In [1]:
```
import pandas as pd
import numpy as np
import math

from matplotlib import pyplot as plt

from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler

from sklearn.metrics import confusion_matrix
from sklearn.metrics import f1_score
from sklearn.metrics import accuracy_score
from sklearn.metrics import mean_squared_error, mean_absolute_error
from sklearn import preprocessing
from sklearn.metrics import classification_report
```

Tạo các hàm

In [2]:
```
def euclidean_distance(point_1,point_2):
  euclid_square = 0
  for x,y in zip(point_1,point_2):
    euclid_square += (x-y)**2
  euclidean_dis = math.sqrt(euclid_square)
  return euclidean_dis

def most_frequent(List):
  return max(set(List), key = List.count)
```

LINEAR REGRESSION

LR Data

In [3]:
```
df_lr_data = pd.read_csv('Nhom11_LR_data.csv')
print(f'Dữ liệu gồm: {(df_lr_data.shape[0]):,} dòng và {df_lr_data.shape[1]} cột')
df_lr_data.head()
```

```
Dữ liệu gồm: 200 dòng và 4 cột
```

Out[3]:

	TV	radio	newspaper	sales
0	230.1	37.8	69.2	2210
1	44.5	39.3	45.1	1040
2	17.2	45.9	69.3	930
3	151.5	41.3	58.5	1850
4	180.8	10.8	58.4	1290

LR with sklearn

In [4]:
```
from sklearn.linear_model import LinearRegression

### Tách X (các features để dự đoán), y giá trị output của phương trình dự đoán
X = df_lr_data.drop('sales',axis= 1)
y = df_lr_data['sales']
display(X)
display(y)
```

	TV	radio	newspaper
0	230.1	37.8	69.2
1	44.5	39.3	45.1
2	17.2	45.9	69.3
3	151.5	41.3	58.5
4	180.8	10.8	58.4
...	...	...	...
195	38.2	3.7	13.8
196	94.2	4.9	8.1
197	177.0	9.3	6.4
198	283.6	42.0	66.2
199	232.1	8.6	8.7

200 rows × 3 columns

```
0      2210
1      1040
2       930
3      1850
4      1290
       ...
195     760
196     970
197    1280
198    2550
199    1340
Name: sales, Length: 200, dtype: int64
```

In [5]:
```
### Tách tập dữ liệu train và test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.1, random_state=100)

model = LinearRegression()
model.fit(X_train, y_train)

predictions = model.predict(X_test)

df_predict = X_test
df_predict['Sales_Actual'] = y_test
df_predict['Sales_Predict_sklearn'] = predictions

df_predict
```

Out[5]:

	TV	radio	newspaper	Sales_Actual	Sales_Predict_sklearn
126	7.8	38.9	50.6	660	1060.539733
104	238.2	34.3	5.3	2070	2018.503961
99	135.2	41.7	45.9	1720	1691.966540
92	217.7	33.5	59.0	1940	1913.765440
111	241.7	38.0	23.2	2180	2105.093184
167	206.8	5.2	19.4	1220	1329.921705
116	139.2	14.3	25.6	1220	1194.014411
96	197.6	3.5	5.9	1170	1255.285170
52	216.4	41.7	39.6	2260	2060.669083
69	216.8	43.9	27.2	2230	2103.019772
164	117.2	14.7	5.4	1190	1100.215772
124	229.5	32.3	74.2	1970	1945.842742
182	56.2	5.7	29.7	870	655.401355
154	187.8	21.1	9.5	1560	1541.657608
125	87.2	11.8	25.9	1060	910.684915
196	94.2	4.9	8.1	970	811.707097
194	149.7	35.6	6.0	1730	1640.680706
177	170.2	7.8	35.2	1170	1213.424389
163	163.5	36.8	7.4	1800	1726.048908
31	112.9	17.4	38.6	1190	1133.550884

LR với công thức toán học

In [6]:
```
y = y_train
X = X_train
one = np.ones((X.shape[0], 1))

Xbar = np.concatenate((one,X), axis =1)

A = np.dot(Xbar.T, Xbar)
b = np.dot(Xbar.T, y)
w = np.dot(np.linalg.pinv(A), b)
w_0, w_1, w_2, w_3 = w[0],w[1],w[2],w[3]

print(f"Phương trình dự đoán y là : \n y = {round(w_0,2)} + {round(w_1,2)}.TV + {round(w_2,2)}.Radio + {round(w_3,2)}.Newspaper")

df_predict['Sales_Predict_math'] = df_predict.apply(lambda x: w_0 + w_1*x["TV"] + w_2*x['radio'] + w_3*x['newspaper'],  axis=1)

df_predict
```

```
Phương trình dự đoán y là :
 y = 290.91 + 4.55.TV + 18.79.Radio + 0.06.Newspaper
```

Out[6]:

	TV	radio	newspaper	Sales_Actual	Sales_Predict_sklearn	Sales_Predict_math
126	7.8	38.9	50.6	660	1060.539733	1060.539733
104	238.2	34.3	5.3	2070	2018.503961	2018.503961
99	135.2	41.7	45.9	1720	1691.966540	1691.966540
92	217.7	33.5	59.0	1940	1913.765440	1913.765440
111	241.7	38.0	23.2	2180	2105.093184	2105.093184
167	206.8	5.2	19.4	1220	1329.921705	1329.921705
116	139.2	14.3	25.6	1220	1194.014411	1194.014411
96	197.6	3.5	5.9	1170	1255.285170	1255.285170
52	216.4	41.7	39.6	2260	2060.669083	2060.669083
69	216.8	43.9	27.2	2230	2103.019772	2103.019772
164	117.2	14.7	5.4	1190	1100.215772	1100.215772
124	229.5	32.3	74.2	1970	1945.842742	1945.842742
182	56.2	5.7	29.7	870	655.401355	655.401355
154	187.8	21.1	9.5	1560	1541.657608	1541.657608
125	87.2	11.8	25.9	1060	910.684915	910.684915
196	94.2	4.9	8.1	970	811.707097	811.707097
194	149.7	35.6	6.0	1730	1640.680706	1640.680706
177	170.2	7.8	35.2	1170	1213.424389	1213.424389
163	163.5	36.8	7.4	1800	1726.048908	1726.048908
31	112.9	17.4	38.6	1190	1133.550884	1133.550884

In [7]:
```
### Sai số trung bình của phương trình LR bằng sklearn là:
round(math.sqrt(mean_squared_error(list(df_predict['Sales_Actual'].astype(float)),list(df_predict['Sales_Predict_sklearn'].astype(float)))),2)
```

Out[7]: 135.46

In [8]:
```
### Sai số trung bình của phương trình LR bằng toán học là:
round(math.sqrt(mean_squared_error(list(df_predict['Sales_Actual'].astype(float)),list(df_predict['Sales_Predict_math'].astype(float)))),2)
```

Out[8]: 135.46

KNN

KNN Data

Data set gồm 9 features:

- 8 features: về các chỉ số sức khỏe.
- 1 features là labels chuẩn đoán cho các bệnh nhân (1 mắc bệnh tim, 0 là không mắc bệnh về tim)

In [9]:
```
df_knn_data = pd.read_csv('Nhom11_KNN_data.csv')
print(f'Dữ liệu gồm: {(df_knn_data.shape[0]):,} dòng và {df_knn_data.shape[1]} cột')
df_knn_data.head()
```

```
Dữ liệu gồm: 768 dòng và 9 cột
```

Out[9]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
0	6	148	72	35	0	33.6	0.627	50	1
1	1	85	66	29	0	26.6	0.351	31	0
2	8	183	64	0	0	23.3	0.672	32	1
3	1	89	66	23	94	28.1	0.167	21	0
4	0	137	40	35	168	43.1	2.288	33	1

KNN with sklearn

In [10]:
```
from sklearn.neighbors import KNeighborsClassifier
```

In [11]:
```
X = df_knn_data.drop('Outcome',axis= 1)
y = df_knn_data['Outcome']
display(X)
display(y)
```

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age
0	6	148	72	35	0	33.6	0.627	50
1	1	85	66	29	0	26.6	0.351	31
2	8	183	64	0	0	23.3	0.672	32
3	1	89	66	23	94	28.1	0.167	21
4	0	137	40	35	168	43.1	2.288	33
...	...	...	...	...	...	...	...	...
763	10	101	76	48	180	32.9	0.171	63
764	2	122	70	27	0	36.8	0.340	27
765	5	121	72	23	112	26.2	0.245	30
766	1	126	60	0	0	30.1	0.349	47
767	1	93	70	31	0	30.4	0.315	23

768 rows × 8 columns

```
0      1
1      0
2      1
3      0
4      1
      ..
763    0
764    0
765    0
766    1
767    0
Name: Outcome, Length: 768, dtype: int64
```

In [12]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=100, train_size=0.9)

scaler = StandardScaler()
df_train_scaled_fit = scaler.fit_transform(X_train)
df_test_scaled_fit = scaler.fit_transform(X_test)

df_train_scaled_fit = pd.DataFrame(df_train_scaled_fit)
df_train_scaled_fit.columns = ['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       'BMI', 'DiabetesPedigreeFunction', 'Age']

df_test_scaled_fit = pd.DataFrame(df_test_scaled_fit)
df_test_scaled_fit.columns = ['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       'BMI', 'DiabetesPedigreeFunction', 'Age']


knn_classifier = KNeighborsClassifier(n_neighbors=3,p=2)
knn_classifier.fit(df_train_scaled_fit, y_train)

predictions = knn_classifier.predict(df_test_scaled_fit)

df_test_scaled_fit['Y_Actual'] = list(y_test)
df_test_scaled_fit['Y_Predict_sklearn'] = list(predictions)

df_test_scaled_fit
```

Out[12]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Y_Actual	Y_Predict_sklearn
0	-0.903391	-1.260135	-0.613450	1.374523	-0.313926	1.525497	0.691927	-0.792945	0	0
1	-1.167882	-1.056717	-0.149787	0.684123	-0.797171	0.376822	-0.931401	-0.648773	0	0
2	0.154573	1.151821	1.936696	-1.525155	-0.797171	0.660261	-1.252378	1.297547	1	0
3	0.948045	-1.666970	0.082044	0.062764	-0.797171	-0.190058	0.404155	0.576688	0	0
4	1.212536	0.018493	-0.033871	1.512602	0.149184	-0.025961	-0.429645	0.432516	0	1
...	...	...	...	...	...	...	...	...	...	...
72	-1.167882	0.425328	-0.149787	-0.558596	0.692834	-1.264144	-1.281893	-0.937117	0	0
73	-1.167882	-0.097746	-0.265703	0.338923	-0.797171	0.824358	-0.853924	-0.865031	0	0
74	2.006008	-1.114836	0.082044	0.615083	-0.797171	-0.533169	-0.713728	0.865031	1	0
75	-1.167882	0.134731	0.545707	1.029323	1.317026	0.451411	1.156789	-0.792945	0	1
76	0.683554	-0.097746	-4.090923	-1.525155	-0.797171	-1.204473	-1.038393	0.216258	0	0

77 rows × 10 columns

In [46]:
```
round(accuracy_score(list(df_test_scaled_fit['Y_Actual']),list(df_test_scaled_fit['Y_Predict_sklearn'])),2)
```

Out[46]:
```
0.65
```

In [14]:
```
confusion_matrix(list(df_test_scaled_fit['Y_Actual']),list(df_test_scaled_fit['Y_Predict_sklearn']))
```

Out[14]:
```
array([[38,  9],
       [18, 12]], dtype=int64)
```

In [15]:
```
from sklearn.model_selection import GridSearchCV

param_grid = {'n_neighbors':np.arange(1,50)}
knn = KNeighborsClassifier()
knn_cv= GridSearchCV(knn,param_grid,cv=5)
knn_cv.fit(X_train, y_train)

print(f"Với k là {knn_cv.best_params_['n_neighbors']} thì mô hình có độ chính xác cao nhất là {knn_cv.best_score_}")
```

```
Với k là 15 thì mô hình có độ chính xác cao nhất là 0.7453133145657387
```

KNN với công thức toán học

In [16]:
```
df_test_scaled_fit_math = df_test_scaled_fit[['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       'BMI', 'DiabetesPedigreeFunction', 'Age']]
```

In [17]:
```
def knn_classifier_math(df_X_train, y_train, df_X_test, k_nn):
  y_predicted_math = []
  for id_test,row_test in df_X_test.iterrows():
    point_1 = list(row_test)
    list_distance = []
    for id_train,row_train in df_X_train.iterrows():
      point_2 = list(row_train)
      list_distance.append(euclidean_distance(point_1,point_2))
    df = pd.DataFrame({'distance':list_distance,'labels':y_train}).sort_values(by='distance')
    list_knn = list(df['labels'][:k_nn])
    y_predicted_math.append(most_frequent(list_knn))
  return y_predicted_math

df_test_scaled_fit['Y_Predict_math'] = knn_classifier_math(df_train_scaled_fit, y_train, df_test_scaled_fit_math,k_nn=3)
```

In [18]:
```
df_test_scaled_fit
```

Out[18]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Y_Actual	Y_Predict_sklearn	Y_Predict_math
0	-0.903391	-1.260135	-0.613450	1.374523	-0.313926	1.525497	0.691927	-0.792945	0	0	0
1	-1.167882	-1.056717	-0.149787	0.684123	-0.797171	0.376822	-0.931401	-0.648773	0	0	0
2	0.154573	1.151821	1.936696	-1.525155	-0.797171	0.660261	-1.252378	1.297547	1	0	0
3	0.948045	-1.666970	0.082044	0.062764	-0.797171	-0.190058	0.404155	0.576688	0	0	0
4	1.212536	0.018493	-0.033871	1.512602	0.149184	-0.025961	-0.429645	0.432516	0	1	1
...	...	...	...	...	...	...	...	...	...	...	...
72	-1.167882	0.425328	-0.149787	-0.558596	0.692834	-1.264144	-1.281893	-0.937117	0	0	0
73	-1.167882	-0.097746	-0.265703	0.338923	-0.797171	0.824358	-0.853924	-0.865031	0	0	0
74	2.006008	-1.114836	0.082044	0.615083	-0.797171	-0.533169	-0.713728	0.865031	1	0	0
75	-1.167882	0.134731	0.545707	1.029323	1.317026	0.451411	1.156789	-0.792945	0	1	1
76	0.683554	-0.097746	-4.090923	-1.525155	-0.797171	-1.204473	-1.038393	0.216258	0	0	0

77 rows × 11 columns

In [47]:
```
round(accuracy_score(list(df_test_scaled_fit['Y_Actual']),list(df_test_scaled_fit['Y_Predict_math'])),2)
```

Out[47]:
```
0.65
```

In [48]:
```
confusion_matrix(list(df_test_scaled_fit['Y_Actual']),list(df_test_scaled_fit['Y_Predict_math']))
```

Out[48]:
```
array([[38,  9],
       [18, 12]], dtype=int64)
```

K-Means

K-Means Data

Dataset về thông tin khách hàng và hiệu ứng với các chiến dịch marketing gồm 29 features và 2240 records được thu thập bởi Viện SAS năm 2014:

- Gồm các thông tin về nhân khẩu học (năm sinh, thu nhập, giáo dục, tình trạng hôn nhân,...)
- Thông tin mua hàng (ngày đầu tiên mua, các thông tin về tần suất mua với các mặt hàng)
- Thông tin về hiệu ứng với các chiến dịch marketing

In [19]:
```
df_km_data = pd.read_csv('Nhom11_KM_data.csv',sep='\t')

print(f'Dữ liệu gồm: {(df_km_data.shape[0]):,} dòng và {df_km_data.shape[1]} cột')
df_km_data.head()
```

```
Dữ liệu gồm: 2,240 dòng và 29 cột
```

Out[19]:

	ID	Year_Birth	Education	Marital_Status	Income	Kidhome	Teenhome	Dt_Customer	Recency	MntWines	...	NumWebVisitsMonth	AcceptedCmp3	AcceptedCmp4	AcceptedCmp5	AcceptedCmp1	AcceptedCmp2	Con
0	5524	1957	Graduation	Single	58138.0	0	0	04-09-2012	58	635	...	7	0	0	0	0	0	
1	2174	1954	Graduation	Single	46344.0	1	1	08-03-2014	38	11	...	5	0	0	0	0	0	
2	4141	1965	Graduation	Together	71613.0	0	0	21-08-2013	26	426	...	4	0	0	0	0	0	
3	6182	1984	Graduation	Together	26646.0	1	0	10-02-2014	26	11	...	6	0	0	0	0	0	
4	5324	1981	PhD	Married	58293.0	1	0	19-01-2014	94	173	...	5	0	0	0	0	0	

5 rows × 29 columns

In [20]:
```
display(df_km_data.isnull().sum())
### Loại bỏ những rows có features Income null
df_km_data = df_km_data[df_km_data['Income'].notnull()]
print(f'Dữ liệu gồm: {(df_km_data.shape[0]):,} dòng và {df_km_data.shape[1]} cột')
```

```
ID                     0
Year_Birth             0
Education              0
Marital_Status         0
Income                24
Kidhome                0
Teenhome               0
Dt_Customer            0
Recency                0
MntWines               0
MntFruits              0
MntMeatProducts        0
MntFishProducts        0
MntSweetProducts       0
MntGoldProds           0
NumDealsPurchases      0
NumWebPurchases        0
NumCatalogPurchases    0
NumStorePurchases      0
NumWebVisitsMonth      0
AcceptedCmp3           0
AcceptedCmp4           0
AcceptedCmp5           0
AcceptedCmp1           0
AcceptedCmp2           0
Complain               0
Z_CostContact          0
Z_Revenue              0
Response               0
dtype: int64

Dữ liệu gồm: 2,216 dòng và 29 cột
```

In [21]:
```
##### Trích chọn những features để phân cụm khách hàng #####

features = ['Year_Birth','Income','Recency']

df_km_data = df_km_data[features].reset_index(drop=True)

### Tính features tuổi
df_km_data['Age'] = 2014 - df_km_data.loc[:,'Year_Birth']

features = ['Age','Income','Recency']
df_km_data = df_km_data[features]

print(f'Dữ liệu gồm: {(df_km_data.shape[0]):,} dòng và {df_km_data.shape[1]} cột')
df_km_data.head()
```

```
Dữ liệu gồm: 2,216 dòng và 3 cột
```

Out[21]:

	Age	Income	Recency
0	57	58138.0	58
1	60	46344.0	38
2	49	71613.0	26
3	30	26646.0	26
4	33	58293.0	94

In [22]:
```
scaler = StandardScaler()

df_km_input = df_km_data.copy()
df_km_input[features] = scaler.fit_transform(df_km_input[features])

print(f'Dữ liệu gồm: {(df_km_input.shape[0]):,} dòng và {df_km_input.shape[1]} cột')
df_km_input.head()
```

```
Dữ liệu gồm: 2,216 dòng và 3 cột
```

Out[22]:

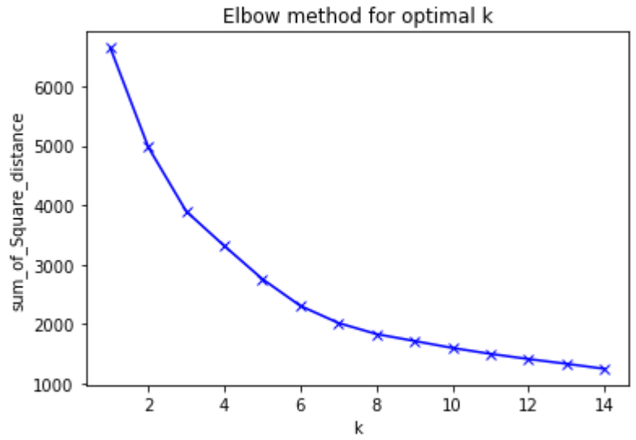
	Age	Income	Recency
0	0.986443	0.234063	0.310532
1	1.236801	-0.234559	-0.380509
2	0.318822	0.769478	-0.795134
3	-1.266777	-1.017239	-0.795134
4	-1.016420	0.240221	1.554407

K-Means sklearn

In [23]:
```
from sklearn.cluster import KMeans
```

In [24]:
```
#Elbow method to minimize WSS (Within cluster sum of Square)
#Phương pháp tìm ra số cụm tối ưu
sum_of_Square_distance=[]
K=range(1,15)
for k in K:
    km = KMeans(n_clusters=k)
    km.fit(df_km_input)
    sum_of_Square_distance.append(km.inertia_)

plt.plot(K,sum_of_Square_distance, 'bx-')
plt.xlabel('k')
plt.ylabel('sum_of_Square_distance')
plt.title('Elbow method for optimal k')
plt.show()
```



In [25]:
```
km = KMeans(n_clusters=3,tol=1e-4,max_iter=300)
y_predicted = km.fit_predict(df_km_input)

df_km_data['Labels_sklearn'] = y_predicted
df_km_data
```

Out[25]:

	Age	Income	Recency	Labels_sklearn
0	57	58138.0	58	0
1	60	46344.0	38	0
2	49	71613.0	26	0
3	30	26646.0	26	1
4	33	58293.0	94	2
...	...	...	...	...
2211	47	61223.0	46	0
2212	68	64014.0	56	0
2213	33	56981.0	91	2
2214	58	69245.0	8	0
2215	60	52869.0	40	0

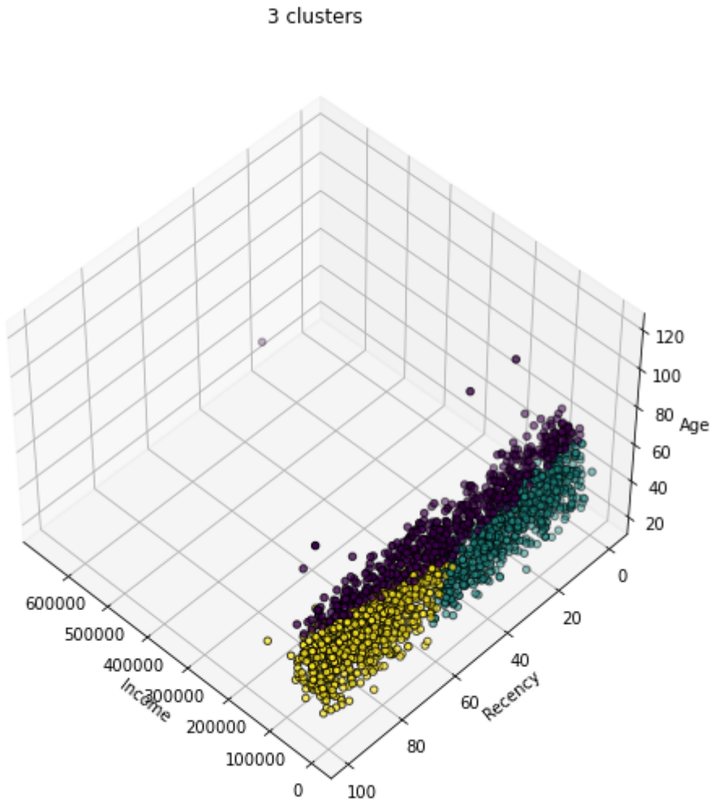
2216 rows × 4 columns

In [26]:
```
import mpl_toolkits.mplot3d  # noqa: F401

fignum = 1
titles = ["3 clusters"]
fig = plt.figure(fignum, figsize=(8, 7))
ax = fig.add_subplot(111, projection="3d", elev=48, azim=134)
ax.set_position([0, 0, 0.95, 1])
labels = km.labels_
ax.scatter(df_km_data.iloc[:,1], df_km_data.iloc[:, 2], df_km_data.iloc[:,0], c=labels.astype(float), edgecolor="k")

ax.set_xlabel("Income")
ax.set_ylabel("Recency")
ax.set_zlabel("Age")

ax.set_title(titles[fignum - 1])
ax.dist = 12
fignum = fignum + 1
```



K-Means Toán học

In [42]:
```
def initiate_centroids(k, dset):
    '''
    Select k data points as centroids
    k: number of centroids
    dset: pandas dataframe
    '''
    centroids = dset.sample(k)
    return centroids
```

In [43]:
```
def kmeans_cluster_math(df_km_input,k_cluster,max_iter=300,tol=1e-4):
  df_working = df_km_input.copy()
  df_centroids = initiate_centroids(k_cluster, df_working).reset_index(drop=True)

  loop = True

  i = 0
  while loop:
    i +=1
    print(f"Vòng {i}")
    label_centroids = []
    for id_data,data_point in df_working.iterrows():
      dict_distance = {}
      dict_distance['distance'] = []
      dict_distance['label_centroids'] = []
      for id_centroid, centroid_point in df_centroids.iterrows():
        dict_distance['distance'].append(euclidean_distance(data_point,centroid_point))
        dict_distance['label_centroids'].append(id_centroid)
      df = pd.DataFrame(dict_distance)
      label_centroids.append(df[(df['distance']) == (df['distance'].min())]['label_centroids'].iat[0])

    df_working['label_centroids'] = label_centroids
    df_centroids_update = df_working.groupby('label_centroids').agg('mean').loc[:, ['Age','Income','Recency']].reset_index(drop = True)

    for (id,centr),(id_upt,centr_upt) in zip(df_centroids.iterrows(),df_centroids_update.iterrows()):
      if euclidean_distance(centr,centr_upt) <= tol :
        error_centroid = False
      else:
        error_centroid = True
        break

    if error_centroid:
      df_centroids = df_centroids_update
      loop = True
      if i > max_iter :
        loop = False
    else:
      loop = False

  return df_working

df_working = kmeans_cluster_math(df_km_input,k_cluster = 3,max_iter=300,tol=1e-4)
```

```
Vòng 1
Vòng 2
Vòng 3
Vòng 4
Vòng 5
Vòng 6
Vòng 7
Vòng 8
Vòng 9
Vòng 10
Vòng 11
Vòng 12
Vòng 13
Vòng 14
Vòng 15
Vòng 16
Vòng 17
```

```
Vòng 18
Vòng 19
Vòng 20
Vòng 21
Vòng 22
Vòng 23
Vòng 24
Vòng 25
Vòng 26
Vòng 27
Vòng 28
Vòng 29
Vòng 30
Vòng 31
Vòng 32
Vòng 33
```

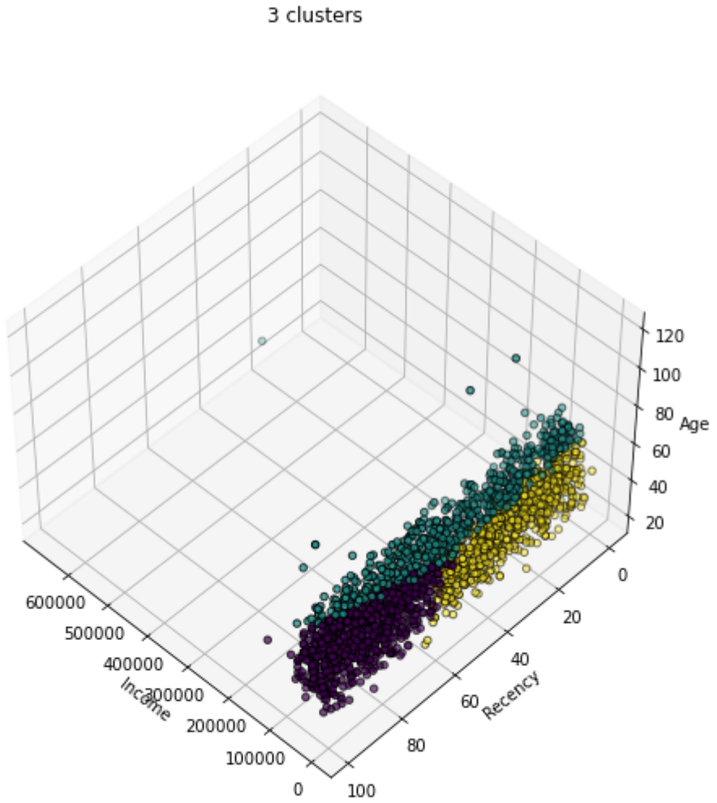
In [44]:
```
df_km_data['Labels_math'] = df_working['label_centroids']
```

In [45]:
```
import mpl_toolkits.mplot3d  # noqa: F401

fignum = 1
titles = ["3 clusters"]
fig = plt.figure(fignum, figsize=(8, 7))
ax = fig.add_subplot(111, projection="3d", elev=48, azim=134)
ax.set_position([0, 0, 1, 1])
labels = df_km_data['Labels_math']
ax.scatter(df_km_data.iloc[:,1], df_km_data.iloc[:, 2], df_km_data.iloc[:,0], c=labels.astype(float), edgecolor="k")

ax.set_xlabel("Income")
ax.set_ylabel("Recency")
ax.set_zlabel("Age")

ax.set_title(titles[fignum - 1])
ax.dist = 12
fignum = fignum + 1
```



NAIVE BAYES

Navie Bayes Data

- Sử dụng lại dataset dự đoán sales ở LR

In [31]:
```
df_nb_data = pd.read_csv('Nhom11_LR_data.csv')
print(f'Dữ liệu gồm: {(df_nb_data.shape[0]):,} dòng và {df_nb_data.shape[1]} cột')
df_nb_data.head()
```

```
Dữ liệu gồm: 200 dòng và 4 cột
```

Out[31]:

	TV	radio	newspaper	sales
0	230.1	37.8	69.2	2210
1	44.5	39.3	45.1	1040
2	17.2	45.9	69.3	930
3	151.5	41.3	58.5	1850
4	180.8	10.8	58.4	1290

In [32]:
```
df_nb_data.describe()
```

Out[32]:

	TV	radio	newspaper	sales
count	200.000000	200.000000	200.000000	200.000000
mean	147.042500	23.264000	30.554000	1402.250000
std	85.854236	14.846809	21.778621	521.745657
min	0.700000	0.000000	0.300000	160.000000
25%	74.375000	9.975000	12.750000	1037.500000
50%	149.750000	22.900000	25.750000	1290.000000
75%	218.825000	36.525000	45.100000	1740.000000
max	296.400000	49.600000	114.000000	2700.000000

In [33]:
```
df_nb_data['labels_sales'] = df_nb_data.apply(lambda x: 'High' if x['sales'] > 2000 else ('Medium' if x['sales'] >= 1200 else 'Low'),axis=1)
df_nb_data = df_nb_data.drop('sales',axis= 1)
print(f'Dữ liệu gồm: {(df_nb_data.shape[0]):,} dòng và {df_nb_data.shape[1]} cột')
df_nb_data.head()
```

```
Dữ liệu gồm: 200 dòng và 4 cột
```

Out[33]:

	TV	radio	newspaper	labels_sales
0	230.1	37.8	69.2	High
1	44.5	39.3	45.1	Low
2	17.2	45.9	69.3	Low
3	151.5	41.3	58.5	Medium
4	180.8	10.8	58.4	Medium

Navie Bayes sklearn

In [34]:
```
from sklearn.naive_bayes import GaussianNB
```

In [35]:
```
X = df_nb_data.drop('labels_sales',axis= 1)
y = df_nb_data['labels_sales']
display(X)
display(y)
```

	TV	radio	newspaper
0	230.1	37.8	69.2
1	44.5	39.3	45.1
2	17.2	45.9	69.3
3	151.5	41.3	58.5
4	180.8	10.8	58.4
...	...	...	...
195	38.2	3.7	13.8
196	94.2	4.9	8.1
197	177.0	9.3	6.4
198	283.6	42.0	66.2
199	232.1	8.6	8.7

200 rows × 3 columns

```
0        High
1         Low
2         Low
3      Medium
4      Medium
        ...
195       Low
196       Low
197    Medium
198      High
199    Medium
Name: labels_sales, Length: 200, dtype: object
```

In [36]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=100, train_size=0.8)

NBModel = GaussianNB()
NBModel.fit(X_train,y_train)

predictions = NBModel.predict(X_test)

df_nb_test = X_test
df_nb_test['Class_Actual'] = list(y_test)

df_nb_predicted = df_nb_test.copy()
df_nb_predicted['Classs_Predict_sklearn'] = list(predictions)

df_nb_predicted
```

Out[36]:

	TV	radio	newspaper	Class_Actual	Classs_Predict_sklearn
126	7.8	38.9	50.6	Low	Low
104	238.2	34.3	5.3	High	Medium
99	135.2	41.7	45.9	Medium	Medium
92	217.7	33.5	59.0	Medium	High
111	241.7	38.0	23.2	High	High
167	206.8	5.2	19.4	Medium	Medium
116	139.2	14.3	25.6	Medium	Medium
96	197.6	3.5	5.9	Low	Medium
52	216.4	41.7	39.6	High	High
69	216.8	43.9	27.2	High	High
164	117.2	14.7	5.4	Low	Low
124	229.5	32.3	74.2	Medium	High
182	56.2	5.7	29.7	Low	Low
154	187.8	21.1	9.5	Medium	Medium
125	87.2	11.8	25.9	Low	Low
196	94.2	4.9	8.1	Low	Low
194	149.7	35.6	6.0	Medium	Medium
177	170.2	7.8	35.2	Low	Medium
163	163.5	36.8	7.4	Medium	Medium
31	112.9	17.4	38.6	Low	Low
11	214.7	24.0	4.0	Medium	Medium
73	129.4	5.7	31.3	Low	Low
15	195.4	47.7	52.9	High	High
41	177.0	33.4	38.7	Medium	Medium
97	184.9	21.0	22.0	Medium	Medium
128	220.3	49.0	3.2	High	High
133	219.8	33.5	45.1	Medium	Medium
82	75.3	20.3	32.5	Low	Low
139	184.9	43.9	1.7	High	Medium

	TV	radio	newspaper	Class_Actual	Classs_Predict_sklearn
123	123.1	34.6	12.4	Medium	Medium
83	68.4	44.5	35.6	Medium	Low
65	69.0	9.3	0.9	Low	Low
151	121.0	8.4	48.7	Low	Low
162	188.4	18.1	25.6	Medium	Medium
170	50.0	11.6	18.4	Low	Low
77	120.5	28.5	14.2	Medium	Low
32	97.2	1.5	30.0	Low	Low
173	168.4	7.1	12.8	Low	Medium
174	222.4	3.4	13.1	Low	Medium
85	193.2	18.4	65.7	Medium	Medium

In [37]:
```
accuracy_score(list(df_nb_predicted['Class_Actual']),list(df_nb_predicted['Classs_Predict_sklearn']))
```

Out[37]: 0.75

Navie Bayes Toán học

In [38]:
```
def cal_likelihood(df,dimension,c,input_value):
  dimension = list(df[df['classes']==c][dimension])
  mean = np.mean(dimension)
  sd = np.std(dimension)

  likelihood = (np.pi*sd) * np.exp(-0.5*((input_value-mean)/sd)**2)

  return likelihood

def cal_prior(df, c):
  prior = (list(df['classes']).count(c))/len(list(df['classes']))
  return prior
```

In [39]:
```
# def GaussianNB_math(X_train, y_train, X_test, y_test):
input_dimensions = X_train.columns

df_nb_train = X_train.copy()
df_nb_train['classes'] = list(y_train)

df_nb_test = X_test.copy()
df_nb_test['classes'] = list(y_test)

list_class = list(df_nb_train['classes'].unique())
classes_nb_output = []
for id,row in df_nb_test.iterrows():
  dict_prob = {}
  dict_prob['classes'] = []
  dict_prob['posterior'] = []
  for c in list_class:
    multi_likelihood = 1
    for dimension in input_dimensions:
      multi_likelihood = multi_likelihood * cal_likelihood(df_nb_train,dimension=dimension,c=c,input_value=row[dimension])
    prior = cal_prior(df_nb_train, c=c)

    posterior = multi_likelihood*prior
    dict_prob['classes'].append(c)
    dict_prob['posterior'].append(posterior)
  df_prob = pd.DataFrame(dict_prob)
  classes_nb_output.append(df_prob[(df_prob['posterior']) == (df_prob['posterior'].max())]['classes'].iat[0])

df_nb_predicted['Class_Predict_math'] = classes_nb_output
```

In [40]:
```
df_nb_predicted
```

Out[40]:

	TV	radio	newspaper	Class_Actual	Classs_Predict_sklearn	Class_Predict_math
126	7.8	38.9	50.6	Low	Low	Low
104	238.2	34.3	5.3	High	Medium	Medium
99	135.2	41.7	45.9	Medium	Medium	Medium
92	217.7	33.5	59.0	Medium	High	Medium
111	241.7	38.0	23.2	High	High	Medium
167	206.8	5.2	19.4	Medium	Medium	Medium
116	139.2	14.3	25.6	Medium	Medium	Low
96	197.6	3.5	5.9	Low	Medium	Medium
52	216.4	41.7	39.6	High	High	Medium
69	216.8	43.9	27.2	High	High	Medium
164	117.2	14.7	5.4	Low	Low	Low
124	229.5	32.3	74.2	Medium	High	Medium
182	56.2	5.7	29.7	Low	Low	Low
154	187.8	21.1	9.5	Medium	Medium	Medium
125	87.2	11.8	25.9	Low	Low	Low
196	94.2	4.9	8.1	Low	Low	Low
194	149.7	35.6	6.0	Medium	Medium	Medium
177	170.2	7.8	35.2	Low	Medium	Medium
163	163.5	36.8	7.4	Medium	Medium	Medium
31	112.9	17.4	38.6	Low	Low	Low
11	214.7	24.0	4.0	Medium	Medium	Medium
73	129.4	5.7	31.3	Low	Low	Low
15	195.4	47.7	52.9	High	High	Medium
41	177.0	33.4	38.7	Medium	Medium	Medium
97	184.9	21.0	22.0	Medium	Medium	Medium
128	220.3	49.0	3.2	High	High	Medium
133	219.8	33.5	45.1	Medium	Medium	Medium
82	75.3	20.3	32.5	Low	Low	Low
139	184.9	43.9	1.7	High	Medium	Medium
123	123.1	34.6	12.4	Medium	Medium	Low
83	68.4	44.5	35.6	Medium	Low	Low
65	69.0	9.3	0.9	Low	Low	Low
151	121.0	8.4	48.7	Low	Low	Low
162	188.4	18.1	25.6	Medium	Medium	Medium
170	50.0	11.6	18.4	Low	Low	Low
77	120.5	28.5	14.2	Medium	Low	Low
32	97.2	1.5	30.0	Low	Low	Low

	TV	radio	newspaper	Class_Actual	Classs_Predict_sklearn	Class_Predict_math
173	168.4	7.1	12.8	Low	Medium	Medium
174	222.4	3.4	13.1	Low	Medium	Medium
85	193.2	18.4	65.7	Medium	Medium	Medium

In [41]:
```
accuracy_score(list(df_nb_predicted['Class_Actual']),list(df_nb_predicted['Class_Predict_math']))
```

Out[41]:
```
0.625
```