Tugas Besar 2

IF3170 - Artificial Intelligence

hani sendiri

Sekar Annisa Ayuningtyas - 13516044

Hani'ah Wafa - 13516053

Dinda Yora Islami - 13516067

Muhammad Alif Arifin - 13516078

Deborah Aprilia Josephine - 13516152

In [1]:

```
# library
import pandas as pd
import numpy as np
import copy

# model
from sklearn.naive_bayes import GaussianNB
from sklearn.tree import DecisionTreeClassifier
from sklearn.neural_network import MLPClassifier
from sklearn.neighbors import KNeighborsClassifier

# plot
import matplotlib.pyplot as plt
import seaborn as sns

# count z-value
from scipy import stats

# save model
from sklearn.externals import joblib

# count std
import statistics

# feature selection
from sklearn.feature_selection import SelectKBest, chi2

# metrics
from sklearn.metrics import accuracy_score, confusion_matrix, f1_score

# model selection
from sklearn.model_selection import KFold, cross_val_score
```

In [2]:

```
# membaca data
df = pd.read_csv('tubes2_HeartDisease_train.csv')
```

In [3]:

```
# melihat data sekilas
df.head()
```

Out[3]:

	Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8
0	54	1	4	125	216	0	0	140
1	55	1	4	158	217	0	0	110
2	54	0	3	135	304	1	0	170
3	48	0	3	120	195	0	0	125
4	50	1	4	120	0	0	1	156

In [4]:

```
# menyimpan daftar atribut
features = list(df)
```

Pengukuran kinerja dilakukan dengan accuracy

Penanganan yang dilakukan

1. Mengubah '?' menjadi NaN lalu mengecek column dengan 2 kondisi
    - Apabila NaN terlalu banyak maka di-drop
    - Selain itu mengganti NaN dengan value
        - Categorical data = modus
        - Numerical data = mean/median
2. Mencari outlier lalu membuang data tersebut. Mencari dengan:
    - Melihat data: column 4 dan 5 terdapat outlier (data bernilai 0) maka dibuang
    - Z-value dengan threshold = +-3 (apabila Z-value > +3 atau Z-value < - 3 (threshold) maka dibuang)
3. Memilih atribut yang significant
    - Menggunakan chi squared
    - Menggunakan tree based

Penanganan 1

In [5]:

```
# mengganti '?' ke NaN
df = df.replace('?', np.nan)
```

In [6]:

```
# melihat head untuk memastikan sudah terganti
df.head()
```

Out[6]:

	Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	C
0	54	1	4	125	216	0	0	140	0
1	55	1	4	158	217	0	0	110	1
2	54	0	3	135	304	1	0	170	0
3	48	0	3	120	195	0	0	125	0
4	50	1	4	120	0	0	1	156	1

In [7]:

```
# menghitung jumlah NaN dan dibandingkan dengan jumlah row
print('Shape dataframe')
print(df.shape)
print('Null Value pada dataframe')
print(df.isnull().sum())
```

```
Shape dataframe
(779, 14)
Null Value pada dataframe
Column1       0
Column2       0
Column3       0
Column4      47
Column5      24
Column6      78
Column7       2
Column8      44
Column9      44
Column10     49
Column11    262
Column12    514
Column13    408
Column14      0
dtype: int64
```

Terlihat apabila atribut Column 12 dan 13 cukup banyak Null value-nya maka di-drop

In [8]:

```
# Column 12 dan 13 terlalu banyak yang tidak diketahui maka di-drop saja
df = df.drop(columns=['Column12', 'Column13'])
```

In [9]:

```
# mengganti type dari object ke numeric
object_type = ['Column4','Column5','Column6','Column7','Column8','Column9','Column10',
'Column11']
df[object_type] = df[object_type].apply(pd.to_numeric, downcast='float', errors='coerc
e', axis=1)
```

In [10]:

```
median_type = ['Column4', 'Column5', 'Column8']
mode_type = ['Column6', 'Column7', 'Column9', 'Column11']
mean_type = ['Column10']

default_value = {}

for feature in median_type :
    df[feature] = df[feature].fillna(df[feature].median())
    default_value[feature] = df[feature].median()

for feature in mode_type :
    df[feature] = df[feature].fillna(df[feature].mode()[0])
    default_value[feature] = df[feature].mode()[0]

for feature in mean_type :
    df[feature] = df[feature].fillna(df[feature].mean())
    default_value[feature] = df[feature].mean()
```

In [11]:

```
# Memastikan null value telah kosong
print('Null Value pada dataframe')
print(df.isnull().sum())
```

```
Null Value pada dataframe
Column1     0
Column2     0
Column3     0
Column4     0
Column5     0
Column6     0
Column7     0
Column8     0
Column9     0
Column10    0
Column11    0
Column14    0
dtype: int64
```

In [12]:

```
# mengganti type sesuai dengan yang seharusnya
float_type = ['Column10']
int_type = ['Column4','Column5','Column6','Column7','Column8','Column9','Column11']

df[float_type] = df[float_type].astype(float)
df[int_type] = df[int_type].astype(int)
```

In [13]:

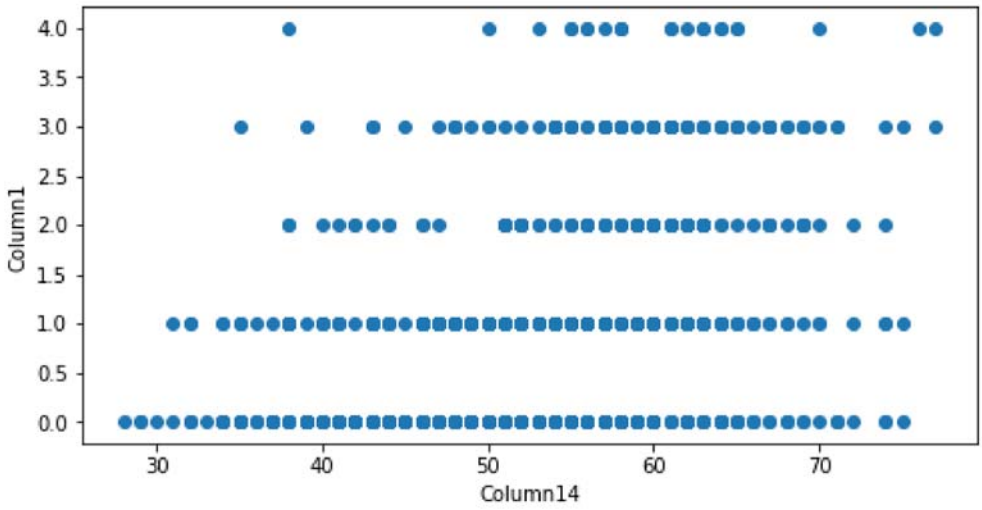
```
print('Tipe data')
print(df.dtypes)
```

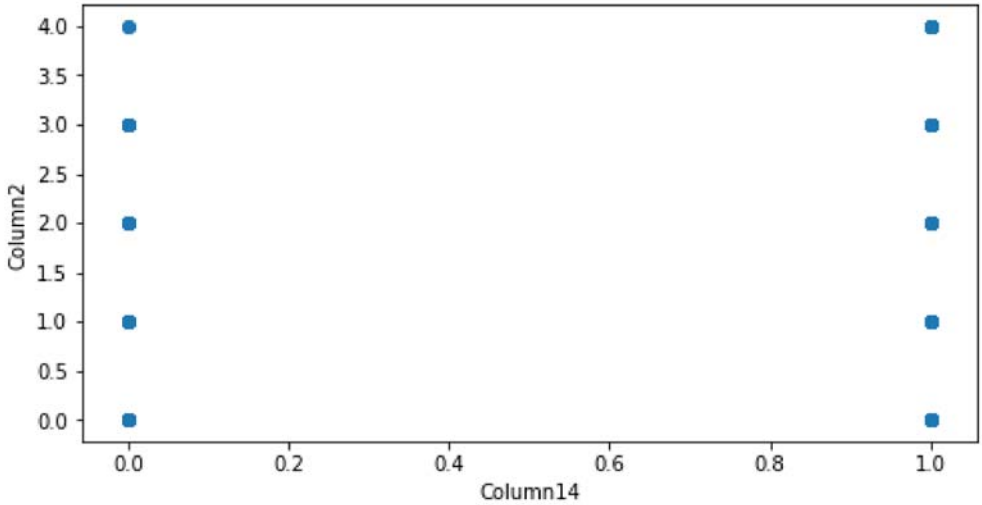
```
Tipe data
Column1       int64
Column2       int64
Column3       int64
Column4       int32
Column5       int32
Column6       int32
Column7       int32
Column8       int32
Column9       int32
Column10    float64
Column11      int32
Column14      int64
dtype: object
```

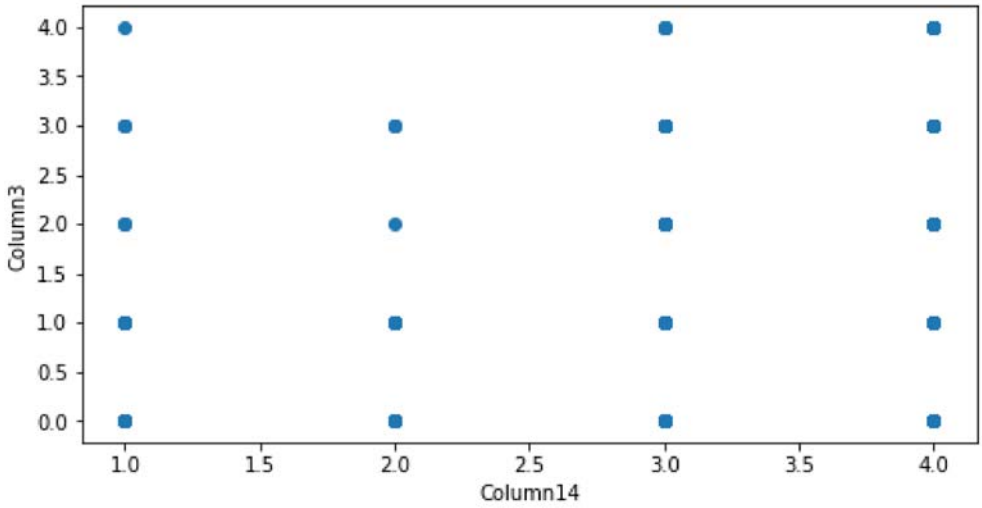
Penanganan 2

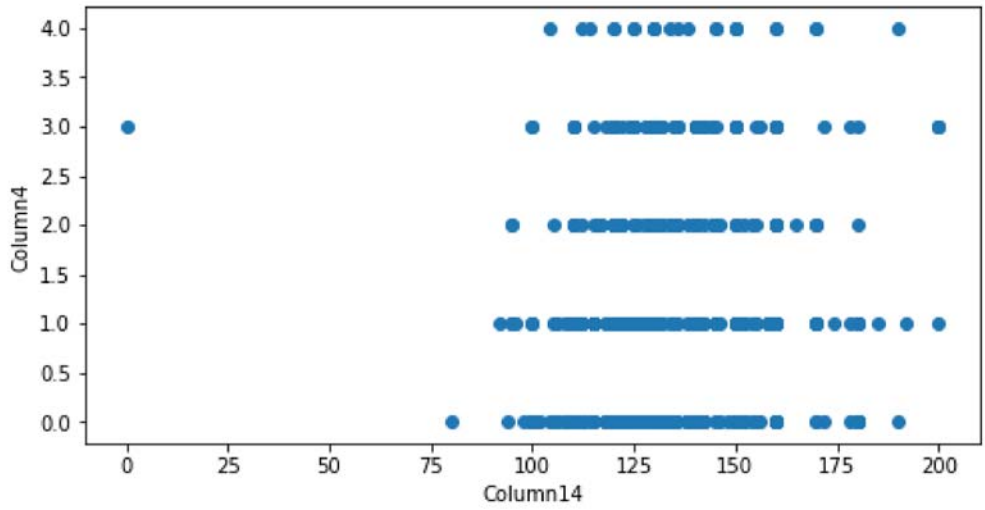
In [14]:

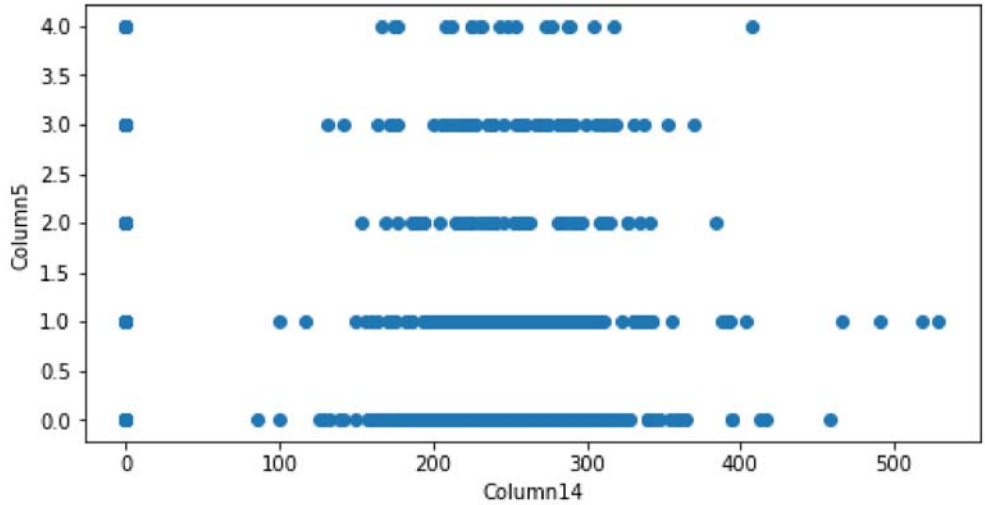
```
# Melihat persebaran data
for column in list(df) :
    fig, ax = plt.subplots(figsize=(8,4))
    ax.scatter(df[column], df['Column14'])
    ax.set_xlabel('Column14')
    ax.set_ylabel(column)
    plt.show()
```

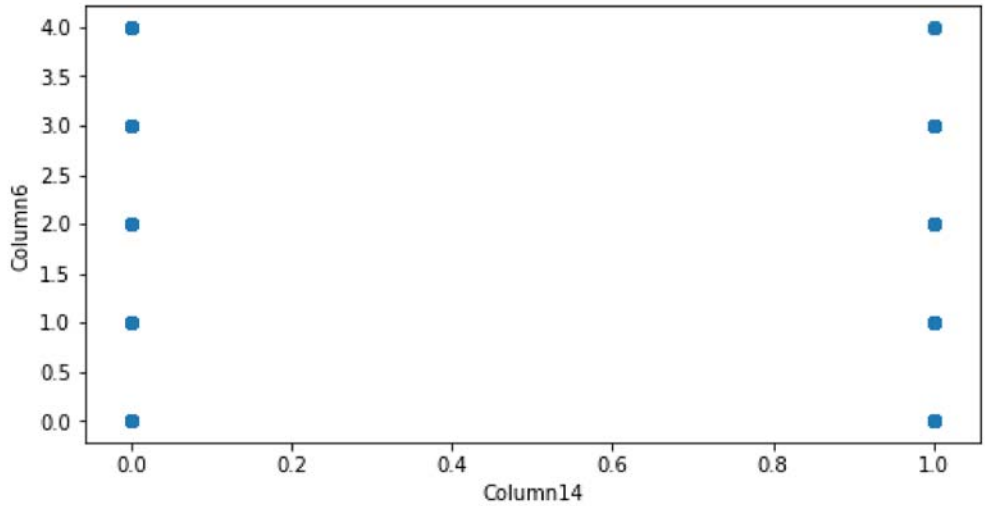

Column1
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
30
40
50
60
70

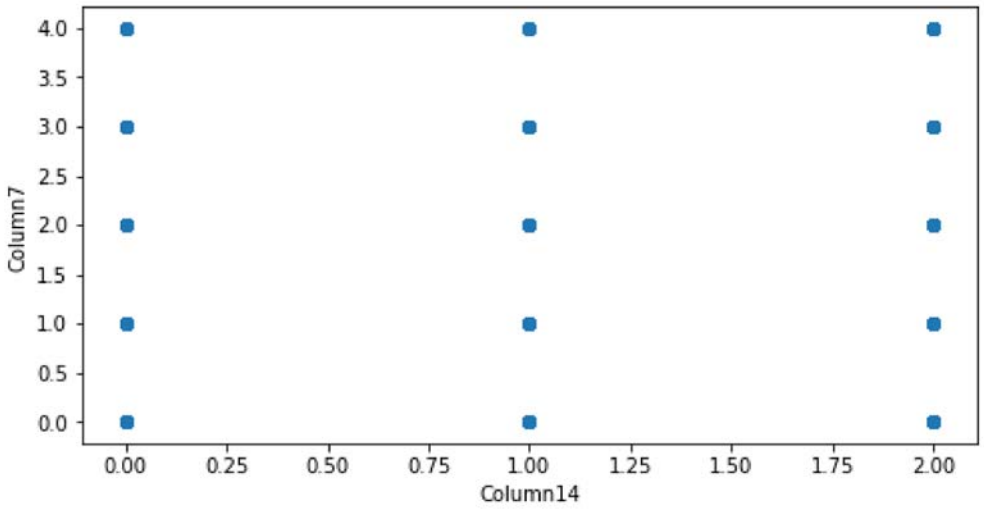

Column2
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
1.0

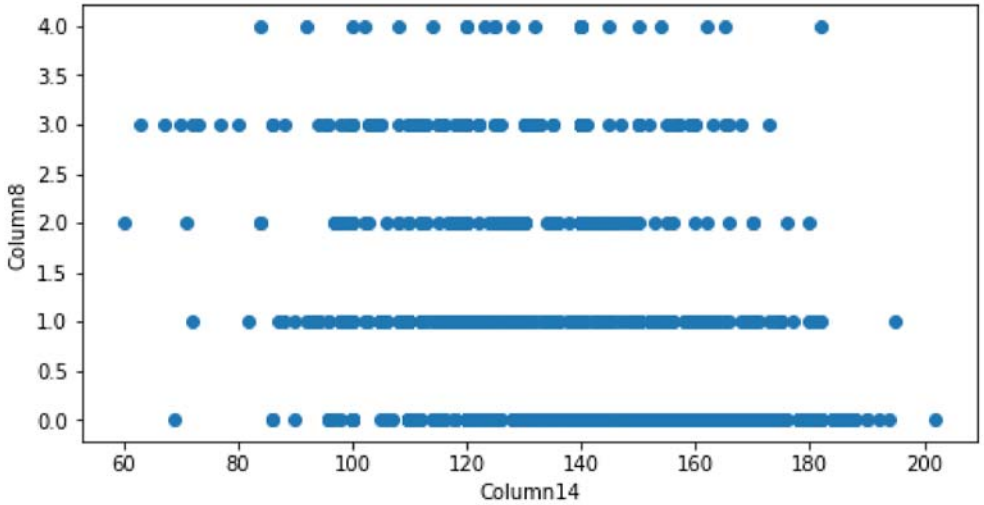

Column3
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0

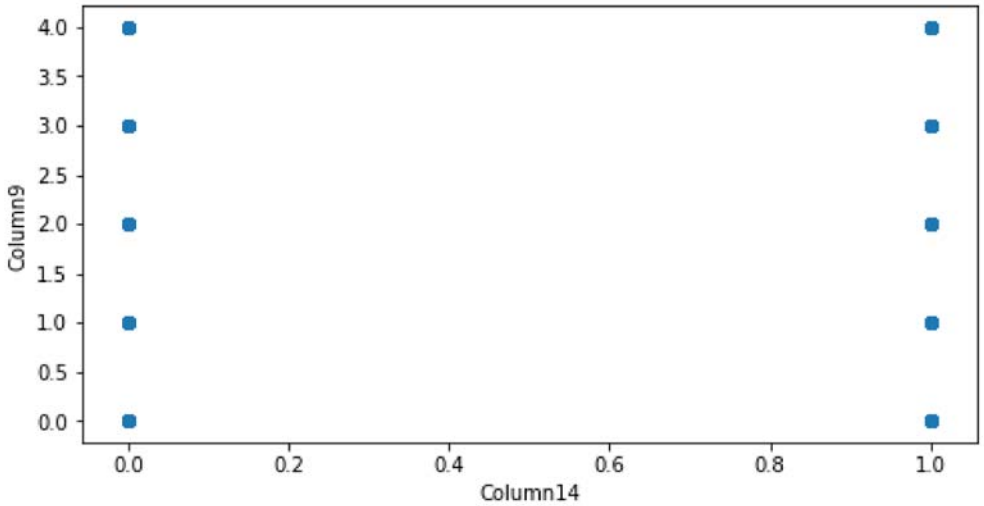

Column4
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
25
50
75
100
125
150
175
200

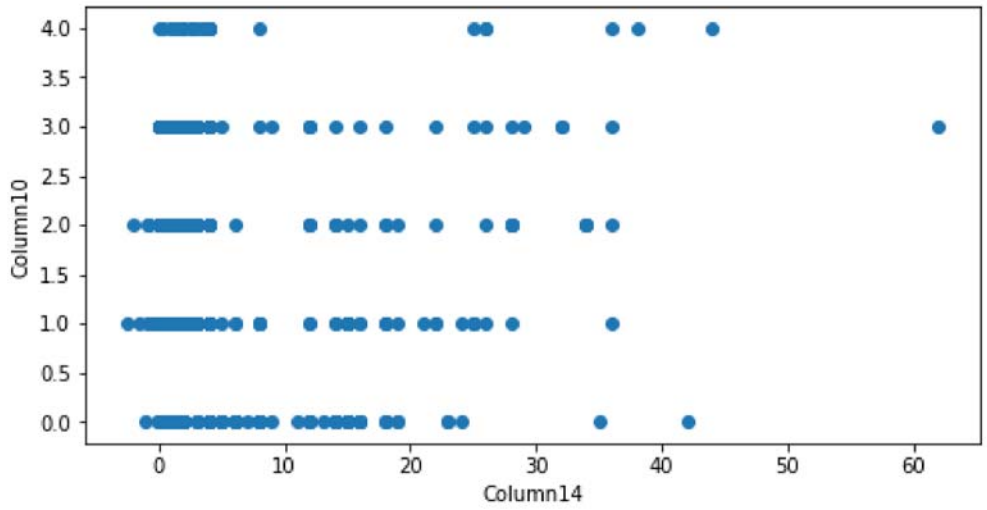

Column5
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
100
200
300
400
500

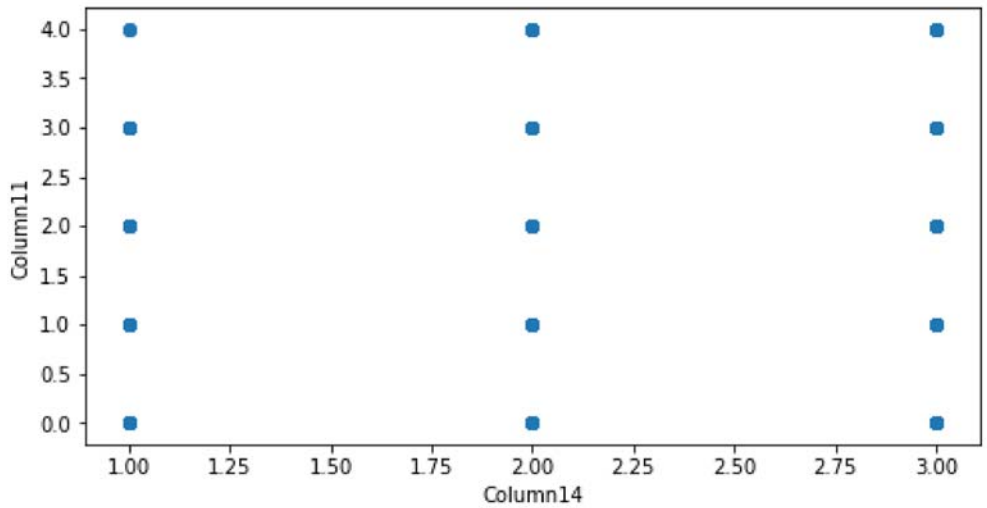

Column6
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.0
0.2
0.4
0.6
0.8
1.0

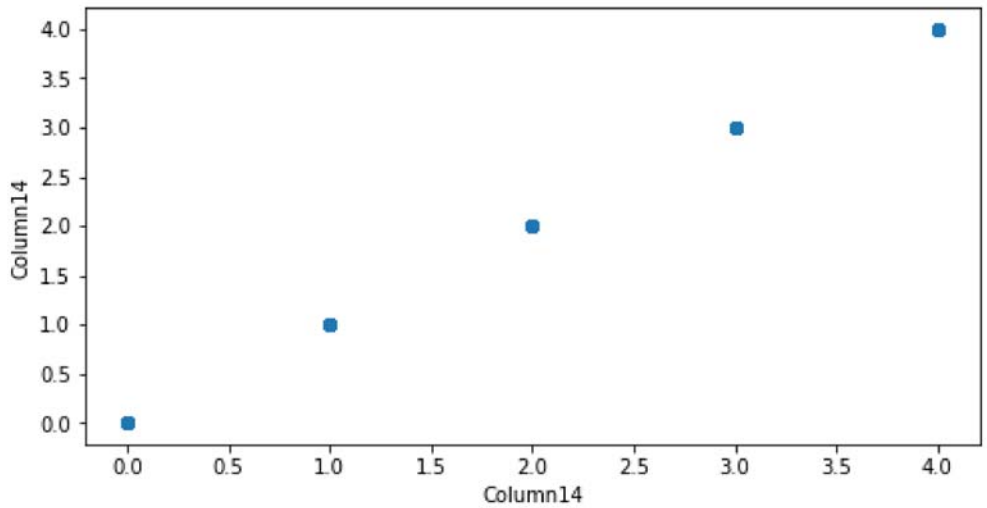

Column7
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00


Column8
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
60
80
100
120
140
160
180
200


Column9
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.0
0.2
0.4
0.6
0.8
1.0







Terlihat bahwa column 4 dan 5 banyak mengandung outlier, maka row dengan nilai 0 akan dibuang

In [15]:

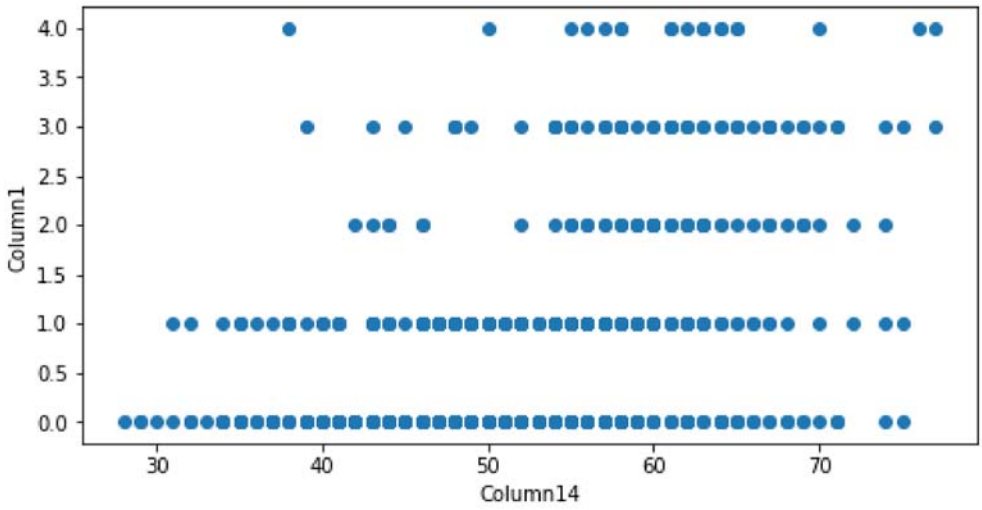
```
df_clean = df[df['Column4'] > 1]
df_clean = df_clean[df_clean['Column5'] > 1]

df_clean.shape
df_clean['Column14'].value_counts()
```

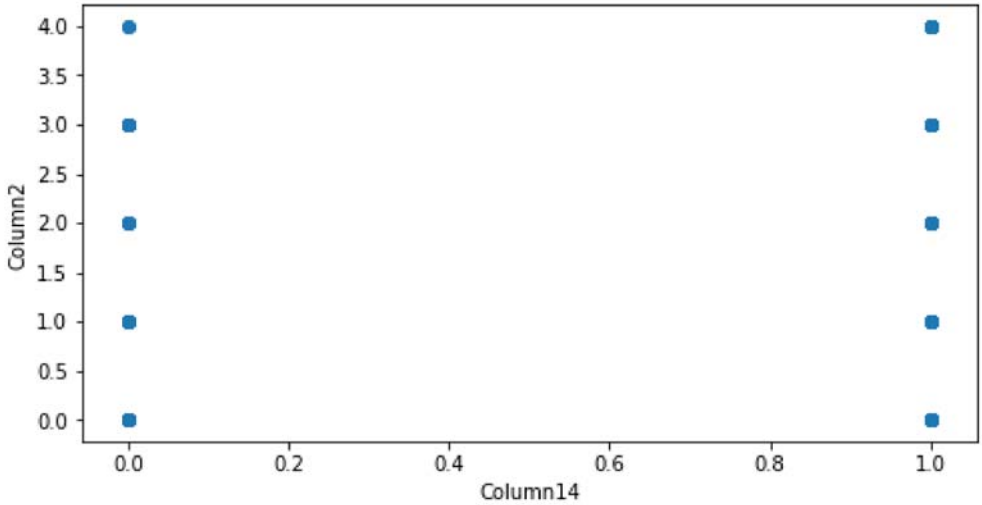
Out[15]:

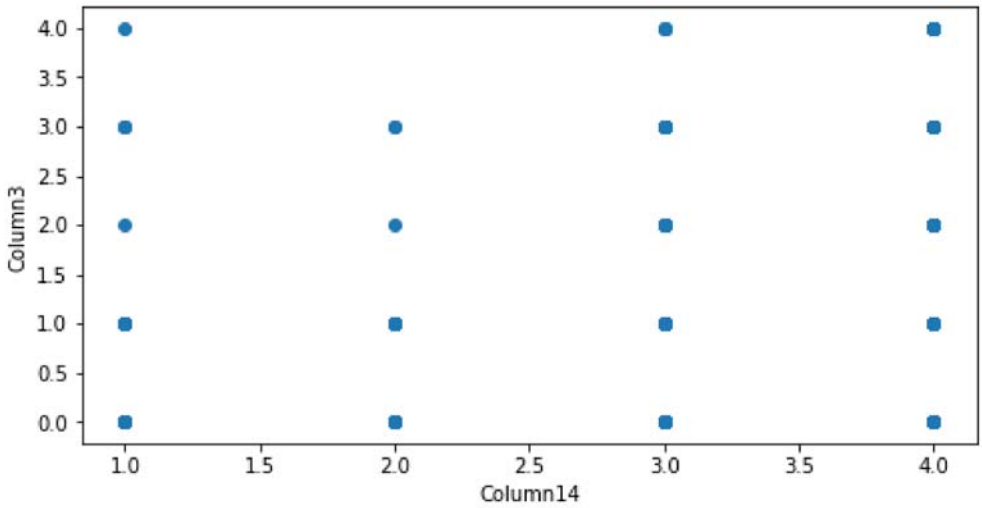
```
0    331
1    173
3     56
2     55
4     19
Name: Column14, dtype: int64
```

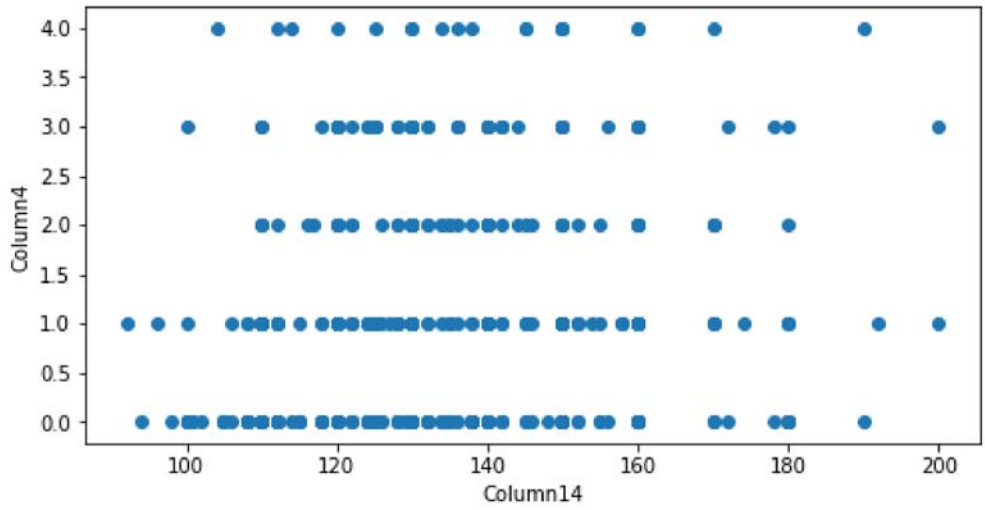
In [16]:

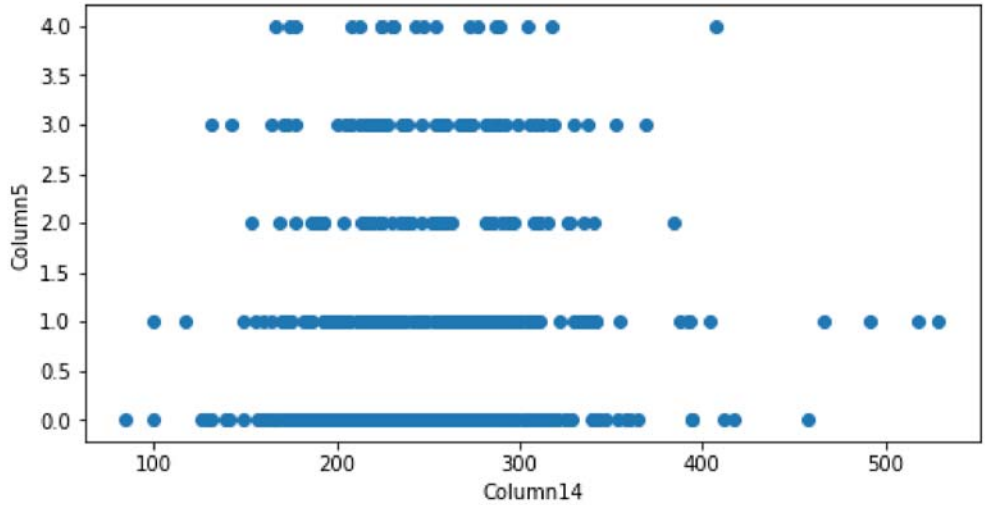
```
# Melihat persebaran data untuk memastikan saja
for column in list(df_clean) :
    fig, ax = plt.subplots(figsize=(8,4))
    ax.scatter(df_clean[column], df_clean['Column14'])
    ax.set_xlabel('Column14')
    ax.set_ylabel(column)
    plt.show()
```

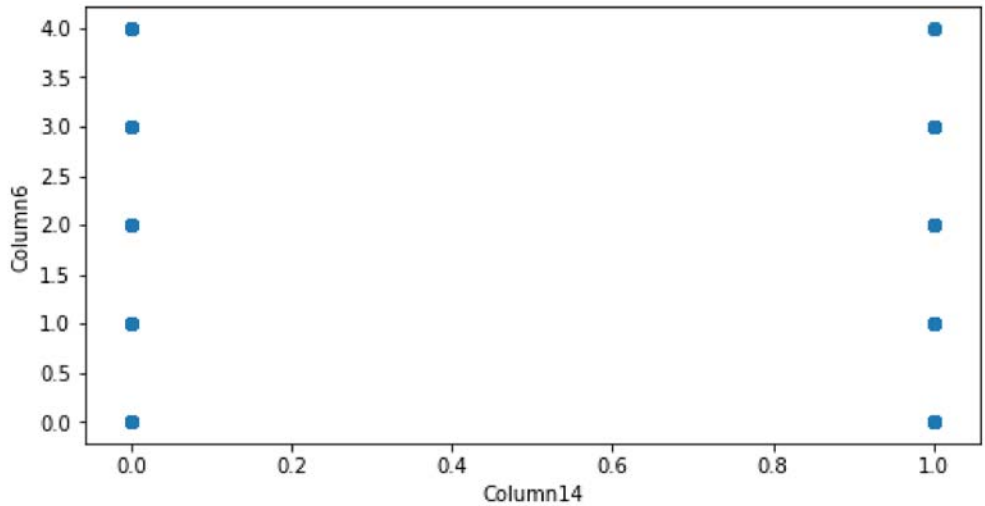

Column1
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
30
40
50
60
70

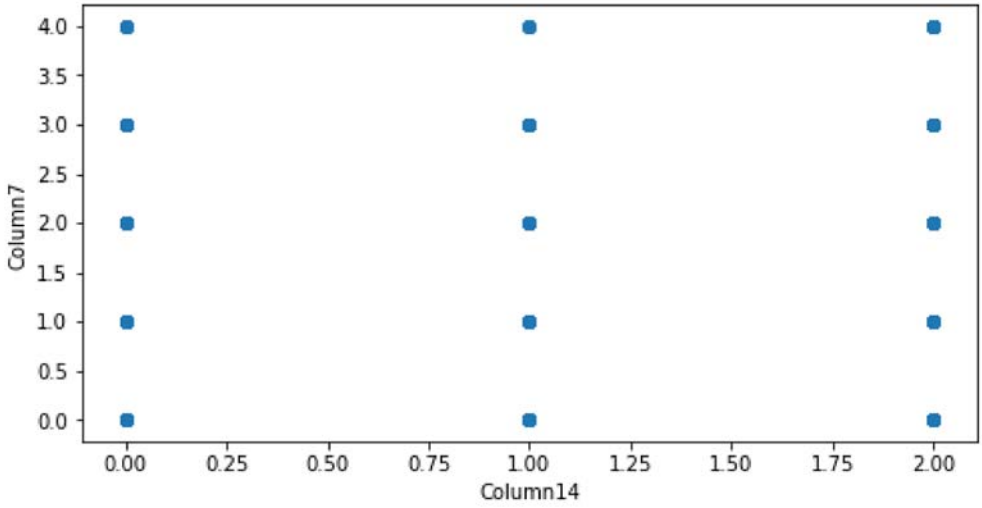

Column2
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
1.0

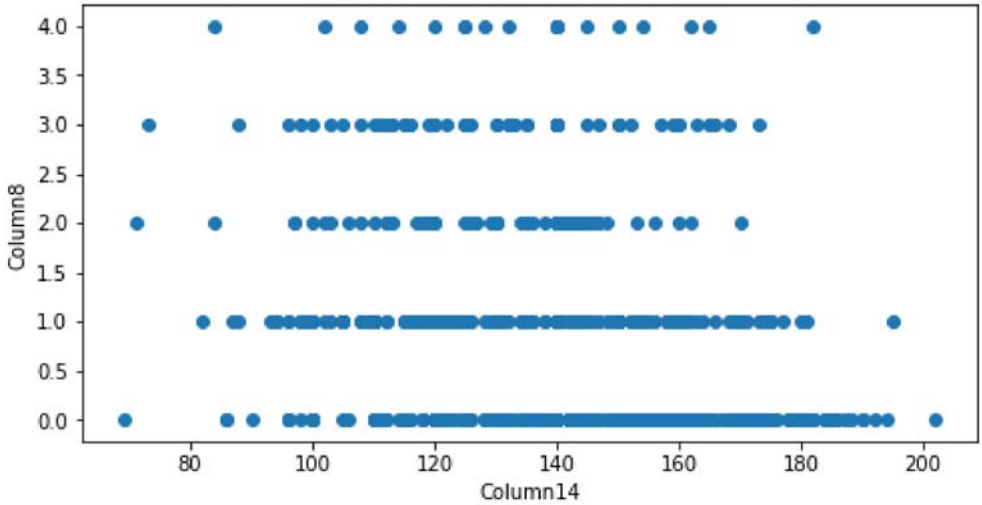

Column3
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0

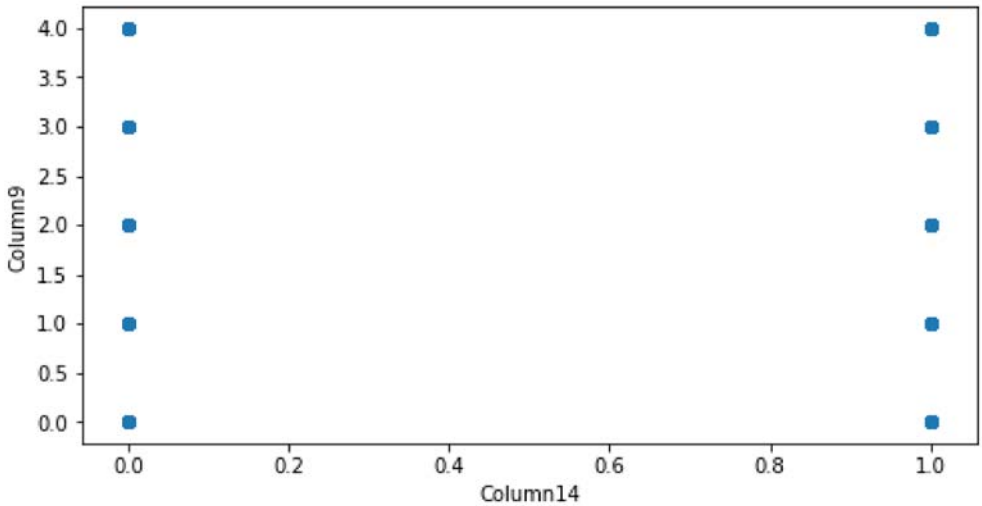

Column4
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
100
120
140
160
180
200

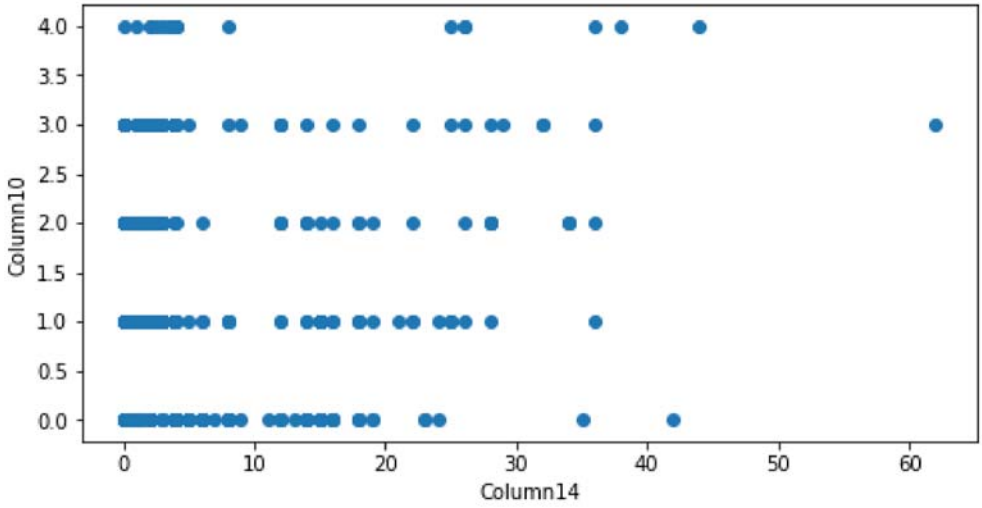

Column5
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
100
200
300
400
500

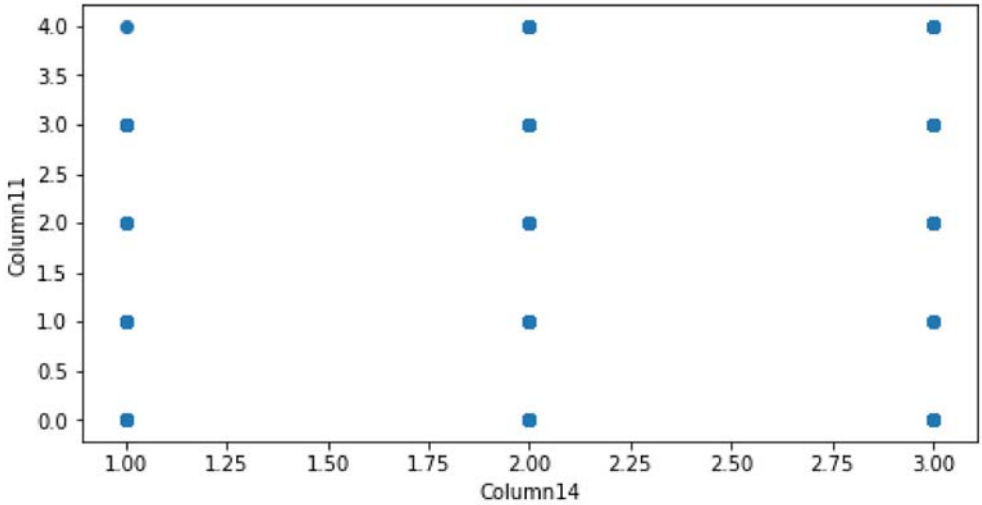

Column6
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
1.0

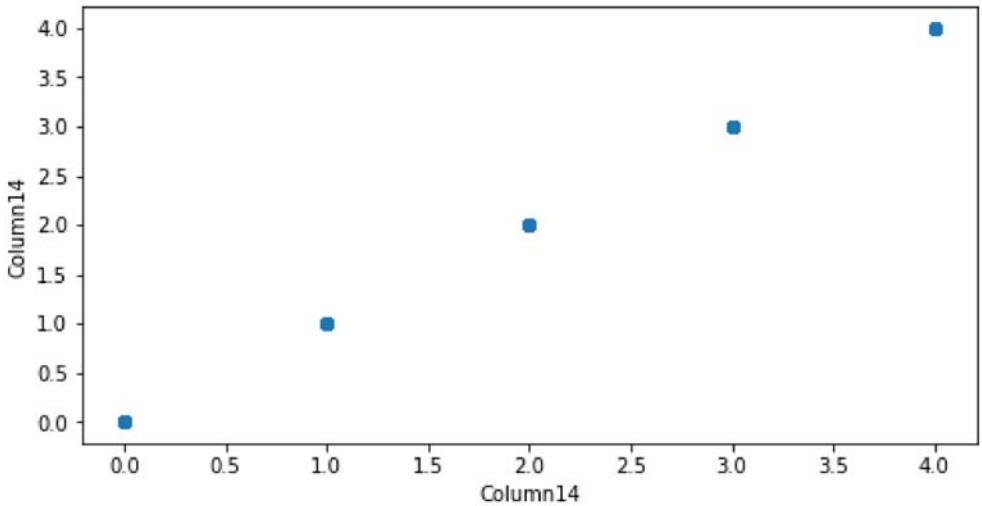

Column7
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00


Column8
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
80
100
120
140
160
180
200


Column9
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.0
0.2
0.4
0.6
0.8
1.0


Column10
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
10
20
30
40
50
60


Column11
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00


Column14
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

In [17]:

```
# Menghitung z value untuk masing-masing data
z = np.abs(stats.zscore(df_clean))
threshold = 3
```

In [18]:

```
# Membuang yang memiliki z >= threshold
df_clean = df_clean[(z < threshold).all(axis=1)]
```

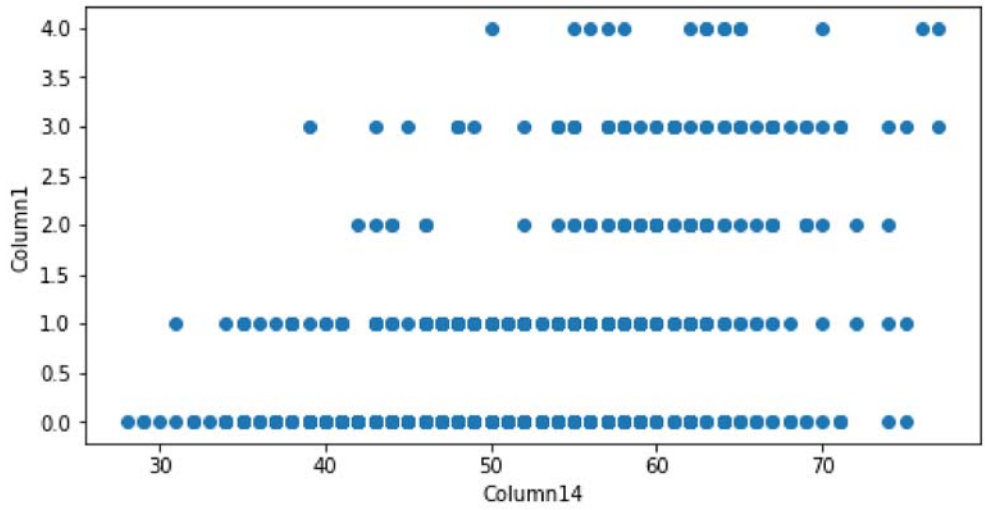
In [19]:

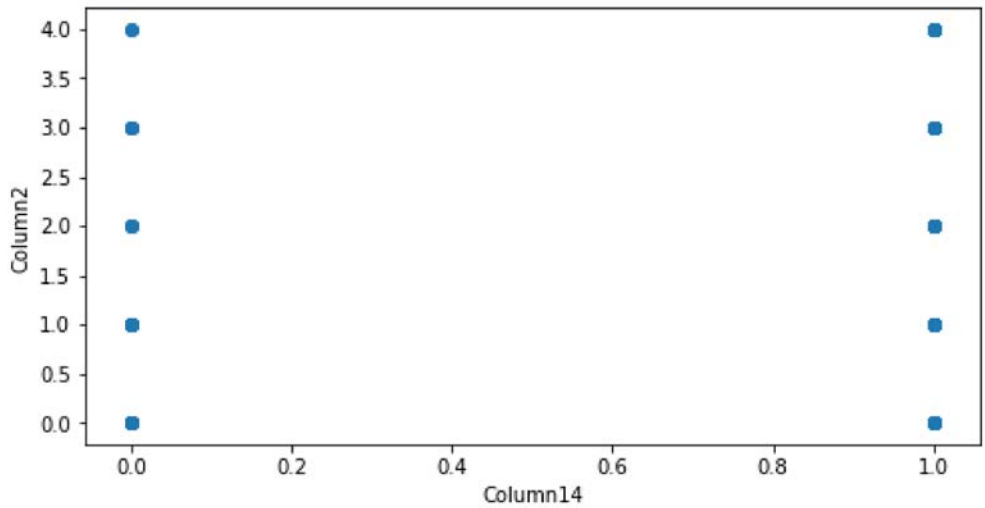
```
# Mengecek banyak row
print('Dataframe shape')
print(df_clean.shape)
# Mengecek persebaran nilai pada Column14
print(df_clean['Column14'].value_counts())
```

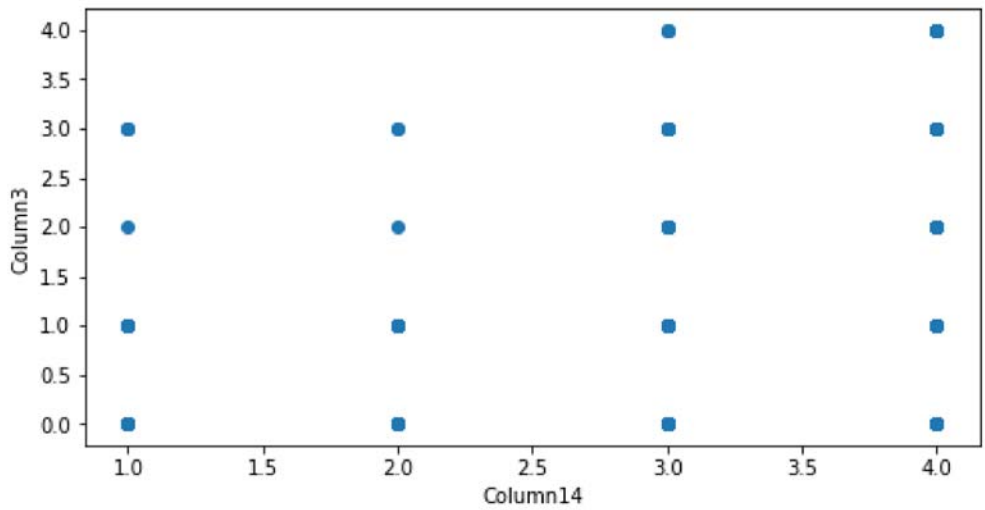
```
Dataframe shape
(609, 12)
0    326
1    166
3     51
2     51
4     15
Name: Column14, dtype: int64
```

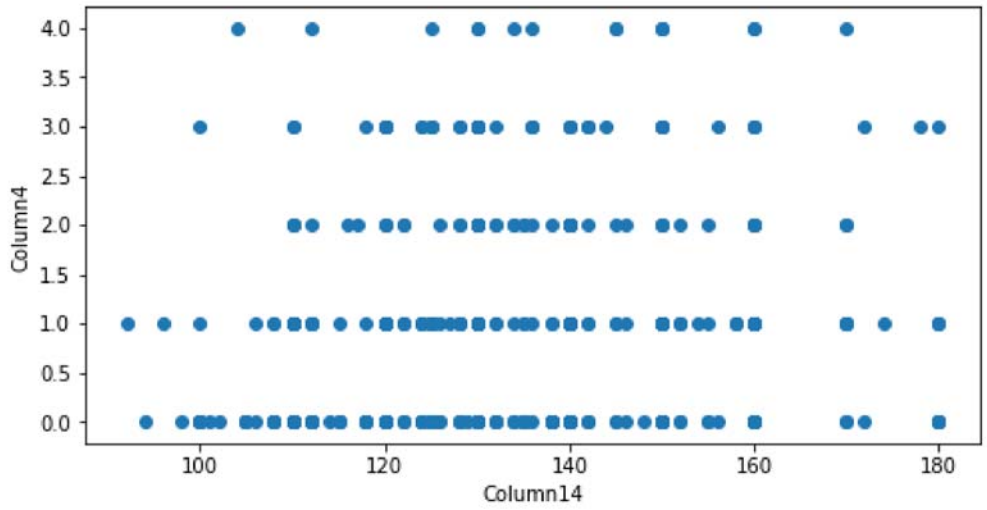
In [20]:

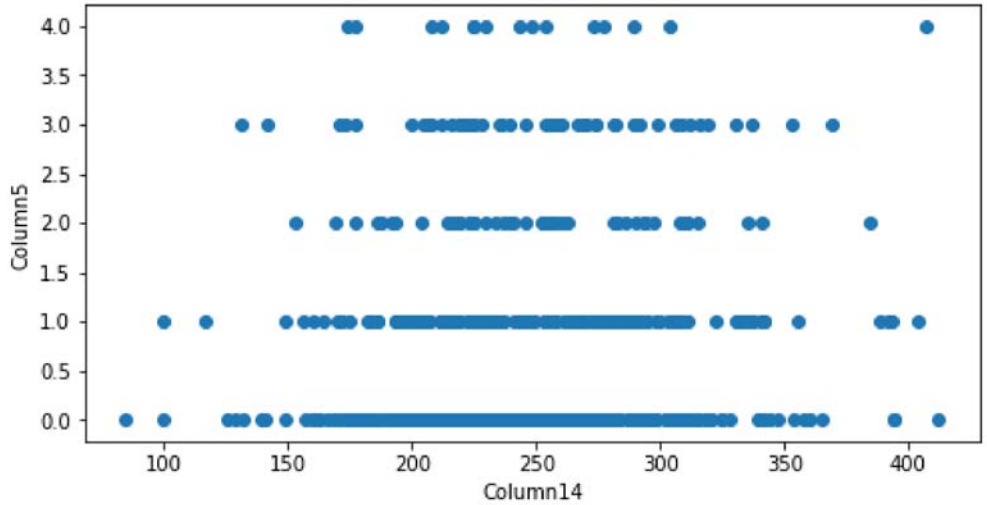
```
# Melihat persebaran data untuk memastikan saja
for column in list(df_clean) :
    fig, ax = plt.subplots(figsize=(8,4))
    ax.scatter(df_clean[column], df_clean['Column14'])
    ax.set_xlabel('Column14')
    ax.set_ylabel(column)
    plt.show()
```

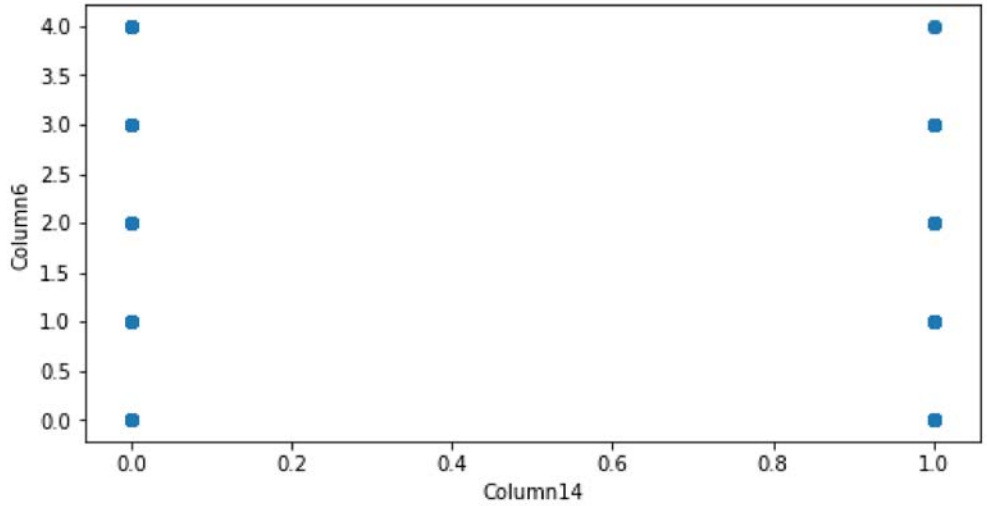

Column1
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
30
40
50
60
70

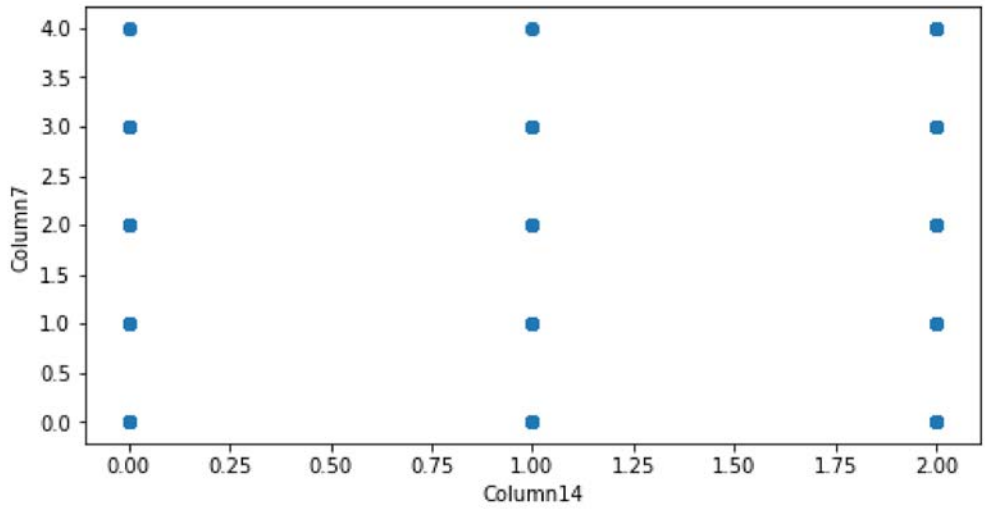

Column2
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
1.0

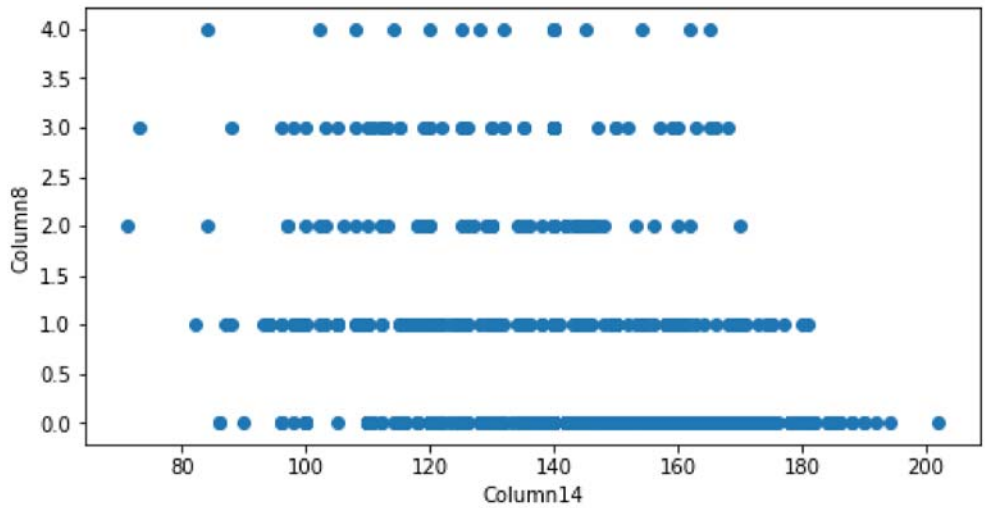

Column3
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0

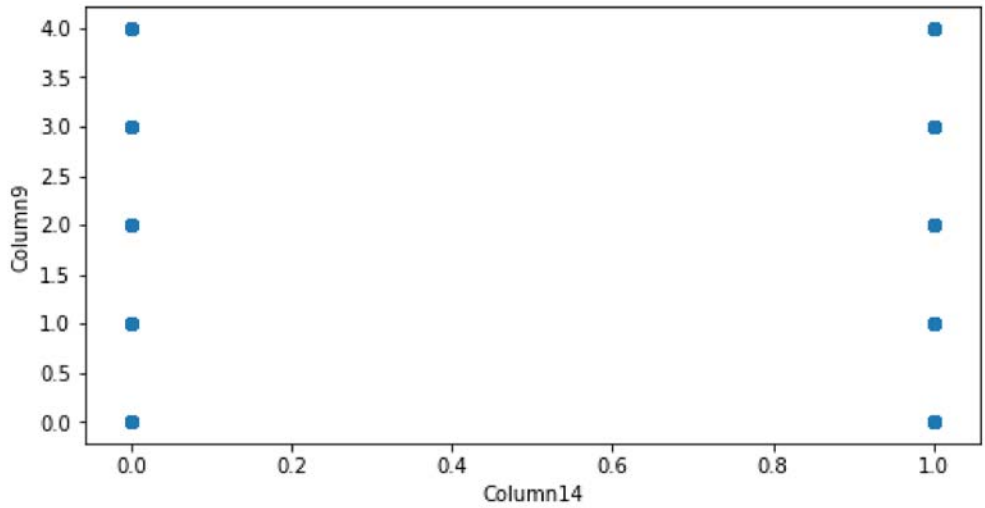

Column4
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
100
120
140
160
180

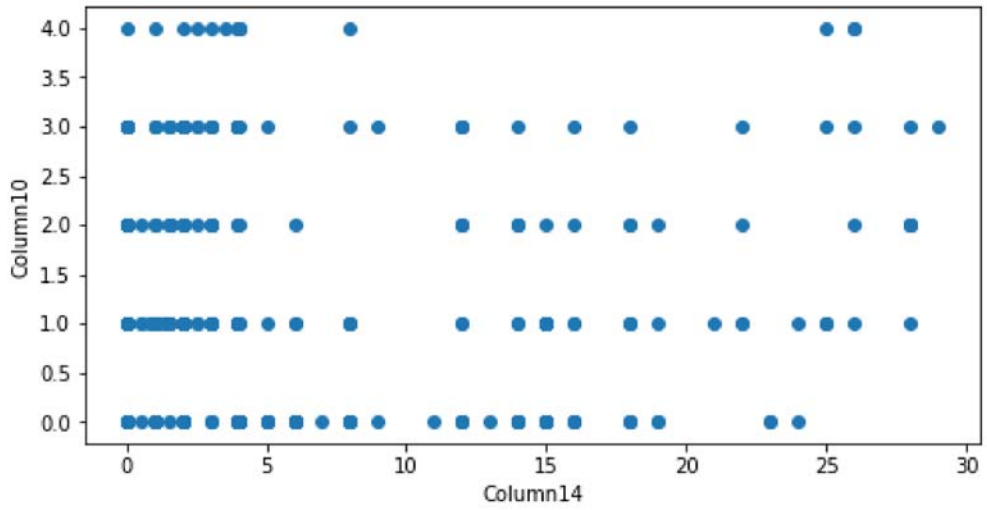

Column5
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
100
150
200
250
300
350
400

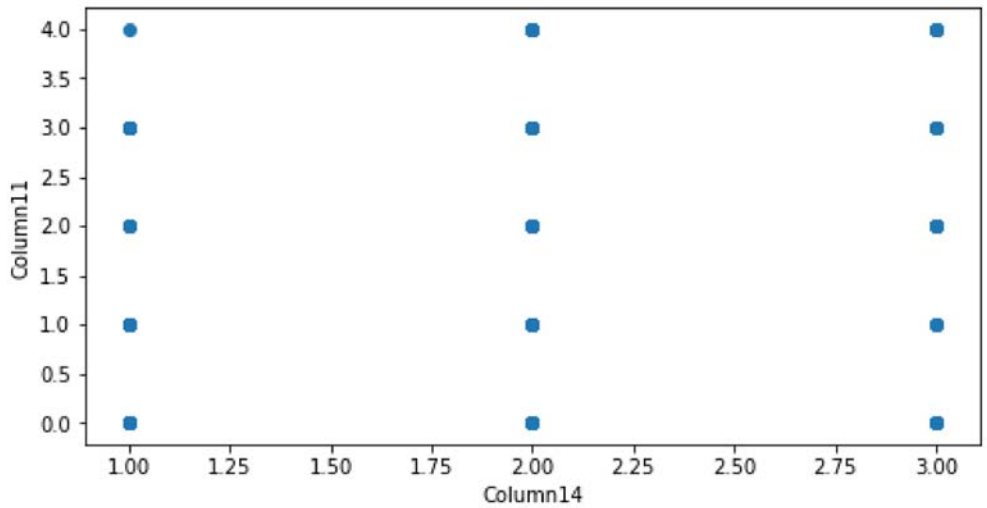

Column6
Column14
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
1.0

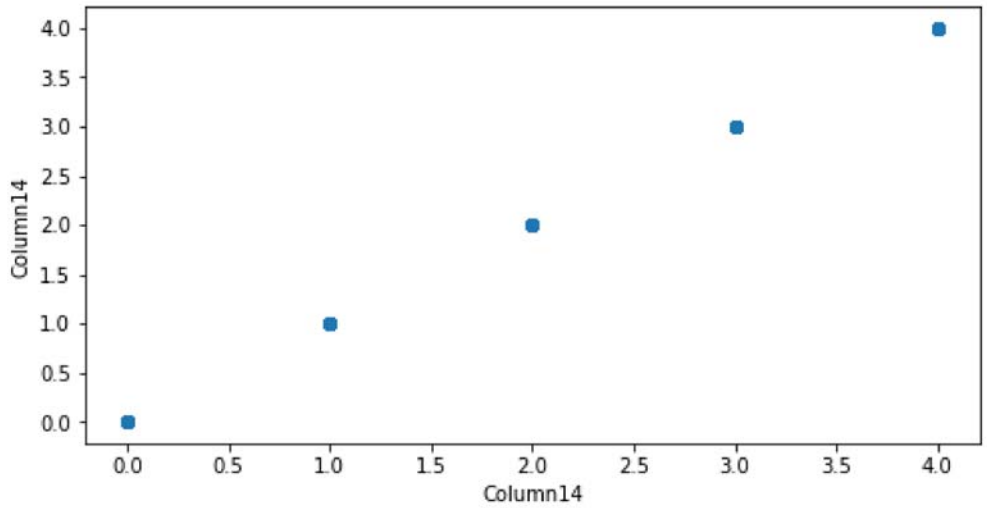

Column7
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00


Column8
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
80
100
120
140
160
180
200


Column9
Column14
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.0
0.2
0.4
0.6
0.8
1.0







Penanganan 3

In [21]:

```
# Menggunakan chi squared untuk menentukan atribut yang paling penting
# Melihat deskripsi data dan memastikan tidak ada yang negatif
df_clean.describe()
```

Out[21]:

	Column1	Column2	Column3	Column4	Column5	Column6	Co
count	609.000000	609.000000	609.000000	609.000000	609.000000	609.000000	609.(
mean	52.852217	0.742200	3.169130	132.027915	244.571429	0.152709	0.628
std	9.583145	0.437783	0.950744	16.192638	50.362782	0.360003	0.83
min	28.000000	0.000000	1.000000	92.000000	85.000000	0.000000	0.000
25%	46.000000	0.000000	2.000000	120.000000	213.000000	0.000000	0.000
50%	54.000000	1.000000	3.000000	130.000000	238.000000	0.000000	0.000
75%	59.000000	1.000000	4.000000	140.000000	275.000000	0.000000	1.000
max	77.000000	1.000000	4.000000	180.000000	412.000000	1.000000	2.000

In [22]:

```
df_X = df_clean.drop(columns=['Column14'])
df_y = df_clean['Column14']
```

In [23]:

```
print('Daftar features')
print(list(df_X))
print('Nilai chi2')
print(chi2(df_X, df_y))
```

```
Daftar features
['Column1', 'Column2', 'Column3', 'Column4', 'Column5', 'Column6', 'Column
7', 'Column8', 'Column9', 'Column10', 'Column11']
Nilai chi2
(array([176.48669525,  15.17741138,  37.54151114,  32.21896859,
        78.44310508,  20.56504346,  28.6778807 , 376.98521773,
       100.8210359 , 499.16817699,   6.31248291]), array([4.23620447e-037,
4.34705080e-003, 1.39311735e-007, 1.72574564e-006,
       3.72181679e-016, 3.86156840e-004, 9.08809143e-006, 2.60790860e-080,
       6.57721749e-021, 1.01382054e-106, 1.76995621e-001]))
```

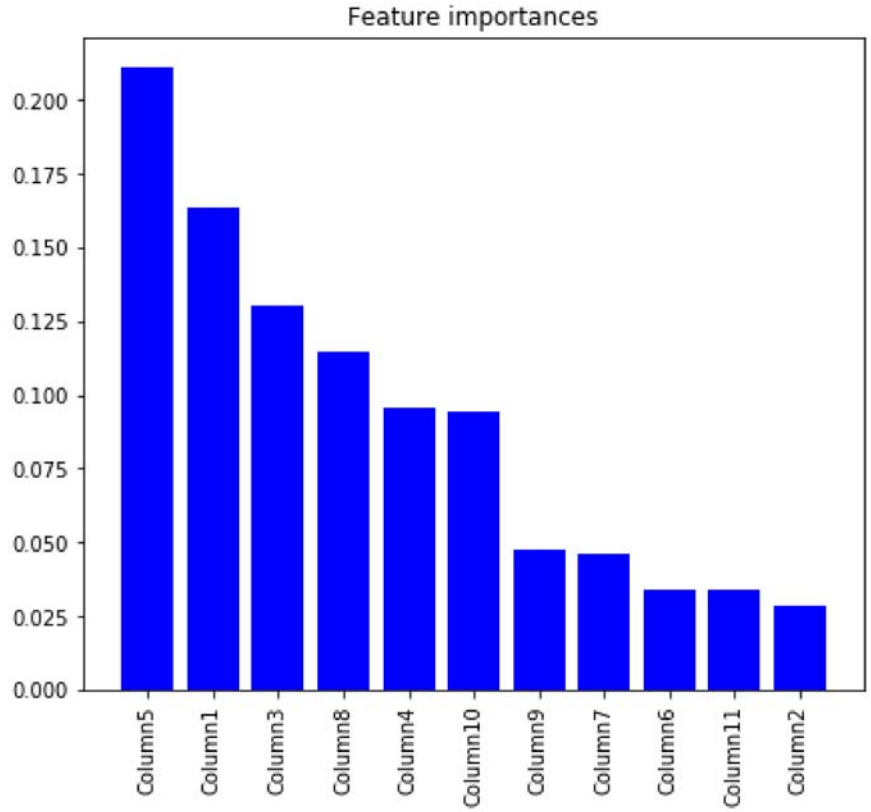
Berdasarkan perhitungan didapatkan ranking dari feature
Feature ranking

1. Column10 = 499
2. Column8 = 376
3. Column1 = 176
4. Column9 = 100
5. Column5 = 78
6. Column3 = 37
7. Column4 = 32
8. Column7 = 28
   dst

In [24]:

```
# Melakukan train dengan decision tree lalu melihat pemilihan atributnya
dt = DecisionTreeClassifier(criterion='entropy')
dt.fit(df_X, df_y)

feature_importances = dt.feature_importances_
indices = np.argsort(feature_importances)[::-1]

print('List features')
print(list(df_X))
print('Value (semakin besar semakin baik)')
print(feature_importances)
print()

print("Feature ranking:")
for f in range(df_X.shape[1]):
    print("%d. feature %d (%f)" % (f + 1, indices[f], feature_importances[indices[f]]))

# Melakukan plot
plt.figure(1, figsize=(7, 6))
plt.title("Feature importances")
plt.bar(range(df_X.shape[1]), feature_importances[indices], color="b", align="center")
plt.xticks(range(df_X.shape[1]), df_X.columns[indices],rotation=90)
plt.xlim([-1, df_X.shape[1]])
plt.show()
```

```
List features
['Column1', 'Column2', 'Column3', 'Column4', 'Column5', 'Column6', 'Column
7', 'Column8', 'Column9', 'Column10', 'Column11']
Value (semakin besar semakin baik)
[0.16365279 0.02863107 0.13027959 0.09601238 0.210912   0.03408692
 0.04596984 0.11496939 0.04751149 0.09431223 0.0336623 ]

Feature ranking:
1. feature 4 (0.210912)
2. feature 0 (0.163653)
3. feature 2 (0.130280)
4. feature 7 (0.114969)
5. feature 3 (0.096012)
6. feature 9 (0.094312)
7. feature 8 (0.047511)
8. feature 6 (0.045970)
9. feature 5 (0.034087)
10. feature 10 (0.033662)
11. feature 1 (0.028631)
```



In [25]:

```
# Dengan hasil chi squared
chi_squared_features = ['Column10', 'Column8', 'Column1', 'Column9', 'Column5', 'Column
3', 'Column4',
                        'Column7', 'Column6', 'Column2', 'Column11']
df_X2_features = []

max_acc_nb = 0
max_acc_ann = 0
max_acc_dt = 0
max_acc_knn = 0

max_features_nb = []
max_features_ann = []
max_features_dt = []
max_features_knn = []

print('Chi Squared Attribute Selection')

for feature in chi_squared_features :
    print("\nCross validation average")
    df_X2_features.append(feature)
    df_X2 = df_clean[df_X2_features]
    print("List Attribute : " + str(df_X2_features))

    model = GaussianNB()
    list_acc = cross_val_score(model, df_X2, df_y, cv=10)
    print("Naive Bayes   : " + str(list_acc.mean()) + ' ' + str(statistics.stdev(list_a
cc)))
    if (list_acc.mean() > max_acc_nb) :
        max_acc_nb = list_acc.mean()
        max_features_nb = copy.deepcopy(df_X2_features)

    model = MLPClassifier()
    list_acc = cross_val_score(model, df_X2, df_y, cv=10)
    print("ANN           : " + str(list_acc.mean()) + ' ' + str(statistics.stdev(list_a
cc)))
    if (list_acc.mean() > max_acc_ann) :
        max_acc_ann = list_acc.mean()
        max_features_ann = copy.deepcopy(df_X2_features)

    model = DecisionTreeClassifier(criterion='entropy')
    list_acc = cross_val_score(model, df_X2, df_y, cv=10)
    print("Decision Tree : " + str(list_acc.mean()) + ' ' + str(statistics.stdev(list_a
cc)))
    if (list_acc.mean() > max_acc_dt) :
        max_acc_dt = list_acc.mean()
        max_features_dt = copy.deepcopy(df_X2_features)

    model = KNeighborsClassifier(n_neighbors=3)
    list_acc = cross_val_score(model, df_X2, df_y, cv=10)
    print("KNN           : " + str(list_acc.mean()) + ' ' + str(statistics.stdev(list_a
cc)))
    if (list_acc.mean() > max_acc_knn) :
        max_acc_knn = list_acc.mean()
        max_features_knn = copy.deepcopy(df_X2_features)
```

```
Chi Squared Attribute Selection

Cross validation average
List Attribute : ['Column10']
Naive Bayes   : 0.5272822199714975 0.024785838848779402
ANN           : 0.5318269691849887 0.014437260819348876
Decision Tree : 0.5712584392842098 0.03727006032796841
KNN           : 0.48120315398990765 0.13120189820403075

Cross validation average
List Attribute : ['Column10', 'Column8']
Naive Bayes   : 0.5518139419327951 0.012716573819248131
ANN           : 0.542065658359401 0.037419383847922046
Decision Tree : 0.5358549137753319 0.038791086583544084
KNN           : 0.5521556167035646 0.051735454737898395

Cross validation average
List Attribute : ['Column10', 'Column8', 'Column1']
Naive Bayes   : 0.5403519486819816 0.03454611989230022
ANN           : 0.5390807202269448 0.03287577886062282
Decision Tree : 0.4837271665964559 0.06251004433609898
KNN           : 0.5033569612750853 0.041024540029810264

Cross validation average
List Attribute : ['Column10', 'Column8', 'Column1', 'Column9']
Naive Bayes   : 0.6009201424678898 0.03929213718539089
ANN           : 0.5418373943478925 0.05905506925869362
Decision Tree : 0.5230322014851796 0.07687342221653254
KNN           : 0.5099725982351728 0.03749096250535891

Cross validation average
List Attribute : ['Column10', 'Column8', 'Column1', 'Column9', 'Column5']
Naive Bayes   : 0.6057904609479335 0.03777721886376315
ANN           : 0.5461551119710674 0.0731328523059886
Decision Tree : 0.5281245938611981 0.044822172589158875
KNN           : 0.5139951649875862 0.05039777326754723

Cross validation average
List Attribute : ['Column10', 'Column8', 'Column1', 'Column9', 'Column5',
'Column3']
Naive Bayes   : 0.5960285507174932 0.03315762678188959
ANN           : 0.4867212498543503 0.12781105122744468
Decision Tree : 0.5021334471268901 0.045627855597524934
KNN           : 0.5154756529591553 0.048563815725926565

Cross validation average
List Attribute : ['Column10', 'Column8', 'Column1', 'Column9', 'Column5',
'Column3', 'Column4']
Naive Bayes   : 0.5926174469386658 0.02530823926109214
ANN           : 0.5439876052039545 0.09497354536663852
Decision Tree : 0.5219615635839705 0.03603227992009589
KNN           : 0.5009469196192491 0.03097394749237733

Cross validation average
List Attribute : ['Column10', 'Column8', 'Column1', 'Column9', 'Column5',
'Column3', 'Column4', 'Column7']
Naive Bayes   : 0.5927950976525738 0.04106459007423122
ANN           : 0.5586279006713335 0.031373801088518886
Decision Tree : 0.5370757390045623 0.04780507073138584
KNN           : 0.5009469196192491 0.03097394749237733
```

```
Cross validation average
List Attribute : ['Column10', 'Column8', 'Column1', 'Column9', 'Column5',
'Column3', 'Column4', 'Column7', 'Column6']
Naive Bayes   : 0.5950033583477489 0.03691844878879444
ANN           : 0.5425013472604397 0.09608946821481892
Decision Tree : 0.5126683655406071 0.054870737011629735
KNN           : 0.5009469196192491 0.03097394749237733

Cross validation average
List Attribute : ['Column10', 'Column8', 'Column1', 'Column9', 'Column5',
'Column3', 'Column4', 'Column7', 'Column6', 'Column2']
Naive Bayes   : 0.5965609006534074 0.0358624392699817
ANN           : 0.5302907001496832 0.12962895580228168
Decision Tree : 0.5270624148508994 0.037328005923345564
KNN           : 0.5009469196192491 0.03097394749237733

Cross validation average
List Attribute : ['Column10', 'Column8', 'Column1', 'Column9', 'Column5',
'Column3', 'Column4', 'Column7', 'Column6', 'Column2', 'Column11']
Naive Bayes   : 0.6196360968324535 0.037321843649050244
ANN           : 0.4898175400424849 0.11554750454271634
Decision Tree : 0.5252034755398005 0.04950162505961684
KNN           : 0.5009469196192491 0.03097394749237733
```

In [26]:

```
# Max Performance
print("Max Performance")
print("Algoritma = Naive Bayes")
print("> Rata-rata akurasi : " + str(max_acc_nb))
print("> Features : " + str(max_features_nb))

print()
print("Algoritma = ANN")
print("> Rata-rata akurasi : " + str(max_acc_ann))
print("> Features : " + str(max_features_ann))

print()
print("Algoritma = Decision Tree")
print("> Rata-rata akurasi : " + str(max_acc_dt))
print("> Features : " + str(max_features_dt))

print()
print("Algoritma = KNN")
print("> Rata-rata akurasi : " + str(max_acc_knn))
print("> Features : " + str(max_features_knn))
```

```
Max Performance
Algoritma = Naive Bayes
> Rata-rata akurasi : 0.6196360968324535
> Features : ['Column10', 'Column8', 'Column1', 'Column9', 'Column5', 'Col
umn3', 'Column4', 'Column7', 'Column6', 'Column2', 'Column11']

Algoritma = ANN
> Rata-rata akurasi : 0.5586279006713335
> Features : ['Column10', 'Column8', 'Column1', 'Column9', 'Column5', 'Col
umn3', 'Column4', 'Column7']

Algoritma = Decision Tree
> Rata-rata akurasi : 0.5712584392842098
> Features : ['Column10']

Algoritma = KNN
> Rata-rata akurasi : 0.5521556167035646
> Features : ['Column10', 'Column8']
```

In [27]:

```
# Dengan pendekatan decision tree
indices

df_X2_features = []

max_acc_nb = 0
max_acc_ann = 0
max_acc_dt = 0
max_acc_knn = 0

max_features_nb = []
max_features_ann = []
max_features_dt = []
max_features_knn = []

print('Tree Approach Attribute Selection')

for index in indices :
    print("\nCross validation average")
    df_X2_features.append(list(df_X)[index])
    df_X2 = df_clean[df_X2_features]

    print("List Attribute : " + str(df_X2_features))

    model = GaussianNB()
    list_acc = cross_val_score(model, df_X2, df_y, cv=10)
    print("Naive Bayes   : " + str(list_acc.mean()) + ' ' + str(statistics.stdev(list_a
cc)))
    if (list_acc.mean() > max_acc_nb) :
        max_acc_nb = list_acc.mean()
        max_features_nb = copy.deepcopy(df_X2_features)

    model = MLPClassifier()
    list_acc = cross_val_score(model, df_X2, df_y, cv=10)
    print("ANN           : " + str(list_acc.mean()) + ' ' + str(statistics.stdev(list_a
cc)))
    if (list_acc.mean() > max_acc_ann) :
        max_acc_ann = list_acc.mean()
        max_features_ann = copy.deepcopy(df_X2_features)

    model = DecisionTreeClassifier(criterion='entropy')
    list_acc = cross_val_score(model, df_X2, df_y, cv=10)
    print("Decision Tree : " + str(list_acc.mean()) + ' ' + str(statistics.stdev(list_a
cc)))
    if (list_acc.mean() > max_acc_dt) :
        max_acc_dt = list_acc.mean()
        max_features_dt = copy.deepcopy(df_X2_features)

    model = KNeighborsClassifier(n_neighbors=3)
    list_acc = cross_val_score(model, df_X2, df_y, cv=10)
    print("KNN           : " + str(list_acc.mean()) + ' ' + str(statistics.stdev(list_a
cc)))
    if (list_acc.mean() > max_acc_knn) :
        max_acc_knn = list_acc.mean()
        max_features_knn = copy.deepcopy(df_X2_features)
```

```
Tree Approach Attribute Selection

Cross validation average
List Attribute : ['Column5']
Naive Bayes   : 0.5240272835644311 0.018814220061945476
ANN           : 0.4555521835142379 0.12705127918502046
Decision Tree : 0.4368717732972421 0.058908516763887336
KNN           : 0.4799845555216951 0.047332051493297195

Cross validation average
List Attribute : ['Column5', 'Column1']
Naive Bayes   : 0.5224280069956708 0.03837790647811159
ANN           : 0.46328122899282065 0.09363635544196933
Decision Tree : 0.4311862922272316 0.06918884518318874
KNN           : 0.4693467439432101 0.05053185939443833

Cross validation average
List Attribute : ['Column5', 'Column1', 'Column3']
Naive Bayes   : 0.5861342252328157 0.018203181424018628
ANN           : 0.49218355065027036 0.08867005736066116
Decision Tree : 0.5070275177244576 0.07348672186068117
KNN           : 0.4841909210891915 0.04402526316485858

Cross validation average
List Attribute : ['Column5', 'Column1', 'Column3', 'Column8']
Naive Bayes   : 0.5861606662693043 0.019411613384912707
ANN           : 0.5340087888436752 0.028039954706554297
Decision Tree : 0.4877206033934158 0.05078485016283451
KNN           : 0.5161214136543306 0.06482523063232605

Cross validation average
List Attribute : ['Column5', 'Column1', 'Column3', 'Column8', 'Column4']
Naive Bayes   : 0.5859726800231247 0.017141675050491228
ANN           : 0.499095234787441 0.07229380101841666
Decision Tree : 0.48338511369645687 0.05447887252719298
KNN           : 0.5080126844150257 0.056314686143304295

Cross validation average
List Attribute : ['Column5', 'Column1', 'Column3', 'Column8', 'Column4',
'Column10']
Naive Bayes   : 0.579558655966263 0.04163775980636556
ANN           : 0.5245709493676559 0.08604434644926116
Decision Tree : 0.4898786709345787 0.04342209120474093
KNN           : 0.5009469196192491 0.03097394749237733

Cross validation average
List Attribute : ['Column5', 'Column1', 'Column3', 'Column8', 'Column4',
'Column10', 'Column9']
Naive Bayes   : 0.5926174469386658 0.02530823926109214
ANN           : 0.5619704090069823 0.04707064463185056
Decision Tree : 0.5188997811892193 0.04361525418078179
KNN           : 0.5009469196192491 0.03097394749237733

Cross validation average
List Attribute : ['Column5', 'Column1', 'Column3', 'Column8', 'Column4',
'Column10', 'Column9', 'Column7']
Naive Bayes   : 0.5927950976525738 0.04106459007423122
ANN           : 0.5427484056951304 0.04641441597372551
Decision Tree : 0.5358437659654565 0.05114083410667538
KNN           : 0.5009469196192491 0.03097394749237733
```

```
Cross validation average
List Attribute : ['Column5', 'Column1', 'Column3', 'Column8', 'Column4',
'Column10', 'Column9', 'Column7', 'Column6']
Naive Bayes   : 0.5950033583477489 0.03691844878879444
ANN           : 0.5429982930966488 0.07013236332697081
Decision Tree : 0.5290828993716892 0.043224916499802056
KNN           : 0.5009469196192491 0.03097394749237733

Cross validation average
List Attribute : ['Column5', 'Column1', 'Column3', 'Column8', 'Column4',
'Column10', 'Column9', 'Column7', 'Column6', 'Column11']
Naive Bayes   : 0.6179701014618756 0.030267982993967973
ANN           : 0.5308856654850362 0.051532294543612196
Decision Tree : 0.5355429711658256 0.05942448592221033
KNN           : 0.5009469196192491 0.03097394749237733

Cross validation average
List Attribute : ['Column5', 'Column1', 'Column3', 'Column8', 'Column4',
'Column10', 'Column9', 'Column7', 'Column6', 'Column11', 'Column2']
Naive Bayes   : 0.6196360968324535 0.037321843649050244
ANN           : 0.5254982062669737 0.1650291297942717
Decision Tree : 0.535161018629727 0.050933924612394724
KNN           : 0.5009469196192491 0.03097394749237733
```

In [28]:

```
# Max Performance
print("Max Performance")
print("Algoritma = Naive Bayes")
print("> Rata-rata akurasi : " + str(max_acc_nb))
print("> Features : " + str(max_features_nb))

print()
print("Algoritma = ANN")
print("> Rata-rata akurasi : " + str(max_acc_ann))
print("> Features : " + str(max_features_ann))

print()
print("Algoritma = Decision Tree")
print("> Rata-rata akurasi : " + str(max_acc_dt))
print("> Features : " + str(max_features_dt))

print()
print("Algoritma = KNN")
print("> Rata-rata akurasi : " + str(max_acc_knn))
print("> Features : " + str(max_features_knn))
```

```
Max Performance
Algoritma = Naive Bayes
> Rata-rata akurasi : 0.6196360968324535
> Features : ['Column5', 'Column1', 'Column3', 'Column8', 'Column4', 'Colu
mn10', 'Column9', 'Column7', 'Column6', 'Column11', 'Column2']

Algoritma = ANN
> Rata-rata akurasi : 0.5619704090069823
> Features : ['Column5', 'Column1', 'Column3', 'Column8', 'Column4', 'Colu
mn10', 'Column9']

Algoritma = Decision Tree
> Rata-rata akurasi : 0.5358437659654565
> Features : ['Column5', 'Column1', 'Column3', 'Column8', 'Column4', 'Colu
mn10', 'Column9', 'Column7']

Algoritma = KNN
> Rata-rata akurasi : 0.5161214136543306
> Features : ['Column5', 'Column1', 'Column3', 'Column8']
```

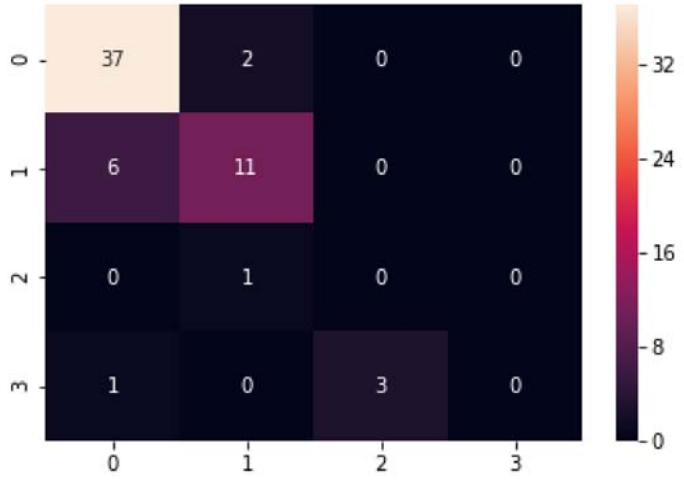
Dipilih algoritma Naive Bayes. Melakukan K-Fold pada features yang menghasilkan 3 akurasi tertinggi (dengan harapan ada ditemukan model terbaik)

1. ['Column10', 'Column8', 'Column1', 'Column9', 'Column5', 'Column3', 'Column4', 'Column7', 'Column6', 'Column2', 'Column11']
2. ['Column10', 'Column8', 'Column1', 'Column9', 'Column5', 'Column3', 'Column4', 'Column7', 'Column6', 'Column2']
3. ['Column10', 'Column8', 'Column1', 'Column9', 'Column5', 'Column3', 'Column4', 'Column7', 'Column6']

In [29]:

```
# Membuat KFold dengan k = 10
kf = KFold(n_splits = 10, shuffle = True, random_state = 0)

max_features = ['Column10', 'Column8', 'Column1', 'Column9', 'Column5', 'Column3', 'Col
umn4',
                'Column7', 'Column6', 'Column2', 'Column11'] + ['Column14']

df_kfold = df_clean[max_features]
acc1_max = 0
train1_max = []
test1_max = []

print('Algoritma : Naive Bayes')
print('Features  : ' + str(max_features))

for train, test in kf.split(df_kfold) :
    # membuat model
    model = GaussianNB()

    # membagi data menjadi X dan y (test dan train)
    df_train = df_kfold.iloc[train]
    df_test = df_kfold.iloc[test]
    X_train = df_train.drop(['Column14'], axis = 1)
    y_train = df_train['Column14']
    X_test = df_test.drop(['Column14'], axis = 1)
    y_test = df_test['Column14']

    # melakukan pemodelan
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    print('akurasinya sebesar = ' + str(accuracy_score(y_pred, y_test)))

    if (accuracy_score(y_pred, y_test) > acc1_max) :
        acc1_max = accuracy_score(y_pred, y_test)
        train1_max = copy.deepcopy(train)
        test1_max = copy.deepcopy(test)

print()
print('Max Performance')
model = GaussianNB()
df_train = df_kfold.iloc[train1_max]
df_test = df_kfold.iloc[test1_max]
X_train = df_train.drop(['Column14'], axis = 1)
y_train = df_train['Column14']
X_test = df_test.drop(['Column14'], axis = 1)
y_test = df_test['Column14']

# melakukan pemodelan
model.fit(X_train, y_train)
y_pred = model.predict(X_test)
print('akurasinya sebesar = ' + str(accuracy_score(y_pred, y_test)))
cm = confusion_matrix(y_test, y_pred)
sns.heatmap(cm, annot=True, fmt="d")
```

```
Algoritma : Naive Bayes
Features  : ['Column10', 'Column8', 'Column1', 'Column9', 'Column5', 'Colu
mn3', 'Column4', 'Column7', 'Column6', 'Column2', 'Column11', 'Column14']
akurasinya sebesar = 0.6885245901639344
akurasinya sebesar = 0.6557377049180327
akurasinya sebesar = 0.639344262295082
akurasinya sebesar = 0.5081967213114754
akurasinya sebesar = 0.5737704918032787
akurasinya sebesar = 0.5409836065573771
akurasinya sebesar = 0.6229508196721312
akurasinya sebesar = 0.5245901639344263
akurasinya sebesar = 0.7868852459016393
akurasinya sebesar = 0.45

Max Performance
akurasinya sebesar = 0.7868852459016393

Out[29]:

<matplotlib.axes._subplots.AxesSubplot at 0x19ed4172588>
```



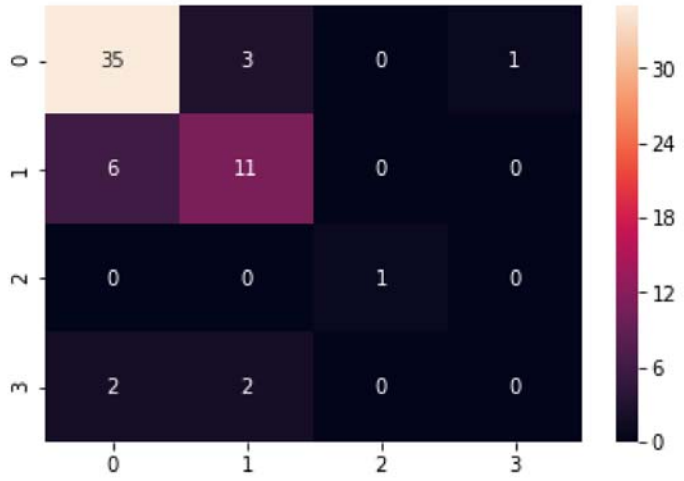
In [30]:

```
# Membuat KFold dengan k = 10
kf = KFold(n_splits = 10, shuffle = True, random_state = 0)

max_features = ['Column5', 'Column1', 'Column3', 'Column4', 'Column10', 'Column8',
                'Column7', 'Column9', 'Column11', 'Column6'] + ['Column14']

df_kfold = df_clean[max_features]
acc2_max = 0
train2_max = []
test2_max = []

print('Algoritma : Naive Bayes')
print('Features  : ' + str(max_features))

for train, test in kf.split(df_kfold) :
    # membuat model
    model = GaussianNB()

    # membagi data menjadi X dan y (test dan train)
    df_train = df_kfold.iloc[train]
    df_test = df_kfold.iloc[test]
    X_train = df_train.drop(['Column14'], axis = 1)
    y_train = df_train['Column14']
    X_test = df_test.drop(['Column14'], axis = 1)
    y_test = df_test['Column14']

    # melakukan pemodelan
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    print('akurasinya sebesar = ' + str(accuracy_score(y_pred, y_test)))

    if (accuracy_score(y_pred, y_test) > acc2_max) :
        acc2_max = accuracy_score(y_pred, y_test)
        train2_max = train
        test2_max = test

print()
print('Max Performance')
model = GaussianNB()
df_train = df_kfold.iloc[train2_max]
df_test = df_kfold.iloc[test2_max]
X_train = df_train.drop(['Column14'], axis = 1)
y_train = df_train['Column14']
X_test = df_test.drop(['Column14'], axis = 1)
y_test = df_test['Column14']

# melakukan pemodelan
model.fit(X_train, y_train)
y_pred = model.predict(X_test)
print('akurasinya sebesar = ' + str(accuracy_score(y_pred, y_test)))
cm = confusion_matrix(y_test, y_pred)
sns.heatmap(cm, annot=True, fmt="d")
```

```
Algoritma : Naive Bayes
Features  : ['Column5', 'Column1', 'Column3', 'Column4', 'Column10', 'Colu
mn8', 'Column7', 'Column9', 'Column11', 'Column6', 'Column14']
akurasinya sebesar = 0.6721311475409836
akurasinya sebesar = 0.7049180327868853
akurasinya sebesar = 0.6885245901639344
akurasinya sebesar = 0.47540983606557374
akurasinya sebesar = 0.6229508196721312
akurasinya sebesar = 0.5409836065573771
akurasinya sebesar = 0.6065573770491803
akurasinya sebesar = 0.5573770491803278
akurasinya sebesar = 0.7704918032786885
akurasinya sebesar = 0.45

Max Performance
akurasinya sebesar = 0.7704918032786885
```

Out[30]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x19ed4202748>
```



In [31]:

```
# Membuat KFold dengan k = 10
kf = KFold(n_splits = 10, shuffle = True, random_state = 2)

max_features = ['Column5', 'Column1', 'Column3', 'Column4', 'Column10',
                'Column8', 'Column7', 'Column9', 'Column11'] + ['Column14']

df_kfold = df_clean[max_features]
acc3_max = 0
train3_max = []
test3_max = []

print('Algoritma : Naive Bayes')
print('Features  : ' + str(max_features))

for train, test in kf.split(df_kfold) :
    # membuat model
    model = GaussianNB()

    # membagi data menjadi X dan y (test dan train)
    df_train = df_kfold.iloc[train]
    df_test = df_kfold.iloc[test]
    X_train = df_train.drop(['Column14'], axis = 1)
    y_train = df_train['Column14']
    X_test = df_test.drop(['Column14'], axis = 1)
    y_test = df_test['Column14']

    # melakukan pemodelan
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    print('akurasinya sebesar = ' + str(accuracy_score(y_pred, y_test)))

    if (accuracy_score(y_pred, y_test) > acc3_max) :
        acc3_max = accuracy_score(y_pred, y_test)
        train3_max = train
        test3_max = test

print()
print('Max Performance')
model = GaussianNB()
df_train = df_kfold.iloc[train3_max]
df_test = df_kfold.iloc[test3_max]
X_train = df_train.drop(['Column14'], axis = 1)
y_train = df_train['Column14']
X_test = df_test.drop(['Column14'], axis = 1)
y_test = df_test['Column14']

# melakukan pemodelan
model.fit(X_train, y_train)
y_pred = model.predict(X_test)
print('akurasinya sebesar = ' + str(accuracy_score(y_pred, y_test)))
cm = confusion_matrix(y_test, y_pred)
sns.heatmap(cm, annot=True, fmt="d")
```

```
Algoritma : Naive Bayes
Features  : ['Column5', 'Column1', 'Column3', 'Column4', 'Column10', 'Colu
mn8', 'Column7', 'Column9', 'Column11', 'Column14']
akurasinya sebesar = 0.4262295081967213
akurasinya sebesar = 0.5737704918032787
akurasinya sebesar = 0.5901639344262295
akurasinya sebesar = 0.45901639344262296
akurasinya sebesar = 0.6885245901639344
akurasinya sebesar = 0.6721311475409836
akurasinya sebesar = 0.639344262295082
akurasinya sebesar = 0.7540983606557377
akurasinya sebesar = 0.6557377049180327
akurasinya sebesar = 0.65

Max Performance
akurasinya sebesar = 0.7540983606557377
```

Out[31]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x19ed4280f60>
```

Dipilih

- Algoritma : Naive Bayes
- feature : ['Column10', 'Column8', 'Column1', 'Column9', 'Column5', 'Column3', 'Column4', 'Column7', 'Column6', 'Column2', 'Column11']

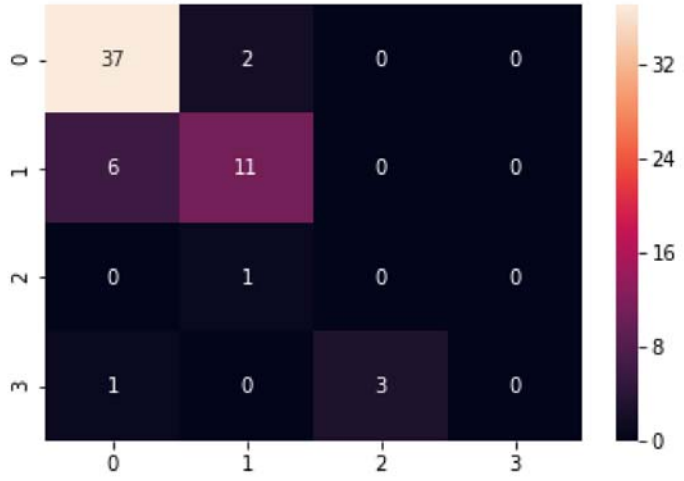
In [32]:

```
# final model
max_features = ['Column10', 'Column8', 'Column1', 'Column9', 'Column5', 'Column3',
                'Column4', 'Column7', 'Column6', 'Column2', 'Column11'] + ['Column14']

model = GaussianNB()

df_train = df_clean[max_features].iloc[train2_max]
df_test = df_clean[max_features].iloc[test2_max]
X_train = df_train.drop(['Column14'], axis = 1)
y_train = df_train['Column14']
X_test = df_test.drop(['Column14'], axis = 1)
y_test = df_test['Column14']

# melakukan pemodelan
model.fit(X_train, y_train)
y_pred = model.predict(X_test)
print('akurasinya sebesar = ' + str(accuracy_score(y_pred, y_test)))
cm = confusion_matrix(y_test, y_pred)
sns.heatmap(cm, annot=True, fmt="d")
```

```
akurasinya sebesar = 0.7868852459016393
```

Out[32]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x19ed3cf52b0>
```



Menyimpan model

In [33]:

```
# menyimpan model
filename_gnb = 'gnb_model.sav'

joblib.dump(model, filename_gnb)
```

Out[33]:

```
['gnb_model.sav']
```

Memprediksi data test

In [34]:

```
# Membuka file test
df_test = pd.read_csv('tubes2_HeartDisease_test.csv')
```

In [35]:

```
df_test.head()
```

Out[35]:

	Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8
0	60	1	2	160	267	1	1	157
1	61	1	4	148	203	0	0	161
2	54	1	4	130	242	0	0	91
3	48	1	4	120	260	0	0	115
4	57	0	1	130	308	0	0	98

Melakukan cleaning data sesuai dengan data train

In [36]:

```
# mengganti '?' ke NaN
df_test = df_test.replace('?', np.nan)
```

In [37]:

```
df_test.isnull().sum()
```

Out[37]:

```
Column1      0
Column2      0
Column3      0
Column4     12
Column5      6
Column6     12
Column7      0
Column8     11
Column9     11
Column10    13
Column11    47
Column12    97
Column13    78
dtype: int64
```

In [38]:

```
# drop Column12 dan Column13
df_test = df_test.drop(columns=['Column12', 'Column13'])
```

In [39]:

```
# mengganti type dari object ke numeric
object_type = ['Column4','Column5','Column6','Column7','Column8','Column9','Column10',
'Column11']
df_test[object_type] = df_test[object_type].apply(pd.to_numeric, downcast='float', erro
rs='coerce', axis=1)
```

In [40]:

```
median_type = ['Column4', 'Column5', 'Column8']
mode_type = ['Column6', 'Column7', 'Column9', 'Column11']
mean_type = ['Column10']

for feature in median_type :
    df_test[feature] = df_test[feature].fillna(default_value[feature])

for feature in mode_type :
    df_test[feature] = df_test[feature].fillna(default_value[feature])

for feature in mean_type :
    df_test[feature] = df_test[feature].fillna(default_value[feature])
```

In [41]:

```
df_test.isnull().sum()
```

Out[41]:

```
Column1     0
Column2     0
Column3     0
Column4     0
Column5     0
Column6     0
Column7     0
Column8     0
Column9     0
Column10    0
Column11    0
dtype: int64
```

In [42]:

```
# mengganti type sesuai dengan yang seharusnya
float_type = ['Column10']
int_type = ['Column4','Column5','Column6','Column7','Column8','Column9','Column11']

df_test[float_type] = df_test[float_type].astype(float)
df_test[int_type] = df_test[int_type].astype(int)
```

In [43]:

```
# Memanggil model yang telah disimpan
model_load = joblib.load(filename_gnb)
```

In [44]:

```
print("Features :")
print(max_features)

try:
    max_features.remove('Column14')
except ValueError:
    pass  # do nothing!

X_test = df_test[max_features]
y_test_pred = model.predict(X_test)
```

```
Features :
['Column10', 'Column8', 'Column1', 'Column9', 'Column5', 'Column3', 'Colum
n4', 'Column7', 'Column6', 'Column2', 'Column11', 'Column14']
```

Hasil Prediksi

In [45]:

```
print("Hasil Prediksi")
print(y_test_pred)
```

```
Hasil Prediksi
[0 0 1 1 0 0 2 1 0 4 1 1 0 0 0 2 1 0 0 0 0 1 0 2 0 0 1 2 3 0 0 1 4 0 1 0 0
 0 0 0 1 0 0 1 1 1 1 4 1 1 1 0 2 2 0 1 0 1 1 0 0 0 1 2 0 0 1 0 0 0 1 0 0 0
 0 0 0 1 0 0 0 2 1 1 0 2 1 0 3 1 1 0 0 1 0 0 0 1 1 0 2 0 0 0 2 0 0 0 1 4 0
 0 3 0 0 2 0 3 0 2 2 1 0 1 1 0 0 2 3 0 0 1 4 0 2 3 0 0 0 0 0]
```