Traveling Salesman Problem Solutions with Ant Colony Optimization and Genetic Algorithms.

```
In [1]: import numpy as np
        class AntColony:
            def init (self, distances, n ants, decay, alpha, beta):
                self.distances = distances
                self.pheromone = np.ones(self.distances.shape) / len(distances)
                self.all inds = range(len(distances))
                self.n ants = n ants
                self.decay = decay
                self.alpha = alpha
                self.beta = beta
            def run(self, n):
                self.all inds = range(len(distances))
                self.shortest path = None
                all_time_shortest_path = ("placeholder", np.inf)
                for i in range(n):
                    all paths = self.gen all paths()
                    self.spread pheronome(all paths, self.pheromone, self.all inds, self.distanc
                    self.pheromone *= self.decay
                    self.shortest path = min(all paths, key=lambda x: x[1])
                    if self.shortest path [1] < all time shortest path[1]:</pre>
                        all time shortest path = self.shortest path
                return all time shortest path
            def spread pheronome(self, all paths, pheromone, all inds, distances):
                pheromone *= self.decay
                for path, dist in all paths:
                    for move in path:
                        pheromone[move] += 1.0 / distances[move]
            def gen path dist(self, path):
                total dist = 0
                for ele in path:
                    total dist += self.distances[ele]
                return total dist
            def gen all paths(self):
                all paths = []
                for i in range(self.n ants):
                   path dist = 0
                    path = []
                    visited inds = set()
                    visited inds.add(self.all inds[i])
                    prev = self.all inds[i]
                    for j in range(len(self.distances) - 1):
                        move = self.pick move(self.pheromone[prev], self.distances[prev], visite
                        path dist += self.distances[prev][move]
                        path.append((prev, move))
                        prev = move
                        visited inds.add(move)
                    all paths.append((path, path_dist))
                return all paths
            def pick move (self, pheromone, dist, visited inds):
                pheromone = np.copy(pheromone)
```

pheromone[list(visited inds)] = 0

```
row = pheromone ** self.alpha * ((1.0 / dist) ** self.beta)
        # Normalize row only if it's not empty
       if row.sum() > 0:
           norm row = row / row.sum()
           move = np.random.choice(self.all inds, 1, p=norm row)[0]
       else:
            # If the row is empty, choose a random move
           move = np.random.choice(list(set(self.all inds) - visited inds), 1)[0]
       return move
class GeneticAlgorithm:
    def init (self, population size, elite size, mutation rate, crossover prob):
       self.population size = population size
       self.elite size = elite size
       self.mutation rate = mutation rate
        self.crossover prob = crossover prob # Add crossover probability
   def crossover(self, parent1, parent2):
        # Order Crossover (OX1) - a common crossover method for TSP
       if np.random.rand() < self.crossover prob:</pre>
            start, end = sorted(np.random.choice(len(parent1), 2, replace=False))
            child = [-1] * len(parent1)
            child[start:end] = parent1[start:end]
           remaining = [item for item in parent2 if item not in child]
           index = 0
           for i in range(len(child)):
                if child[i] == -1:
                    child[i] = remaining[index]
                    index += 1
           return child
       else:
           return parent1 # If no crossover, return the first parent as the child
    def mutate(self, individual):
        # Swap Mutation - swap two cities in the individual
       mutate index1, mutate index2 = np.random.choice(len(individual), 2, replace=Fals
       individual[mutate index1], individual[mutate index2] = individual[mutate index2]
       return individual
    def evolve(self, population):
       elite size = int(self.elite size * len(population))
       elites = sorted(population, key=lambda x: x[1])[:elite size]
       # Crossover
       children = []
       while len(children) < (len(population) - elite size):</pre>
           parent1, parent2 = np.random.choice(elites, 2, replace=False)
           child = self.crossover(parent1[0], parent2[0])
            children.append((child, -1))
        # Mutation
       for i in range(len(children)):
            if np.random.rand() < self.mutation rate:</pre>
                children[i] = (self.mutate(children[i][0]), -1)
        # Combine elites and children
       population = elites + children
       return population
class ACOGA:
   def init (self, distances, n ants, decay, alpha, beta, ga population size, ga eli
       self.aco = AntColony(distances, n ants, decay, alpha, beta)
        self.ga = GeneticAlgorithm(ga population size, ga elite size, ga mutation rate,
```

```
def run(self):
                for gen in range(self.generations):
                    aco shortest path = self.aco.run(10)
                    ga population = self.generate ga population(aco shortest path)
                    ga population = self.ga.evolve(ga population)
                    best ga solution = min(ga population, key=lambda x: x[1])
                    self.aco.pheromone *= self.aco.decay
                    self.aco.spread pheronome([best ga solution], self.aco.pheromone, self.aco.a
                return aco shortest path
            def generate ga population(self, aco solution):
                # Generate GA population from ACO solution
                ga population = [(aco solution[0], -1) for in range(self.ga.population size)]
                return ga population
        # Example usage:
        if name == " main ":
           distances = np.array([[np.inf, 2, 2, 5, 7],
                                 [2, np.inf, 4, 8, 2],
                                 [2, 4, np.inf, 1, 3],
                                 [5, 8, 1, np.inf, 2],
                                 [7, 2, 3, 2, np.inf]])
            aco ga = ACOGA(distances, n ants=5, decay=0.95, alpha=1, beta=2, ga population size=
            result = aco ga.run()
            print("ACO-GA Combined Solution:", result)
        ACO-GA Combined Solution: ([(0, 2), (2, 3), (3, 4), (4, 1)], 7.0)
        import numpy as np
In [2]:
        import re
        def euclidean distance(coord1, coord2):
            return np.sqrt((coord2[0] - coord1[0])**2 + (coord2[1] - coord1[1])**2)
        def read coordinates from file (file path):
            coordinates = []
            with open(file path, 'r') as file:
                for line in file:
                    new line = re.split(r' \s+', line.strip())
                    if new line[0].isdigit():
                        id, x, y = new line[0], float(new line[1]), float(new line[2])
                        coordinates.append((x, y))
            return coordinates
        # Specify the path to the file containing coordinates
        #file path = "burma14.tsp"
        #file path = "eil51.tsp"
        #file path = "berlin52.tsp"
        file path = "eil76.tsp"
        #file path = "lin105.tsp"
        #file path = "bier127.tsp"
        #file path = "gr137.tsp"
        #file path = "rat195.tsp"
        #file path = "lin318.tsp"
        #file path = "rat575.tsp"
        # Read coordinates from the file
        coordinates = read coordinates from file(file path)
        # Create a distance matrix using NumPy array
```

