In [18]:
```
pip install pygad
```

```
Requirement already satisfied: pygad in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (3.0.1)
Requirement already satisfied: cloudpickle in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (from pyg
ad) (2.2.1)
Requirement already satisfied: matplotlib in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (from pyga
d) (3.7.1)
Requirement already satisfied: numpy in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (from pygad)
(1.24.3)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (fro
m matplotlib->pygad) (1.0.7)
Requirement already satisfied: cycler>=0.10 in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (from ma
tplotlib->pygad) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (fr
om matplotlib->pygad) (4.39.4)
Requirement already satisfied: kiwisolver>=1.0.1 in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (fr
om matplotlib->pygad) (1.4.4)
Requirement already satisfied: packaging>=20.0 in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (from
matplotlib->pygad) (23.1)
Requirement already satisfied: pillow>=6.2.0 in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (from m
atplotlib->pygad) (9.5.0)
Requirement already satisfied: pyparsing>=2.3.1 in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (fro
m matplotlib->pygad) (3.0.9)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages
(from matplotlib->pygad) (2.8.2)
Requirement already satisfied: six>=1.5 in c:\users\anu\appdata\local\programs\python\python311\lib\site-packages (from python
-dateutil>=2.7->matplotlib->pygad) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

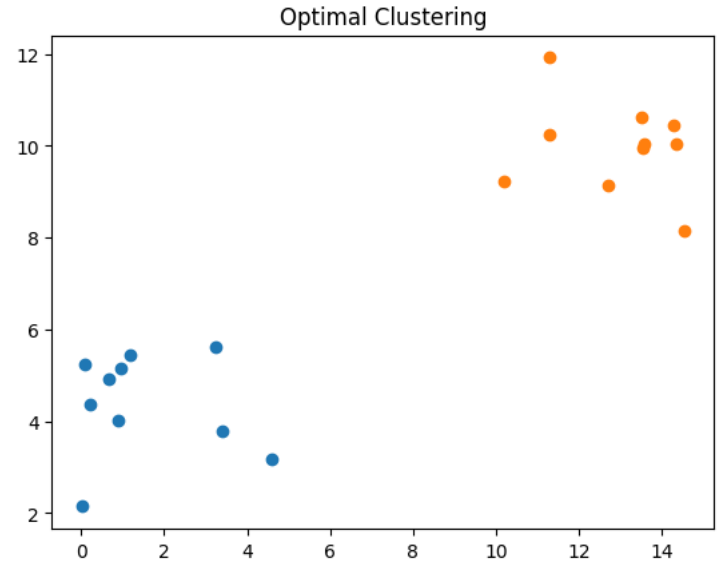
In [19]:
```
import numpy
import matplotlib.pyplot
import pygad
```

In [20]:
```
cluster1_num_samples = 10
cluster1_x1_start = 0
cluster1_x1_end = 5
cluster1_x2_start = 2
cluster1_x2_end = 6
cluster1_x1 = numpy.random.random(size=(cluster1_num_samples))
cluster1_x1 = cluster1_x1 * (cluster1_x1_end - cluster1_x1_start) + cluster1_x1_start
cluster1_x2 = numpy.random.random(size=(cluster1_num_samples))
cluster1_x2 = cluster1_x2 * (cluster1_x2_end - cluster1_x2_start) + cluster1_x2_start
cluster2_num_samples = 10
cluster2_x1_start = 10
cluster2_x1_end = 15
cluster2_x2_start = 8
cluster2_x2_end = 12
cluster2_x1 = numpy.random.random(size=(cluster2_num_samples))
cluster2_x1 = cluster2_x1 * (cluster2_x1_end - cluster2_x1_start) + cluster2_x1_start
cluster2_x2 = numpy.random.random(size=(cluster2_num_samples))
cluster2_x2 = cluster2_x2 * (cluster2_x2_end - cluster2_x2_start) + cluster2_x2_start
```

In [21]:
```
c1 = numpy.array([cluster1_x1, cluster1_x2]).T
c2 = numpy.array([cluster2_x1, cluster2_x2]).T
data = numpy.concatenate((c1, c2), axis=0)
data
```

Out[21]:
```
array([[ 1.1775946 ,  5.43290772],
       [ 0.95993863,  5.15502756],
       [ 0.88300444,  4.02848543],
       [ 0.01913205,  2.14206383],
       [ 4.58301362,  3.17572358],
       [ 3.41728352,  3.78600333],
       [ 0.08511803,  5.25113991],
       [ 0.67057827,  4.91649955],
       [ 3.24288757,  5.62494897],
       [ 0.20925684,  4.37867254],
       [14.34022737, 10.04592314],
       [14.28643765, 10.44567791],
       [11.27999188, 11.92117175],
       [13.52117636, 10.61339111],
       [13.54540002,  9.9519066 ],
       [10.18423373,  9.23892201],
       [11.29558292, 10.2508982 ],
       [14.5396121 ,  8.1466815 ],
       [13.58803204, 10.0357953 ],
       [12.71364296,  9.12674093]])
```

In [22]:
```
matplotlib.pyplot.scatter(cluster1_x1, cluster1_x2)
matplotlib.pyplot.scatter(cluster2_x1, cluster2_x2)
matplotlib.pyplot.title("Optimal Clustering")
matplotlib.pyplot.show()
```



In [23]:
```
def euclidean_distance(X, Y):
 return numpy.sqrt(numpy.sum(numpy.power(X - Y, 2), axis=1))
```

In [37]:
```
def cluster_data(solution, solution_idx):
    global num_cluster, data
    feature_vector_length = data.shape[1]
    cluster_centers = []
    all_clusters_dists = []
    clusters = []
    clusters_sum_dist = []
    for clust_idx in range(num_clusters):
        cluster_centers.append(solution[feature_vector_length*clust_idx:feature_vector_length*(clust_idx+1)])
        cluster_center_dists = euclidean_distance(data, cluster_centers[clust_idx])
        all_clusters_dists.append(numpy.array(cluster_center_dists))
        cluster_centers = numpy.array(cluster_centers)
        all_clusters_dists = numpy.array(all_clusters_dists)
        cluster_indices = numpy.argmin(all_clusters_dists, axis=0)
        for clust_idx in range(num_clusters):
            clusters.append(numpy.where(cluster_indices == clust_idx)[0])
            if len(clusters[clust_idx]) == 0:
                clusters_sum_dist.append(0)
            else:
                    clusters_sum_dist.append(numpy.sum(all_clusters_dists[clust_idx, clusters[clust_idx]]))
                    clusters_sum_dist = numpy.array(clusters_sum_dist)
                    return cluster_centers, all_clusters_dists, cluster_indices, clusters, clusters_sum_dist
```

In [38]:
```
def fitness_func(ga_instance,solution, solution_idx):
 _, _, _, _, clusters_sum_dist = cluster_data(solution, solution_idx)
 fitness = 1.0 / (numpy.sum(clusters_sum_dist) + 0.00000001)
 return fitness
```

In [39]:
```
num_clusters = 2
num_genes = num_clusters * data.shape[1]
ga_instance = pygad.GA(num_generations=100,
 sol_per_pop=10,
num_parents_mating=5,
init_range_low=-6,
init_range_high=20,
keep_parents=2,
num_genes=num_genes,
fitness_func=fitness_func,
 suppress_warnings=True)
ga_instance.run()
```

In [40]:
```
best_solution, best_solution_fitness, best_solution_idx = ga_instance.best_solution()
print("Best solution is {bs}".format(bs=best_solution))
print("Fitness of the best solution is {bsf}".format(bsf=best_solution_fitness))
print("Best solution found after {gen} generations".format(gen=ga_instance.best_solution_generation))
```

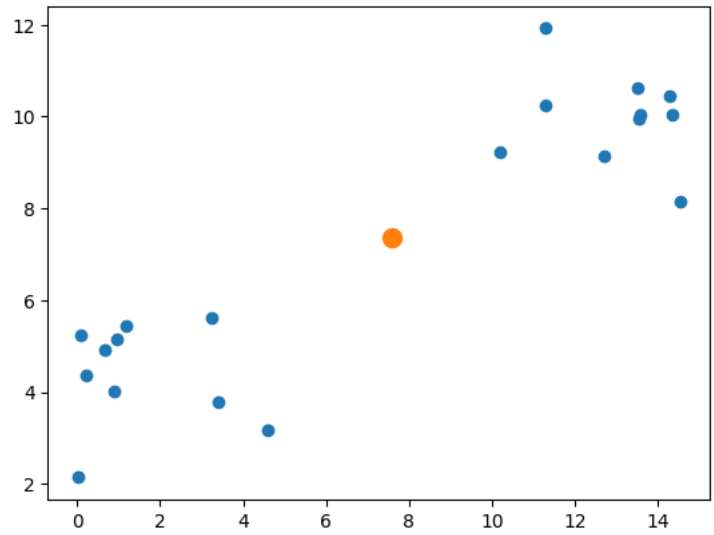
```
Best solution is [ 7.58942819  7.37734258 18.86590325 13.75295893]
Fitness of the best solution is 0.00772580444078046
Best solution found after 88 generations
```

In [44]:
```
cluster_centers, all_clusters_dists, cluster_indices, clusters, clusters_sum_dist = cluster_data(best_solution, best_solution_i
```

In [45]:
```
for cluster_idx in range(num_clusters):
 cluster_x = data[clusters[cluster_idx], 0]
 cluster_y = data[clusters[cluster_idx], 1]
 matplotlib.pyplot.scatter(cluster_x, cluster_y)
 matplotlib.pyplot.scatter(cluster_centers[cluster_idx, 0], cluster_centers[cluster_idx, 1], linewidths=5)
matplotlib.pyplot.title("Clustering using PyGAD")
matplotlib.pyplot.show()
```

```
---------------------------------------------------------------------------
IndexError                                Traceback (most recent call last)
Cell In[45], line 2
      1 for cluster_idx in range(num_clusters):
----> 2  cluster_x = data[clusters[cluster_idx], 0]
      3  cluster_y = data[clusters[cluster_idx], 1]
      4  matplotlib.pyplot.scatter(cluster_x, cluster_y)

IndexError: list index out of range
```



In [ ]: