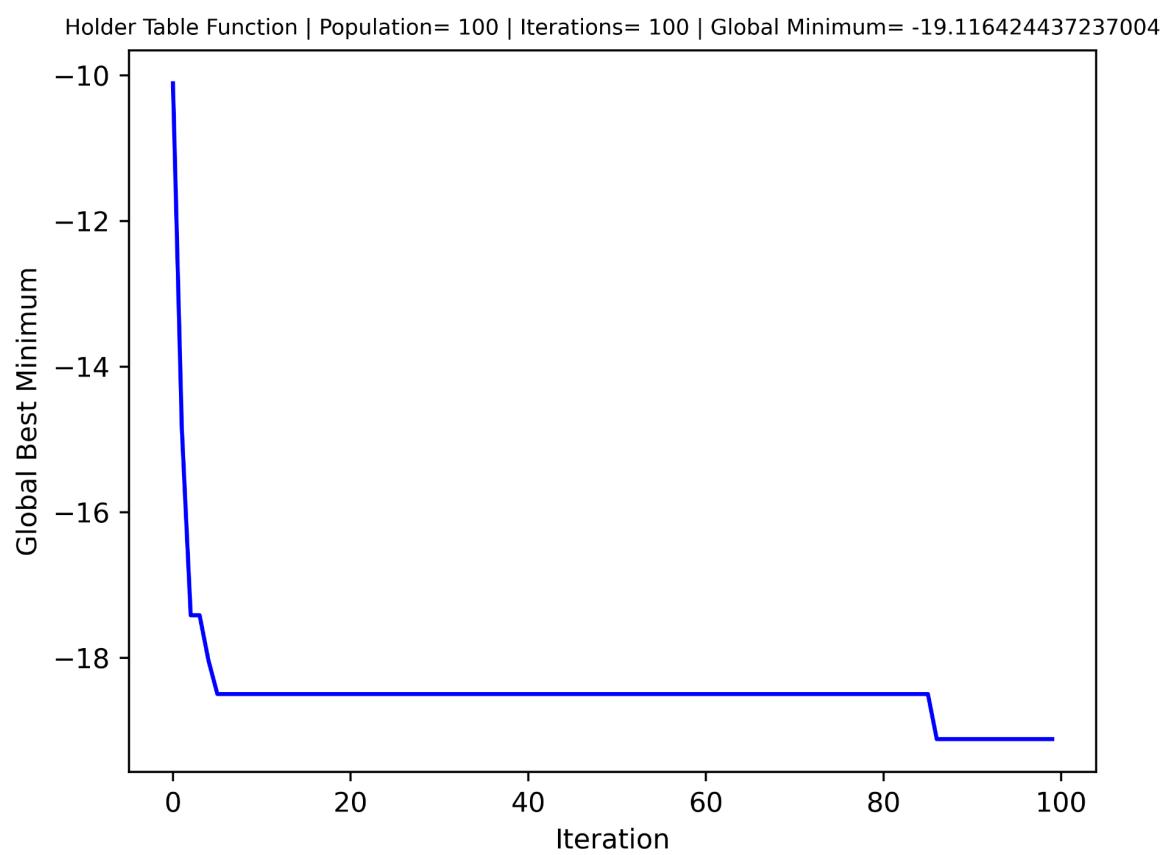
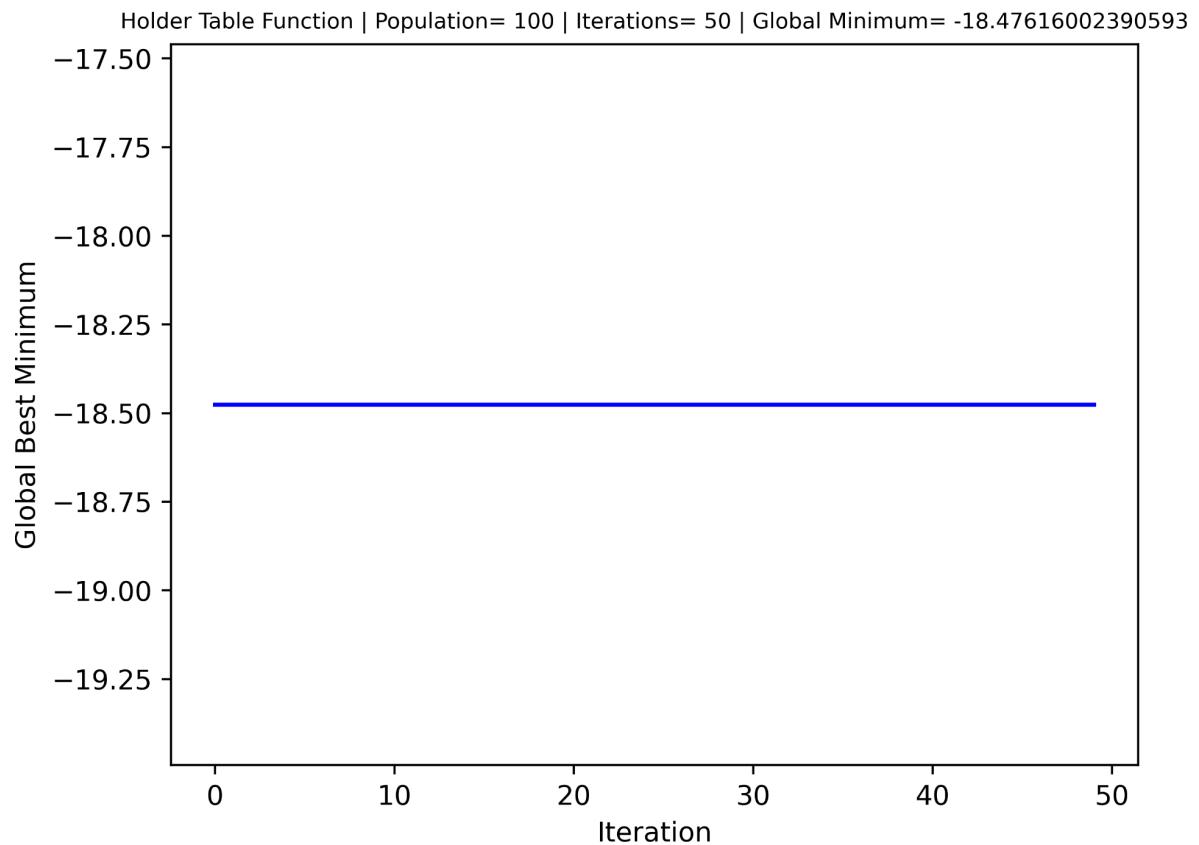


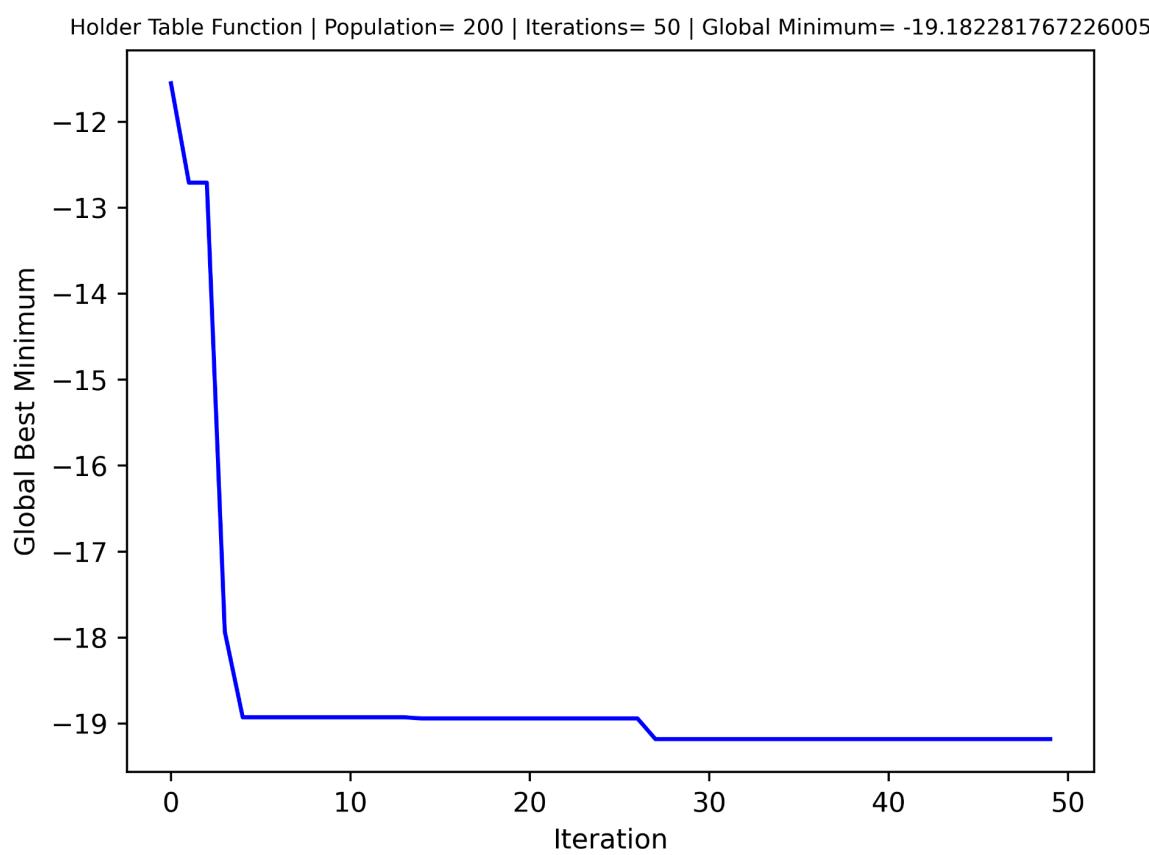
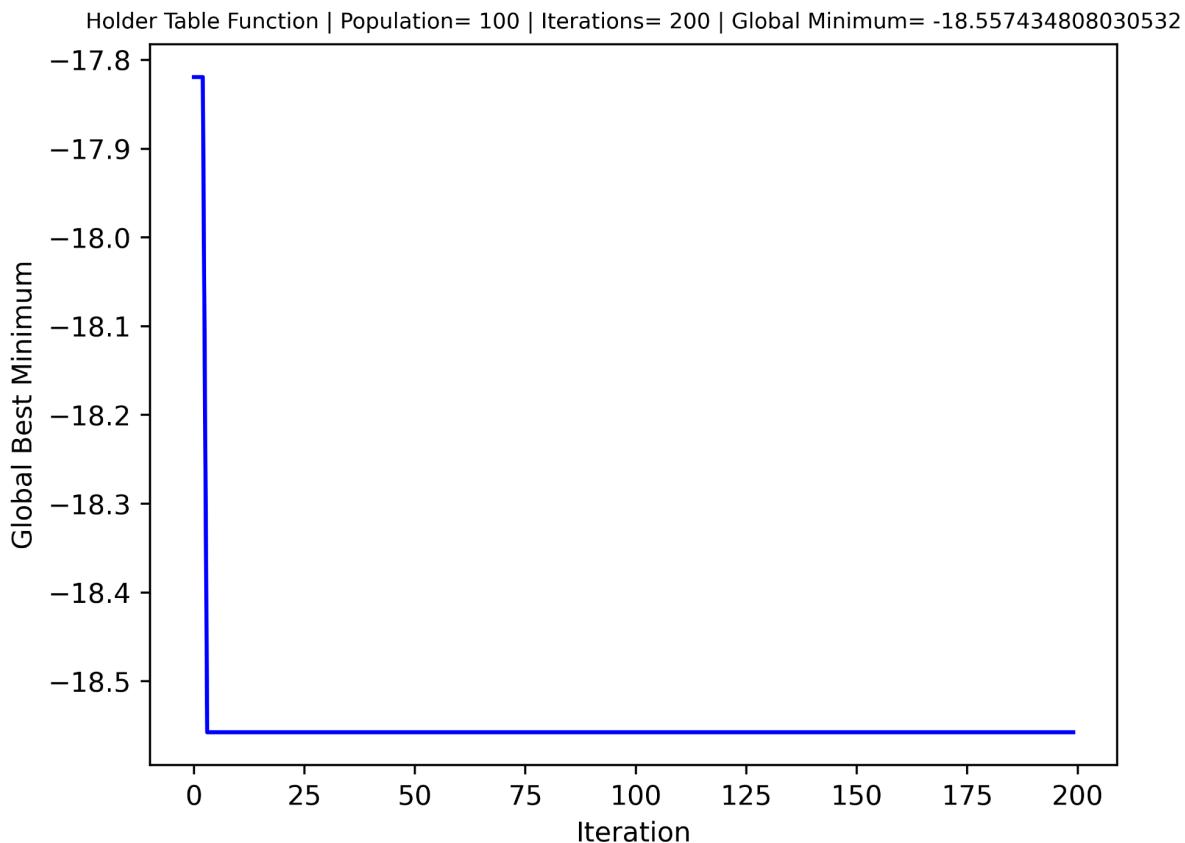
Holder Table Function | Population= 50 | Iterations= 100 | Global Minimum= -16.158035711509342



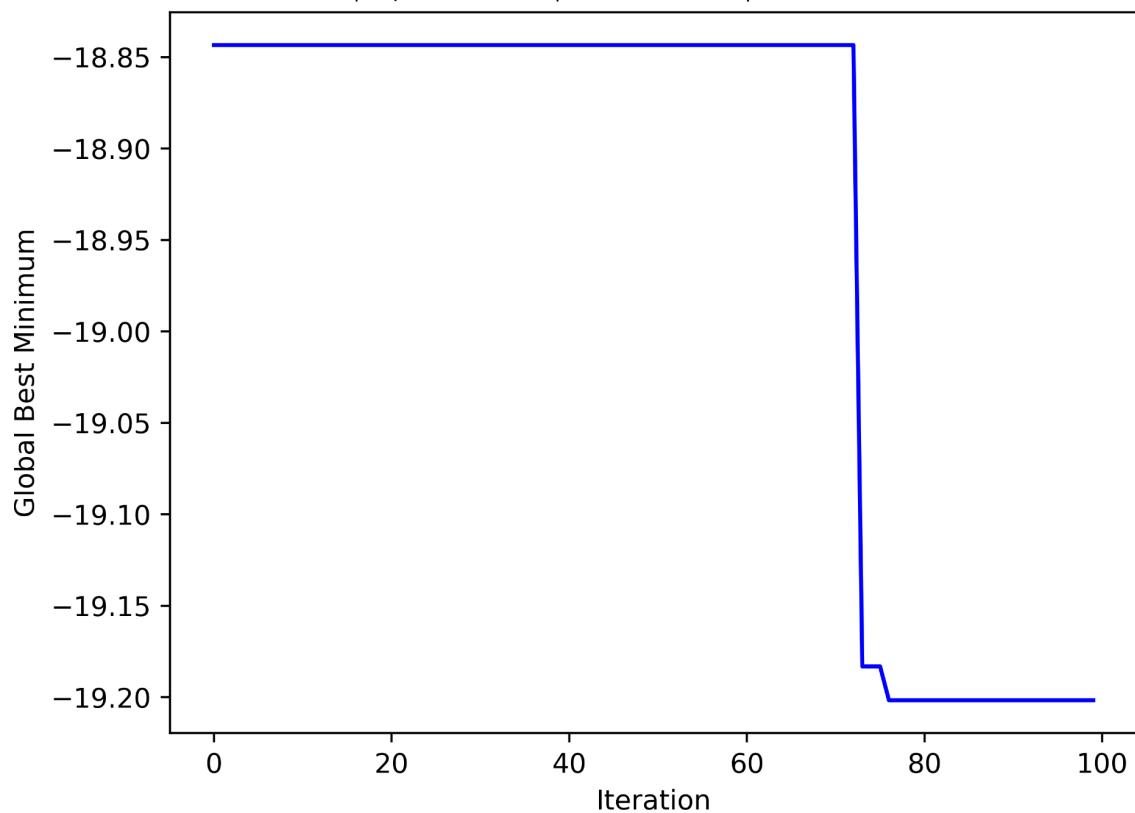
Holder Table Function | Population= 50 | Iterations= 200 | Global Minimum= -14.777228897960379







Holder Table Function | Population= 200 | Iterations= 100 | Global Minimum= -19.20160819404123



Holder Table Function | Population= 200 | Iterations= 200 | Global Minimum= -18.88191009471347