self.generations = generations

num points = len(coordinates)

```
distance matrix = np.zeros((num points, num points))
for i in range(num points):
   for j in range(num points):
      if i != j:
          distance matrix[i, j] = euclidean distance(coordinates[i], coordinates[j])
       else:
          distance matrix[i, j] = np.inf
# Replace inf values with np.inf
distance matrix = np.where(np.isinf(distance matrix), np.inf, distance matrix)
# Round the values in the distance array to 2 decimal places
distances = np.round(distance matrix, 2)
print("Distance Matrix:")
# Print column indices
print(" ", end="")
for i in range(num_points):
   print(f" {i:<6}", end="")</pre>
print()
# Print the matrix with row indices
for i in range(num points):
   print(f"{i:2} | ", end="")
   for value in distances[i]:
      print(f"{value:7.2f}", end=" ")
   print()
# ACOGA implementation using the read coordinates.
aco ga = ACOGA(distances, n ants=5, decay=0.95, alpha=1, beta=2, ga population size=400,
result = aco ga.run()
best path indices = result[0]
print("Best Path Indices:", best path indices)
print("Best Path length:", np.round(result[1], 2))
Distance Matrix:
                           3
                                  4
                                         5
                                                6
                                                       7
                                                              8
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      0
             1
                    2
10
      11
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32
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                  35
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            67
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65
      66
                   68
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                                                                     75
     inf 14.56 23.02 26.42 33.06 16.28 39.60 40.22 37.22 47.54
0 |
4.20 31.78 42.06 53.15 40.05 14.04 24.60 36.40 47.71 44.72 23.77
9.85 12.53 25.81 42.30 30.61 35.11 14.32 30.27 21.38 54.74 31.00
           43.28
                         38.64 50.61 38.83 29.12 11.18 10.63
                  34.18
8.06 33.29
                                                                    6.71
6.02 29.12 35.23 28.86 26.02 18.87 34.71 18.38 35.78 48.10 48.85
                                                                          4
9.48 16.28 43.29 42.05 63.78 45.69 21.26 8.25
                                                      8.25 18.38 55.57
1.03 30.48 19.42 33.29 46.17 40.72 40.16 5.39 18.11 23.43 25.46
            inf 24.21 12.73 19.92 8.54 27.78 26.87 34.48 40.20
1 | 14.56
3.38 25.02 27.51 40.46 26.08 18.03 18.25 40.36 34.06 32.31 15.26
                                                                           1
6.40 25.08 33.62 42.49 20.62 20.62 10.05 16.00 7.00 50.25 30.41
                                                                           1
0.44 19.80 30.61
                  24.08 26.40 41.48 34.53 24.74 25.63 24.19 21.19
6.63 14.56 21.93 17.80 13.00 26.83 36.62 14.76 21.63 36.36 34.44
                                                                           5
1.11 30.02 29.02 34.23 50.99 35.61 20.00 8.49 16.49 29.70 46.17
                                                                           5
0.57 18.36
            7.28 26.08 34.99 31.14 34.01
                                               9.22
                                                      7.21 11.70 14.56
2 | 23.02 24.21
                   inf 26.00 42.20 16.28 29.43 34.00 14.87 28.32
9.45 15.23 42.20 42.72 46.07 9.00 12.04 16.28 41.11 54.64 39.41
                                                                           3
2.39 19.72 14.14 19.42 20.02 35.74 32.20 36.36 29.07 32.57
                                                                    8.06
6.76 29.43 34.37 48.10 49.20 33.42 17.49 10.30 29.41 31.58 26.48
3.00 \quad 32.65 \quad 30.15 \quad 41.73 \quad 36.12 \quad 11.40 \quad 12.53 \quad 10.00 \quad 33.73 \quad 36.06 \quad 46.17
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7.31	25.00	47.54	24.21	52.55	59.41	41.79	26.57	15.03	40.45	38.29	4
5.00	24.19	20.81	50.22	58.26	55.17	20.52	21.84	31.40	20.62	19.65	
3	26.42	12.73	26.00	inf	18.03	12.04	15.81	14.14	30.61	31.40	3
1.62	18.87	17.00	27.80	20.25	24.02	15.00	41.68	21.40	29.70	22.02	2
9.07	34.71	38.83	40.31	11.70	10.05	21.47	11.40	9.22	43.32	29.21	1
9.92	7.07	18.03	26.57	25.00	31.06	29.15	21.21	37.59	36.62	33.12	2
7.29	7.07	9.22	20.62	14.32	33.14	36.62	16.49	9.49	24.17	22.80	4
9.50	40.26	21.54	25.50	38.29	36.36	30.36	21.21	25.50	42.43	35.36	3
8.90	7.00	7.28	31.40	34.21	33.11	26.93	21.10	15.81	5.39	7.07	4
4	33.06	19.92	42.20	18.03	inf	26.08	30.41	25.00	48.60	48.38	4
5.00 9.83	36.89 44.72	16.55 53.23	37.66 58.14	8.06 29.53	37.58 14.00	32.56 20.40	58.41 6.71	28.86 13.42	12.53 60.93	13.04 46.67	2
0.36	20.62	30.00	10.05	7.07	46.69	47.17	39.05	43.10	40.45	39.01	3 4
4.05	11.18	22.36	7.07	7.07	46.62	53.81	32.20	18.03	37.00	24.19	6
7.27	49.25	12.21	42.72	46.49	18.36	23.60	25.00	36.40	42.72	50.25	5
2.04	24.17	21.40	16.76	16.28	15.52	44.72	28.28	15.00	22.67	25.00	
5	16.28	8.54	16.28	12.04	26.08	inf	23.35	24.60	25.96	32.76	3
8.01	17.12	29.02	37.01	30.68	12.17	10.00	32.56	32.20	38.59	23.71	2
2.14	22.80	27.51	34.00	14.42	22.00	18.11	20.62	12.81	42.05	21.95	
8.60	18.03	27.20	31.89	33.02	34.93	26.17	16.28	27.02	26.91	22.67	1
8.44	17.46	19.70	25.50	19.85	21.38	28.43	6.40	21.38	31.83	34.71	4
2.72	28.46	32.76	26.93	47.63	43.14	28.16	14.32	13.60	34.13	39.81	4
4.94	14.42	5.10	34.48		38.95	26.08	11.66		7.62	9.22	
6	39.60	27.78	29.43	15.81	30.41	23.35	inf	7.07	25.63	18.87	1
5.81	15.03	19.21	13.89	28.64	32.20	18.03	41.44	12.17	39.40	37.48	4
4.10 1.89	44.78 10.00	43.57 5.00	35.85 40.20	9.85 36.40	16.76 16.28	37.16 22.36	24.08	25.00 50.33	32.20 50.21	28.16 46.01	3 2
9.07	20.00	8.06	35.00	29.07	39.85	35.51	23.71	12.65	8.60	19.24	4
4.72	50.61	27.46	14.14	24.41	48.08	46.17	36.06	36.06	57.01	20.00	2
3.09	9.43	20.81	46.00	44.94	45.89	18.03	34.71	31.62	16.40	14.14	2
7	40.22	26.87	34.00	14.14	25.00	24.60	7.07	inf	32.20	25.81	2
0.00	20.88	12.21	13.89	22.14	35.17	22.02	47.30	7.62	32.89	33.84	4
3.19	47.17	48.04	42.49	14.04	11.00	35.23	19.24	22.47	39.20	33.96	3
3.12	7.07	5.00	35.01	30.41	22.47	29.15	25.50	51.31	50.61	46.87	3
4.13	15.81	5.00	30.41	25.00	43.57	41.48	26.68	7.07	12.00	12.65	5
1.48	52.92	20.59	21.21	24.21	41.98	43.38	35.36	38.08	56.57	25.50	2
7.07	10.44	20.81	41.30	38.60	40.20	25.00	35.00	29.15	17.00	15.81	
8	37.22			30.61						15.65	2
9.61	12.04		36.06		23.54		17.26	37.64		49.40	4
6.00	34.44	24.84	10.30	19.85	38.29	43.93 4.12	42.01 9.85	37.12	17.72 46.32	7.21	3
0.00	30.61 37.64	30.36	56.44 50.12	55.61 43.91	22.14 25.24	11.40	20.22	44.27 35.00	29.07	41.23 44.78	1 1
9.42	39.45	50.45	14.04	44.28	66.85	53.94	39.20	29.61	55.11	26.40	3
3.62	25.50	28.64			63.29	9.06	35.20	41.44	26.08	23.60	5
9	47.54	40.20	28.32		48.38	32.76	18.87	25.81	15.65	inf	1
5.03	15.81	38.01	23.77		35.51	23.09	32.57	28.43	58.14	53.15	5
4.82	47.80	40.22	23.09	20.02	35.34	50.25	41.76	40.11	13.45	22.20	3
9.56	27.86	21.93	57.72	54.78	7.00	11.66	18.87	56.44	57.70	52.77	2
6.17	37.36	26.40	51.97	45.71	39.60	26.93	29.15	31.30	17.49	36.80	3
0.27	53.26	46.32	6.00		66.48	60.13	47.07	41.18	65.92	10.77	1
8.03		33.06	62.80		63.89		43.97	46.00		26.00	
10	54.20	43.38	39.45		45.00	38.01	15.81	20.00	29.61	15.03	_
inf	24.41	30.81	10.63	41.59	44.69	30.41		18.38	52.17	53.15	5
9.54 6.23	57.49 25.50	52.80			31.00	52.92	39.12	40.80	26.40	35.11	4
8.01	35.36	15.00 23.35	55.01 50.25		8.06 50.77	25.50 41.00	29.15 36.77	64.44 27.02	64.82 8.00	60.31 26.83	3 4
5.28	63.25	39.29	15.81		61.66	61.98	51.48	49.50		7.07	4
7.28	25.08	36.24	61.20		60.13	20.62	49.65	47.43	31.76	29.15	
11	31.78	25.02	15.23		36.89	17.12	15.03	20.88	12.04	15.81	2
4.41	inf	31.38	27.66	38.18	20.52	7.28	26.48	27.17	48.27	39.05	3
9.05	33.24	29.12	22.20	7.81	26.25	35.00	30.23	26.25	25.32	13.15	2
3.77	18.60	20.02	45.19	43.83	19.21	10.30	5.10	41.05	42.06	37.22	1
4.32	25.81	18.36	39.00	32.70	26.42	20.62	13.42	23.02	20.88	33.53	3
1.40	38.95	38.42	10.30		55.23	45.01	31.40	25.81	50.16	24.21	3
0.41	13.45	18.25	49.34		51.88	9.00		31.40	14.87	12.08	_
12	42.06	27.51	42.20	17.00	16.55	29.02	19.21	12.21	43.27	38.01	3

0.81	31.38	inf	22.00	11.00	41.01	30.36	57.01	13.00	21.38	28.43	4
2.19	51.48	55.58	53.54	23.71	7.07	33.02	13.45	21.02	51.40	43.86	3
6.50	13.00	16.55	26.25	20.10	34.44	40.61	35.34	53.14	51.48	48.70	4
3.01	13.00	13.04	23.32	19.80	50.09	51.48	33.24	8.54	23.09	7.81	6
2.68	56.89	8.54	33.30	30.08	31.06	38.95	35.34	42.30	55.76	37.00	3
7.34	18.38	24.08	33.24	27.29	30.15	36.80	36.69	26.63	22.09	22.56	
13	53.15	40.46	42.72	27.80	37.66	37.01	13.89	13.89	36.06	23.77	1_
0.63	27.66	22.00	inf	33.00	46.07	31.78		9.00	43.19	47.54	5
6.85 5.61	58.67 20.81	56.75 9.90	45.54 47.68	23.71 42.05	24.04 17.49	49.09 32.14	32.57 32.76	36.36 64.03	36.36 63.70	40.20 59.67	4
1.98	29.55	18.60	47.68	38.63	53.49	47.01	37.59	20.62	7.00	16.76	5
3.60	64.50	30.15	22.20	10.63	53.49	57.25	48.92	49.93	70.09	17.69	1
5.81	22.67	33.94	54.34	49.16	52.09			43.05	29.73	27.80	_
14	40.05	26.08	46.07	20.25	8.06	30.68	28.64	22.14	50.21	47.41	4
1.59	38.18	11.00	33.00	inf	42.72	35.23	61.91	24.00	10.77	21.10	3
7.64	51.16	58.19	60.21	30.41	12.21	28.16	10.20	19.10	60.54	49.41	3
6.35	20.00	26.93	16.12	9.22	44.60	48.17	41.23	50.49	48.05	46.27	4
7.51	13.42	21.10	15.00	14.32	51.92	56.86	36.25	16.12	33.73	17.72	6
9.43	56.01	4.24	42.19	40.79	20.10	31.62	32.25	42.43	50.70	47.54	4
8.26	24.76	25.63	23.32		19.24	45.00		22.36	25.55	27.20	
15	14.04	18.03	9.00	24.02	37.58	12.17	32.20	35.17	23.54	35.51	4
4.69	20.52	41.01	46.07	42.72	inf	14.42	23.32	42.72	50.09	32.53	2
3.54 8.60	12.81 29.27	15.65 36.77	28.28 42.01	22.36 44.29	34.06 39.70	24.41 25.63	32.57 16.64	24.17 21.02	41.23 22.80	17.03 17.72	1
2.00	29.27	30.59	35.81	30.89	9.22	20.88	8.54	33.06	39.96	46.27	3
5.74	18.60	44.91	30.61	56.44	53.60	33.54	18.36	6.08	31.58	44.69	5
0.91	24.74	17.26	43.19		49.04	27.78	13.42	24.84	19.03	19.42	Ü
16	24.60	18.25	12.04	15.00	32.56	10.00	18.03	22.02	16.55	23.09	3
0.41	7.28	30.36	31.78	35.23	14.42	inf	26.83	29.27	44.60	32.89	3
1.78	27.20	26.02	25.61	8.25	24.17	28.07	26.17	20.59	32.06	14.21	1
6.55	17.46	22.80	39.96	39.62	26.08	16.28	6.71	34.21	34.99	30.23	1
2.65	22.02	18.11	33.62	27.46	21.84	21.63	6.40	21.84	25.55	34.13	3
4.71	33.02	36.24	17.46	42.06	50.61	38.12	24.19	19.10	42.95	31.06	3
6.88	12.17	12.08	43.46		46.87	16.12	20.88	25.00	9.90	8.06	
17	36.40	40.36	16.28		58.41	32.56	41.44	47.30	17.26	32.57	4
6.87	26.48	57.01	53.01	61.91	23.32 50.99	26.83	inf 52.43	53.60	70.80	55.44	4
6.24 1.91	28.07 44.01	13.15 46.39	11.31 64.35	33.53 65.44	39.29	47.71 21.38	21.84	45.34 39.12	29.73 42.43	13.34 37.66	1
4.42	48.55	44.27	57.98	52.40	18.25	6.00	26.25	48.47	46.01	59.91	1
4.04	31.14	63.06	31.26	61.52	75.69	56.82	41.68	28.23	51.35	43.32	5
0.60	38.63	37.01	66.22	74.52	71.42	26.31	36.72	47.51	36.36	34.89	
18	47.71	34.06	41.11		28.86	32.20	12.17	7.62	37.64	28.43	1
8.38	27.17	13.00	9.00	24.00	42.72	29.27	53.60	inf	34.23	39.36	5
0.21	54.78	55.23	47.76	21.10	15.65	41.87	24.17	29.07	41.77	40.31	4
0.71	14.42	7.28	38.83	33.06	23.43	34.18	32.06	58.83	58.01	54.38	4
1.00	21.63	12.53	35.11	30.41	50.99	47.68	34.21	12.81	11.40	8.60	5
6.46	60.54	21.21	25.06	17.89	44.05	49.40	42.52	45.69	63.70	25.06	2
4.52	18.03	28.30	45.61	40.20	43.10	29.55	42.44	35.61	24.60	23.41	_
19	44.72	32.31 21.38	54.64 43.19	29.70 10.77	12.53 50.09	38.59 44.60	39.40 70.80	32.89 34.23	60.21 inf	58.14 22.02	5
2.17 0.01	48.27 56.75	65.74	70.01	40.61	22.83	31.06	18.44	25.94	71.20	58.80	4
2.72	30.73	37.64	12.65	6.08	55.36	58.41	50.91	54.08	51.00	50.25	5
6.40	22.63	31.76	16.03	19.31	59.09	66.07	44.65	26.83	44.38	27.02	7
9.20	61.00	13.04	52.84	50.16	10.20	31.05	36.50	48.70	51.79	58.24	5
8.69	35.00	33.84	18.87	6.00	11.40	55.47	40.26	26.68	34.71	36.77	
20	23.77	15.26	39.41	22.02	13.04	23.71	37.48	33.84	49.40	53.15	5
3.15	39.05	28.43	47.54	21.10	32.53	32.89	55.44	39.36	22.02	inf	1
8.00	36.25	47.63	57.71	33.14	23.71	9.49	15.26	13.04	64.33	45.65	2
4.08	27.66	38.60	10.44	16.12	53.08	49.04	39.56	32.25	29.02	28.64	4
1.88	18.03	29.83	6.32	8.94	40.61	51.87	30.02	26.93	45.35	36.24	6
6.37	39.85	25.24	47.17	57.25	21.93	10.63	15.65	29.41	30.08	57.31	6
0.42	29.02	20.88	10.82		17.00	47.85		8.06	24.33	27.29	F
21 9.54	9.85 39.05	16.40 42.19	32.39 56.85		29.83 23.54	22.14 31.78	44.10 46.24	43.19 50.21	46.00 40.01	54.82 18.00	5
9.54 inf	21.21	35.51	51.79	36.25	35.81	9.49	29.07	21.40		40.20	1
6.00	36.12	47.01	28.16	34.06	57.01	47.17		14.56	11.05	11.66	3

9.20 23.32 41.44 49.04 67.36 39.05 12.21 8.06 18.03 13.60 61.85	5.36	29.41	38.29	24.08	23.41	28.65	44.38	26.17	37.54	52.70	49.65	5
6.6 0 34.67 23.32 25.63 40.31 33.96 47.85 11.05 15.65 27.78 30.41 7.22 28.07 44.71 24.72 22.80 44.78 45.71 34.44 47.80 5 7.49 33.24 51.48 58.67 51.16 12.81 27.20 28.07 54.78 56.75 36.25 7.73 27.31 27.20 28.07 54.78 56.75 36.25 7.73 27.20 28.07 54.78 56.75 36.25 7.73 27.20 28.08 29.10 1.66 10.03 34.99 44.41 26.83 41.11 37.66 10.05 28.26 21.10 44.15 55.70 57.49 2.01 5.83 54.01 43.19 58.52 53.23 40.00 16.69 30.08 30.36 31.38 3.66 36.77 27.46 45.79 58.52 53.23 40.00 16.49 30.08 30.36 31.38 3.51 55.53 56												6
7.49 33.24 51.48 58.67 51.16 12.81 27.20 28.07 54.78 56.75 36.25 1.21 inf 15.52 36.50 34.99 44.41 26.83 31.05 52.00 27.31 2.36 39.05 42.38 41.11 37.66 10.05 28.28 21.10 44.15 52.70 57.49 3.06 36.77 27.46 45.79 58.52 53.23 40.00 16.49 30.08 30.36 31.38 23.1 25.81 33.62 14.14 38.83 53.23 40.00 16.49 30.08 30.36 31.38 5.280 29.12 55.58 56.75 58.19 15.65 26.02 13.15 55.23 65.74 47.63 5.51 15.52 13.62 48.13 48.83 53.23 40.01 21.31 80.01 38.14 34.09 48.10 39.81 40.80 88.25 7.77 70.00 80.03 39.03 <td>6.65</td> <td>34.67</td> <td>23.32</td> <td>25.63</td> <td>40.31</td> <td>33.96</td> <td>47.85</td> <td>11.05</td> <td>15.65</td> <td>27.78</td> <td>30.41</td> <td></td>	6.65	34.67	23.32	25.63	40.31	33.96	47.85	11.05	15.65	27.78	30.41	
1,21	22	12.53	25.08	19.72	34.71	44.72	22.80	44.78	47.17	34.44	47.80	5
S. 10												2
2.36 39.05 42.38 41.11 37.66 10.05 28.28 21.10 44.15 52.70 57.49 2.01 5.83 54.01 43.19 69.12 58.18 33.30 20.62 9.22 23.35 57.31 3.66 36.77 27.46 45.79 58.52 53.23 40.00 16.49 30.08 30.36 31.38 23 25.81 33.62 14.14 38.83 53.23 27.51 43.57 48.04 24.84 40.22 5 2.80 29.12 55.58 56.75 58.19 15.65 26.02 13.15 55.23 65.74 47.63 5.51 15.52 inf 23.26 34.13 48.84 38.90 48.10 39.81 40.80 18.03 3.60 43.10 48.51 57.43 59.94 46.14 28.60 24.04 26.48 30.08 25.63 7.17 18.03 60.17 37.12 66.41 69.07 47.01 32.53 18.38 38.83 50.77 7.80 38.01 32.57 58.05 68.60 64.40 32.76 27.59 40.22 33.54 33.14 44 42.30 42.49 19.42 40.31 58.14 34.00 35.85 42.49 10.30 23.09 3 8.01 22.20 53.54 45.54 60.21 28.28 25.61 11.31 47.76 70.01 57.71 1.79 36.50 23.26 inf 30.00 48.41 51.26 51.66 46.04 418.44 12.08 6.49 47.38 40.50 55.46 65.19 30.07 13.60 19.10 47.27 50.04 45.01 6.49 47.38 40.50 59.08 53.01 26.48 8.25 27.73 45.22 38.64 55.04 9.22 40.52 60.61 23.35 53.00 76.22 61.03 45.88 34.13 59.03 33.54 0.79 35.61 37.44 68.48 74.41 72.42 18.44 41.23 49.65 35.47 33.24 2.51 30.61 20.62 20.02 11.70 29.53 14.42 9.85 14.04 19.85 0.70 0.82 14.56 38.28 36.36 20.88 17.80 11.70 41.01 41.23 36.80 0.10 18.36 10.77 32.28 25.96 30.08 27.86 13.89 15.26 17.80 26.48 0.53 5.66 13.34 42.95 45.49 44.78 44.78 44.2 9.85 44.44 44.41 48.84 44.41 48.44 44.41 48.84 44.41 48.44 44.41 48.84 44.41 48.44 44.41 48.84 44.41 48.84 44.41 48.84 44.41 48.84 44.41 48.84 44.41 48.84 44.41 48.84 44.41 48.84 44.41 48.84 44.41 48.84 44.41 48.84 44.41 48.84 4												1
2.01 5.83 54.01 43.19 69.12 58.18 33.30 20.62 9.22 23.35 57.31 23 25.81 33.62 14.14 38.83 53.23 40.00 16.49 30.08 30.36 31.38 23 25.81 33.62 14.14 38.83 53.23 27.51 43.57 48.04 24.84 40.22 5 2.80 29.12 55.58 56.75 58.19 15.65 26.02 13.15 55.23 65.74 47.63 3.60 43.10 48.51 57.43 59.94 46.14 28.60 24.04 26.48 30.08 25.63 4.87 44.92 44.01 51.31 46.53 7.07 15.26 22.36 47.27 50.00 60.03 7.17 18.03 60.17 37.12 66.41 69.07 47.01 32.53 18.38 38.83 50.77 7.80 38.01 32.57 58.05 68.60 64.40 32.76 27.59 40.22 33.54 33.14 42 42.30 42.49 19.42 40.31 58.14 34.00 35.85 42.49 10.30 23.09 38.01 32.57 58.05 66.50 64.40 32.76 27.59 40.02 33.54 33.14 40.80 40.50 65.46 65.19 30.07 13.60 11.31 47.76 70.01 57.71 1.79 36.50 23.26 inf 30.00 48.41 51.26 51.66 46.04 18.44 12.08 6.14 40.80 40.50 65.46 65.19 30.07 13.60 13.60 47.27 50.04 45.01 6.49 47.38 40.50 59.08 53.01 26.48 8.25 27.73 45.22 38.64 55.04 9.22 40.52 60.61 23.35 53.00 76.22 61.03 45.88 34.13 59.03 33.54 42.51 30.61 20.62 20.02 11.70 29.53 14.42 9.85 14.04 19.85 20.02 20.25 2.67 10.82 14.56 38.28 36.36 20.88 17.80 11.89 15.26 17.80 26.48 9.20 40.82 30.61 14.04 34.13 37.89 40.31 28.23 26.40 48.55 27.83 9.43 7.81 16.00 24.02 19.65 32.35 44.70 29.53 14.42 9.85 14.04 49.83 38.08 9.43 7.81 16.00 24.02 19.65 32.98 36.07 29.68 46.24 44.12 44.12 48.87 38.08 9.43 7.81 16.00 24.02 19.65 32.98 36.07 29.68 46.24 44.12 44.13 38.08 9.43 7.81 16.00 24.02 19.65 32.98 36.07 29.68 46.24 44.12 44.17 38.09 9.44 7.81 48.84 48.41 18.44 inf 26.91 inf 1												2
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5.51 15.52 inf 23.26 34.13 48.84 38.90 48.10 39.81 40.80 18.03 3.60 43.10 48.51 57.43 59.94 46.14 28.60 24.04 26.48 30.08 25.63 7.17 18.03 60.17 37.12 66.41 69.07 47.01 32.53 18.38 38.93 50.77 7.80 38.01 32.57 58.05 68.60 64.40 32.76 27.59 40.22 33.54 33.14 4 42.30 42.49 19.42 40.31 58.14 34.00 35.85 42.49 10.30 23.09 3 8.01 22.20 53.54 45.54 60.21 28.28 25.61 11.31 47.76 70.01 57.71 1.79 36.50 23.26 inf 30.07 13.60 19.10 47.27 50.04 45.01 6.14 40.80 40.50 65.06 65.19 30.07 13.60												3
3.60 43.10 48.51 57.43 59.94 46.14 28.60 24.04 26.48 30.08 25.63 4.87 44.92 44.01 51.31 46.53 7.07 15.26 22.36 47.27 50.00 60.03 7.17 18.03 60.17 37.12 66.41 69.07 47.01 32.53 18.38 38.35 50.77 7.80 38.01 32.57 58.05 68.60 64.40 32.76 27.59 40.22 33.54 33.14 24 42.30 42.49 19.42 40.31 58.14 34.00 35.85 42.49 10.30 23.09 3 6.14 40.80 40.50 65.46 65.19 30.00 13.60 19.10 47.27 50.04 45.01 6.49 47.38 40.50 59.08 53.01 26.48 8.25 27.73 45.22 38.64 55.04 9.79 35.61 37.4 68.48 74.41 72.42												2
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27 14.32 10.05 32.20 21.47 20.40 18.11 37.16 35.23 43.93 50.25 5 2.92 35.00 33.02 49.09 28.16 24.41 28.07 47.71 41.87 31.06 9.49 9.49 26.83 38.90 51.26 30.59 26.91 inf 19.72 12.81 60.13 39.22 5.81 28.30 39.45 19.92 25.02 51.42 44.28 34.37 23.02 20.10 19.24 4.93 20.52 30.53 15.03 13.93 31.83 44.72 23.77 29.07 45.62 40.61 9.51 30.36 31.95 44.28 59.41 31.38 10.05 6.40 20.52 22.83 56.04 0.17 27.86 17.26 19.21 32.02 26.40 44.00 11.31 6.40 21.59 24.52 28 30.27 16.00 36.36 11.40 6.71 20.62 24.08 19.24 42.01 41.76 3 9.07 41.05												J
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5.81 28.30 39.45 19.92 25.02 51.42 44.28 34.37 23.02 20.10 19.24 4.93 20.52 30.53 15.03 13.93 31.83 44.72 23.77 29.07 45.62 40.61 9.51 30.36 31.95 44.28 59.41 31.38 10.05 6.40 20.52 22.83 56.04 0.17 27.86 17.26 19.21 32.02 26.40 44.00 11.31 6.40 21.59 24.52 28 30.27 16.00 36.36 11.40 6.71 20.62 24.08 19.24 42.01 41.76 3 9.12 30.23 13.45 32.57 10.20 32.57 26.17 52.43 24.17 18.44 15.26 9.07 41.05 48.10 51.66 22.83 8.54 19.72 inf 9.00 54.23 40.36 6.17 14.14 24.19 16.12 13.60 40.31 40.50 32.56 41.00 38.90 36.67 8.01 4.47 16.03 11.18 6.40 41.76 47.63 26.42 12.17 31.14 21.21 0.83 46.01												
4.93 20.52 30.53 15.03 13.93 31.83 44.72 23.77 29.07 45.62 40.61 9.51 30.36 31.95 44.28 59.41 31.38 10.05 6.40 20.52 22.83 56.04 0.17 27.86 17.26 19.21 32.02 26.40 44.00 11.31 6.40 21.59 24.52 28 30.27 16.00 36.36 11.40 6.71 20.62 24.08 19.24 42.01 41.76 3 9.12 30.23 13.45 32.57 10.20 32.57 26.17 52.43 24.17 18.44 15.26 9.07 41.05 48.10 51.66 22.83 8.54 19.72 inf 9.00 54.23 40.36 6.17 14.14 24.19 16.12 13.60 40.31 40.50 32.56 41.00 38.90 36.67 8.01 4.47 16.03 11.18 6.40 41.76 47.63 26.42 12.17 31.14 21.21 0.83 46.01	9.49	26.83	38.90	51.26	30.59	26.91	inf	19.72	12.81	60.13	39.22	1
9.51 30.36 31.95 44.28 59.41 31.38 10.05 6.40 20.52 22.83 56.04 0.17 27.86 17.26 19.21 32.02 26.40 44.00 11.31 6.40 21.59 24.52 28 30.27 16.00 36.36 11.40 6.71 20.62 24.08 19.24 42.01 41.76 3 9.12 30.23 13.45 32.57 10.20 32.57 26.17 52.43 24.17 18.44 15.26 3 9.07 41.05 48.10 51.66 22.83 8.54 19.72 inf 9.00 54.23 40.36 6.17 14.14 24.19 16.12 13.60 40.31 40.50 32.56 41.00 38.90 36.67 8.01 4.47 16.03 11.18 6.40 41.76 47.63 26.42 12.17 31.14 21.21 0.83 46.01 13.04 36.06 42.05 25.06 25.61 22.80 32.25 42.54 44.05	5.81	28.30	39.45	19.92	25.02	51.42	44.28	34.37	23.02	20.10	19.24	3
0.17 27.86 17.26 19.21 32.02 26.40 44.00 11.31 6.40 21.59 24.52 28 30.27 16.00 36.36 11.40 6.71 20.62 24.08 19.24 42.01 41.76 3 9.12 30.23 13.45 32.57 10.20 32.57 26.17 52.43 24.17 18.44 15.26 9.07 41.05 48.10 51.66 22.83 8.54 19.72 inf 9.00 54.23 40.36 6.17 14.14 24.19 16.12 13.60 40.31 40.50 32.56 41.00 38.90 36.67 8.01 4.47 16.03 11.18 6.40 41.76 47.63 26.42 12.17 31.14 21.21 0.83 46.01 13.04 36.06 42.05 25.06 25.61 22.80 32.25 42.54 44.05												5
28 30.27 16.00 36.36 11.40 6.71 20.62 24.08 19.24 42.01 41.76 3 9.12 30.23 13.45 32.57 10.20 32.57 26.17 52.43 24.17 18.44 15.26 9.07 41.05 48.10 51.66 22.83 8.54 19.72 inf 9.00 54.23 40.36 6.17 14.14 24.19 16.12 13.60 40.31 40.50 32.56 41.00 38.90 36.67 8.01 4.47 16.03 11.18 6.40 41.76 47.63 26.42 12.17 31.14 21.21 0.83 46.01 13.04 36.06 42.05 25.06 25.61 22.80 32.25 42.54 44.05												6
9.12 30.23 13.45 32.57 10.20 32.57 26.17 52.43 24.17 18.44 15.26 9.07 41.05 48.10 51.66 22.83 8.54 19.72 inf 9.00 54.23 40.36 6.17 14.14 24.19 16.12 13.60 40.31 40.50 32.56 41.00 38.90 36.67 8.01 4.47 16.03 11.18 6.40 41.76 47.63 26.42 12.17 31.14 21.21 0.83 46.01 13.04 36.06 42.05 25.06 25.61 22.80 32.25 42.54 44.05												
9.07 41.05 48.10 51.66 22.83 8.54 19.72 inf 9.00 54.23 40.36 6.17 14.14 24.19 16.12 13.60 40.31 40.50 32.56 41.00 38.90 36.67 8.01 4.47 16.03 11.18 6.40 41.76 47.63 26.42 12.17 31.14 21.21 0.83 46.01 13.04 36.06 42.05 25.06 25.61 22.80 32.25 42.54 44.05												
6.17 14.14 24.19 16.12 13.60 40.31 40.50 32.56 41.00 38.90 36.67 8.01 4.47 16.03 11.18 6.40 41.76 47.63 26.42 12.17 31.14 21.21 0.83 46.01 13.04 36.06 42.05 25.06 25.61 22.80 32.25 42.54 44.05												2
8.01 4.47 16.03 11.18 6.40 41.76 47.63 26.42 12.17 31.14 21.21 0.83 46.01 13.04 36.06 42.05 25.06 25.61 22.80 32.25 42.54 44.05												2
0.83 46.01 13.04 36.06 42.05 25.06 25.61 22.80 32.25 42.54 44.05												6
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0.80 26.25 21.02 36.36 19.10 24.17 20.59 45.34 29.07 25.94 13.04	0.80	26.25	21.02	36.36	19.10	24.17	20.59	45.34	29.07	25.94	13.04	2
1.40 32.06 39.81 46.04 20.10 14.42 12.81 9.00 inf 51.42 34.21	1.40	32.06	39.81	46.04	20.10	14.42	12.81	9.00	inf	51.42	34.21	1
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8.08 16.12 8.60 23.09 29.21 26.40 34.93 16.12 6.71 11.40 14.32												^
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6.31 36.77 43.57 74.46 76.48 76.32 16.49 52.15 56.72 40.02 37.11												

31	31.00	30.41	8.06	29.21	46.67	21.95	28.16	33.96	7.21	22.20	3
5.11	13.15	43.86	40.20	49.41	17.03	14.21	13.34	40.31	58.80	45.65	4
0.20	27.31	18.03	12.08	20.25	38.08	39.22	40.36	34.21	24.70	inf	2
4.33	30.87	33.14	53.60	53.74	28.18	10.63	8.54	37.36	39.62	34.53	
5.10	36.24	31.02	47.20	41.23	18.03	7.62	15.65	35.34	33.24	46.57	2
0.81	32.25	50.25	19.31	49.24	64.54	49.04	33.96	23.09	48.51	32.76	3
9.82	25.50	25.61	56.44	62.94	60.61	14.76	29.43	37.59	24.08	22.20	
32	8.06	10.44	16.76	19.92	30.36	8.60	31.89	33.12	30.00	39.56	4
6.23	23.77	36.50	45.61	36.35	8.60	16.55	31.91	40.71	42.72	24.08	1
6.00 inf	15.03 26.40	23.60 35.81	36.14 33.84	22.67 36.77	29.43 42.54	15.81 31.26	26.17 21.38	17.26 18.44	47.27 18.60	24.33 14.14	1
9.65	24.02	28.18	27.78	23.41	16.64	29.15	10.44	29.41	40.31	42.72	4
4.01	20.40	39.05	34.01	56.22	45.49	25.08	9.85	6.08	26.40	47.51	5
3.01	23.02	12.65	34.66		40.80	32.28	5.10	16.64	16.12	17.80	9
33	33.29	19.80	29.43	7.07	20.62	18.03	10.00	7.07	30.61	27.86	2
5.50	18.60	13.00	20.81	20.00	29.27	17.46	44.01	14.42	30.53	27.66	3
6.12	40.80	43.10	40.80	10.82	7.81	28.30	14.14	15.65	40.71	30.87	2
6.40	inf	11.18	30.27	26.93	26.17	28.28	22.36	44.42	43.60	39.96	3
0.08	10.00	2.24	25.00	19.10	38.05	38.48	21.02	4.47	17.72	17.03	5
0.00	46.49	19.85	22.36	31.24	38.63	36.77	28.28	31.62	49.50	30.00	3
2.76	5.39	13.89	36.00	35.78	36.14	25.00	28.02	22.36	10.44	10.00	
34	43.28	30.61	34.37	18.03	30.00	27.20	5.00	5.00	30.36	21.93	1
5.00	20.02	16.55	9.90	26.93	36.77	22.80	46.39	7.28	37.64	38.60	4
7.01	49.19	48.51	40.50	14.56	16.00	39.45	24.19	26.83	35.38	33.14	3
5.81 4.06	11.18 20.62	inf 8.94	40.01 35.36	35.36 29.83	17.89 44.64	26.93 40.45	25.00 28.23	54.20 12.04	53.81	49.82 15.00	3 4
9.24	55.01	25.08	18.03	29.63	44.64	47.93	39.05	40.31	60.21	20.62	2
2.09	12.81	24.04	46.27	43.42	45.18	22.36	38.21	33.54	19.85	18.03	2
35	34.18	24.08	48.10	26.57	10.05	31.89	40.20	35.01	56.44	57.72	5
5.01	45.19	26.25	47.68	16.12	42.01	39.96	64.35	38.83	12.65	10.44	2
8.16	46.62	57.43	65.46	38.28	24.02	19.92	16.12	19.42	69.89	53.60	3
3.84	30.27	40.01	inf	7.81	56.44	55.46	46.65	42.58	39.20	39.05	5
0.33	20.40	32.14	6.40	12.53	50.48	60.31	38.29	28.00	47.01	33.62	7
4.40	50.29	20.25	51.92	56.32	11.66	18.44	26.00	39.45	39.32	60.13	6
2.07	33.24	28.02	7.21	12.17	7.07	53.49	30.41	17.20	30.41	33.11	
36	38.64	26.40	49.20	25.00	7.07	33.02	36.40	30.41		54.78	5
0.25	43.83	20.10	42.05	9.22	44.29	39.62	65.44	33.06	6.08	16.12	3
4.06	50.70	59.94	65.19	36.36	19.65	25.02	13.60	20.25	67.54	53.74	3
6.77	26.93	35.36	7.81	inf	52.63	54.08	46.10	48.04	45.01	44.18	5
1.09 4.33	18.03 54.92	28.46 13.00	10.00 49.24	13.42 50.01	53.23 11.70	60.88 25.63	39.20 30.41	23.77 42.72	42.30 46.10	26.93 55.90	7 5
7.08	30.89	28.43	14.87	9.22	10.05	51.48	34.21	20.62	29.73	32.02	J
37	50.61	41.48	33.42	31.06	46.69	34.93		22.47	22.14	7.00	
8.06	19.21	34.44	17.49	44.60	39.70	26.08	39.29	23.43	55.36	53.08	5
7.01	52.35	46.14	30.07	20.88	32.98	51.42	40.31	40.20	18.87	28.18	4
2.54	26.17	17.89	56.44	52.63	inf	18.03	23.35	60.22	61.06	56.30	3
1.62	36.12	24.33	51.09	45.01	44.82	33.53	32.45	28.86	12.04	32.02	3
7.22	57.98	42.95	9.22	23.09	64.29	61.00	49.04	45.00	68.88	5.00	1
1.66	24.08	34.21	62.07	61.03	62.17	13.42		46.53	29.83	26.93	
38	38.83	34.53	17.49	29.15	47.17	26.17		29.15	4.12	11.66	2
5.50	10.30	40.61	32.14	48.17	25.63	16.28	21.38	34.18	58.41	49.04	4
7.17	37.22	28.60	13.60	17.80	36.07	44.28	40.50	36.40	16.03	10.63	3
1.26 5.00	28.28 36.06	26.93 27.66	55.46 49.24	54.08 42.95	18.03 28.43	inf 15.52	10.00	46.62 32.56	48.38 25.18	43.32 41.59	1 2
2.36	42.44	48.10	10.00	40.20	65.51	54.33	40.00	31.62	57.01	22.36	2
9.55	23.43	28.16	59.46	63.25	62.18	5.00	36.12	41.23	25.08	22.36	2
39	29.12	24.74	10.30	21.21	39.05	16.28	20.00	25.50	9.85	18.87	2
9.15	5.10	35.34	32.76	41.23	16.64	6.71	21.84	32.06	50.91	39.56	3
7.22	29.07	24.04	19.10	11.70	29.68	34.37	32.56	27.29	26.02	8.54	2
1.38	22.36	25.00	46.65	46.10	23.35	10.00	inf	37.59	39.00	34.01	
9.22	28.28	22.47	40.31	34.13	21.63	16.16	11.05	26.83	25.96	38.08	2
8.28	34.66	41.88	14.14	42.38	57.20	44.41	30.00	22.36	47.43	28.28	3
4.83	17.00	18.79	50.16	55.32	53.54	11.18		31.62	16.40	14.14	
40	11.18	25.63	29.41		43.10	27.02		51.31		56.44	6
4.44	41.05	53.14	64.03	50.49	21.02	34.21	39.12	58.83	54.08	32.25	1
4.56	11.05	26.48	47.27	41.01	46.24	23.02	41.00	32.28	61.98	37.36	1

8.44	44.42	54.20	42.58	48.04	60.22	46.62	37.59	inf	4.24	4.47	3
2.28	40.16	46.32	38.05	36.22	21.00	39.12	27.80	46.96	58.73	60.01	5
3.04	10.00	53.94	51.31	74.65	53.60	26.40	18.25	15.26	12.37	65.22	7
1.06	41.40	30.53	40.16		48.51	48.76	16.55	28.16	34.41	36.24	
41	10.63	24.19	31.58	36.62	40.45	26.91	50.21	50.61	46.32	57.70	6
4.82	42.06	51.48	63.70	48.05	22.80	34.99		58.01	51.00	29.02	1
1.05	14.56	30.08	50.04	41.23	44.72	20.10	38.90	30.46	64.03	39.62	1
8.60	43.60	53.81	39.20	45.01	61.06	48.38	39.00	4.24	inf 58.73	5.10	3 5
4.53 6.22	38.48 14.21	45.61 51.66	35.01 52.35	33.73 74.33	24.19 50.01	42.00 22.47	28.65 16.16	45.79 16.76	9.00	58.59 66.04	5 7
1.61	41.04	29.83	36.40		44.91	50.16	15.62	25.71	33.97	36.07	/
42	6.71	21.19	26.48	33.12	39.01	22.67	46.01	46.87		52.77	6
0.31	37.22	48.70	59.67	46.27	17.72	30.23		54.38	50.25	28.64	1
1.66	10.30	25.63	45.01	36.80	41.79	19.24	36.67	27.89	58.94	34.53	1
4.14	39.96	49.82	39.05	44.18	56.30	43.32	34.01	4.47	5.10	inf	2
9.43	35.74	41.88	34.23	32.06	19.42	37.01	23.85	42.49	54.45	55.54	5
1.35	11.66	49.65	47.51	70.29	50.29	23.85	14.04	11.70	14.04	61.29	6
7.01	37.01	26.08	37.16		45.22	45.19		24.02	30.00	31.89	
43	26.02	26.63	3.00	27.29	44.05	18.44		34.13	12.08	26.17	3
8.01	14.32	43.01	41.98		12.00	12.65		41.00	56.40	41.88	3
5.36	22.36	14.87	16.49		36.77	34.93	38.01	31.11	29.73	5.10 29.43	1
9.65 inf	30.08 34.13	34.06 30.59	50.33 43.93	51.09 38.18	31.62 13.45	15.00 10.00	9.22 12.04	32.28 34.48	34.53 35.17	46.53	2
4.60	27.46	48.75	22.47		61.52	44.60		18.03	43.42	36.40	4
3.27	24.74		52.70					33.84		20.62	1
44	29.12	14.56	32.65	7.07	11.18	17.46		15.81	37.64	37.36	3
5.36	25.81	13.00	29.55	13.42	29.61	22.02	48.55	21.63	22.63	18.03	2
9.41	39.05	44.92	47.38	18.36	6.40	20.52	4.47	8.06	49.77	36.24	2
4.02	10.00	20.62	20.40	18.03	36.12	36.06	28.28	40.16	38.48	35.74	3
4.13	inf	12.04	15.00	9.22	38.83	43.60	22.85	8.94	27.46	20.25	5
6.57	44.28	15.30	31.62	39.45	29.53	27.78	22.36	30.00	43.01	40.00	4
2.58	13.00	12.37	26.00	27.20	26.57	33.54	23.77	14.14	12.21	14.14	0
45	35.23	21.93	30.15	9.22	22.36	19.70	8.06	5.00	30.23	26.40	2
3.35 8.29	18.36 42.38	13.04 44.01	18.60 40.50	21.10 10.77	30.59 8.94	18.11 30.53	44.27 16.03	12.53 17.89	31.76 39.45	29.83 31.02	3 2
8.18	2.24	8.94	32.14	28.46	24.33	27.66	22.47	46.32	45.61	41.88	3
0.59	12.04	inf	27.02	21.21	39.20	38.63	22.20	5.00	15.52	16.03	4
9.65	48.10	20.52	21.10	29.07		39.00	30.41		51.62	28.02	3
0.59	6.00	15.81	38.01	37.16	37.85	24.08	30.00		12.08	11.18	
46	28.86	17.80	41.73	20.62	7.07	25.50	35.00	30.41	50.12	51.97	5
0.25	39.00	23.32	43.68	15.00	35.81	33.62	57.98	35.11		6.32	2
4.08	41.11	51.31	59.08	32.28	19.65	15.03	11.18	13.04	63.89	47.20	2
7.78	25.00	35.36	6.40	10.00	51.09	49.24	40.31	38.05	35.01	34.23	4
3.93	15.00	27.02	inf	6.32	44.42	53.91	31.89	23.35	42.30	31.06	6
8.01 7.43	45.12 27.46	19.21	46.10	52.92	17.80	16.64	20.62 24.70	33.54 11.18	36.40	55.00	5
47	26.02	21.63 13.00	11.00 36.12	17.46 14.32	13.45 7.07	47.43 19.85	29.07	25.00	24.17 43.91	26.93 45.71	4
4.55	32.70	19.80	38.63	14.32	30.89	27.46	52.40	30.41	19.31	8.94	2
3.41	37.66	46.53	53.01	25.96	14.76	13.93	6.40	7.07	57.57	41.23	2
3.41	19.10	29.83	12.53	13.42	45.01	42.95	34.13	36.22	33.73	32.06	3
8.18	9.22	21.21	6.32	inf	39.81	48.10	26.17	18.03	36.67	27.59	6
2.01	42.19	18.03	39.81	48.30	23.35	19.21	18.03	29.41	36.67	49.04	5
1.79	21.21	15.62	17.12	22.20	19.42	41.11	21.21	8.06	17.89	20.62	
48	18.87	26.83	11.40	33.14	46.62	21.38	39.85	43.57	25.24	39.60	5
0.77	26.42	50.09	53.49	51.92	9.22	21.84	18.25	50.99	59.09	40.61	2
8.65	10.05	7.07	26.48	30.08	43.19	31.83	41.76	33.24	42.49	18.03	1
6.64 3.45	38.05 38.83	44.64 39.20	50.48	53.23 39.81	44.82 inf	28.43 18.25	21.63 17.03	21.00 42.00	24.19 47.01	19.42 55.08	1
2.06	14.32	54.13	35.61	63.56	62.13	40.00	25.46	11.31	33.14	49.68	<i>5</i>
6.40	33.24	26.48	50.99	61.77	57.43	31.83	20.52	33.29	28.02	28.07	J
49	34.71	36.62	12.53	36.62	53.81	28.43	35.51	41.48	11.40	26.93	4
1.00	20.62	51.48	47.01	56.86	20.88	21.63	6.00	47.68	66.07	51.87	4
4.38	28.28	15.26	8.25	27.86	45.65	44.72	47.63	41.04	25.61	7.62	2
9.15	38.48	40.45	60.31	60.88	33.53	15.52	16.16	39.12	42.00	37.01	1
0.00	43.60	38.63	53.91	48.10	18.25	inf	22.02	42.95	40.01	54.12	1
4.87	32.28	57.80	25.32	55.58	71.45	54.23	39.00	26.48	51.00	37.70	4

4.94	33.11	32.53	62.68	70.04	67.36	20.40	34.18	43.83	31.40	29.68	
50	18.38	14.76	10.00		32.20	6.40	23.71		20.22	29.15	3
6.77	13.42	33.24	37.59	36.25	8.54	6.40	26.25	34.21	44.65	30.02	2
6.17	21.10	22.36	27.73	13.89	26.48		26.42	19.10	37.05	15.65	1
0.44	21.02	28.23	38.29	39.20	32.45	21.02	11.05	27.80	28.65	23.85	1
2.04	22.85	22.20	31.89	26.17	17.03	22.02	inf	25.02	31.62	38.05	3
6.36	26.93	37.95	23.71	48.02	49.50	33.73	19.03	12.73	36.77	37.44	4
3.28	16.28	10.82	40.82	48.27	45.34	21.84	15.13	21.95	11.18	11.05	
51	35.78	21.63	33.73	9.49	18.03	21.38	12.65	7.07	35.00	31.30	2
7.02	23.02	8.54	20.62	16.12	33.06	21.84	48.47	12.81	26.83	26.93	3
7.54	44.15	47.27	45.22	15.26	4.12	29.07	12.17	16.28	44.42	35.34	2
9.41	4.47	12.04	28.00	23.77	28.86	32.56	26.83	46.96	45.79	42.49	3
4.48	8.94	5.00	23.35	18.03	42.00	42.95	25.02	inf	19.03	13.34	5
4.41	49.73	15.56	26.08		35.44	36.72	30.00	34.93	51.09	32.25	3
4.13	9.85	16.76	34.23		33.38	29.07		22.80		14.14	
52	48.10	36.36	36.06		37.00	31.83	8.60	12.00		17.49	
8.00	20.88	23.09	7.00	33.73	39.96	25.55	46.01	11.40	44.38	45.35	5
2.70	52.70	50.00	38.64		23.00	45.62	31.14	33.24		33.24	4
0.31	17.72	7.00	47.01		12.04	25.18	25.96		58.73	54.45	3
5.17	27.46	15.52	42.30		47.01	40.01	31.62	19.03	inf	20.00	4
6.84	58.52	31.62	15.30		53.76	54.42	44.65	44.20	65.60	13.93	1
5.13	18.03	29.41	53.24		52.15		43.28	39.92	25.00	22.67	_
53	48.85	34.44	46.17		24.19		19.24	12.65		36.80	2
6.83	33.53	7.81	16.76		46.27		59.91	8.60	27.02	36.24	4
9.65	57.49	60.03	55.04		13.89	40.61	21.21	28.30	50.21	46.57	4
2.72	17.03	15.00	33.62		32.02	41.59	38.08	60.01	58.59	55.54	4
6.53	20.25	16.03	31.06		55.08	54.12	38.05	13.34	20.00	inf	6 3
3.95 2.57	63.06 22.02	14.14 30.08	33.02 40.72		37.12	46.75	42.54	48.27	63.25 27.29	33.62 27.02	3
54	49.48	51.11	27.31		36.88 67.27		43.46 44.72		19.42	30.27	4
5.28	31.40	62.68	53.60	69.43	35.74				79.20	66.37	5
9.20	42.01	27.17	9.22		57.63		60.83	55.00	21.84	20.81	4
4.01	50.00	49.24	74.40	74.33	37.03	22.36	28.28	53.04	56.22	51.35	2
4.60	56.57	49.65	68.01		32.06		36.36		46.84	63.95	2
inf	45.18	69.81	31.62		85.28	69.08	53.85	41.23	65.19	40.00	4
7.04			77.18		81.40		49.04			42.43	1
		30.02	25.00	40.26				52.92			6
3.25	38.95	56.89	64.50	56.01	18.60	33.02	31.14	60.54	61.00	39.85	2
3.32	5.83	18.03	40.52	40.82	49.82	30.36	46.01	37.01	56.80	32.25	2
0.40	46.49	55.01	50.29	54.92	57.98	42.44	34.66	10.00	14.21	11.66	2
7.46	44.28	48.10	45.12	42.19	14.32	32.28	26.93	49.73	58.52	63.06	4
5.18	inf	59.03	48.80	74.95	61.68	35.51	24.52	14.87	21.93	62.94	6
9.35	42.54	32.98	48.75	62.36	56.65	45.45	21.02	34.37	36.06	37.16	
56	43.29	29.02	47.54	21.54	12.21	32.76	27.46	20.59	50.45	46.32	3
9.29	38.42	8.54	30.15	4.24	44.91	36.24	63.06	21.21	13.04	25.24	4
1.44	54.01	60.17	60.61	30.61	12.21	31.95	13.04	22.02	59.64	50.25	3
9.05	19.85	25.08	20.25	13.00	42.95	48.10	41.88	53.94	51.66	49.65	4
8.75	15.30	20.52	19.21	18.03	54.13	57.80	37.95	15.56	31.62	14.14	6
9.81	59.03	inf	41.40	37.34	23.02	35.81	35.69	45.10	54.63	45.54	4
5.71	25.00	27.66	27.46	19.03	22.80	44.60	38.12	25.96	26.93	28.18	
57	42.05	34.23	24.21		42.72	26.93	14.14	21.21	14.04	6.00	1
5.81	10.30	33.30	22.20	42.19	30.61	17.46	31.26	25.06	52.84	47.17	4
9.04	43.19	37.12	23.35	14.04	30.02	44.28	36.06	34.13	18.36	19.31	3
4.01	22.36	18.03	51.92	49.24	9.22	10.00	14.14	51.31	52.35	47.51	2
2.47	31.62	21.10	46.10	39.81	35.61	25.32	23.71	26.08	15.30	33.02	3
1.62	48.80	41.40	inf	30.27	60.93	54.15	41.23	36.06	60.42	14.14	2
0.81 58	18.68 63.78	27.07 50.99	56.89 52.55	58.14 38.29	58.19 46.49	5.00 47.63	38.28 24.41	40.00	23.00 44.28	20.00	1
5.03	37.34	30.08	10.63	40.79	56.44	47.63	61.52	17.89	50.16	57.25	
7.36	69.12	66.41	53.00	34.13	33.54	59.41	42.05	46.62	40.80	49.24	6 5
6.22	31.24	20.52	56.32	50.01	23.09	40.20	42.03	74.65	74.33	70.29	5
1.55	39.45	29.07	52.92	48.30	63.56	55.58	48.02	30.53	16.55	23.19	6
0.30	74.95	37.34	30.27	inf	60.30	67.23	59.46	60.46	80.66	20.88	1
5.26	33.30	44.55	63.25	56.14	60.02	35.23	58.73	53.25	40.36	38.42	_
59	45.69	35.61	59.41		18.36	43.14	48.08	41.98	66.85	66.48	6
1.66	55.23	31.06	53.04	20.10	53.60	50.61	75.69	44.05	10.20	21.93	3
	-		-	-		-			-		

9.05	58.18	69.07	76.22	47.89	31.32	31.38	25.06	30.41	79.20	64.54	4
5.49	38.63	46.87	11.66	11.70	64.29	65.51	57.20	53.60	50.01	50.29	6
1.52	29.53	40.16	17.80	23.35	62.13	71.45	49.50	35.44	53.76	37.12	8
5.28	61.68	23.02	60.93	60.30	inf	28.07	37.58	51.11	49.01	67.47	6
8.36	42.49	38.95	14.00	4.47	5.10	63.06	42.06	28.84	40.80	43.27	
60	21.26	20.00	41.79	30.36	23.60	28.16	46.17	43.38	53.94	60.13	6
1.98	45.01	38.95	57.25	31.62	33.54	38.12	56.82	49.40	31.05	10.63	1
2.21	33.30	47.01	61.03	40.31	33.84	10.05	25.61	21.19	70.18	49.04	2
5.08	36.77	47.93	18.44	25.63	61.00	54.33	44.41	26.40	22.47	23.85	4
4.60 9.08	27.78	39.00 35.81	16.64 54.15	19.21 67.23	40.00	54.23	33.73 15.23	36.72 28.84	54.42 21.02	46.75 65.51	6 6
9.06	35.51 37.11	27.07	14.14	30.07	23.02	inf 54.01	20.12	14.56	31.26	34.23	О
61	8.25	8.49	26.57	21.21	25.02	14.32	36.06	35.36	39.20	47.07	5
1.48	31.40	35.34	48.92	32.25	18.36	24.19	41.68	42.52	36.50	15.65	9
8.06	20.62	32.53	45.88	28.23	28.65	6.40	22.80	14.32	56.01	33.96	
9.85	28.28	39.05	26.00	30.41	49.04	40.00	30.00	18.25	16.16	14.04	2
9.41	22.36	30.41	20.62	18.03	25.46	39.00	19.03	30.00	44.65	42.54	5
3.85	24.52	35.69	41.23	59.46	37.58	15.23	inf	14.14	21.21	53.85	5
8.59	26.63	15.26	25.61	37.95	32.65	40.31	5.00	10.00	19.72	22.36	
62	8.25	16.49	15.03	25.50	36.40	13.60	36.06	38.08	29.61	41.18	4
9.50	25.81	42.30	49.93	42.43	6.08	19.10	28.23	45.69	48.70	29.41	1
8.03	9.22	18.38	34.13	26.40	35.23	20.52	32.25	23.35	47.30	23.09	
6.08	31.62	40.31	39.45	42.72	45.00	31.62	22.36	15.26	16.76	11.70	1
8.03	30.00	33.24	33.54	29.41	11.31	26.48	12.73	34.93	44.20	48.27	4
1.23 5.97	14.87 27.73	45.10 18.25	36.06 39.70	60.46 50.99	51.11 46.32	28.84 33.54	14.14 9.22	inf 22.36	25.50 21.19	50.00	5
63	18.38	29.70	40.45	42.43	40.32	34.13	57.01	56.57	55.11	65.92	7
2.11	50.16	55.76	70.09	50.70	31.58	42.95	51.35	63.70	51.79	30.08	1
3.60	23.35	38.83	59.03	48.55	49.41	22.83	42.54	35.00	72.78	48.51	2
6.40	49.50	60.21	39.32	46.10	68.88	57.01	47.43	12.37	9.00	14.04	4
3.42	43.01	51.62	36.40	36.67	33.14	51.00	36.77	51.09	65.60	63.25	6
5.19	21.93	54.63	60.42	80.66	49.01	21.02	21.21	25.50	inf	73.82	7
9.08	47.63	36.24	35.01	51.09	44.00	58.52	22.47	29.15	40.61	43.01	
64	55.57	46.17	38.29	35.36	50.25	39.81	20.00	25.50	26.40	10.77	
7.07	24.21	37.00	17.69	47.54	44.69	31.06	43.32	25.06	58.24	57.31	6
1.85	57.31	50.77	33.54	25.63	36.35	56.04	44.05	44.55	19.92	32.76	4
7.51	30.00	20.62	60.13	55.90	5.00	22.36	28.28	65.22	66.04	61.29	3
6.40	40.00		55.00		49.68		37.44		13.93	33.62	4
0.00	62.94	45.54	14.14	20.88	67.47 65.62	65.51	53.85 51.43	50.00	73.82	inf	
7.28 65	28.44 61.03	38.90 50.57	66.00 45.00	38.90	52.04	18.03 44.94	23.09	50.99 27.07	34.48 33.62	31.62 18.03	
7.28	30.41	37.34	15.81	48.26	50.91	36.88	50.60	24.52	58.69	60.42	6
6.65	63.66	57.80	40.79	30.53	38.05	60.17	46.27	48.08	26.31	39.82	5
3.01	32.76	22.09	62.07	57.08	11.66	29.55	34.83	71.06	71.61	67.01	4
3.27	42.58	30.59	57.43	51.79	56.40	44.94	43.28	34.13	15.13	32.57	4
7.04	69.35	45.71	20.81	15.26	68.36	69.26	58.59	55.97	79.08	7.28	
inf	32.31	43.38	68.36	64.63	67.03	25.06	56.60	54.71	38.91	36.24	
66	30.48	18.36	24.19	7.00	24.17	14.42	9.43	10.44	25.50	24.52	2
5.08	13.45	18.38	22.67	24.76	24.74	12.17	38.63	18.03	35.00	29.02	3
4.67	36.77	38.01	35.61	5.66	12.81	27.86	17.46	16.12	36.77	25.50	2
3.02	5.39	12.81	33.24	30.89	24.08	23.43	17.00	41.40	41.04	37.01	2
4.74	13.00	6.00	27.46	21.21	33.24	33.11	16.28	9.85	18.03	22.02	4
4.82 2.31	42.54 inf	25.00 11.40	18.68 38.33	33.30 39.96	42.49 39.56	37.11 20.59	26.63 25.46	27.73 22.56	47.63 7.07	28.44 5.39	3
67	19.42	7.28	20.81	7.28	21.40	5.10	20.81	20.81	28.64	33.06	3
6.24	18.25	24.08	33.94	25.63	17.26	12.08	37.01	28.30	33.84	20.88	2
3.32	27.46	32.57	37.44	13.34	17.03	17.26	15.65	8.60	43.57	25.61	1
2.65	13.89	24.04	28.02	28.43	34.21	28.16	18.79	30.53	29.83	26.08	2
2.67	12.37	15.81	21.63	15.62	26.48	32.53	10.82	16.76	29.41	30.08	4
6.40	32.98	27.66	27.07	44.55	38.95	27.07	15.26	18.25	36.24	38.90	4
3.38	11.40	inf	31.38	37.54	35.00	27.17	14.21	13.15	4.47	7.28	
68	33.29	26.08	50.22	31.40	16.76	34.48	46.00	41.30	60.01	62.80	6
1.20	49.34	33.24	54.34	23.32	43.19	43.46	66.22	45.61	18.87	10.82	2
5.63	45.79	58.05	68.48	42.95	30.41	19.21	22.09	23.09	74.46	56.44	3
4.66	36.00	46.27	7.21	14.87	62.07	59.46	50.16	40.16	36.40	37.16	5
2.70	26.00	38.01	11.00	17.12	50.99	62.68	40.82	34.23	53.24	40.72	7

7.18	48.75	27.46	56.89	63.25	14.00	14.14	25.61	39.70	35.01	66.00	6
8.36	38.33	31.38	inf	16.49	9.06	57.97	30.48	18.87	34.48	37.36	
69	46.17	34.99	58.26	34.21	16.28	42.01	44.94	38.60	64.82	63.56	5
8.05	53.01	27.29	49.16	16.49	53.00	48.84	74.52	40.20	6.00	22.56	4
0.31	58.52	68.60	74.41	45.49	28.23	32.02	22.80	29.21	76.48	62.94	4
5.18	35.78	43.42	12.17	9.22	61.03	63.25	55.32	54.74	51.35	51.20	6
0.21	27.20	37.16	17.46	22.20	61.77	70.04	48.27	32.31	50.22	33.02	8
3.55	62.36	19.03	58.14	56.14	4.47	30.07	37.95	50.99	51.09	64.03	6
4.63	39.96	37.54	16.49	inf	7.62	60.54	42.15	28.64	38.95	41.23	
70	40.72	31.14	55.17	33.11	15.52	38.95	45.89	40.20	63.29	63.89	6
0.13	51.88	30.15	52.09	19.24	49.04	46.87	71.42	43.10	11.40	17.00	3
3.96	53.23	64.40	72.42	44.78	29.27	26.40	22.14	26.40	76.32	60.61	4
0.80	36.14	45.18	7.07	10.05	62.17	62.18	53.54	48.51	44.91	45.22	5
7.38	26.57	37.85	13.45	19.42	57.43	67.36	45.34	33.38	52.15	36.88	8
1.40	56.65	22.80	58.19	60.02	5.10	23.02	32.65	46.32	44.00	65.62	6
7.03	39.56	35.00	9.06	7.62	inf	60.01	37.22	24.21	37.22	39.82	
71	40.16	34.01	20.52	26.93	44.72	26.08	18.03	25.00	9.06	7.81	2
0.62	9.00	36.80	27.17	45.00	27.78	16.12	26.31	29.55	55.47	47.85	4
7.85	40.00	32.76	18.44	15.23	32.80	44.00	38.01	34.93	16.49	14.76	3
2.28	25.00	22.36	53.49	51.48	13.42	5.00	11.18	48.76	50.16	45.19	1
8.44	33.54	24.08	47.43	41.11	31.83	20.40	21.84	29.07	20.22	37.22	2
6.93	45.45	44.60	5.00	35.23	63.06	54.01	40.31	33.54	58.52	18.03	2
5.06	20.59	27.17	57.97	60.54	60.01	inf	36.88	40.31	23.54	20.62	
72	5.39	9.22	21.84	21.10	28.28	11.66	34.71	35.00	35.01	43.97	4
9.65	28.16	36.69	48.10	35.00	13.42	20.88	36.72	42.44	40.26	20.25	1
1.05	16.49	27.59	41.23	26.08	29.73	11.31	25.08	16.12	52.15	29.43	
5.10	28.02	38.21	30.41	34.21	46.52	36.12	26.17	16.55	15.62	12.08	2
4.74	23.77	30.00	24.70	21.21	20.52	34.18	15.13	30.41	43.28	43.46	4
9.04	21.02	38.12	38.28	58.73	42.06	20.12	5.00	9.22	22.47	51.43	5
6.60	25.46	14.21	30.48	42.15	37.22	36.88	inf	13.60	18.38	20.62	
73	18.11	7.21	31.40	15.81	15.00	15.65	31.62	29.15	41.44	46.00	4
7.43	31.40	26.63	43.05	22.36	24.84	25.00	47.51	35.61	26.68	8.06	1
5.65	30.08	40.22	49.65	26.02	20.52	6.40	13.42	6.71	56.72	37.59	1
6.64	22.36	33.54	17.20	20.62	46.53	41.23	31.62	28.16	25.71	24.02	3
3.84	14.14	24.60	11.18	8.06	33.29	43.83	21.95	22.80	39.92	34.21	5 5
8.31	34.37	25.96	40.00	53.25	28.84	14.56	10.00	22.36	29.15	50.99	5
4.71	22.56	13.15	18.87	28.64	24.21	40.31	13.60	inf	17.00	20.00	2
74	23.43	11.70	20.62	5.39	22.67	7.62	16.40	17.00	26.08	29.00	3
1.76	14.87	22.09	29.73	25.55	19.03	9.90	36.36	24.60	34.71	24.33	2
7.78 6.12	30.36	33.54 19.85	35.47 30.41	9.06	15.30 29.83	21.59 25.08	16.28 16.40	11.40	40.02 33.97	30.00	1
1.95	10.44 12.21	12.08	24.17	29.73	28.02	31.40	11.18	34.41 14.04	25.00	27.29	2
				17.89 40.36		31.40	19.72	21.19	40.61		4
4.60 8.91	36.06 7.07	26.93 4.47	23.00 34.48	38.95	40.80 37.22	23.54	18.38	17.00	inf	34.48	J
75	25.46	14.56	19.65	7.07	25.00	9.22	14.14	15.81	23.60	26.00	2
9.15	12.08	22.56	27.80	27.20	19.42	8.06	34.89	23.41	36.77	27.29	3
0.41	31.38	33.14	33.24	6.08	16.16	24.52	18.44	14.32	37.11	22.20	1
7.80	10.00	18.03	33.11	32.02	26.93	22.36	14.14	36.24	36.07	31.89	2
0.62	14.14	11.18	26.93	20.62	28.07	29.68	11.05	14.14	22.67	27.02	4
2.43	37.16	28.18	20.00	38.42	43.27	34.23	22.36	22.36	43.01	31.62	3
6.24	5.39	7.28	37.36	41.23	39.82	20.62		20.00	3.00	inf	J
				(73, 29)							1).
				(7, 34),							
				, (72, 3							
				75), (75							
), (37,							
				56), (56							
				46), (46							
				41), (4							
				24, 54),				·	•		
	Path len										

```
def euclidean distance(coord1, coord2):
    return np.sqrt((coord2[0] - coord1[0])**2 + (coord2[1] - coord1[1])**2)
def read coordinates from file(file path):
   coordinates = []
   with open(file path, 'r') as file:
        for line in file:
            new line = re.split(r' \s+', line.strip())
            if new line[0].isdigit():
                id, x, y = new line[0], float(new line[1]), float(new line[2])
                coordinates.append((x, y))
    return coordinates
# Specify the path to the file containing coordinates
#file path = "burma14.tsp"
#file path = "eil51.tsp"
#file path = "berlin52.tsp"
file path = "eil76.tsp"
#file path = "lin105.tsp"
#file path = "bier127.tsp"
#file path = "gr137.tsp"
#file path = "rat195.tsp"
#file path = "lin318.tsp"
#file path = "rat575.tsp"
# Read coordinates from the file
coordinates = read coordinates from file(file path)
# Create a distance matrix using NumPy array
num points = len(coordinates)
distance matrix = np.zeros((num points, num points))
for i in range(num points):
    for j in range(num points):
       if i != j:
            distance matrix[i, j] = euclidean distance(coordinates[i], coordinates[j])
        else:
            distance matrix[i, j] = np.inf
# Replace inf values with np.inf
distance matrix = np.where(np.isinf(distance matrix), np.inf, distance matrix)
# Round the values in the distance array to 2 decimal places
distances = np.round(distance matrix, 2)
print("Distance Matrix:")
# Print column indices
print(" ", end="")
for i in range(num points):
   print(f" {i:<6}", end="")</pre>
print()
# Print the matrix with row indices
for i in range(num points):
   print(f"{i:2} | ", end="")
   for value in distances[i]:
       print(f"{value:7.2f}", end=" ")
    print()
# Run ACOGA with 30 different random seeds
for run in range(30):
   # Set a different random seed for each run
   random seed = run + 1
   np.random.seed(random seed)
```

```
# ACOGA implementation using the read coordinates.
aco_ga = ACOGA(distances, n_ants=5, decay=0.95, alpha=1, beta=2, ga_population_size=
result = aco_ga.run()

best_path_indices = result[0]

print(f"\nRun {run + 1} - Best Path Indices: {best_path_indices}")
print(f"Run {run + 1} - Best Path Length: {np.round(result[1], 2)}")
```

F	orint(f"F	Run {run	+ 1} - E	Best Path	Length:	{np.rou	ınd(resul	t[1], 2)	} ")		
Dista	ınce Matr	ix:									
	0	1	2	3	4	5	6	7	8	9	
10	11	12	13	14	15	16	17	18	19	20	
21	22	23	24	25	26	27	28	29	30	31	
32	33	34	35	36	37	38	39	40	41	42	
43		45	46	47	48	49	50	51	52	53	
54	55	56	57	58	59	60	61	62	63	64	
65			68	69		71	72	73	74	75	
0		14.56	23.02		33.06	16.28		40.22		47.54	5
4.20	31.78	42.06	53.15		14.04	24.60		47.71	44.72	23.77	J
9.85	12.53	25.81	42.30	30.61	35.11	14.32	30.27		54.74	31.00	
8.06	33.29	43.28	34.18	38.64		38.83	29.12		10.63	6.71	2
6.02	29.12	35.23	28.86	26.02	18.87	34.71	18.38		48.10	48.85	4
9.48	16.28	43.29	42.05	63.78	45.69	21.26		8.25	18.38	55.57	6
1.03	30.48	19.42	33.29	46.17		40.16	5.39		23.43	25.46	O
1	14.56	inf	24.21		19.92					40.20	4
3.38	25.02	27.51	40.46		18.03	18.25	40.36				1
6.40	25.02	33.62	42.49	20.62	20.62	10.05		7.00	50.25	30.41	1
0.44	19.80	30.61	24.08	26.40					24.19		2
6.63	14.56	21.93	17.80	13.00		36.62	14.76		36.36		
1.11	30.02	29.02	34.23	50.99		20.00	8.49		29.70	46.17	
0.57		7.28	26.08	34.99		34.01		7.21	11.70	14.56	J
2	23.02	24.21		26.00		16.28			14.87	28.32	3
9.45	15.23	42.20	42.72	46.07		12.04			54.64	39.41	3
2.39	19.72	14.14	19.42	20.02	35.74	32.20	36.36			8.06	1
6.76	29.43	34.37	48.10	49.20		17.49			31.58	26.48	_
3.00	32.65	30.15	41.73	36.12		12.53			36.06	46.17	2
7.31	25.00	47.54	24.21	52.55	59.41	41.79	26.57		40.45	38.29	4
5.00	24.19	20.81	50.22	58.26		20.52	21.84		20.62	19.65	7
3	26.42	12.73			18.03	12.04		14.14		31.40	3
1.62	18.87	17.00	27.80			15.00		21.40	29.70	22.02	2
9.07	34.71	38.83	40.31	11.70		21.47		9.22		29.21	1
9.92	7.07	18.03	26.57	25.00	31.06	29.15	21.21		36.62	33.12	2
7.29	7.07	9.22	20.62	14.32	33.14	36.62		9.49			4
9.50	40.26	21.54	25.50	38.29		30.36	21.21		42.43	35.36	3
8.90	7.00	7.28	31.40	34.21	33.11	26.93	21.10	15.81	5.39	7.07	J
4			42.20					25.00		48.38	4
5.00	36.89	16.55	37.66	8.06	37.58	32.56	58.41	28.86	12.53	13.04	2
9.83	44.72	53.23	58.14	29.53	14.00	20.40	6.71	13.42	60.93	46.67	3
0.36	20.62	30.00	10.05	7.07	46.69	47.17	39.05	43.10	40.45	39.01	4
4.05	11.18	22.36	7.07	7.07	46.62	53.81	32.20	18.03	37.00	24.19	6
7.27	49.25	12.21	42.72	46.49	18.36	23.60	25.00	36.40	42.72	50.25	5
2.04	24.17	21.40	16.76	16.28	15.52	44.72	28.28	15.00	22.67	25.00	9
5	16.28	8.54	16.28	12.04	26.08	inf	23.35	24.60	25.96	32.76	3
8.01	17.12	29.02	37.01	30.68	12.17	10.00	32.56	32.20	38.59	23.71	2
2.14	22.80	27.51	34.00	14.42	22.00	18.11	20.62	12.81	42.05	21.95	_
8.60	18.03	27.20	31.89	33.02	34.93	26.17	16.28	27.02	26.91	22.67	1
8.44	17.46	19.70	25.50	19.85	21.38	28.43	6.40	21.38	31.83	34.71	4
2.72	28.46	32.76	26.93	47.63	43.14	28.16	14.32	13.60	34.13	39.81	4
4.94	14.42	5.10	34.48	42.01	38.95	26.08	11.66	15.65	7.62	9.22	7
6	39.60	27.78	29.43	15.81	30.41	23.35	inf	7.07	25.63	18.87	1
5.81	15.03	19.21	13.89	28.64	32.20	18.03	41.44	12.17	39.40	37.48	4
4.10	44.78	43.57	35.85	9.85	16.76	37.16	24.08	25.00	32.20	28.16	3
1.89	10.00	5.00	40.20	36.40	16.28	22.36	20.00	50.33	50.21	46.01	2
9.07	20.00	8.06	35.00	29.07	39.85	35.51	23.71	12.65	8.60	19.24	4
4.72	50.61	27.46	14.14	24.41	48.08	46.17	36.06	36.06	57.01	20.00	2
3.09	9.43	20.81	46.00	44.94	45.89	18.03	34.71	31.62	16.40	14.14	_
5.09	9.43	20.01	40.00	44.34	40.03	10.03	04./I	21.02	10.40	T4.T4	

7	40.22	26.87	34.00	14.14	25.00	24.60	7.07	inf	32.20	25.81	2
0.00	20.88	12.21	13.89	22.14	35.17	22.02	47.30	7.62	32.89	33.84	4
3.19	47.17	48.04	42.49	14.04	11.00	35.23	19.24	22.47	39.20	33.96	3
3.12	7.07	5.00	35.01	30.41	22.47	29.15	25.50	51.31	50.61	46.87	3
4.13	15.81	5.00	30.41	25.00	43.57	41.48	26.68	7.07	12.00	12.65	5
1.48	52.92	20.59	21.21	24.21	41.98	43.38	35.36	38.08	56.57	25.50	2
7.07	10.44	20.81	41.30	38.60	40.20	25.00	35.00	29.15	17.00	15.81	
8	37.22	34.48	14.87	30.61	48.60	25.96	25.63	32.20	inf	15.65	2
9.61	12.04	43.27	36.06	50.21	23.54	16.55	17.26	37.64	60.21	49.40	4
6.00 0.00	34.44 30.61	24.84	10.30 56.44	19.85 55.61	38.29 22.14	43.93 4.12	42.01 9.85	37.12 44.27	17.72 46.32	7.21 41.23	3 1
2.08	37.64	30.36	50.12	43.91	25.24	11.40	20.22	35.00	29.07	41.23	1
9.42	39.45	50.45	14.04	44.28	66.85	53.94	39.20	29.61	55.11	26.40	3
3.62	25.50	28.64	60.01	64.82	63.29	9.06	35.20	41.44	26.08	23.60	J
9	47.54	40.20	28.32	31.40	48.38	32.76	18.87	25.81	15.65	inf	1
5.03	15.81	38.01	23.77	47.41	35.51	23.09	32.57	28.43	58.14	53.15	5
4.82	47.80	40.22	23.09	20.02	35.34	50.25	41.76	40.11	13.45	22.20	3
9.56	27.86	21.93	57.72	54.78	7.00	11.66	18.87	56.44	57.70	52.77	2
6.17	37.36	26.40	51.97	45.71	39.60	26.93	29.15	31.30	17.49	36.80	3
0.27	53.26	46.32	6.00	30.07	66.48	60.13	47.07	41.18	65.92	10.77	1
8.03	24.52	33.06	62.80		63.89	7.81	43.97	46.00	29.00	26.00	
10	54.20	43.38	39.45	31.62	45.00	38.01	15.81	20.00	29.61	15.03	
inf	24.41	30.81	10.63	41.59	44.69	30.41	46.87	18.38	52.17	53.15	5
9.54	57.49	52.80	38.01	23.60	31.00	52.92	39.12	40.80	26.40	35.11	4
6.23	25.50	15.00	55.01	50.25	8.06	25.50	29.15	64.44	64.82	60.31	3
8.01	35.36	23.35	50.25	44.55	50.77	41.00	36.77	27.02	8.00	26.83	4
5.28	63.25	39.29	15.81	15.03	61.66	61.98	51.48	49.50	72.11	7.07	
7.28	25.08	36.24	61.20	58.05	60.13	20.62		47.43	31.76	29.15	0
11	31.78	25.02	15.23	18.87	36.89	17.12	15.03	20.88	12.04	15.81	2
4.41 9.05	inf 33.24	31.38 29.12	27.66 22.20	38.18 7.81	20.52 26.25	7.28 35.00	26.48 30.23	27.17 26.25	48.27 25.32	39.05 13.15	3 2
3.77	18.60	20.02	45.19	43.83	19.21	10.30	5.10	41.05	42.06	37.22	1
4.32	25.81	18.36	39.00	32.70	26.42	20.62	13.42	23.02	20.88	33.53	3
1.40	38.95	38.42	10.30	37.34	55.23	45.01	31.40	25.81	50.16	24.21	3
0.41	13.45	18.25	49.34	53.01	51.88	9.00	28.16	31.40	14.87	12.08	0
12	42.06	27.51	42.20	17.00	16.55	29.02	19.21	12.21	43.27	38.01	3
0.81	31.38	inf	22.00	11.00	41.01	30.36	57.01	13.00	21.38	28.43	4
2.19	51.48	55.58	53.54	23.71	7.07	33.02	13.45	21.02	51.40	43.86	3
6.50	13.00	16.55	26.25	20.10	34.44	40.61	35.34	53.14	51.48	48.70	4
3.01	13.00	13.04	23.32	19.80	50.09	51.48	33.24	8.54	23.09	7.81	6
2.68	56.89	8.54	33.30	30.08	31.06	38.95	35.34	42.30	55.76	37.00	3
7.34	18.38	24.08	33.24	27.29	30.15	36.80	36.69	26.63	22.09	22.56	
13	53.15	40.46	42.72		37.66	37.01	13.89	13.89	36.06	23.77	1
0.63	27.66	22.00	inf	33.00	46.07	31.78	53.01	9.00	43.19	47.54	5
6.85	58.67	56.75	45.54	23.71	24.04	49.09		36.36	36.36	40.20	4
5.61	20.81	9.90	47.68	42.05	17.49	32.14	32.76	64.03	63.70	59.67	4
1.98	29.55	18.60	43.68	38.63	53.49	47.01	37.59	20.62	7.00	16.76	5
3.60	64.50	30.15	22.20	10.63	53.04	57.25	48.92	49.93	70.09	17.69	1
5.81 14	22.67 40.05	33.94 26.08	54.34 46.07	49.16 20.25	52.09 8.06	27.17 30.68	48.10 28.64	43.05 22.14	29.73 50.21	27.80 47.41	4
1.59	38.18	11.00	33.00	inf	42.72	35.23	61.91	24.00	10.77	21.10	3
7.64	51.16	58.19	60.21	30.41	12.21	28.16	10.20	19.10	60.54	49.41	3
6.35	20.00	26.93	16.12	9.22	44.60	48.17	41.23	50.49	48.05	46.27	4
7.51	13.42	21.10	15.00	14.32	51.92	56.86	36.25	16.12	33.73	17.72	6
9.43	56.01	4.24	42.19	40.79	20.10	31.62	32.25	42.43	50.70	47.54	4
8.26	24.76	25.63	23.32	16.49	19.24	45.00	35.00	22.36	25.55	27.20	
15	14.04	18.03	9.00	24.02	37.58	12.17		35.17		35.51	4
4.69	20.52	41.01	46.07	42.72	inf	14.42	23.32	42.72	50.09	32.53	2
3.54	12.81	15.65	28.28	22.36	34.06	24.41	32.57	24.17	41.23	17.03	
8.60	29.27	36.77	42.01	44.29	39.70	25.63	16.64	21.02	22.80	17.72	1
2.00	29.61	30.59	35.81	30.89	9.22	20.88	8.54	33.06	39.96	46.27	3
5.74	18.60	44.91	30.61	56.44	53.60	33.54		6.08	31.58	44.69	5
0.91	24.74	17.26	43.19		49.04	27.78	13.42	24.84	19.03	19.42	
16	24.60	18.25	12.04	15.00	32.56	10.00	18.03	22.02		23.09	3
0.41	7.28	30.36	31.78	35.23	14.42	inf	26.83	29.27	44.60	32.89	3
1.78	27.20	26.02	25.61	8.25	24.17	28.07	26.17	20.59	32.06	14.21	1

6.55	17.46	22.80	39.96	39.62	26.08	16.28	6.71	34.21	34.99	30.23	1
2.65	22.02	18.11	33.62	27.46	21.84	21.63	6.40	21.84	25.55	34.13	3
4.71	33.02	36.24	17.46	42.06	50.61	38.12	24.19	19.10	42.95	31.06	3
6.88	12.17	12.08	43.46		46.87	16.12	20.88	25.00	9.90	8.06	
17	36.40	40.36	16.28	41.68	58.41	32.56	41.44	47.30	17.26	32.57	4
6.87	26.48	57.01	53.01	61.91	23.32	26.83	inf	53.60	70.80	55.44	4
6.24	28.07	13.15	11.31	33.53	50.99	47.71	52.43	45.34	29.73	13.34	3
1.91 4.42	44.01 48.55	46.39 44.27	64.35 57.98	65.44 52.40	39.29 18.25	21.38	21.84 26.25	39.12 48.47	42.43	37.66 59.91	1 1
4.42	31.14	63.06	31.26	61.52	75.69	56.82	41.68	28.23	51.35	43.32	5
0.60	38.63	37.01	66.22	74.52	71.42	26.31	36.72	47.51	36.36	34.89	J
18	47.71	34.06	41.11	21.40	28.86	32.20	12.17	7.62	37.64	28.43	1
8.38	27.17	13.00	9.00		42.72	29.27	53.60	inf	34.23	39.36	5
0.21	54.78	55.23	47.76	21.10	15.65	41.87	24.17	29.07	41.77	40.31	4
0.71	14.42	7.28	38.83	33.06	23.43	34.18	32.06	58.83	58.01	54.38	4
1.00	21.63	12.53	35.11	30.41	50.99	47.68	34.21	12.81	11.40	8.60	5
6.46	60.54	21.21	25.06	17.89	44.05	49.40	42.52	45.69	63.70	25.06	2
4.52	18.03	28.30	45.61	40.20	43.10	29.55	42.44	35.61	24.60	23.41	_
19	44.72 48.27	32.31 21.38	54.64	29.70	12.53 50.09	38.59	39.40	32.89 34.23	60.21	58.14	5
2.17	48.27 56.75	65.74	43.19 70.01	10.77 40.61	22.83	44.60 31.06	70.80 18.44	25.94	inf 71.20	22.02 58.80	4
2.72	30.53	37.64	12.65	6.08	55.36	58.41	50.91	54.08	51.00	50.25	5
6.40	22.63	31.76	16.03	19.31	59.09	66.07	44.65	26.83	44.38	27.02	7
9.20	61.00	13.04	52.84	50.16	10.20	31.05	36.50	48.70	51.79	58.24	5
8.69	35.00	33.84	18.87	6.00	11.40	55.47		26.68	34.71	36.77	
20	23.77	15.26	39.41	22.02	13.04	23.71	37.48	33.84	49.40	53.15	5
3.15	39.05	28.43	47.54	21.10	32.53	32.89	55.44	39.36	22.02	inf	1
8.00	36.25	47.63	57.71	33.14	23.71	9.49	15.26	13.04	64.33	45.65	2
4.08	27.66	38.60	10.44	16.12	53.08	49.04	39.56	32.25	29.02	28.64	4
1.88	18.03	29.83	6.32	8.94	40.61	51.87	30.02	26.93	45.35	36.24	6
6.37	39.85	25.24	47.17	57.25	21.93	10.63	15.65	29.41	30.08	57.31	6
0.42 21	29.02 9.85	20.88 16.40	10.82 32.39	22.56 29.07	17.00 29.83	47.85 22.14	20.25 44.10	8.06 43.19	24.33 46.00	27.29 54.82	5
9.54	39.05	42.19	56.85		23.54	31.78		50.21	40.00	18.00	J
inf	21.21	35.51	51.79	36.25	35.81	9.49	29.07	21.40	63.20	40.20	1
6.00	36.12	47.01	28.16	34.06	57.01	47.17	37.22	14.56	11.05	11.66	3
5.36	29.41	38.29	24.08	23.41	28.65	44.38	26.17	37.54	52.70	49.65	5
9.20	23.32	41.44	49.04	67.36	39.05	12.21		18.03	13.60	61.85	6
6.65			25.63	40.31		47.85		15.65	27.78	30.41	
22	12.53	25.08						47.17		47.80	5
7.49	33.24	51.48	58.67	51.16	12.81	27.20	28.07	54.78	56.75	36.25	2
1.21	inf 40.80	15.52	36.50	34.99	44.41	26.83	41.05	32.06	52.00	27.31	1
5.03 2.36	39.05	49.19 42.38	46.62 41.11	50.70 37.66	52.35 10.05	37.22 28.28	29.07 21.10	11.05 44.15	14.56 52.70	10.30 57.49	2
2.01	5.83	54.01	43.19	69.12	58.18	33.30		9.22	23.35	57.49	6
3.66	36.77	27.46	45.79	58.52	53.23	40.00		30.08	30.36	31.38	Ü
23	25.81	33.62	14.14		53.23	27.51	43.57	48.04	24.84	40.22	5
2.80	29.12	55.58	56.75	58.19	15.65	26.02	13.15	55.23	65.74	47.63	3
5.51	15.52	inf	23.26	34.13	48.84	38.90	48.10	39.81	40.80	18.03	2
3.60	43.10	48.51	57.43	59.94	46.14	28.60	24.04	26.48	30.08	25.63	1
4.87	44.92	44.01	51.31		7.07	15.26	22.36	47.27	50.00	60.03	2
7.17	18.03	60.17	37.12	66.41	69.07	47.01	32.53	18.38	38.83	50.77	5
7.80	38.01 42.30	32.57 42.49	58.05 19.42	68.60 40.31	64.40 58.14	32.76 34.00	27.59 35.85	40.22 42.49	33.54 10.30	33.14 23.09	3
24 8.01	22.20	53.54	45.54	60.21	28.28	25.61	11.31	42.49	70.01	57.71	5 5
1.79	36.50	23.26	inf	30.00	48.41	51.26	51.66	46.04	18.44	12.08	3
6.14	40.80	40.50	65.46	65.19	30.07	13.60	19.10	47.27	50.04	45.01	1
6.49	47.38	40.50	59.08	53.01	26.48	8.25	27.73	45.22	38.64	55.04	_
9.22	40.52	60.61	23.35	53.00	76.22	61.03	45.88	34.13	59.03	33.54	4
0.79	35.61	37.44	68.48	74.41	72.42	18.44	41.23	49.65	35.47	33.24	
25	30.61	20.62	20.02	11.70	29.53	14.42	9.85	14.04	19.85	20.02	2
3.60	7.81	23.71	23.71	30.41	22.36	8.25	33.53	21.10	40.61	33.14	3
6.25	34.99	34.13	30.00	inf	18.44	30.59	22.83	20.10	31.62	20.25	2
2.67	10.82	14.56	38.28	36.36	20.88	17.80	11.70	41.01	41.23	36.80	2
0.10 9.20	18.36 40.82	10.77 30.61	32.28 14.04	25.96 34.13	30.08 47.89	27.86 40.31	13.89 28.23	15.26 26.40	17.80 48.55	26.48 25.63	3
J.∠U	40.04	70.0T	14.04	24.13	4/.03	40.3I	20.23	20.40	40.00	20.03	3

0.53	5.66	13.34	42.95	45.49	44.78	15.23	26.08	26.02	9.06	6.08	
26	35.11	20.62	35.74	10.05	14.00	22.00	16.76	11.00	38.29	35.34	3
1.00	26.25	7.07	24.04	12.21	34.06	24.17	50.99	15.65	22.83	23.71	3
5.81	44.41	48.84	48.41	18.44	inf	26.91	8.54	14.42	48.37	38.08	2
9.43	7.81	16.00	24.02	19.65	32.98	36.07	29.68	46.24	44.72	41.79	3
6.77	6.40	8.94	19.65	14.76	43.19	45.65	26.48	4.12	23.00	13.89	5
7.63	49.82	12.21	30.02	33.54	31.32	33.84	28.65	35.23	49.41	36.35	3
8.05	12.81	17.03	30.41	28.23	29.27	32.80	29.73	20.52	15.30	16.16	E
27 2.92	14.32 35.00	10.05 33.02	32.20 49.09	21.47 28.16	20.40 24.41	18.11 28.07	37.16 47.71	35.23 41.87	43.93 31.06	50.25	5
9.49	26.83	38.90	51.26	30.59	26.91	20.07 inf	19.72	12.81	60.13	39.22	1
5.81	28.30	39.45	19.92	25.02	51.42	44.28	34.37	23.02	20.10	19.24	3
4.93	20.52	30.53	15.03	13.93	31.83	44.72	23.77	29.07	45.62	40.61	5
9.51	30.36	31.95	44.28	59.41	31.38	10.05	6.40	20.52	22.83	56.04	6
0.17	27.86	17.26	19.21	32.02	26.40	44.00	11.31	6.40	21.59	24.52	
28	30.27	16.00	36.36	11.40	6.71	20.62	24.08	19.24	42.01	41.76	3
9.12	30.23	13.45	32.57	10.20	32.57	26.17	52.43	24.17	18.44	15.26	2
9.07	41.05	48.10	51.66	22.83	8.54	19.72	inf	9.00	54.23	40.36	2
6.17	14.14	24.19	16.12	13.60	40.31	40.50	32.56	41.00	38.90	36.67	3
8.01	4.47	16.03	11.18	6.40	41.76	47.63	26.42	12.17	31.14	21.21	6
0.83	46.01	13.04	36.06	42.05	25.06	25.61	22.80	32.25	42.54	44.05	4
6.27	17.46	15.65	22.09	22.80	22.14	38.01		13.42	16.28	18.44	4
29 0.80	21.38	7.00	29.07	9.22	13.42	12.81	25.00	22.47	37.12	40.11	4
1.40	26.25 32.06	21.02 39.81	36.36 46.04	19.10 20.10	24.17 14.42	20.59	45.34	29.07 inf	25.94 51.42	13.04 34.21	2 1
7.26	15.65	26.83	19.42	20.10	40.20	36.40	27.29	32.28	30.46	27.89	3
1.11	8.06	17.89	13.04	7.07	33.24	41.04	19.10	16.28	33.24	28.30	5
5.00	37.01	22.02	34.13	46.62	30.41	21.19	14.32	23.35	35.00	44.55	4
8.08	16.12	8.60	23.09	29.21	26.40	34.93	16.12	6.71	11.40	14.32	
30	54.74	50.25	32.57	43.32	60.93	42.05	32.20	39.20	17.72	13.45	2
6.40	25.32	51.40	36.36	60.54	41.23	32.06	29.73	41.77	71.20	64.33	6
3.20	52.00	40.80	18.44	31.62	48.37	60.13	54.23	51.42	inf	24.70	4
7.27	40.71	35.38	69.89	67.54	18.87	16.03	26.02	61.98	64.03	58.94	2
9.73	49.77	39.45	63.89	57.57	42.49	25.61	37.05	44.42	30.61	50.21	2
1.84	56.80	59.64	18.36	40.80	79.20	70.18	56.01	47.30	72.78	19.92	2
6.31	36.77	43.57	74.46	76.48	76.32	16.49	52.15	56.72	40.02	37.11	0
31	31.00	30.41 43.86	8.06	29.21	46.67	21.95	28.16	33.96	7.21	22.20	3
5.11 0.20	13.15 27.31	18.03	40.20	49.41 20.25	17.03 38.08	14.21 39.22	13.34 40.36	40.31 34.21	58.80 24.70	45.65 inf	4 2
4.33	30.87	33.14	53.60	53.74	28.18	10.63	8.54	37.36	39.62	34.53	2
5.10	36.24	31.02	47.20	41.23	18.03	7.62	15.65	35.34	33.24	46.57	2
0.81	32.25	50.25	19.31	49.24	64.54	49.04	33.96	23.09	48.51	32.76	3
9.82	25.50	25.61	56.44		60.61	14.76	29.43	37.59	24.08	22.20	
32	8.06	10.44	16.76		30.36	8.60	31.89	33.12	30.00	39.56	4
6.23	23.77	36.50	45.61	36.35	8.60	16.55	31.91	40.71		24.08	1
6.00	15.03	23.60	36.14	22.67		15.81		17.26		24.33	
inf	26.40	35.81	33.84		42.54	31.26		18.44		14.14	1
9.65	24.02	28.18	27.78	23.41	16.64	29.15	10.44	29.41		42.72	4
4.01	20.40	39.05	34.01		45.49	25.08		6.08	26.40	47.51	5
3.01 33	23.02	12.65	34.66		40.80	32.28	5.10	16.64	16.12	17.80	2
5.50	33.29 18.60	19.80 13.00	29.43 20.81	7.07 20.00	20.62 29.27	18.03 17.46	10.00 44.01	7.07 14.42	30.61 30.53	27.86 27.66	2
6.12	40.80	43.10	40.80	10.82	7.81	28.30	14.14	15.65	40.71	30.87	2
6.40	inf	11.18	30.27	26.93	26.17	28.28	22.36	44.42	43.60	39.96	3
0.08	10.00	2.24	25.00	19.10	38.05	38.48	21.02	4.47	17.72	17.03	5
0.00	46.49	19.85	22.36	31.24	38.63	36.77	28.28	31.62	49.50	30.00	3
2.76	5.39	13.89	36.00	35.78	36.14	25.00	28.02	22.36	10.44	10.00	
34	43.28	30.61	34.37	18.03	30.00	27.20	5.00	5.00	30.36	21.93	1
5.00	20.02	16.55	9.90	26.93	36.77	22.80	46.39	7.28	37.64	38.60	4
7.01	49.19	48.51	40.50	14.56	16.00	39.45	24.19	26.83	35.38	33.14	3
5.81	11.18	inf	40.01	35.36	17.89	26.93	25.00	54.20	53.81	49.82	3
4.06	20.62	8.94	35.36	29.83	44.64	40.45	28.23	12.04	7.00	15.00	4
9.24	55.01	25.08	18.03	20.52	46.87	47.93	39.05	40.31	60.21	20.62	2
2.09 35	12.81	24.04	46.27		45.18	22.36	38.21	33.54	19.85	18.03	5
5.01	34.18 45.19	24.08 26.25	48.10 47.68	26.57 16.12	10.05 42.01	31.89 39.96	40.20 64.35	35.01 38.83	56.44 12.65	57.72 10.44	5 2
J.∪⊥	⊒J•⊥J	20.23	41.00	⊥ U • ⊥∠	74.UT	57.50	UT.JJ	50.05	14.UJ	TO . 44	

8.16	46.62	57.43	65.46	38.28	24.02	19.92	16.12	19.42	69.89	53.60	3
3.84	30.27	40.01	inf	7.81	56.44	55.46	46.65	42.58	39.20	39.05	5
0.33	20.40	32.14	6.40	12.53	50.48	60.31	38.29	28.00	47.01	33.62	7
4.40	50.29	20.25	51.92	56.32	11.66	18.44	26.00	39.45	39.32	60.13	6
2.07	33.24	28.02	7.21	12.17	7.07	53.49		17.20	30.41	33.11	
36	38.64	26.40	49.20	25.00	7.07	33.02	36.40	30.41	55.61	54.78	5
0.25	43.83	20.10	42.05	9.22	44.29	39.62		33.06	6.08	16.12	3
4.06	50.70	59.94	65.19	36.36	19.65	25.02	13.60	20.25	67.54	53.74	3
6.77	26.93	35.36	7.81	inf	52.63	54.08	46.10	48.04	45.01	44.18	5 7
1.09 4.33	18.03 54.92	28.46 13.00	10.00 49.24	13.42 50.01	53.23 11.70	60.88 25.63	39.20 30.41	23.77 42.72	42.30 46.10	26.93 55.90	5
7.08	30.89	28.43	14.87	9.22	10.05	51.48	34.21	20.62	29.73	32.02	3
37	50.61	41.48	33.42	31.06	46.69	34.93	16.28	20.02	22.14	7.00	
8.06	19.21	34.44	17.49	44.60	39.70	26.08	39.29	23.43	55.36	53.08	5
7.01	52.35	46.14	30.07	20.88	32.98	51.42	40.31	40.20	18.87	28.18	4
2.54	26.17	17.89	56.44	52.63	inf	18.03	23.35	60.22	61.06	56.30	3
1.62	36.12	24.33	51.09	45.01	44.82	33.53	32.45	28.86	12.04	32.02	3
7.22	57.98	42.95	9.22	23.09	64.29	61.00	49.04	45.00	68.88	5.00	1
1.66	24.08	34.21	62.07	61.03	62.17	13.42	46.52	46.53	29.83	26.93	
38	38.83	34.53	17.49	29.15	47.17	26.17	22.36	29.15	4.12	11.66	2
5.50	10.30	40.61	32.14	48.17	25.63	16.28		34.18	58.41	49.04	4
7.17	37.22	28.60	13.60	17.80	36.07	44.28	40.50	36.40	16.03	10.63	3
1.26	28.28	26.93	55.46	54.08	18.03	inf	10.00	46.62	48.38	43.32	1
5.00	36.06	27.66	49.24	42.95	28.43	15.52	21.02	32.56	25.18	41.59	2
2.36	42.44	48.10	10.00	40.20	65.51	54.33	40.00	31.62	57.01	22.36	2
9.55	23.43	28.16	59.46		62.18	5.00		41.23	25.08	22.36	
39	29.12	24.74	10.30	21.21	39.05	16.28	20.00	25.50	9.85	18.87	2
9.15	5.10	35.34	32.76	41.23	16.64			32.06	50.91	39.56	3
7.22	29.07	24.04	19.10	11.70	29.68	34.37	32.56	27.29	26.02	8.54	2
1.38 9.22	22.36 28.28	25.00 22.47	46.65	46.10 34.13	23.35 21.63	10.00 16.16	inf 11.05	37.59 26.83	39.00 25.96	34.01 38.08	2
8.28	34.66	41.88	14.14	42.38	57.20	44.41	30.00	22.36	47.43	28.28	3
4.83	17.00	18.79	50.16		53.54	11.18		31.62	16.40	14.14	J
40	11.18	25.63	29.41	37.59	43.10	27.02	50.33	51.31		56.44	6
4.44	41.05	53.14	64.03	50.49	21.02	34.21		58.83	54.08	32.25	1
4.56	11.05	26.48	47.27	41.01	46.24	23.02	41.00	32.28	61.98	37.36	1
8.44	44.42	54.20	42.58	48.04	60.22	46.62	37.59	inf	4.24	4.47	3
2.28	40.16	46.32	38.05	36.22	21.00	39.12	27.80	46.96	58.73	60.01	5
3.04	10.00	53.94	51.31	74.65	53.60	26.40	18.25	15.26	12.37	65.22	7
1.06	41.40	30.53	40.16	54.74	48.51	48.76	16.55	28.16	34.41	36.24	
41	10.63	24.19	31.58	36.62	40.45	26.91	50.21	50.61	46.32	57.70	6
4.82	42.06	51.48	63.70	48.05	22.80	34.99	42.43	58.01		29.02	1
1.05	14.56	30.08	50.04	41.23	44.72	20.10	38.90	30.46	64.03	39.62	1
8.60	43.60	53.81	39.20	45.01	61.06	48.38		4.24	inf	5.10	3
4.53	38.48	45.61	35.01	33.73	24.19	42.00	28.65	45.79	58.73	58.59	5
6.22	14.21	51.66	52.35	74.33	50.01	22.47	16.16	16.76	9.00	66.04	7
1.61	41.04	29.83	36.40		44.91	50.16	15.62	25.71	33.97	36.07	_
42 0.31	6.71	21.19	26.48	33.12	39.01	22.67 30.23		46.87		52.77	6
1.66	37.22 10.30	48.70 25.63	59.67 45.01	46.27 36.80	17.72 41.79	19.24	37.66 36.67	54.38 27.89	50.25 58.94	28.64 34.53	1 1
4.14	39.96	49.82	39.05	44.18	56.30	43.32	34.01	4.47	5.10	inf	2
9.43	35.74	41.88	34.23		19.42	37.01	23.85	42.49	54.45	55.54	5
1.35	11.66	49.65	47.51	70.29	50.29	23.85	14.04	11.70	14.04	61.29	6
7.01	37.01	26.08	37.16		45.22	45.19	12.08	24.02	30.00	31.89	Ü
43	26.02	26.63	3.00		44.05	18.44		34.13		26.17	3
8.01	14.32	43.01	41.98		12.00	12.65		41.00	56.40	41.88	3
5.36	22.36	14.87	16.49		36.77	34.93		31.11		5.10	1
9.65	30.08	34.06	50.33		31.62	15.00		32.28	34.53	29.43	
inf	34.13	30.59	43.93	38.18	13.45	10.00	12.04	34.48	35.17	46.53	2
4.60	27.46	48.75	22.47		61.52			18.03	43.42	36.40	4
3.27		22.67	52.70		57.38			33.84		20.62	
44	29.12	14.56	32.65		11.18	17.46		15.81		37.36	3
5.36	25.81	13.00	29.55	13.42	29.61	22.02	48.55	21.63	22.63	18.03	2
9.41	39.05	44.92	47.38		6.40	20.52		8.06	49.77	36.24	2
4.02	10.00	20.62	20.40	18.03	36.12	36.06	28.28	40.16	38.48	35.74	3
4.13	inf	12.04	15.00	9.22	38.83	43.60	22.85	8.94	27.46	20.25	5

6.57	44.28	15.30	31.62	39.45	29.53	27.78	22.36	30.00	43.01	40.00	4
2.58	13.00	12.37	26.00	27.20	26.57	33.54	23.77	14.14	12.21	14.14	
45	35.23	21.93	30.15	9.22	22.36	19.70	8.06	5.00	30.23	26.40	2
3.35	18.36	13.04	18.60	21.10	30.59	18.11	44.27	12.53	31.76	29.83	3
8.29	42.38	44.01	40.50	10.77	8.94	30.53	16.03	17.89	39.45	31.02	2
8.18	2.24	8.94	32.14	28.46	24.33	27.66	22.47	46.32	45.61	41.88	3
0.59	12.04	inf	27.02	21.21	39.20	38.63	22.20	5.00	15.52	16.03	4
9.65	48.10	20.52	21.10	29.07	40.16	39.00	30.41	33.24	51.62	28.02	3
0.59	6.00	15.81	38.01	37.16	37.85	24.08	30.00	24.60	12.08	11.18	
46	28.86	17.80	41.73	20.62	7.07	25.50	35.00	30.41	50.12	51.97	5
0.25	39.00	23.32	43.68	15.00	35.81	33.62	57.98	35.11	16.03	6.32	2
4.08	41.11	51.31	59.08	32.28	19.65	15.03	11.18	13.04	63.89	47.20	2
7.78	25.00	35.36	6.40	10.00	51.09	49.24	40.31	38.05	35.01	34.23	4
3.93	15.00 45.12	27.02 19.21	inf	6.32 52.92	44.42	53.91	31.89	23.35	42.30	31.06	6 5
8.01 7.43	27.46	21.63	46.10	17.46	17.80 13.45	16.64 47.43	20.62	11.18	36.40 24.17	55.00 26.93	5
47	26.02	13.00	36.12	14.32	7.07		29.07	25.00	43.91	45.71	4
4.55	32.70	19.80	38.63	14.32	30.89	27.46	52.40	30.41	19.31	8.94	2
3.41	37.66	46.53	53.01	25.96	14.76	13.93	6.40	7.07	57.57	41.23	2
3.41	19.10	29.83	12.53	13.42	45.01	42.95	34.13	36.22	33.73	32.06	3
8.18	9.22	21.21	6.32	inf	39.81	48.10	26.17	18.03	36.67	27.59	6
2.01	42.19	18.03	39.81	48.30	23.35	19.21	18.03	29.41	36.67	49.04	5
1.79	21.21	15.62	17.12		19.42	41.11	21.21	8.06	17.89	20.62	
48	18.87	26.83	11.40	33.14	46.62	21.38	39.85	43.57		39.60	5
0.77	26.42	50.09	53.49	51.92	9.22	21.84	18.25	50.99	59.09	40.61	2
8.65	10.05	7.07	26.48	30.08	43.19	31.83	41.76	33.24	42.49	18.03	1
6.64	38.05	44.64	50.48	53.23	44.82	28.43	21.63	21.00	24.19	19.42	1
3.45	38.83	39.20	44.42	39.81	inf	18.25	17.03	42.00	47.01	55.08	3
2.06	14.32	54.13	35.61	63.56	62.13	40.00	25.46	11.31	33.14	49.68	5
6.40	33.24	26.48	50.99		57.43	31.83	20.52	33.29	28.02	28.07	
49	34.71	36.62	12.53	36.62	53.81	28.43	35.51	41.48	11.40	26.93	4
1.00	20.62	51.48	47.01	56.86	20.88	21.63	6.00	47.68	66.07	51.87	4
4.38	28.28	15.26	8.25	27.86	45.65	44.72	47.63	41.04	25.61	7.62	2
9.15	38.48	40.45	60.31	60.88	33.53	15.52	16.16	39.12	42.00	37.01	1
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2.04	22.85	22.20	31.89	26.17	17.03	22.02	inf	25.02	31.62	38.05	3
6.36	26.93	37.95	23.71	48.02	49.50	33.73	19.03	12.73	36.77	37.44	4
3.28	16.28	10.82	40.82		45.34	21.84	15.13	21.95	11.18	11.05	_
51		21.63	33.73		18.03		12.65	7.07		31.30	2
7.02	23.02	8.54	20.62		33.06	21.84	48.47	12.81	26.83	26.93	3
7.54	44.15	47.27	45.22		4.12	29.07	12.17	16.28	44.42	35.34	2
9.41	4.47	12.04	28.00		28.86	32.56	26.83	46.96	45.79	42.49	3
4.48	8.94	5.00	23.35	18.03	42.00	42.95	25.02	inf	19.03	13.34	5
4.41	49.73	15.56	26.08	30.53	35.44	36.72	30.00	34.93	51.09	32.25	3
4.13	9.85	16.76	34.23		33.38	29.07	30.41	22.80		14.14	
52		36.36	36.06		37.00		8.60	12.00	29.07	17.49	
8.00	20.88	23.09	7.00		39.96	25.55	46.01	11.40	44.38	45.35	5
2.70	52.70	50.00	38.64		23.00	45.62		33.24		33.24	4
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5.17	27.46	15.52	42.30		47.01	40.01	31.62	19.03	inf	20.00	4
6.84	58.52	31.62	15.30		53.76	54.42	44.65	44.20	65.60	13.93	1
5.13	18.03	29.41	53.24		52.15		43.28	39.92	25.00	22.67	^
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3.95	63.06	14.14	33.02	23.19	37.12		42.54	48.27		33.62	3
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                                          48.27
                                                32.31 50.22
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3.55
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          19.03
                 58.14
                        56.14 4.47 30.07
                                          37.95
                                                50.99 51.09
                                                              64.03
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                                   60.54
                                          42.15
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                 55.17 33.11 15.52 38.95 45.89 40.20 63.29
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                       19.24 49.04 46.87 71.42 43.10 11.40
                                                             17.00
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                                          22.14
                                                26.40 76.32
                                                             60.61
                        10.05 62.17 62.18
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                                                48.51 44.91
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     36.14 45.18
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     26.57 37.85 13.45
                       19.42 57.43 67.36 45.34
                                                33.38 52.15 36.88
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                58.19
                       60.02 5.10 23.02
                                          32.65
                                                46.32 44.00
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                        7.62 inf
                                                24.21
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    39.56
                                   60.01
71 | 40.16 34.01 20.52 26.93 44.72 26.08 18.03 25.00 9.06
                                                              7.81
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                       45.00 27.78
                                   16.12 26.31 29.55 55.47
                                                              47.85
7.85
     40.00
           32.76
                 18.44
                        15.23 32.80
                                   44.00
                                          38.01
                                                34.93 16.49
                                                              14.76
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                        51.48 13.42
                                     5.00
                                          11.18
                                                48.76 50.16
                                                              45.19
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     33.54 24.08 47.43
                        41.11 31.83 20.40
                                          21.84
                                                29.07 20.22
                                                              37.22
                                                                     2
6.93
     45.45
           44.60
                5.00
                        35.23 63.06 54.01
                                          40.31 33.54 58.52
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                57.97
                       60.54 60.01
                                   inf
                                          36.88 40.31 23.54
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     20.59
           27.17
                                                             20.62
                       21.10 28.28 11.66 34.71 35.00 35.01 43.97
72 |
     5.39
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9.65
     28.16 36.69 48.10 35.00 13.42 20.88 36.72 42.44 40.26 20.25
                                                                    1
1.05
     16.49
           27.59 41.23 26.08 29.73 11.31 25.08 16.12 52.15 29.43
5.10
      28.02 38.21 30.41 34.21 46.52 36.12 26.17
                                                 16.55 15.62 12.08
24.74 23.77 30.00 24.70 21.21 20.52 34.18 15.13 30.41 43.28 43.46
49.04 21.02 38.12 38.28 58.73 42.06 20.12 5.00 9.22 22.47 51.43
       25.46 14.21
56.60
                   30.48 42.15 37.22 36.88 inf 13.60
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                7.21
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                13.15
                         18.87
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74 |
      23.43
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                                          22.67
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                                           15.30
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                                                             16.28
                                                                     11.40
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                19.85
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                                                    25.08
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1.95
                12.08
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                         34.48
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                                           37.22
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                22.56
                         27.80
                                           19.42
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       31.38
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7.80
       10.00
                18.03
                         33.11
                                  32.02
                                           26.93
                                                    22.36
                                                             14.14
                                                                     36.24
                                                                              36.07
                                                                                       31.89
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0.62
       14.14
                11.18
                         26.93
                                  20.62
                                           28.07
                                                    29.68
                                                             11.05
                                                                     14.14
                                                                              22.67
                                                                                       27.02
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                                                    34.23
                                                             22.36
                                                                                                3
2.43
       37.16
                28.18
                         20.00
                                  38.42
                                           43.27
                                                                     22.36
                                                                              43.01
                                                                                       31.62
6.24
        5.39
                 7.28
                         37.36
                                  41.23
                                           39.82
                                                    20.62
                                                             20.62
                                                                     20.00
                                                                               3.00
                                                                                         inf
Run 1 - Best Path Indices: [(2, 43), (43, 31), (31, 8), (8, 38), (38, 30), (30, 24), (2
4, 54), (54, 17), (17, 49), (49, 23), (23, 48), (48, 22), (22, 55), (55, 40), (40, 41),
 (41, 42), (42, 0), (0, 21), (21, 63), (63, 60), (60, 68), (68, 35), (35, 70), (70, 59),
 (59, 69), (69, 19), (19, 36), (36, 4), (4, 14), (14, 56), (56, 12), (12, 53), (53, 18),
 (18, 34), (34, 6), (6, 7), (7, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28),
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(28, 47), (47, 46), (46, 20), (20, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 61)2), (62, 15), (15, 50), (50, 5), (5, 67), (67, 1), (1, 29), (29, 3), (3, 74), (74, 75), (75, 66), (66, 25), (25, 16), (16, 39), (39, 11), (11, 71), (71, 57), (57, 9), (9, 37),(37, 64), (64, 65), (65, 10), (10, 52), (52, 13), (13, 58)Run 1 - Best Path Length: 549.72

Run 2 - Best Path Indices: [(4, 36), (36, 19), (19, 69), (69, 59), (59, 70), (70, 35), (35, 46), (46, 47), (47, 28), (28, 44), (44, 3), (3, 29), (29, 73), (73, 27), (27, 60),(60, 21), (21, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 50), (50, 5), (5, 67),(67, 74), (74, 75), (75, 66), (66, 25), (25, 11), (11, 39), (39, 16), (16, 43), (43, 16)2), (2, 31), (31, 8), (8, 38), (38, 71), (71, 57), (57, 9), (9, 37), (37, 64), (64, 1 0), (10, 65), (65, 58), (58, 13), (13, 52), (52, 6), (6, 34), (34, 7), (7, 45), (45, 3 3), (33, 51), (51, 26), (26, 12), (12, 53), (53, 18), (18, 14), (14, 56), (56, 68), (68, 68)20), (20, 1), (1, 0), (0, 42), (42, 40), (40, 41), (41, 63), (63, 22), (22, 55), (55, 4 8), (48, 23), (23, 49), (49, 17), (17, 24), (24, 54), (54, 30)] Run 2 - Best Path Length: 602.69

Run 3 - Best Path Indices: [(2, 43), (43, 39), (39, 11), (11, 25), (25, 16), (16, 50), (50, 5), (5, 1), (1, 67), (67, 75), (75, 74), (74, 3), (3, 44), (44, 28), (28, 4), (4, 40)36), (36, 19), (19, 69), (69, 59), (59, 70), (70, 68), (68, 35), (35, 46), (46, 20), (2 0, 47), (47, 29), (29, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15),(15, 48), (48, 23), (23, 17), (17, 49), (49, 31), (31, 8), (8, 38), (38, 71), (71, 57),(57, 9), (9, 37), (37, 64), (64, 10), (10, 65), (65, 58), (58, 13), (13, 52), (52, 6),(6, 34), (34, 7), (7, 18), (18, 53), (53, 12), (12, 26), (26, 51), (51, 33), (33, 45),(45, 66), (66, 56), (56, 14), (14, 60), (60, 21), (21, 0), (0, 42), (42, 40), (40, 41),(41, 63), (63, 55), (55, 22), (22, 24), (24, 54), (54, 30)] Run 3 - Best Path Length: 610.23

Run 4 - Best Path Indices: [(0, 42), (42, 41), (41, 40), (40, 22), (22, 55), (55, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 9), (9, 57), (57, 71),(71, 38), (38, 8), (8, 31), (31, 43), (43, 2), (2, 15), (15, 62), (62, 32), (32, 72),(72, 61), (61, 27), (27, 73), (73, 29), (29, 1), (1, 67), (67, 5), (5, 50), (50, 16),(16, 39), (39, 11), (11, 25), (25, 75), (75, 74), (74, 3), (3, 44), (44, 28), (28, 47),(47, 46), (46, 20), (20, 60), (60, 21), (21, 63), (63, 68), (68, 35), (35, 70), (70, 5)9), (59, 69), (69, 19), (19, 36), (36, 4), (4, 14), (14, 56), (56, 12), (12, 53), (53, 8), (18, 34), (34, 7), (7, 45), (45, 33), (33, 66), (66, 6), (6, 52), (52, 13), (13, 5)8), (58, 65), (65, 10), (10, 37), (37, 64), (64, 51), (51, 26)] Run 4 - Best Path Length: 593.52

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Run 5 - Best Path Indices: [(4, 56), (56, 14), (14, 53), (53, 18), (18, 12), (12, 3),
 (3, 74), (74, 75), (75, 66), (66, 25), (25, 11), (11, 39), (39, 16), (16, 50), (50, 5),
 (5, 67), (67, 1), (1, 29), (29, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62),
 (62, 15), (15, 2), (2, 43), (43, 31), (31, 8), (8, 38), (38, 71), (71, 57), (57, 9),
 (9, 37), (37, 64), (64, 10), (10, 65), (65, 58), (58, 13), (13, 52), (52, 34), (34, 6),
 (6, 7), (7, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 20),
 (20, 46), (46, 35), (35, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 68), (68, 69)
0), (60, 21), (21, 0), (0, 42), (42, 40), (40, 41), (41, 63), (63, 55), (55, 22), (22, 40)
8), (48, 23), (23, 49), (49, 17), (17, 24), (24, 54), (54, 30)
Run 5 - Best Path Length: 576.0
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Run 6 - Best Path Indices: [(0, 42), (42, 40), (40, 41), (41, 63), (63, 21), (21, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 48), (48, 23), (23, 17), (17, 49), (49, 23)4), (24, 54), (54, 30), (30, 9), (9, 57), (57, 71), (71, 38), (38, 8), (8, 31), (31, 4)3), (43, 2), (2, 39), (39, 11), (11, 25), (25, 66), (66, 33), (33, 45), (45, 7), (7, 3 4), (34, 6), (6, 52), (52, 13), (13, 58), (58, 65), (65, 10), (10, 64), (64, 37), (37, 1 8), (18, 53), (53, 12), (12, 26), (26, 51), (51, 44), (44, 28), (28, 47), (47, 46), (46, 51)20), (20, 73), (73, 29), (29, 1), (1, 67), (67, 5), (5, 50), (50, 16), (16, 75), (75, 4), (74, 3), (3, 56), (56, 14), (14, 4), (4, 36), (36, 19), (19, 69), (69, 59), (59, 7)0), (70, 35), (35, 68), (68, 60), (60, 27), (27, 55), (55, 22)] Run 6 - Best Path Length: 588.41

Run 7 - Best Path Indices: [(3, 74), (74, 75), (75, 66), (66, 33), (33, 45), (45, 51), (51, 26), (26, 12), (12, 53), (53, 18), (18, 34), (34, 7), (7, 6), (6, 52), (52, 13),(13, 58), (58, 65), (65, 10), (10, 64), (64, 37), (37, 9), (9, 71), (71, 38), (38, 8),(8, 31), (31, 43), (43, 2), (2, 39), (39, 11), (11, 25), (25, 16), (16, 50), (50, 5),(5, 67), (67, 1), (1, 29), (29, 47), (47, 28), (28, 44), (44, 14), (14, 56), (56, 4),(4, 36), (36, 19), (19, 69), (69, 59), (59, 70), (70, 68), (68, 35), (35, 46), (46, 2)0), (20, 73), (73, 27), (27, 60), (60, 0), (0, 42), (42, 40), (40, 41), (41, 63), (63, 2 1), (21, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 48), (48, 22), (22, 55), (55, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 57)] Run 7 - Best Path Length: 576.66

Run 8 - Best Path Indices: [(1, 20), (20, 46), (46, 35), (35, 68), (68, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 4), (4, 14), (14, 56), (56, 12), (12, 53), (53, 18),(18, 34), (34, 7), (7, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47),(47, 60), (60, 21), (21, 61), (61, 27), (27, 73), (73, 29), (29, 3), (3, 66), (66, 25),(25, 75), (75, 74), (74, 67), (67, 5), (5, 50), (50, 16), (16, 11), (11, 39), (39, 31),(31, 43), (43, 2), (2, 15), (15, 62), (62, 32), (32, 72), (72, 0), (0, 42), (42, 40),(40, 41), (41, 63), (63, 22), (22, 55), (55, 48), (48, 23), (23, 17), (17, 49), (49, 2 4), (24, 54), (54, 30), (30, 9), (9, 37), (37, 64), (64, 65), (65, 10), (10, 52), (52, 1 3), (13, 58), (58, 6), (6, 57), (57, 71), (71, 38), (38, 8)Run 8 - Best Path Length: 580.35

Run 9 - Best Path Indices: [(2, 43), (43, 31), (31, 8), (8, 38), (38, 71), (71, 57), (5 7, 9), (9, 37), (37, 64), (64, 65), (65, 10), (10, 13), (13, 52), (52, 34), (34, 6), (6, 10), (10, 13),7), (7, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 29), (29, 47)73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 50), (50, 16), (15, 16)6, 11), (11, 39), (39, 25), (25, 66), (66, 75), (75, 74), (74, 67), (67, 5), (5, 3), (3, 1), (1, 0), (0, 42), (42, 40), (40, 41), (41, 63), (63, 21), (21, 60), (60, 20), (20, 4 6), (46, 35), (35, 68), (68, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 4), (4, 1 4), (14, 56), (56, 12), (12, 53), (53, 18), (18, 58), (58, 30), (30, 54), (54, 24), (24, 49), (49, 17), (17, 23), (23, 48), (48, 22), (22, 55)] Run 9 - Best Path Length: 578.52

Run 10 - Best Path Indices: [(3, 74), (74, 75), (75, 66), (66, 33), (33, 45), (45, 51), (51, 7), (7, 6), (6, 34), (34, 52), (52, 13), (13, 58), (58, 65), (65, 64), (64, 37),(37, 10), (10, 18), (18, 53), (53, 12), (12, 26), (26, 44), (44, 28), (28, 47), (47, 48)(6), (46, 20), (20, 60), (60, 21), (21, 61), (61, 72), (72, 0), (0, 42), (42, 40), (40, 40)1), (41, 63), (63, 55), (55, 22), (22, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 9), (9, 57), (57, 71), (71, 38), (38, 8), (8, 31), (31, 43), (43, 2), (2, 15), (15, 62), (62, 32), (32, 1), (1, 67), (67, 5), (5, 50), (50, 16), (16, 3 9), (39, 11), (11, 25), (25, 29), (29, 73), (73, 27), (27, 68), (68, 35), (35, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 4), (4, 14), (14, 56)] Run 10 - Best Path Length: 579.6

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(69, 19), (19, 36), (36, 68), (68, 20), (20, 60), (60, 21), (21, 0), (0, 22), (22, 55),
 (55, 40), (40, 41), (41, 42), (42, 63), (63, 1), (1, 29), (29, 73), (73, 27), (27, 61),
 (61, 72), (72, 32), (32, 62), (62, 15), (15, 48), (48, 23), (23, 17), (17, 49), (49, 23)
4), (24, 54), (54, 30), (30, 9), (9, 57), (57, 71), (71, 38), (38, 8), (8, 31), (31, 4
3), (43, 2), (2, 39), (39, 11), (11, 25), (25, 66), (66, 75), (75, 74), (74, 67), (67, 74)
 5), (5, 50), (50, 16), (16, 3), (3, 44), (44, 28), (28, 56), (56, 14), (14, 12), (12, 2
6), (26, 51), (51, 33), (33, 45), (45, 7), (7, 34), (34, 6), (6, 52), (52, 13), (13, 5
8), (58, 65), (65, 10), (10, 64), (64, 37), (37, 18), (18, 53)]
Run 11 - Best Path Length: 600.95
Run 12 - Best Path Indices: [(0, 42), (42, 40), (40, 41), (41, 63), (63, 55), (55, 22),
 (22, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 38), (38, 7)
1), (71, 57), (57, 9), (9, 37), (37, 64), (64, 10), (10, 65), (65, 58), (58, 13), (13, 1
8), (18, 53), (53, 12), (12, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 29), (29, 47)
 1), (1, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 2), (2, 4
3), (43, 31), (31, 8), (8, 39), (39, 16), (16, 50), (50, 5), (5, 67), (67, 74), (74, 7
5), (75, 66), (66, 25), (25, 11), (11, 3), (3, 33), (33, 45), (45, 7), (7, 34), (34, 6),
 (6, 52), (52, 56), (56, 14), (14, 4), (4, 36), (36, 19), (19, 69), (69, 59), (59, 70),
 (70, 35), (35, 68), (68, 20), (20, 46), (46, 60), (60, 21)
Run 12 - Best Path Length: 593.5
Run 13 - Best Path Indices: [(0, 42), (42, 41), (41, 40), (40, 55), (55, 22), (22, 48),
 (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 9), (9, 57), (57, 71),
 (71, 38), (38, 8), (8, 31), (31, 43), (43, 2), (2, 39), (39, 11), (11, 16), (16, 50),
 (50, 5), (5, 67), (67, 1), (1, 29), (29, 73), (73, 27), (27, 61), (61, 72), (72, 32),
 (32, 62), (62, 15), (15, 63), (63, 21), (21, 60), (60, 20), (20, 68), (68, 70), (70, 50)
9), (59, 69), (69, 19), (19, 36), (36, 4), (4, 14), (14, 56), (56, 12), (12, 53), (53, 1
8), (18, 7), (7, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47,
6), (46, 35), (35, 3), (3, 74), (74, 75), (75, 66), (66, 25), (25, 6), (6, 34), (34, 5
2), (52, 13), (13, 58), (58, 65), (65, 10), (10, 37), (37, 64)]
Run 13 - Best Path Length: 581.37
Run 14 - Best Path Indices: [(4, 47), (47, 29), (29, 73), (73, 27), (27, 61), (61, 72),
 (72, 32), (32, 62), (62, 15), (15, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 5)
4), (54, 30), (30, 9), (9, 57), (57, 71), (71, 38), (38, 8), (8, 31), (31, 2), (2, 43),
 (43, 16), (16, 50), (50, 5), (5, 67), (67, 1), (1, 0), (0, 42), (42, 41), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), (41, 40), 
0, 55), (55, 22), (22, 63), (63, 21), (21, 60), (60, 20), (20, 46), (46, 35), (35, 68),
 (68, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 14), (14, 56), (56, 12), (12, 5)
3), (53, 18), (18, 34), (34, 6), (6, 52), (52, 10), (10, 37), (37, 64), (64, 65), (65, 5
8), (58, 13), (13, 51), (51, 26), (26, 28), (28, 44), (44, 3), (3, 74), (74, 75), (75, 6)
6), (66, 33), (33, 45), (45, 7), (7, 25), (25, 11), (11, 39)]
Run 14 - Best Path Length: 588.9
Run 15 - Best Path Indices: [(1, 29), (29, 73), (73, 27), (27, 61), (61, 72), (72, 32),
 (32, 62), (62, 15), (15, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 34)
(30, 9), (37, 64), (64, 10), (10, 65), (65, 58), (58, 13), (13, 52), (52, 38)
4), (34, 6), (6, 7), (7, 18), (18, 53), (53, 12), (12, 56), (56, 14), (14, 36), (36, 14)
9), (19, 69), (69, 59), (59, 70), (70, 35), (35, 68), (68, 20), (20, 46), (46, 47), (47,
 (28), (28, 44), (44, 3), (3, 75), (75, 74), (74, 67), (67, 5), (5, 50), (50, 2), (2, 4)
3), (43, 31), (31, 8), (8, 38), (38, 71), (71, 57), (57, 11), (11, 39), (39, 16), (16, 2
5), (25, 66), (66, 33), (33, 45), (45, 51), (51, 26), (26, 4), (4, 60), (60, 21), (21, 6
3), (63, 41), (41, 40), (40, 22), (22, 55), (55, 42), (42, 0)
Run 15 - Best Path Length: 568.78
Run 16 - Best Path Indices: [(3, 7), (7, 34), (34, 6), (6, 52), (52, 13), (13, 58), (58,
 10), (10, 64), (64, 37), (37, 65), (65, 18), (18, 53), (53, 12), (12, 56), (56, 14), (1
4, 4), (4, 36), (36, 19), (19, 69), (69, 70), (70, 59), (59, 68), (68, 35), (35, 46), (4
(6, 20), (20, 60), (60, 21), (21, 0), (0, 42), (42, 40), (40, 41), (41, 63), (63, 55), (50, 40)
5, 22), (22, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 9),
 (9, 57), (57, 71), (71, 38), (38, 8), (8, 31), (31, 43), (43, 2), (2, 39), (39, 11), (11)
1, 25), (25, 16), (16, 50), (50, 5), (5, 67), (67, 74), (74, 75), (75, 66), (66, 33), (3
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3, 45), (45, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 29), (29, 1), (1, 73), (7, 7

3, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15)]

Run 16 - Best Path Length: 578.61

Run 11 - Best Path Indices: [(4, 47), (47, 46), (46, 35), (35, 70), (70, 59), (59, 69),

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Run 17 - Best Path Indices: [(0, 72), (72, 32), (32, 62), (62, 15), (15, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 9), (9, 57), (57, 71), (71, 38), (38, 8), (8, 31), (31, 43), (43, 2), (2, 22), (22, 55), (55, 42), (42, 41), (41, 40), (40, 63), (63, 21), (21, 60), (60, 20), (20, 73), (73, 27), (27, 61), (61, 1), (1, 3), (3, 74), (74, 75), (75, 66), (66, 33), (33, 45), (45, 51), (51, 26), (26, 44), (44, 28), (28, 29), (29, 47), (47, 46), (46, 35), (35, 68), (68, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 4), (4, 14), (14, 56), (56, 12), (12, 53), (53, 18), (18, 7), (7, 34), (34, 6), (64, 65), (65, 10), (10, 52), (52, 13), (13, 58)]

Run 18 - Best Path Indices: [(3, 44), (44, 28), (28, 47), (47, 46), (46, 35), (35, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 4), (4, 14), (14, 56), (56, 26), (26, 51), (51, 33), (33, 45), (45, 7), (7, 18), (18, 53), (53, 12), (12, 52), (52, 13), (13, 58),
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Run 18 - Best Path Indices: [(3, 44), (44, 28), (28, 47), (47, 46), (46, 35), (35, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 4), (4, 14), (14, 56), (56, 26), (26, 51), (51, 33), (33, 45), (45, 7), (7, 18), (18, 53), (53, 12), (12, 52), (52, 13), (13, 58), (58, 65), (65, 64), (64, 37), (37, 10), (10, 6), (6, 34), (34, 66), (66, 25), (25, 16), (16, 39), (39, 11), (11, 50), (50, 5), (5, 67), (67, 74), (74, 75), (75, 1), (1, 29), (29, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 9), (9, 57), (57, 71), (71, 38), (38, 8), (8, 31), (31, 43), (43, 2), (2, 22), (22, 55), (55, 40), (40, 41), (41, 63), (63, 21), (21, 0), (0, 42), (42, 60), (60, 20), (20, 68)]
Run 18 - Best Path Length: 610.08

Run 19 - Best Path Indices: [(2, 43), (43, 31), (31, 49), (49, 17), (17, 24), (24, 54), (54, 30), (30, 71), (71, 38), (38, 8), (8, 39), (39, 11), (11, 16), (16, 50), (50, 5), (5, 67), (67, 74), (74, 75), (75, 25), (25, 66), (66, 33), (33, 45), (45, 51), (51, 26), (26, 12), (12, 53), (53, 18), (18, 34), (34, 6), (6, 7), (7, 10), (10, 65), (65, 64), (64, 37), (37, 9), (9, 57), (57, 52), (52, 13), (13, 58), (58, 56), (56, 14), (14, 4), (4, 36), (36, 19), (19, 69), (69, 59), (59, 70), (70, 35), (35, 46), (46, 20), (20, 47), (47, 28), (28, 44), (44, 3), (3, 29), (29, 1), (1, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 48), (48, 23), (23, 22), (22, 55), (55, 40), (40, 41), (41, 42), (42, 0), (0, 21), (21, 60), (60, 68), (68, 63)]
Run 19 - Best Path Length: 612.53

Run 20 - Best Path Indices: [(0, 72), (72, 32), (32, 62), (62, 15), (15, 50), (50, 16), (16, 39), (39, 11), (11, 25), (25, 66), (66, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 4), (4, 46), (46, 35), (35, 68), (68, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 14), (14, 56), (56, 12), (12, 53), (53, 18), (18, 13), (13, 52), (52, 6), (6, 34), (34, 7), (7, 3), (3, 74), (74, 75), (75, 67), (67, 5), (5, 1), (1, 29), (29, 73), (73, 27), (27, 61), (61, 21), (21, 60), (60, 20), (20, 63), (63, 41), (41, 42), (42, 40), (40, 55), (55, 22), (22, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 9), (9, 37), (37, 64), (64, 65), (65, 10), (10, 58), (58, 57), (57, 71), (71, 38), (38, 8), (8, 31), (31, 43), (43, 2)]
Run 20 - Best Path Length: 584.1

Run 21 - Best Path Indices: [(2, 43), (43, 31), (31, 8), (8, 38), (38, 71), (71, 57), (57, 9), (9, 37), (37, 64), (64, 10), (10, 65), (65, 58), (58, 13), (13, 52), (52, 18), (18, 53), (53, 12), (12, 26), (26, 51), (51, 33), (33, 45), (45, 7), (7, 34), (34, 6), (6, 66), (66, 75), (75, 74), (74, 67), (67, 5), (5, 50), (50, 16), (16, 11), (11, 39), (39, 25), (25, 3), (3, 44), (44, 28), (28, 47), (47, 46), (46, 35), (35, 68), (68, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 4), (4, 14), (14, 56), (56, 20), (20, 60), (60, 21), (21, 0), (0, 42), (42, 40), (40, 41), (41, 63), (63, 55), (55, 22), (22, 1), (1, 29), (29, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30)]Run 21 - Best Path Length: 578.01

Run 22 - Best Path Indices: [(0, 42), (42, 72), (72, 32), (32, 62), (62, 15), (15, 48), (48, 23), (23, 22), (22, 55), (55, 40), (40, 41), (41, 63), (63, 21), (21, 61), (61, 27), (27, 73), (73, 29), (29, 1), (1, 67), (67, 5), (5, 50), (50, 2), (2, 43), (43, 31), (31, 49), (49, 17), (17, 24), (24, 54), (54, 30), (30, 9), (9, 57), (57, 71), (71, 38), (38, 8), (8, 39), (39, 11), (11, 16), (16, 25), (25, 6), (6, 34), (34, 7), (7, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 46), (46, 20), (20, 60), (60, 68), (68, 35), (35, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 4), (4, 14), (14, 56), (56, 12), (12, 53), (53, 18), (18, 13), (13, 58), (58, 65), (65, 64), (64, 37), (37, 10), (10, 52), (52, 3), (3, 74), (74, 75), (75, 66)]
Run 22 - Best Path Length: 573.81

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(34, 7), (7, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 46),
  (46, 35), (35, 68), (68, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 20), (20, 60)
0), (60, 21), (21, 61), (61, 27), (27, 73), (73, 29), (29, 1), (1, 67), (67, 5), (5, 5
0), (50, 16), (16, 11), (11, 39), (39, 25), (25, 66), (66, 75), (75, 74), (74, 3), (3,
 6), (6, 52), (52, 13), (13, 58), (58, 65), (65, 10), (10, 64), (64, 37), (37, 9), (9, 5
7), (57, 71), (71, 38), (38, 8), (8, 31), (31, 43), (43, 2), (2, 15), (15, 62), (62, 3)
2), (32, 72), (72, 0), (0, 42), (42, 40), (40, 41), (41, 63), (63, 55), (55, 22), (22, 4
8), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30)
Run 23 - Best Path Length: 553.99
Run 24 - Best Path Indices: [(1, 29), (29, 47), (47, 46), (46, 20), (20, 73), (73, 27),
  (27, 61), (61, 72), (72, 32), (32, 15), (15, 62), (62, 22), (22, 55), (55, 40), (40, 40)
1), (41, 42), (42, 0), (0, 21), (21, 60), (60, 68), (68, 35), (35, 70), (70, 59), (59, 60)
9), (69, 19), (19, 36), (36, 4), (4, 28), (28, 44), (44, 26), (26, 51), (51, 33), (33,
5), (45, 7), (7, 34), (34, 6), (6, 52), (52, 13), (13, 58), (58, 10), (10, 37), (37, 6
4), (64, 65), (65, 9), (9, 57), (57, 71), (71, 38), (38, 8), (8, 31), (31, 43), (43, 2),
 (2, 39), (39, 11), (11, 25), (25, 16), (16, 50), (50, 5), (5, 67), (67, 74), (74, 75),
  (75, 66), (66, 3), (3, 18), (18, 53), (53, 12), (12, 56), (56, 14), (14, 63), (63, 48),
  (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30)
Run 24 - Best Path Length: 620.3
Run 25 - Best Path Indices: [(3, 74), (74, 75), (75, 66), (66, 25), (25, 11), (11, 39),
  (39, 16), (16, 50), (50, 5), (5, 67), (67, 1), (1, 29), (29, 73), (73, 27), (27, 61),
  (61, 0), (0, 72), (72, 32), (32, 62), (62, 15), (15, 2), (2, 43), (43, 31), (31, 8),
  (8, 38), (38, 71), (71, 57), (57, 9), (9, 37), (37, 64), (64, 10), (10, 65), (65, 58),
  (58, 13), (13, 18), (18, 53), (53, 12), (12, 56), (56, 14), (14, 4), (4, 36), (36, 19),
  (19, 69), (69, 59), (59, 70), (70, 35), (35, 68), (68, 20), (20, 46), (46, 47), (47, 2)
8), (28, 44), (44, 26), (26, 51), (51, 45), (45, 33), (33, 7), (7, 34), (34, 6), (6, 5
2), (52, 30), (30, 54), (54, 24), (24, 49), (49, 17), (17, 23), (23, 48), (48, 55), (55,
 22), (22, 42), (42, 40), (40, 41), (41, 63), (63, 21), (21, 60)]
Run 25 - Best Path Length: 555.44
Run 26 - Best Path Indices: [(2, 43), (43, 31), (31, 8), (8, 38), (38, 71), (71, 57), (5
7, 9), (9, 37), (37, 64), (64, 65), (65, 10), (10, 52), (52, 18), (18, 13), (13, 58), (52, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18), (18, 18)
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 66), (66, 75), (75, 74), (74, 67), (67, 5), (5, 1), (1, 29), (29, 73), (73, 27), (27, 6
1), (61, 72), (72, 32), (32, 62), (62, 15), (15, 50), (50, 16), (16, 39), (39, 11), (11,
 25), (25, 3), (3, 44), (44, 28), (28, 47), (47, 46), (46, 35), (35, 68), (68, 70), (70,
 59), (59, 69), (69, 19), (19, 36), (36, 4), (4, 56), (56, 14), (14, 20), (20, 60), (60,
 21), (21, 0), (0, 63), (63, 41), (41, 42), (42, 40), (40, 55), (55, 22), (22, 48), (48,
 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30)]
Run 26 - Best Path Length: 570.13
Run 27 - Best Path Indices: [(3, 74), (74, 75), (75, 66), (66, 25), (25, 6), (6, 34), (3
4, 7), (7, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 29), (28, 48), (48, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48), (49, 48)
9, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 50), (50, 16),
  (16, 11), (11, 39), (39, 43), (43, 2), (2, 31), (31, 8), (8, 38), (38, 71), (71, 57),
  (57, 9), (9, 37), (37, 64), (64, 10), (10, 65), (65, 58), (58, 13), (13, 52), (52, 18),
  (18, 53), (53, 12), (12, 56), (56, 14), (14, 4), (4, 36), (36, 19), (19, 69), (69, 59),
  (59, 70), (70, 68), (68, 35), (35, 46), (46, 20), (20, 60), (60, 21), (21, 0), (0, 42),
  (42, 40), (40, 41), (41, 63), (63, 55), (55, 22), (22, 48), (48, 23), (23, 17), (17, 4
9), (49, 24), (24, 54), (54, 30), (30, 5), (5, 67), (67, 1)]
Run 27 - Best Path Length: 576.64
Run 28 - Best Path Indices: [(3, 44), (44, 28), (28, 4), (4, 47), (47, 46), (46, 35), (3
5, 68), (68, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36, 14), (14, 56), (56, 12),
 (12, 26), (26, 51), (51, 45), (45, 33), (33, 7), (7, 34), (34, 6), (6, 52), (52, 13),
  (13, 18), (18, 53), (53, 58), (58, 65), (65, 10), (10, 64), (64, 37), (37, 9), (9, 57),
  (57, 71), (71, 38), (38, 8), (8, 39), (39, 11), (11, 16), (16, 50), (50, 5), (5, 74),
  (74, 75), (75, 66), (66, 25), (25, 67), (67, 1), (1, 29), (29, 73), (73, 27), (27, 61),
  (61, 72), (72, 32), (32, 62), (62, 15), (15, 2), (2, 43), (43, 31), (31, 49), (49, 17),
  (17, 24), (24, 54), (54, 30), (30, 23), (23, 48), (48, 22), (22, 55), (55, 42), (42, 42)
1), (41, 40), (40, 63), (63, 21), (21, 60), (60, 20), (20, 0)]
```

Run 28 - Best Path Length: 608.09

Run 23 - Best Path Indices: [(4, 14), (14, 56), (56, 12), (12, 53), (53, 18), (18, 34),

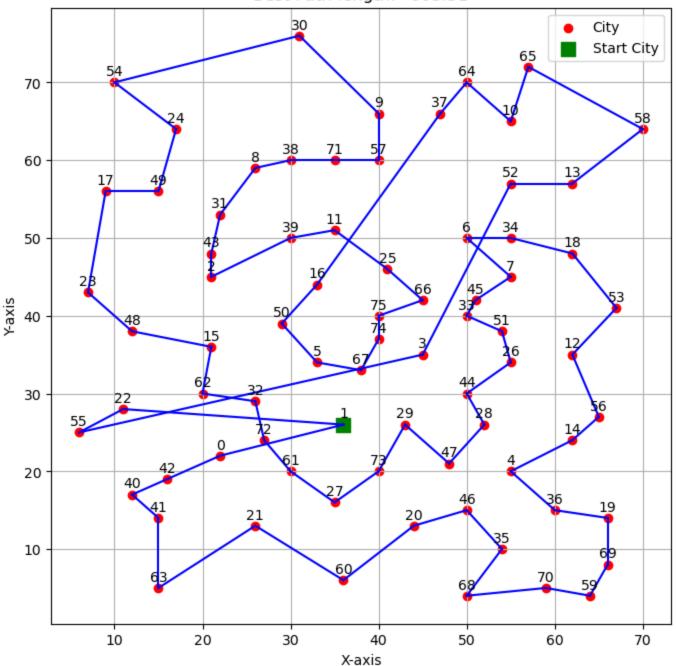
```
2), (2, 43), (43, 31), (31, 8), (8, 38), (38, 71), (71, 57), (57, 9), (9, 37), (37, 6)
4), (64, 10), (10, 65), (65, 58), (58, 13), (13, 52), (52, 6), (6, 34), (34, 7), (7, 4)
5), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 4), (4, 46), (46, 2
0), (20, 35), (35, 68), (68, 70), (70, 59), (59, 69), (69, 36), (36, 19), (19, 56), (56,
14), (14, 12), (12, 53), (53, 18), (18, 3), (3, 74), (74, 75), (75, 66), (66, 25), (25,
16), (16, 50), (50, 5), (5, 67), (67, 1), (1, 29), (29, 73), (73, 27), (27, 61), (61, 7)
2), (72, 32), (32, 15), (15, 62), (62, 63), (63, 21), (21, 60)]
Run 29 - Best Path Length: 598.72
Run 30 - Best Path Indices: [(1, 0), (0, 42), (42, 40), (40, 41), (41, 63), (63, 21), (2
1, 60), (60, 20), (20, 46), (46, 35), (35, 68), (68, 70), (70, 59), (59, 69), (69, 19),
 (19, 36), (36, 4), (4, 14), (14, 56), (56, 12), (12, 53), (53, 18), (18, 34), (34, 6),
 (6, 7), (7, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 29),
 (29, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 48), (48, 2)
3), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 9), (9, 57), (57, 71), (71, 3)
8), (38, 8), (8, 31), (31, 43), (43, 2), (2, 39), (39, 11), (11, 25), (25, 66), (66, 7
5), (75, 74), (74, 67), (67, 5), (5, 50), (50, 16), (16, 37), (37, 64), (64, 10), (10, 6
5), (65, 58), (58, 13), (13, 52), (52, 3), (3, 55), (55, 22)]
Run 30 - Best Path Length: 603.51
```

Run 29 - Best Path Indices: [(0, 42), (42, 41), (41, 40), (40, 55), (55, 22), (22, 23), (23, 48), (48, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 11), (11, 39), (39,

Calculating Best Path and Plot

```
import matplotlib.pyplot as plt
# Extract x and y coordinates from the list of coordinates
x coords, y coords = zip(*coordinates)
# Plot the coordinates
plt.figure(figsize=(8, 8))
plt.scatter(x coords, y coords, c='red', marker='o', label='City')
# Annotate each point with its index
for i, (x, y) in enumerate(coordinates):
    plt.annotate(str(i), (x, y), textcoords="offset points", xytext=(0, 5), ha='center')
# Connect the points in the order of the best path indices
for start, end in best path indices:
   x start, y start = coordinates[start]
    x end, y end = coordinates[end]
    plt.plot([x start, x end], [y start, y end], linestyle='-', color='blue')
# Connect back to the starting point
x start, y start = coordinates[best path indices[-1][1]]
x end, y end = coordinates[best path indices[0][0]]
plt.plot([x start, x end], [y start, y end], linestyle='-', color='blue')
# Mark the starting point with a different marker or color
start index = best path indices[0][0]
x start, y start = coordinates[start index]
plt.scatter(x start, y start, c='green', marker='s', s=100, label='Start City')
# Show the legend
plt.legend()
# Show the plot
plt.title(f'Coordinates Plot with Best Path\n\nDataset Instance={file path}\nBest Path l
plt.xlabel('X-axis')
plt.ylabel('Y-axis')
plt.grid(True)
plt.show()
```

Dataset Instance=eil76.tsp Best Path length:=603.51



Plotting Generation vs Execution time and Generation vs Best Path Length

```
In [5]: import time

# Lists to store data for plotting
generations_list = []
execution_times_list = []
best_path_lengths_list = []

# Run ACOGA for multiple generations
for generations in range(10, 500, 50):
    # Initialize ACOGA instance
    aco_ga = ACOGA(distances, n_ants=5, decay=0.95, alpha=1, beta=2, ga_population_size=
```

```
start time = time.time()
       # Run ACOGA
       result = aco ga.run()
       # Measure execution time
       execution time = time.time() - start time
      print(f"Generations: {generations}, Execution Time: {execution time:.4f} seconds")
       # Store data for plotting
       generations list.append(generations)
       execution times list.append(execution time)
      best path lengths list.append(result[1]) # Appending the best path length
       # Extract result data
      best path indices = result[0]
      best path length = np.round(result[1], 2)
       # Print results
      print("Best Path Indices:", best path indices)
      print("Best Path Length:", best path length)
# Plot time vs. generation
plt.plot(generations list, execution times list, marker='o')
plt.title('Execution Time vs. Generation')
plt.xlabel('Generation')
plt.ylabel('Execution Time (seconds)')
plt.grid(True)
plt.show()
# Plot best path length vs. generation
plt.plot(generations list, best path lengths list, marker='o')
plt.title('Best Path Length vs. Generation')
plt.xlabel('Generation')
plt.ylabel('Best Path Length')
plt.grid(True)
plt.show()
Generations: 10, Execution Time: 2.1861 seconds
Best Path Indices: [(2, 43), (43, 31), (31, 49), (49, 17), (17, 24), (24, 54), (54, 30),
(30, 9), (9, 57), (57, 71), (71, 38), (38, 8), (8, 39), (39, 11), (11, 16), (16, 50), (50)
0, 5), (5, 67), (67, 1), (1, 29), (29, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32,
62), (62, 15), (15, 48), (48, 23), (23, 55), (55, 22), (22, 0), (0, 42), (42, 40), (40,
41), (41, 63), (63, 21), (21, 60), (60, 20), (20, 46), (46, 47), (47, 28), (28, 44), (4
4, 3), (3, 74), (74, 75), (75, 25), (25, 66), (66, 33), (33, 45), (45, 7), (7, 34), (34,
6), (6, 52), (52, 10), (10, 64), (64, 37), (37, 65), (65, 58), (58, 13), (13, 18), (18,
53), (53, 56), (56, 14), (14, 36), (36, 4), (4, 35), (35, 68), (68, 70), (70, 59), (59,
69), (69, 19), (19, 12), (12, 26), (26, 51)]
Best Path Length: 573.67
Generations: 60, Execution Time: 12.0900 seconds
Best Path Indices: [(0, 42), (42, 40), (40, 41), (41, 63), (63, 21), (21, 61), (61, 72),
(72, 32), (32, 62), (62, 15), (15, 50), (50, 16), (16, 11), (11, 39), (39, 43), (43, 2),
(2, 31), (31, 8), (8, 38), (38, 71), (71, 57), (57, 9), (9, 30), (30, 37), (37, 64), (6, 71)
4, 10), (10, 65), (65, 58), (58, 13), (13, 52), (52, 34), (34, 6), (6, 7), (7, 18), (18, 18)
53), (53, 12), (12, 56), (56, 14), (14, 4), (4, 36), (36, 19), (19, 69), (69, 59), (59,
70), (70, 35), (35, 68), (68, 60), (60, 20), (20, 46), (46, 47), (47, 28), (28, 44), (4
4, 3), (3, 74), (74, 75), (75, 25), (25, 66), (66, 33), (33, 45), (45, 51), (51, 26), (25, 26), (27, 28), (28, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28), (29, 28)
(6, 67), (67, 5), (5, 1), (1, 29), (29, 73), (73, 27), (27, 22), (22, 55), (55, 48), (48, 48)
23), (23, 17), (17, 49), (49, 24), (24, 54)]
Best Path Length: 568.45
Generations: 110, Execution Time: 23.2635 seconds
Best Path Indices: [(3, 66), (66, 33), (33, 45), (45, 51), (51, 26), (26, 12), (12, 53),
(53, 18), (18, 34), (34, 6), (6, 7), (7, 44), (44, 28), (28, 47), (47, 29), (29, 1), (1, 10)
73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 50), (50, 16), (1
```

Measure execution time

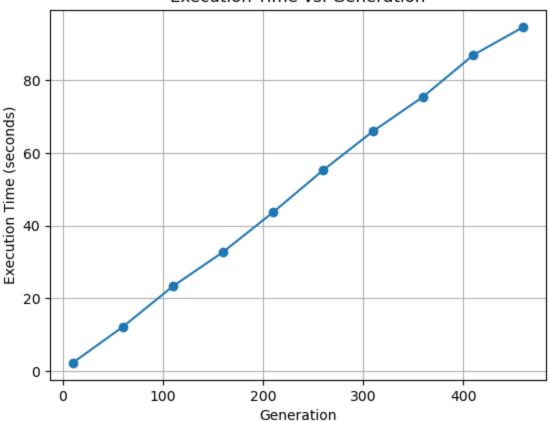
```
6, 39), (39, 11), (11, 25), (25, 75), (75, 74), (74, 67), (67, 5), (5, 2), (2, 43), (43,
31), (31, 8), (8, 38), (38, 71), (71, 57), (57, 9), (9, 37), (37, 64), (64, 65), (65, 1)
0), (10, 13), (13, 52), (52, 58), (58, 56), (56, 14), (14, 4), (4, 36), (36, 19), (19, 6
9), (69, 59), (59, 70), (70, 68), (68, 35), (35, 46), (46, 20), (20, 60), (60, 21), (21,
0), (0, 42), (42, 40), (40, 41), (41, 63), (63, 55), (55, 22), (22, 48), (48, 23), (23,
17), (17, 49), (49, 24), (24, 54), (54, 30)]
Best Path Length: 583.06
Generations: 160, Execution Time: 32.6805 seconds
Best Path Indices: [(0, 42), (42, 40), (40, 41), (41, 63), (63, 21), (21, 60), (60, 68),
(68, 47), (47, 28), (28, 44), (44, 3), (3, 74), (74, 75), (75, 66), (66, 33), (33, 45),
(45, 7), (7, 6), (6, 34), (34, 52), (52, 13), (13, 18), (18, 53), (53, 12), (12, 56), (52, 13), (13, 18), (14, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18), (15, 18)
6, 14), (14, 4), (4, 36), (36, 19), (19, 69), (69, 59), (59, 70), (70, 35), (35, 46), (4
(6, 20), (20, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 48),
(48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 71), (71, 57), (57, 9),
(9, 37), (37, 64), (64, 10), (10, 65), (65, 58), (58, 26), (26, 51), (51, 67), (67, 1),
(1, 29), (29, 5), (5, 50), (50, 16), (16, 25), (25, 11), (11, 39), (39, 38), (38, 8),
(8, 31), (31, 43), (43, 2), (2, 22), (22, 55)]
Best Path Length: 604.09
Generations: 210, Execution Time: 43.6257 seconds
Best Path Indices: [(0, 72), (72, 32), (32, 62), (62, 15), (15, 50), (50, 5), (5, 67),
(67, 74), (74, 75), (75, 66), (66, 25), (25, 11), (11, 39), (39, 16), (16, 2), (2, 43),
(43, 31), (31, 49), (49, 17), (17, 23), (23, 48), (48, 55), (55, 22), (22, 40), (40, 4
1), (41, 42), (42, 63), (63, 21), (21, 61), (61, 1), (1, 29), (29, 73), (73, 27), (27, 6
0), (60, 20), (20, 46), (46, 35), (35, 70), (70, 59), (59, 69), (69, 19), (19, 36), (36,
4), (4, 14), (14, 56), (56, 12), (12, 53), (53, 18), (18, 7), (7, 34), (34, 6), (6, 45),
(45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 68), (68, 3), (3, 57),
(57, 71), (71, 38), (38, 8), (8, 24), (24, 54), (54, 30), (30, 9), (9, 37), (37, 64), (60, 10)
4, 10), (10, 65), (65, 58), (58, 13), (13, 52)]
Best Path Length: 602.06
Generations: 260, Execution Time: 55.2325 seconds
Best Path Indices: [(0, 72), (72, 61), (61, 27), (27, 73), (73, 29), (29, 1), (1, 67),
(67, 5), (5, 50), (50, 16), (16, 39), (39, 11), (11, 25), (25, 66), (66, 75), (75, 74),
(74, 3), (3, 44), (44, 28), (28, 47), (47, 46), (46, 20), (20, 60), (60, 21), (21, 63),
(63, 41), (41, 40), (40, 42), (42, 22), (22, 55), (55, 48), (48, 23), (23, 15), (15, 6
2), (62, 32), (32, 2), (2, 43), (43, 31), (31, 49), (49, 17), (17, 24), (24, 54), (54, 3
0), (30, 9), (9, 57), (57, 71), (71, 38), (38, 8), (8, 37), (37, 64), (64, 65), (65, 1
0), (10, 52), (52, 13), (13, 58), (58, 7), (7, 34), (34, 6), (6, 18), (18, 53), (53, 1
2), (12, 26), (26, 51), (51, 33), (33, 45), (45, 56), (56, 14), (14, 4), (4, 36), (36, 1
9), (19, 69), (69, 59), (59, 70), (70, 35), (35, 68)]
Best Path Length: 589.46
Generations: 310, Execution Time: 65.9934 seconds
Best Path Indices: [(1, 0), (0, 42), (42, 40), (40, 41), (41, 63), (63, 21), (21, 60),
(60, 20), (20, 46), (46, 35), (35, 68), (68, 70), (70, 59), (59, 69), (69, 19), (19, 3)
6), (36, 4), (4, 14), (14, 56), (56, 12), (12, 53), (53, 18), (18, 34), (34, 6), (6, 7),
(7, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 29), (29, 73),
(73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 50), (50, 16), (16, 3)
9), (39, 11), (11, 25), (25, 66), (66, 75), (75, 74), (74, 3), (3, 67), (67, 5), (5, 3
0), (30, 10), (10, 52), (52, 13), (13, 58), (58, 65), (65, 64), (64, 37), (37, 9), (9,
7), (57, 71), (71, 38), (38, 8), (8, 2), (2, 43), (43, 31), (31, 49), (49, 17), (17, 5)
4), (54, 24), (24, 23), (23, 48), (48, 22), (22, 55)]
Best Path Length: 592.85
Generations: 360, Execution Time: 75.4846 seconds
Best Path Indices: [(3, 44), (44, 28), (28, 47), (47, 46), (46, 20), (20, 73), (73, 27),
(27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 48), (48, 23), (23, 17), (17, 48)
9), (49, 24), (24, 54), (54, 30), (30, 71), (71, 57), (57, 9), (9, 37), (37, 64), (64, 6
5), (65, 10), (10, 52), (52, 13), (13, 18), (18, 53), (53, 12), (12, 26), (26, 51), (51,
(33), (33, 45), (45, 7), (7, 34), (34, 6), (6, 66), (66, 75), (75, 74), (74, 67), (67, 75)
5), (5, 50), (50, 16), (16, 39), (39, 11), (11, 25), (25, 38), (38, 8), (8, 31), (31, 4
3), (43, 2), (2, 55), (55, 22), (22, 42), (42, 40), (40, 41), (41, 63), (63, 21), (21, 63)
0), (60, 0), (0, 1), (1, 29), (29, 68), (68, 35), (35, 70), (70, 59), (59, 69), (69, 1
9), (19, 36), (36, 4), (4, 14), (14, 56), (56, 58)]
Best Path Length: 616.05
Generations: 410, Execution Time: 86.9588 seconds
Best Path Indices: [(0, 42), (42, 40), (40, 41), (41, 63), (63, 55), (55, 22), (22, 2),
(2, 43), (43, 39), (39, 11), (11, 16), (16, 50), (50, 5), (5, 67), (67, 74), (74, 75),
```

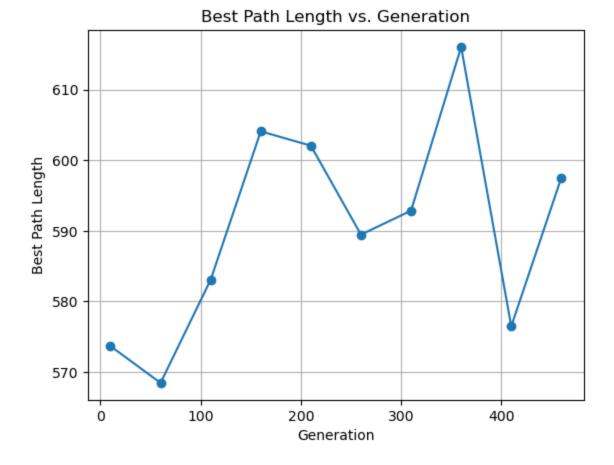
(75, 25), (25, 66), (66, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 44)

(18, 53), (53, 12), (12, 56), (56, 14), (14, 4), (4, 36), (36, 19), (19, 69), (69, 59),(59, 70), (70, 35), (35, 68), (68, 60), (60, 21), (21, 61), (61, 72), (72, 32), (32, 61)2), (62, 15), (15, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 9), (9, 57), (57, 71), (71, 38), (38, 8), (8, 31)] Best Path Length: 576.47 Generations: 460, Execution Time: 94.6785 seconds Best Path Indices: [(1, 67), (67, 5), (5, 50), (50, 32), (32, 62), (62, 15), (15, 48), (48, 23), (23, 17), (17, 49), (49, 24), (24, 54), (54, 30), (30, 9), (9, 57), (57, 71),(71, 38), (38, 8), (8, 37), (37, 64), (64, 10), (10, 65), (65, 58), (58, 13), (13, 18),(18, 53), (53, 12), (12, 56), (56, 14), (14, 4), (4, 28), (28, 47), (47, 29), (29, 0),(0, 42), (42, 40), (40, 41), (41, 63), (63, 21), (21, 60), (60, 68), (68, 70), (70, 59),(59, 69), (69, 19), (19, 36), (36, 35), (35, 46), (46, 20), (20, 73), (73, 27), (27, 6 1), (61, 72), (72, 55), (55, 22), (22, 2), (2, 43), (43, 31), (31, 39), (39, 11), (11, 12)6), (16, 25), (25, 66), (66, 75), (75, 74), (74, 3), (3, 44), (44, 26), (26, 51), (51, 3 3), (33, 45), (45, 7), (7, 34), (34, 6), (6, 52)] Best Path Length: 597.54

7), (47, 46), (46, 20), (20, 27), (27, 73), (73, 1), (1, 29), (29, 3), (3, 7), (7, 34), (34, 6), (6, 52), (52, 13), (13, 58), (58, 65), (65, 64), (64, 37), (37, 10), (10, 18),

Execution Time vs. Generation





Plotting Best Path on different Parameters

```
In [6]: # Lists to store data for plotting
        generations list = []
        execution times list = []
        best path lengths list = []
        # Various Parameter combination to achieve best solution
        parameter combinations = [
            (5, 0.9, 1, 1, 100, 2, 0.7, 0.8, 500),
            (7, 0.95, 2, 2, 200, 2, 0.8, 0.7, 600),
            (10, 0.99, 3, 3, 300, 2, 0.9, 0.9, 700),
        for params in parameter combinations:
            n ants, decay, alpha, beta, ga population size, ga elite size, ga mutation rate, ga
            aco ga = ACOGA(distances, n ants=n ants, decay=decay, alpha=alpha, beta=beta,
                           ga population size=ga population size, ga elite size=ga elite size,
                           ga mutation rate=ga mutation rate, ga crossover prob = ga crossover p
            # Measure execution time
            start time = time.time()
            # Run ACOGA
            result = aco ga.run()
            # Measure execution time
            execution time = time.time() - start time
            print(f"Generations: {generations}, Execution Time: {execution time:.4f} seconds")
            # Store data for plotting
            generations list.append(generations)
            execution times list.append(execution time)
            best path lengths list.append(result[1]) # Appending the best path length
```

```
best path indices = result[0]
    best path length = np.round(result[1], 2)
    # Print results
    print("Best Path Indices:", best path indices)
    print("Best Path Length:", best path length)
    # Extract x and y coordinates from the list of coordinates
    x coords, y coords = zip(*coordinates)
    # Plot the coordinates
    plt.figure(figsize=(8, 8))
    plt.scatter(x coords, y coords, c='red', marker='o', label='City')
    # Annotate each point with its index
    for i, (x, y) in enumerate(coordinates):
        plt.annotate(str(i), (x, y), textcoords="offset points", xytext=(0, 5), ha='cent
    # Connect the points in the order of the best path indices
    for start, end in best path indices:
        x start, y start = coordinates[start]
        x end, y end = coordinates[end]
        plt.plot([x_start, x_end], [y_start, y_end], linestyle='-', color='blue')
    # Connect back to the starting point
    x start, y start = coordinates[best path indices[-1][1]]
    x end, y end = coordinates[best path indices[0][0]]
    plt.plot([x start, x end], [y start, y end], linestyle='-', color='blue')
    # Mark the starting point with a different marker or color
    start index = best path indices[0][0]
    x start, y start = coordinates[start index]
    plt.scatter(x start, y start, c='green', marker='s', s=100, label='Start City')
    # Show the legend
    plt.legend()
    # Show the plot
    #plt.title('Coordinates Plot with Best Path')
    plt.title(f'Coordinates Plot with Best Path\n\nParameters:n ants={n ants},decay={dec
    plt.xlabel('X-axis')
    plt.ylabel('Y-axis')
   plt.grid(True)
   plt.show()
Generations: 500, Execution Time: 103.7992 seconds
Best Path Indices: [(2, 43), (43, 31), (31, 8), (8, 38), (38, 57), (57, 71), (71, 9),
(9, 64), (64, 37), (37, 30), (30, 54), (54, 24), (24, 17), (17, 49), (49, 48), (48, 23),
(23, 15), (15, 50), (50, 16), (16, 39), (39, 11), (11, 25), (25, 75), (75, 66), (66, 3)
3), (33, 45), (45, 7), (7, 34), (34, 6), (6, 52), (52, 10), (10, 65), (65, 58), (58, 1
3), (13, 18), (18, 53), (53, 12), (12, 26), (26, 51), (51, 56), (56, 14), (14, 19), (19,
36), (36, 35), (35, 70), (70, 59), (59, 69), (69, 68), (68, 20), (20, 46), (46, 60), (6
```

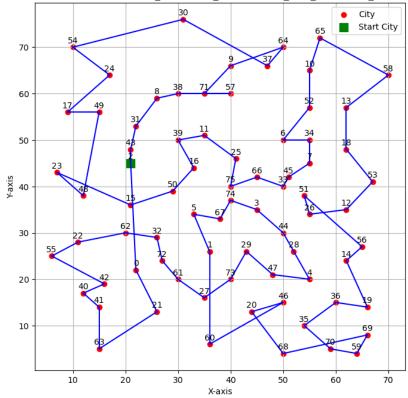
0, 1), (1, 5), (5, 67), (67, 74), (74, 3), (3, 44), (44, 28), (28, 4), (4, 47), (47, 2 9), (29, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 22), (22, 55), (55,

42), (42, 40), (40, 41), (41, 63), (63, 21), (21, 0)]

Best Path Length: 612.07

Extract result data

Parameters:n_ants=5,decay=0.9, alpha=1, beta=1, ga_population_size=100, ga_elite_size=2, ga_mutation_rate=0.7, generations=500

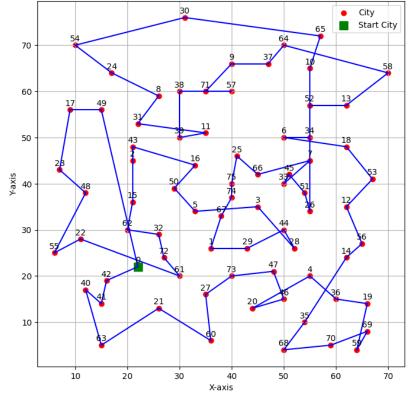


Generations: 600, Execution Time: 173.3319 seconds

Best Path Indices: [(0, 42), (42, 41), (41, 40), (40, 63), (63, 21), (21, 60), (60, 27), (27, 73), (73, 47), (47, 46), (46, 20), (20, 4), (4, 36), (36, 19), (19, 59), (59, 69), (69, 70), (70, 68), (68, 35), (35, 14), (14, 56), (56, 12), (12, 53), (53, 18), (18, 6), (6, 34), (34, 52), (52, 13), (13, 58), (58, 64), (64, 37), (37, 9), (9, 71), (71, 57), (57, 38), (38, 39), (39, 11), (11, 31), (31, 8), (8, 24), (24, 54), (54, 30), (30, 65), (65, 10), (10, 26), (26, 51), (51, 45), (45, 33), (33, 7), (7, 66), (66, 25), (25, 75), (75, 74), (74, 67), (67, 1), (1, 29), (29, 44), (44, 28), (28, 3), (3, 5), (5, 50), (50, 16), (16, 43), (43, 2), (2, 15), (15, 62), (62, 32), (32, 72), (72, 61), (61, 22), (22, 55), (55, 48), (48, 23), (23, 17), (17, 49)]

Best Path Length: 665.37

Parameters:n_ants=7,decay=0.95, alpha=2, beta=2, ga_population_size=200, ga_elite_size=2, ga_mutation_rate=0.8, generations=600



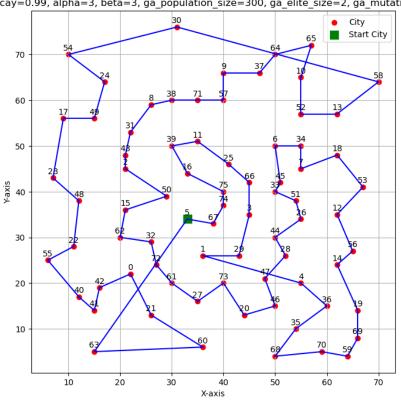
Generations: 700, Execution Time: 306.5323 seconds

Best Path Indices: [(5, 67), (67, 74), (74, 75), (75, 16), (16, 39), (39, 11), (11, 25), (25, 66), (66, 3), (3, 29), (29, 1), (1, 4), (4, 36), (36, 35), (35, 68), (68, 70), (70, 59), (59, 69), (69, 19), (19, 14), (14, 56), (56, 12), (12, 53), (53, 18), (18, 7), (7, 34), (34, 6), (6, 45), (45, 33), (33, 51), (51, 26), (26, 44), (44, 28), (28, 47), (47, 46), (46, 20), (20, 73), (73, 27), (27, 61), (61, 72), (72, 32), (32, 62), (62, 15), (15, 50), (50, 2), (2, 43), (43, 31), (31, 8), (8, 38), (38, 71), (71, 57), (57, 9), (9, 37), (37, 64), (64, 65), (65, 10), (10, 52), (52, 13), (13, 58), (58, 30), (30, 54), (54, 24), (24, 49), (49, 17), (17, 23), (23, 48), (48, 22), (22, 55), (55, 40), (40, 41), (41, 42), (42, 0), (0, 21), (21, 60), (60, 63)]

Best Path Length: 582.77

Coordinates Plot with Best Path

Parameters:n_ants=10,decay=0.99, alpha=3, beta=3, ga_population_size=300, ga_elite_size=2, ga_mutation_rate=0.9, generations=700

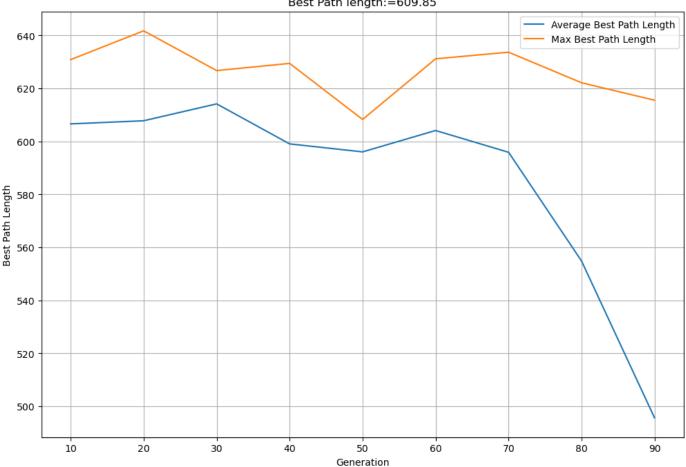


Plotting avg-avg and max-avg versus number of generations

```
In [7]: import numpy as np
        import matplotlib.pyplot as plt
        import time
        # Lists to store data for plotting
        generations list = []
        execution times list = []
        overall avg best path lengths list = []
        overall max best path lengths list = []
        # Define the parameter combinations for ACOGA
        parameter combinations = [(10, 5, 0.95, 1, 2, 400, 2, 0.8, 0.9)]
        # Run ACOGA for multiple generations
        for generations in range(10, 100, 10):
            # Initialize arrays to store path length values
            num generations acoga = generations
            avg best path length = np.zeros((num generations acoga,))
            max best path length = np.zeros((num generations acoga,))
            num runs = 5
            for params idx, params in enumerate(parameter combinations):
                num of generations, n ants, decay, alpha, beta, ga population size, ga elite siz
                for run in range(num runs):
                    # Initialize ACOGA instance
                    aco ga = ACOGA(distances, n ants=n ants, decay=decay, alpha=alpha, beta=beta
                                   ga elite size=ga elite size, ga mutation rate=ga mutation rat
                                   generations=num of generations)
                    # Measure execution time
                    start time = time.time()
                    # Run ACOGA
                    result = aco ga.run()
                    # Measure execution time
                    execution time = time.time() - start time
                    # Store data for plotting
                    execution times list.append(execution time)
                    # Extract result data
                    best path indices = result[0]
                    # Calculate best path length
                    best path length = np.sum([distances[i, j] for i, j in best path indices])
                    # Update best path length arrays
                    avg best path length[:len(best path indices)] += np.array([best path length]
                    max best path length[:len(best path indices)] = np.maximum(max best path len
                    # Print results
                    #print("Best Path Indices:", best path indices)
                   # print("Best Path Length:", best path length)
            # Print average and maximum best path lengths after all runs for each generation
```

```
overall avg best path length = np.mean(avg best path length[:num generations acoga])
    overall max best path length = np.max(max best path length[:num generations acoga])
    print("generations:", generations)
    print("overall avg best path length:", overall avg best path length)
    print("overall max best path length:", overall max best path length)
    generations list.append(generations)
    overall avg best path lengths list.append(overall avg best path length)
    overall max best path lengths list.append(overall max best path length)
# Plotting with magnified figure size
plt.figure(figsize=(12, 8))
# Plotting
plt.plot(generations list, overall avg best path lengths list, label='Average Best Path
plt.plot(generations list, overall max best path lengths list, label='Max Best Path Leng
# Customize plot appearance
plt.xlabel('Generation')
plt.ylabel('Best Path Length')
plt.title('Overall Best Path Lengths vs. Generation')
plt.title(f'Tour Length vs. Generation\n\nDataset Instance={file path}\nBest Path length
plt.legend()
plt.grid(True)
plt.show()
generations: 10
overall avg best path length: 606.582000000001
overall max best path length: 630.83
generations: 20
overall avg best path length: 607.760000000001
overall max best path length: 641.69
generations: 30
overall avg best path length: 614.132000000002
overall max best path length: 626.69
generations: 40
overall avg best path length: 599.028000000001
overall_max_best_path length: 629.4000000000002
generations: 50
overall avg best path length: 596.020000000001
overall max best path length: 608.25
generations: 60
overall avg best path length: 604.080000000002
overall max best path length: 631.13
generations: 70
overall avg best path length: 595.872000000002
overall max best path length: 633.630000000001
generations: 80
overall avg best path length: 554.840625
overall max best path length: 622.09
generations: 90
overall avg best path length: 495.6733333333333
overall max best path length: 615.5099999999999
```

Dataset Instance=eil76.tsp Best Path length:=609.85



```
import numpy as np
In [8]:
        import matplotlib.pyplot as plt
        import time
        # Lists to store data for plotting
        generations list = []
        execution times list = []
        overall avg best path lengths list = []
        overall max best path lengths list = []
        # Define the parameter combinations for ACOGA
        # Define the parameter combinations for ACOGA
        parameter combinations = [(10, 5, 0.95, 1, 2, 400, 2, 0.8, 0.9)]
        # Run ACOGA for multiple generations
        for generations in range(10, 500, 10):
            # Initialize arrays to store path length values
            num generations acoga = generations
            avg best path length = np.zeros((num generations acoga,))
            max best path length = np.zeros((num generations acoga,))
            for params idx, params in enumerate (parameter combinations):
                num of generations, n ants, decay, alpha, beta, ga population size, ga elite siz
                num runs = 30
                for run in range(num runs):
                    # Initialize ACOGA instance
                    aco ga = ACOGA(distances, n ants=n ants, decay=decay, alpha=alpha, beta=beta
                                   ga elite size=ga elite size, ga mutation rate=ga mutation rat
                                   generations=num of generations)
```

```
# Measure execution time
            start time = time.time()
            # Run ACOGA
            result = aco ga.run()
            # Measure execution time
            execution time = time.time() - start time
            # Store data for plotting
            execution times list.append(execution time)
            # Extract result data
            best path indices = result[0]
            # Calculate best path length
            best path length = np.sum([distances[i, j] for i, j in best path indices])
            # Update best path length arrays
            avg best path length[:len(best path indices)] = np.array([best path length])
            max best path length[:len(best path indices)] = np.maximum(max best path len
            # Print results
            #print("Best Path Indices:", best path indices)
            #print("Best Path Length:", best path length)
    # Print average and maximum best path lengths after all runs for each generation
    #overall avg best path length = np.mean(avg best path length[:num generations acoga]
    #overall max best path length = np.max(max best path length[:num generations acoga])
    overall avg best path length = np.mean(avg best path length[:num runs])
    overall max best path length = np.max(max best path length[:num runs])
    print("generations:", generations)
   print("overall avg best path length:", overall avg best path length)
    print("overall max best path length:", overall max best path length)
    generations list.append(generations)
    overall avg best path lengths list.append(overall avg best path length)
    overall max best path lengths list.append(overall max best path length)
# Plotting with magnified figure size
plt.figure(figsize=(12, 8))
# Plotting
plt.plot(generations list, overall avg best path lengths list, label='Avg-Avg Tour Lengt
plt.plot(generations list, overall max best path lengths list, label='Max-Avg Tour Lengt
# Customize plot appearance
plt.xlabel('Generation')
plt.ylabel('Best Path Length')
plt.title('Overall Best Path Lengths vs. Generation')
plt.title(f'Tour Length vs. Generation\nDataset Instance={file path}\n\nParameters:n ant
plt.legend()
plt.grid(True)
plt.show()
generations: 10
```

overall_avg_best_path_length: 578.82 overall_max_best_path_length: 623.89

```
generations: 20
overall avg best path length: 596.170000000001
overall max best path length: 621.629999999999
generations: 30
overall avg best path length: 619.28
overall max best path length: 632.140000000001
generations: 40
overall avg best path length: 578.120000000001
overall max best path length: 630.650000000001
generations: 50
overall avg best path length: 588.810000000001
overall max best path length: 642.03
generations: 60
overall avg best path length: 573.7900000000003
overall max best path length: 658.85
generations: 70
overall avg best path length: 602.930000000001
overall max best path length: 628.23
generations: 80
overall avg best path length: 572.19
overall max best path length: 629.630000000001
generations: 90
overall avg best path length: 620.430000000001
overall max best path length: 636.99
generations: 100
overall avg best path length: 595.360000000001
overall max best path length: 631.249999999999
generations: 110
overall avg best path length: 602.360000000001
overall max best path length: 624.65
generations: 120
overall avg best path length: 614.97
overall max best path length: 631.22
generations: 130
overall avg best path length: 597.360000000001
overall max best path length: 626.85
generations: 140
overall avg best path length: 594.45
overall max best path length: 622.87
generations: 150
overall avg best path length: 588.729999999998
overall max best path length: 637.620000000001
generations: 160
overall avg best path length: 605.9799999999999
overall max best path length: 646.41
generations: 170
overall avg best path length: 614.5400000000003
overall max best path length: 626.6499999999999
generations: 180
overall avg best path length: 611.5800000000003
overall max best path length: 626.75
generations: 190
overall avg best path length: 611.500000000001
overall max best path length: 632.270000000001
generations: 200
overall avg best path length: 587.589999999999
overall max best path length: 641.119999999999
generations: 210
overall avg best path length: 610.78
overall max best path length: 639.92
generations: 220
overall avg best path length: 646.4799999999999
overall max best path length: 646.48
generations: 230
overall avg best path length: 623.84
```

overall max best path length: 648.730000000001

```
generations: 240
overall avg best path length: 608.130000000003
overall max best path length: 648.3199999999999
generations: 250
overall avg best path length: 616.28
overall max best path length: 630.370000000001
generations: 260
overall avg best path length: 621.049999999998
overall max best path length: 635.940000000002
generations: 270
overall avg best path length: 580.950000000002
overall max best path length: 632.44
generations: 280
overall avg best path length: 614.209999999998
overall max best path length: 640.32
generations: 290
overall avg best path length: 569.209999999998
overall max best path length: 641.05
generations: 300
overall avg best path length: 613.610000000002
generations: 310
overall avg best path length: 588.209999999998
overall max best path length: 654.819999999999
generations: 320
overall avg best path length: 602.379999999999
overall max best path length: 622.43
generations: 330
overall avg best path length: 568.440000000002
overall max best path length: 643.310000000001
generations: 340
overall max best path length: 626.37
generations: 350
overall avg best path length: 619.88
overall max best path length: 639.920000000001
generations: 360
overall avg best path length: 586.900000000001
overall max best path length: 634.29
generations: 370
overall avg best path length: 576.79999999998
overall max best path length: 630.910000000001
generations: 380
overall avg best path length: 625.509999999998
overall max best path length: 640.8
generations: 390
overall avg best path length: 604.0099999999999
overall max best path length: 632.64
generations: 400
overall avg best path length: 612.169999999997
overall max best path length: 627.45
generations: 410
overall avg best path length: 574.01
overall max best path length: 639.439999999998
generations: 420
overall avg best path length: 620.310000000002
overall max best path length: 627.089999999999
generations: 430
overall avg best path length: 632.31
overall max best path length: 632.309999999998
generations: 440
overall avg best path length: 611.860000000001
overall max best path length: 632.110000000001
generations: 450
overall avg best path length: 599.700000000002
```

overall max best path length: 634.650000000001

```
generations: 460

overall_avg_best_path_length: 582.669999999998

overall_max_best_path_length: 628.63

generations: 470

overall_avg_best_path_length: 593.95000000000002

overall_max_best_path_length: 632.5000000000001

generations: 480

overall_avg_best_path_length: 606.0400000000002

overall_max_best_path_length: 637.960000000002

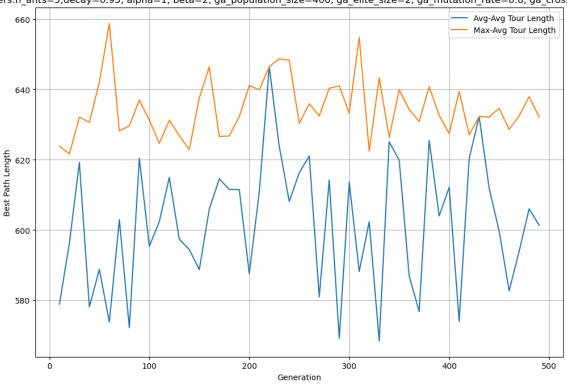
generations: 490

overall_avg_best_path_length: 601.349999999999

overall_max_best_path_length: 632.119999999999
```

Tour Length vs. Generation Dataset Instance=eil76.tsp

Parameters:n_ants=5,decay=0.95, alpha=1, beta=2, ga_population_size=400, ga_elite_size=2, ga_mutation_rate=0.8, ga_crossover_prob=0.9



Tn []: