```
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
import math
```

```
!wget https://course.ccs.neu.edu/cs6220/homework-4/data/f150_motor_distributors.txt
```

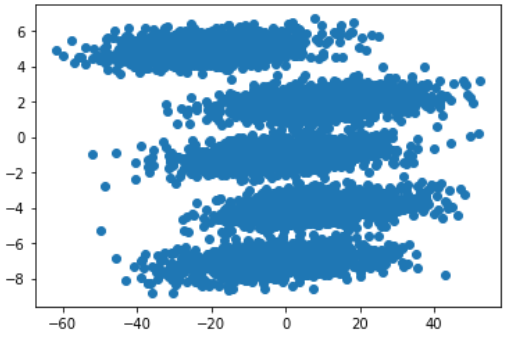
```
--2023-03-01 14:02:39--  https://course.ccs.neu.edu/cs6220/homework-4/data/f150
Resolving course.ccs.neu.edu (course.ccs.neu.edu)... 129.10.117.35
Connecting to course.ccs.neu.edu (course.ccs.neu.edu)|129.10.117.35|:443... cor
HTTP request sent, awaiting response... 200 OK
Length: 255541 (250K) [text/plain]
Saving to: ‘f150_motor_distributors.txt.1’

f150_motor_distribu 100%[===================>] 249.55K  --.-KB/s    in 0.1s

2023-03-01 14:02:40 (1.88 MB/s) - ‘f150_motor_distributors.txt.1’ saved [255541
```

```
df = pd.read_csv('/content/f150_motor_distributors.txt', delimiter= ',', names=["tim
df.head(10)
```

	timing_speed	coil_gap
0	-11.969996	-8.039628
1	-26.961416	-6.962109
2	-12.915849	-1.378941
3	22.476144	2.066612
4	-13.146631	4.835322
5	36.851734	2.470103
6	-9.067511	-1.179764
7	-22.889891	-1.020943
8	-2.358063	1.240317
9	22.832520	1.705266

```
plt.scatter(df["timing_speed"], df["coil_gap"])
```

```
<matplotlib.collections.PathCollection at 0x7fbecbf68d90>
```




```
x1 = np.array([10.0, 10.0])
x2 = np.array([-10.0, -10.0])
x3 = np.array([2.0, 2.0])
x4 = np.array([3.0, 3.0])
x5 = np.array([-3.0, -3.0])
```

```
centroids = np.array([x1, x2, x3, x4, x5])
```

```
data = df.iloc[:, [0, 1]].values
data
```

Resources ×

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Python 3 Google Compute Engine backend
Showing resources from 4:37 AM to 8:16 AM

System RAM
1.6 / 12.7 GB

Disk
25.8 / 225.8 GB

```
array([[-11.96999577,  -8.03962819],
       [-26.96141582,  -6.96210943],
       [-12.91584891,  -1.37894148],
       ...,
       [ 12.92550271,  -0.10319682],
       [-34.33677838,   4.4057531 ],
       [-26.81273855,  -1.63995599]])
```

```
class KMeans:
  def __init__(self, n_clusters, max_iter, centroids):
    self.n_clusters = n_clusters
    self.max_iter = max_iter
    self.centroids = centroids

  def fit(self, X):
    for i in range(self.max_iter):
      distances = np.sqrt(((X - self.centroids[:, np.newaxis])**2).sum(axis=2))
      cluster_labels = np.argmin(distances, axis=0)

    for j in range(self.n_clusters):
      self.centroids[j] = X[cluster_labels == j].mean(axis=0)

  def predict(self, X):
    distances = np.sqrt(((X - self.centroids[:, np.newaxis])**2).sum(axis=2))
    return np.argmin(distances, axis=0)


km = KMeans(5, 100, centroids)
km.fit(data)
```

Question 1a

Centroids after 100 iterations

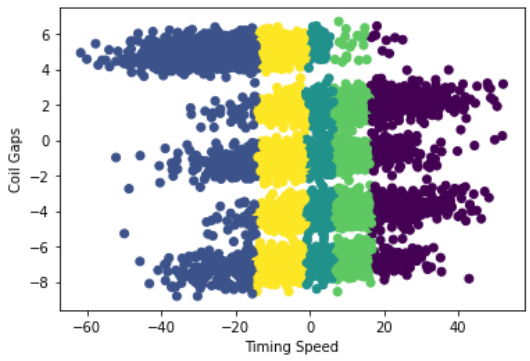
```
km.centroids
```

```
array([[ 23.23559962,  -0.37277404],
       [-23.07182069,  -0.55933281],
       [  3.48813997,  -1.49181348],
       [  9.85453395,  -1.08932849],
       [ -5.32034801,  -1.63246345]])
```

Question 1b

```
labels = km.predict(data)
```

```
plt.scatter(data[:, 0], data[:, 1], c=labels)
plt.xlabel('Timing Speed')
plt.ylabel('Coil Gaps')
plt.show()
```

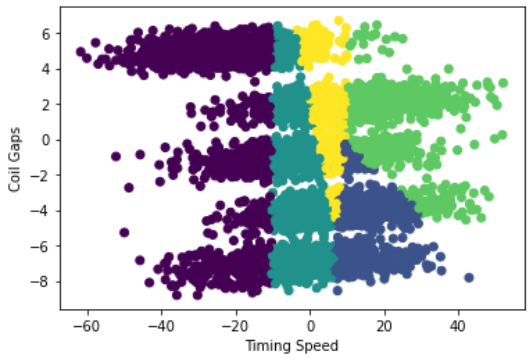


Question 1c

It can be seen that the data distributed in 5 strips along the x-axis, so the number of clusters = 5 is reasonable and logical

It does not cluster well, since each cluster does not showed inner relationship

```
x6 = np.array([-10, -8])
x7 = np.array([10, -5])
x8 = np.array([1, -1])
x9 = np.array([10, 2])
x10 = np.array([5, 5])

update_centroids = np.array([x6, x7, x8, x9, x10])

km1 = KMeans(5, 100, update_centroids)
km1.fit(data)
new_labels = km1.predict(data)

plt.scatter(data[:, 0], data[:, 1], c=new_labels)
plt.xlabel('Timing Speed')
plt.ylabel('Coil Gaps')
plt.show()
```



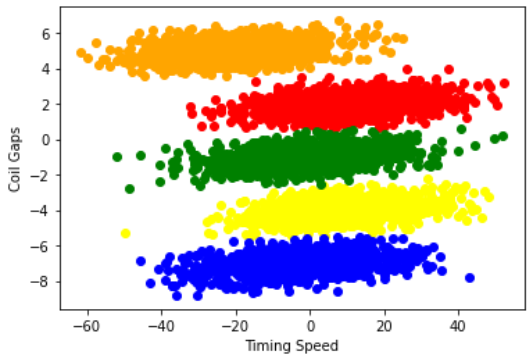
Question 2a

```
def mahalanobis_distance(X, Y, P):
  diff = X - Y
  cov_inv = np.dot(P.T, P)
  cov_inv = np.linalg.inv(cov_inv)
  return np.sqrt(np.dot(np.dot(diff.T, cov_inv), diff))


P = np.array([[10.0, 0.5], [-10.0, 0.25]])
```

```
for i in range(100):

  clusters = [[], [], [], [], []]

  for j in range(5000):
      distances = [mahalanobis_distance(data[j], centroids[k], P) for k in range(5)]
      cluster = np.argmin(distances)
      clusters[cluster].append(j)
  for c in range(5):
      if clusters[c]:
          centroids[c] = np.mean(data[clusters[c]], axis=0)

output_centroids = centroids
centroids = np.array([x1, x2, x3, x4, x5])


print("Clusters:", clusters)
print("Centroids:", output_centroids)
```

```
Clusters: [[3, 5, 8, 9, 13, 17, 21, 24, 28, 29, 33, 34, 37, 45, 51, 56, 62, 63,
Centroids: [[  9.97451285   2.00207148]
 [-20.40310599   5.00655283]
 [  8.71408722  -4.00981947]
 [ -1.09670369  -0.9992032 ]
 [ -3.24764066  -7.01766444]]
```

```
colors=['red', 'orange', 'yellow', 'green', 'blue']
labels=['cluster 1','cluster 2','cluster 3','cluster 4','cluster 5']
for i, cluster in enumerate(clusters):
    plt.scatter(data[cluster, 0], data[cluster, 1], color = colors[i],label=labels[i
plt.xlabel('Timing Speed')
plt.ylabel('Coil Gaps')
plt.show()
```



Question 2b

```
new_df = df - df.mean()
new_df
```

	timing_speed	coil_gap
0	-10.749873	-7.036019
1	-25.741293	-5.958501

```
cov = np.cov(new_df.T)
eigenvalues, eigenvectors = np.linalg.eig(cov)
eigenvalues, eigenvectors
```

```
(array([322.50713273,  17.38845582]), array([[ 0.99838317,  0.05684225],
       [-0.05684225,  0.99838317]]))
```

4995	8.072791	2.552685

```
indices = np.argsort(eigenvalues)[::-1]
indices
```

```
array([0, 1])
```

```
eigenvectors_sorted = eigenvectors[:, indices]
eigenvectors_sorted
```

```
array([[ 0.99838317,  0.05684225],
       [-0.05684225,  0.99838317]])
```

Question 2c

No, they are not the same

```
len(cluster)
```

```
1000
```

```
len(clusters[1])
```

```
1000
```

```
for i, cluster in enumerate(clusters):
  cov = np.cov((data[cluster] - data[cluster].mean()).T)
  eigenvalues, eigenvectors = np.linalg.eig(cov)
  indices = np.argsort(eigenvalues)[::-1]
  print(i)
  print("eigenvalues: ", eigenvectors[:, indices])
```

```
0
eigenvalues:  [[ 0.99993306 -0.01157047]
 [ 0.01157047  0.99993306]]
1
eigenvalues:  [[ 0.99993527 -0.01137789]
 [ 0.01137789  0.99993527]]
2
eigenvalues:  [[ 0.99989374 -0.01457781]
 [ 0.01457781  0.99989374]]
3
eigenvalues:  [[ 0.99990986 -0.01342629]
 [ 0.01342629  0.99990986]]
4
eigenvalues:  [[ 0.99992533 -0.01222027]
 [ 0.01222027  0.99992533]]
```

Question 2d

```
eig1, eig2 = np.linalg.eig(P.T)
new_P = np.dot(eig1, eig2.T).T
new_P
```

```
array([10.02645889,  1.04999268])
```

The P' is transformed from the relationship matrix

So it is still can be seen as a relationship matrix for data

Question 3a

```
frequent_3_itemsets = [    [1, 2, 3],
    [1, 2, 4],
    [1, 2, 5],
    [1, 3, 4],
    [2, 3, 4],
    [2, 3, 5],
    [3, 4, 5],
]
```

```
frequent_1_itemsets = [[1], [2], [3], [4], [5]]
```

```
def generate_candidate_4_itemsets(frequent_3_itemsets, frequent_1_itemsets):
    candidate_4_itemsets = set()
    for itemset_1 in frequent_3_itemsets:
        for itemset_2 in frequent_1_itemsets:
            if itemset_2[0] not in itemset_1:
                candidate_4_itemset = tuple(sorted(itemset_1 + itemset_2))
                candidate_4_itemsets.add(candidate_4_itemset)
    return candidate_4_itemsets
```

```
candidate_4_itemsets = generate_candidate_4_itemsets(frequent_3_itemsets, frequent_1_
print("Candidate 4-itemsets:", candidate_4_itemsets)
```

```
Candidate 4-itemsets: {(1, 3, 4, 5), (1, 2, 3, 5), (1, 2, 3, 4), (2, 3, 4, 5),
```

Question 3b

```
def new_generate_candidate_4_itemsets(frequent_k_itemsets):
    candidate_4_itemsets = set()
    for i in range(len(frequent_k_itemsets)):
        for j in range(i+1, len(frequent_k_itemsets)):
            if frequent_k_itemsets[i][:-1] == frequent_k_itemsets[j][:-1]:
                candidate_4_itemset = tuple(frequent_k_itemsets[i]) + (frequent_k_it
                candidate_4_itemsets.add(candidate_4_itemset)
    return candidate_4_itemsets
```

```
candidate_4_itemsets = new_generate_candidate_4_itemsets(frequent_3_itemsets)
print("Candidate 4-itemsets:", candidate_4_itemsets)
```

```
Candidate 4-itemsets: {(1, 2, 3, 4), (1, 2, 3, 5), (1, 2, 4, 5), (2, 3, 4, 5)}
```

Question 3c

```
candidate_4_itemsets = generate_candidate_4_itemsets(frequent_3_itemsets, frequent_1_
print("Candidate 4-itemsets:", candidate_4_itemsets)
```

```
Candidate 4-itemsets: {(1, 3, 4, 5), (1, 2, 3, 5), (1, 2, 3, 4), (2, 3, 4, 5),
```

Manual count:

(1,3,4,5): 2

(1,2,3,5): 3

(1,2,3,4): 4

(2,3,4,5): 3

(1,2,4,5) : 2

so it is (1,2,3,4)

Question 4a

3*(3^1 + 3^2 + 3^3 + 3^4 + #^5 + 3^6) = 603

Question 4b:

2/4 = 0.5

Question 4c

2

Question 4d

True. Since {a,b} is a subset of {a,b,c,d}, and {a, b, c, d} is a frquent itemset, {a, b} must has the same frequency. Thus, {a, b} is always a frequent itemset

Question 4e

True. If all of 3 are frequent itemsets, it means that each of them has comparative frquency among the whole dataset. {a, b, c} as the superset of them, must also appeaered frequently in the dataset, which make itself a frequent dataset

Question 4f

false, since {b} is a subset of {b, c} so it also appeared as {b, c} appeared. So, the support if {b} should be large or equal to 30

Question 4g

False. The maximum number of size-2 frequent itemsets that can be extracted from a dataset with 5 items is 5C2 = 10.

Change runtime type

✓ 0s completed at 7:54 AM