In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

In [81]:
```
df=pd.read_csv('bank_marketing_part1_Data.csv')
```

In [82]:
```
df.head()
```

Out[82]:

	spending	advance_payments	probability_of_full_payment	current_balance	credit_limit	min_paymen
0	19.94	16.92	0.8752	6.675	3.763	
1	15.99	14.89	0.9064	5.363	3.582	
2	18.95	16.42	0.8829	6.248	3.755	
3	10.83	12.96	0.8099	5.278	2.641	
4	17.99	15.86	0.8992	5.890	3.694	

In [83]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 210 entries, 0 to 209
Data columns (total 7 columns):
spending                      210 non-null float64
advance_payments              210 non-null float64
probability_of_full_payment   210 non-null float64
current_balance               210 non-null float64
credit_limit                  210 non-null float64
min_payment_amt               210 non-null float64
max_spent_in_single_shopping  210 non-null float64
dtypes: float64(7)
memory usage: 11.6 KB
```

In [84]:
```
df.describe()
```

Out[84]:

	spending	advance_payments	probability_of_full_payment	current_balance	credit_limit	min_p
count	210.000000	210.000000	210.000000	210.000000	210.000000	
mean	14.847524	14.559286	0.870999	5.628533	3.258605	
std	2.909699	1.305959	0.023629	0.443063	0.377714	
min	10.590000	12.410000	0.808100	4.899000	2.630000	
25%	12.270000	13.450000	0.856900	5.262250	2.944000	
50%	14.355000	14.320000	0.873450	5.523500	3.237000	
75%	17.305000	15.715000	0.887775	5.979750	3.561750	
max	21.180000	17.250000	0.918300	6.675000	4.033000	

In [85]:
```
df.duplicated().sum()
```

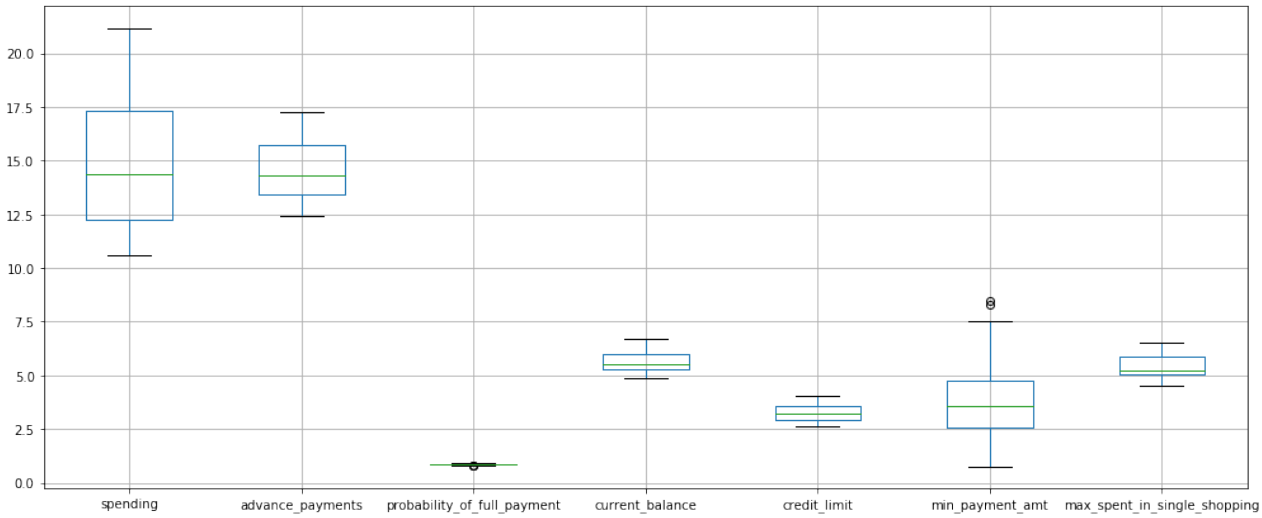
Out[85]:
```
0
```

In [86]:
```
df.isnull().sum()
```

Out[86]:
```
spending                      0
advance_payments              0
probability_of_full_payment   0
current_balance               0
credit_limit                  0
min_payment_amt               0
max_spent_in_single_shopping  0
dtype: int64
```

In [87]:
```
plt.figure(figsize=(17,7))
df.boxplot()
```

Out[87]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1891ad5ea20>
```

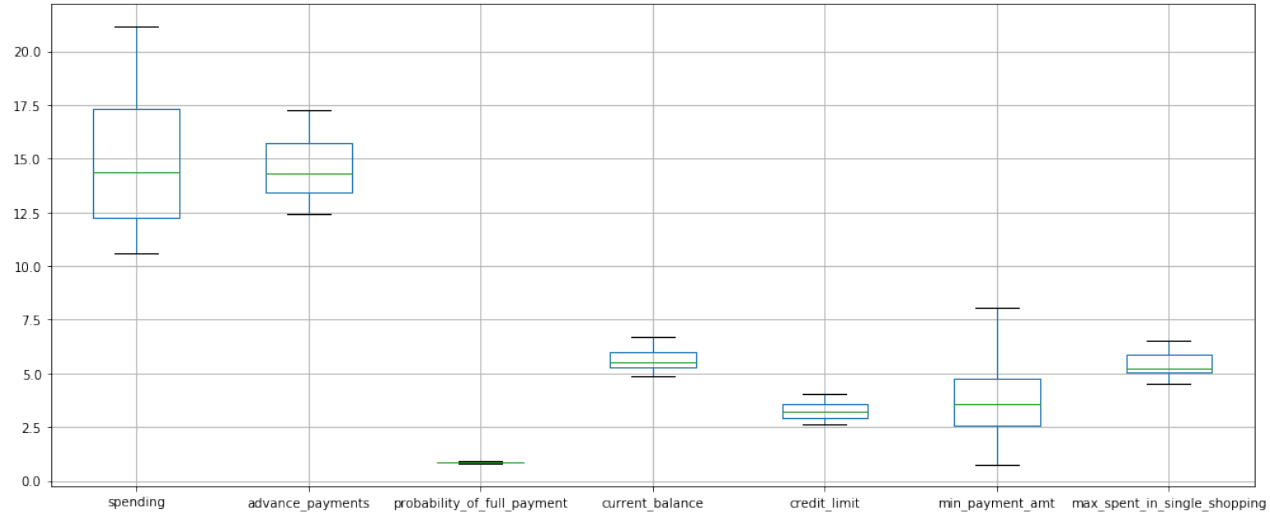


In [88]:
```
def treat_outlier(col):
    sorted(col)
    Q1,Q3=np.percentile(col,[25,75])
    IQR=Q3-Q1
    lower_range= Q1-(1.5 * IQR)
    upper_range= Q3+(1.5 * IQR)
    return lower_range, upper_range
```

In [89]:
```
for feature in df[['spending', 'advance_payments', 'probability_of_full_payment', 'current_balance','credit_limit','min_payment_amt','max_spent_in_single_shopping']]:
    lr,ur=treat_outlier(df[feature])
    df[feature]=np.where(df[feature]>ur,ur,df[feature])
    df[feature]=np.where(df[feature]<lr,lr,df[feature])
```

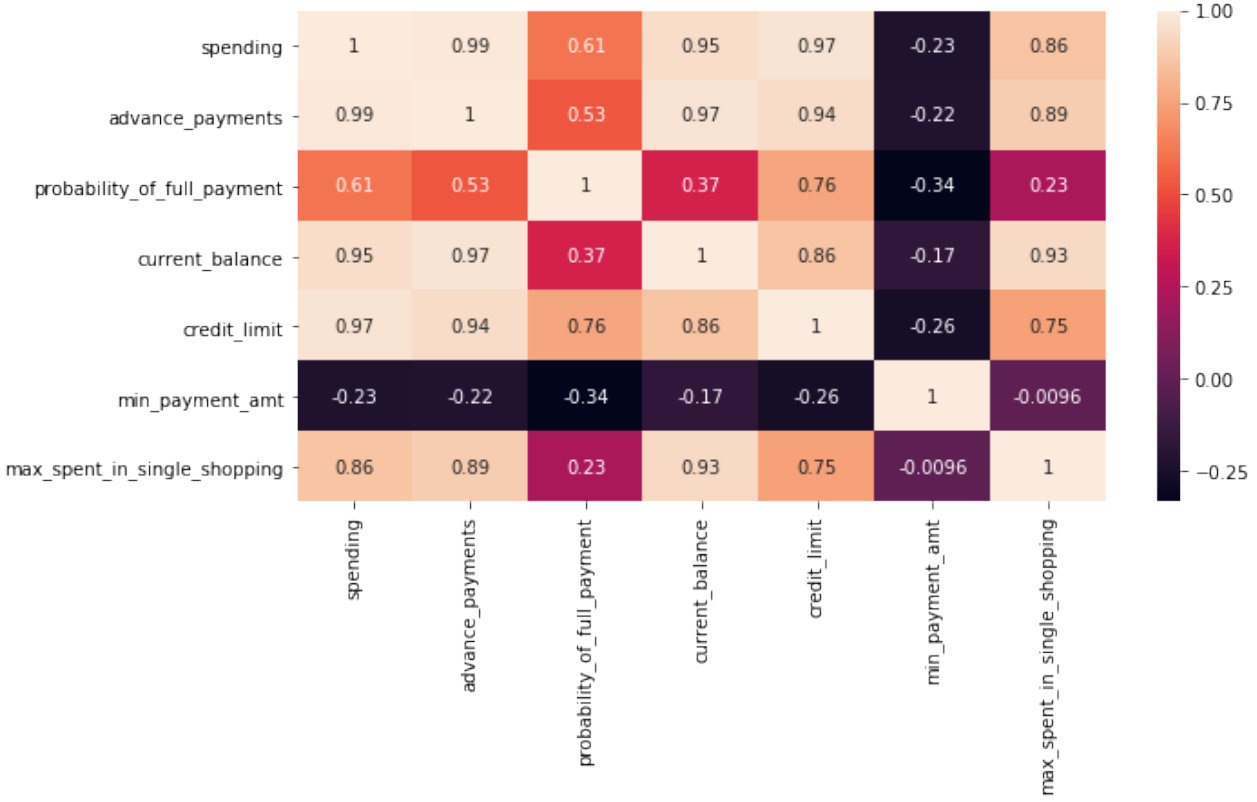
In [90]:
```
plt.figure(figsize=(17,7))
df.boxplot()
```

Out[90]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1891b27f828>
```



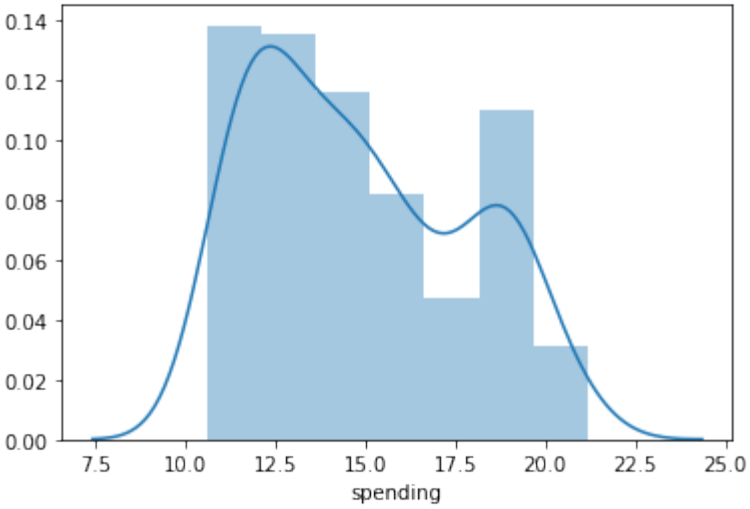
In [91]:
```
x=df.corr()
plt.figure(figsize=(10,5))
sns.heatmap(x,annot=True)
```

Out[91]: <matplotlib.axes._subplots.AxesSubplot at 0x1891b0a1438>



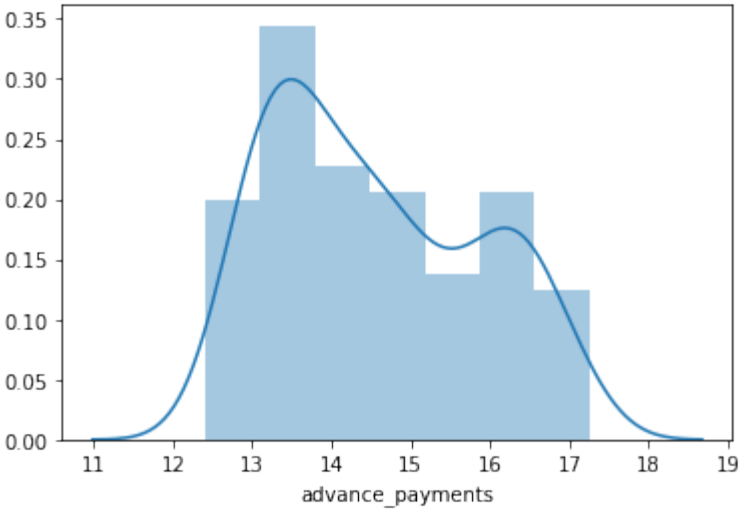
In [92]:
```
sns.distplot(df['spending'])
```

Out[92]: <matplotlib.axes._subplots.AxesSubplot at 0x1891b1b9a58>



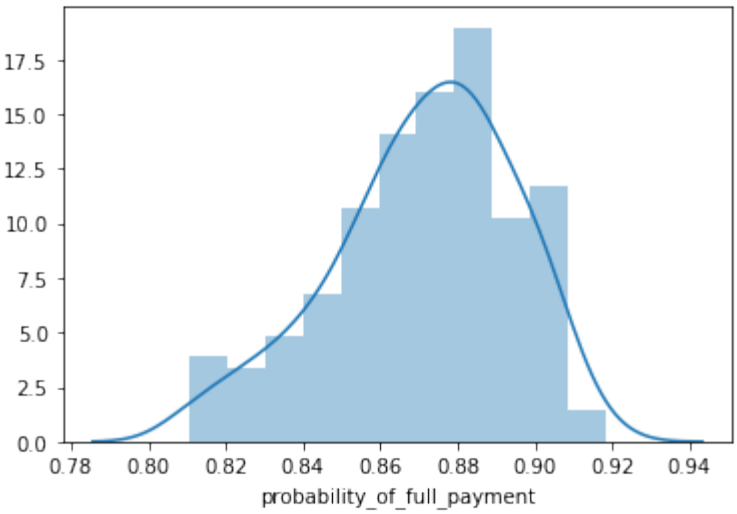
In [93]:
```
sns.distplot(df['advance_payments'])
```

Out[93]: <matplotlib.axes._subplots.AxesSubplot at 0x1891b245978>



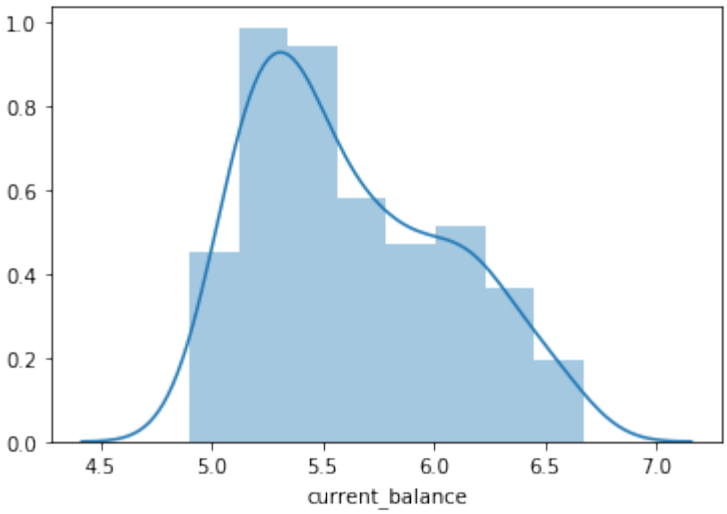
In [94]:
```
sns.distplot(df['probability_of_full_payment'])
```

Out[94]: <matplotlib.axes._subplots.AxesSubplot at 0x1891b604f60>



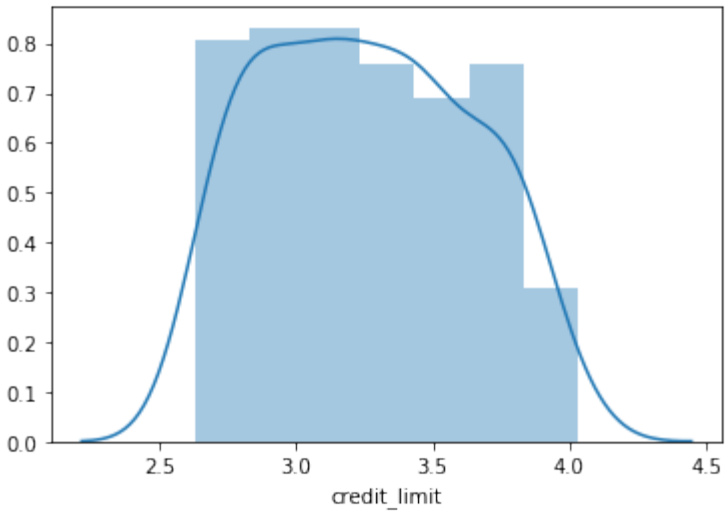
In [95]:
```
sns.distplot(df['current_balance'])
```

Out[95]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1891b67e978>
```



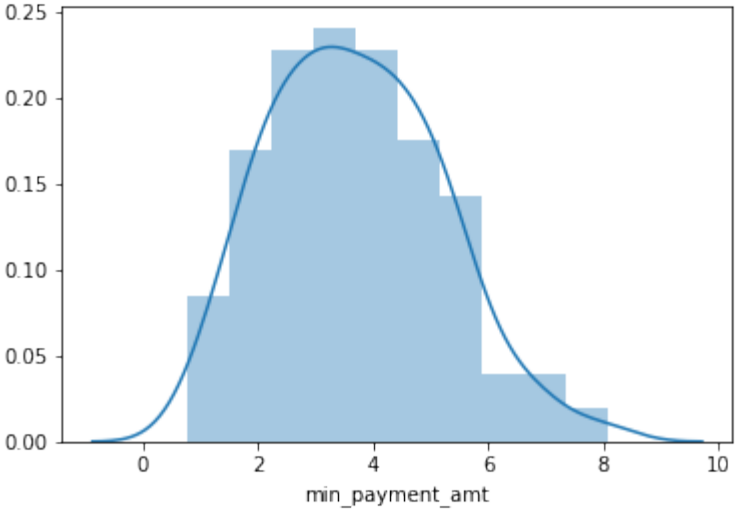
In [96]:
```
sns.distplot(df['credit_limit'])
```

Out[96]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1891b8cf630>
```



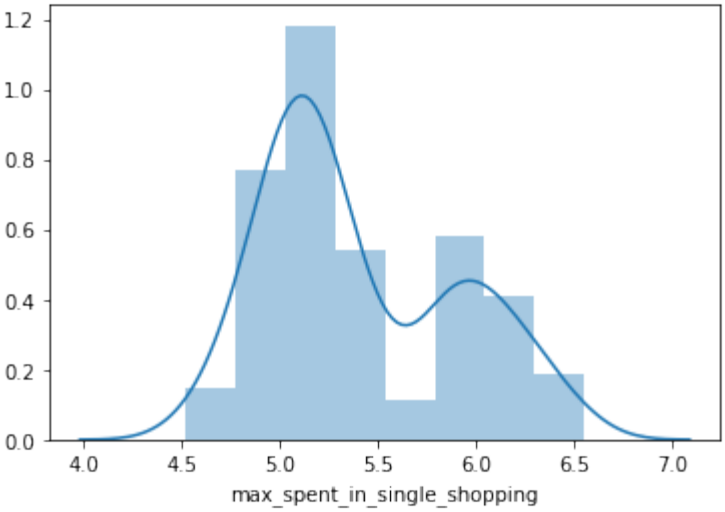
In [97]:
```
sns.distplot(df['min_payment_amt'])
```

Out[97]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1891b93b438>
```



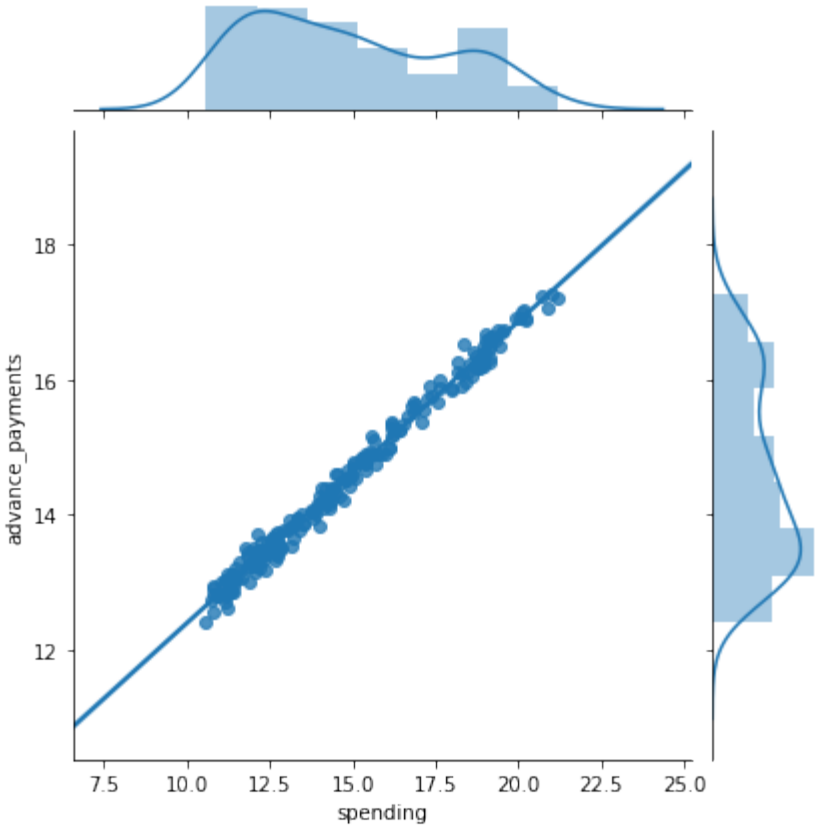
In [98]:
```
sns.distplot(df['max_spent_in_single_shopping'])
```

Out[98]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1891b9bc668>
```



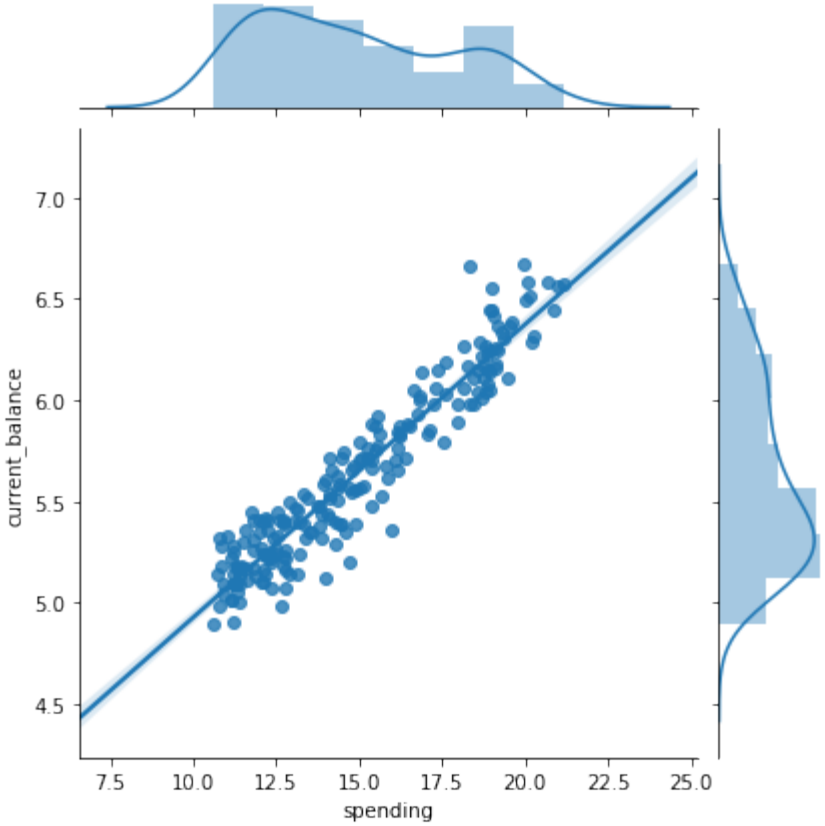
In [99]:
```
sns.jointplot(df['spending'],df['advance_payments'],kind='reg')
```

Out[99]:
```
<seaborn.axisgrid.JointGrid at 0x1891ba23208>
```



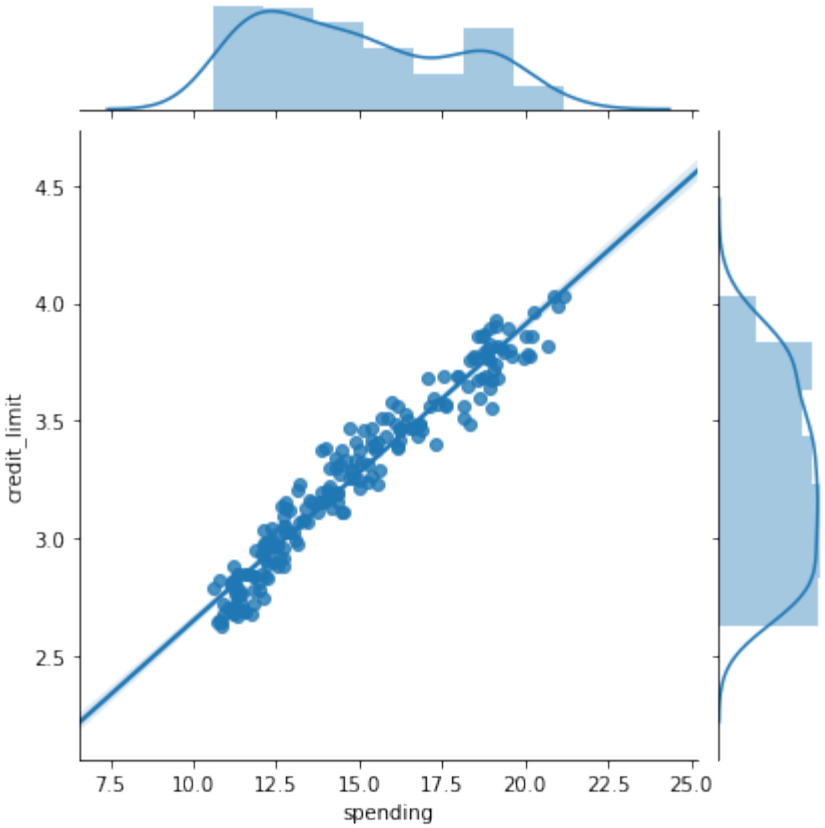
In [100]:
```
sns.jointplot(df['spending'],df['current_balance'],kind='reg')
```

Out[100]:
```
<seaborn.axisgrid.JointGrid at 0x1891adbaac8>
```



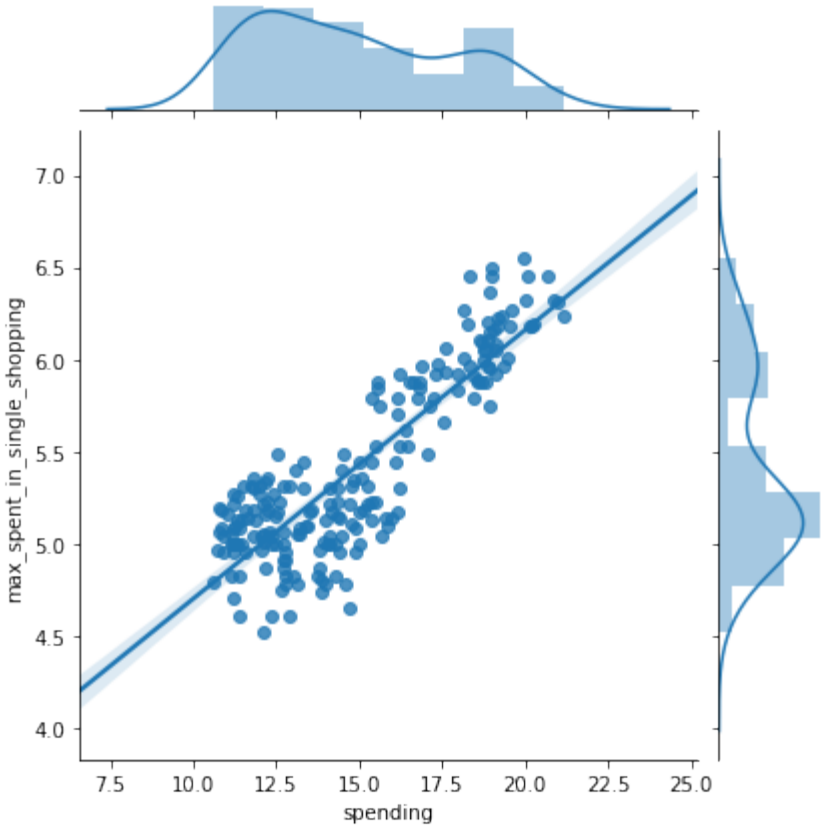
In [101]:
```
sns.jointplot(df['spending'],df['credit_limit'],kind='reg')
```

Out[101]: <seaborn.axisgrid.JointGrid at 0x1891ac1f898>



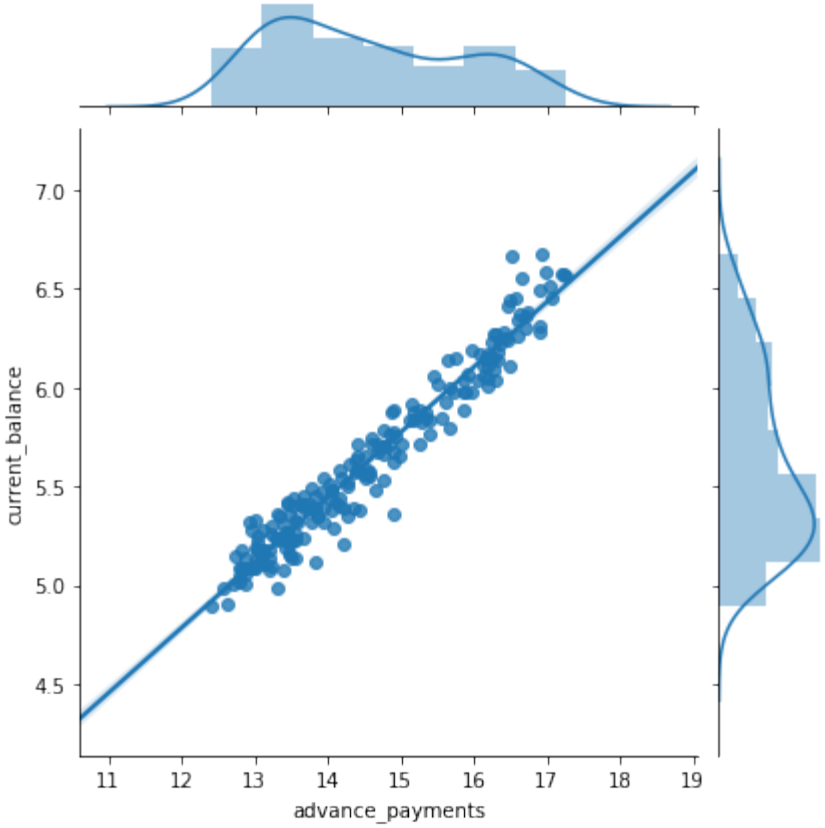
In [102]:
```
sns.jointplot(df['spending'],df['max_spent_in_single_shopping'],kind='reg'
)
```

Out[102]: <seaborn.axisgrid.JointGrid at 0x1891bb14e48>



In [103]:
```
sns.jointplot(df['advance_payments'],df['current_balance'],kind='reg')
```

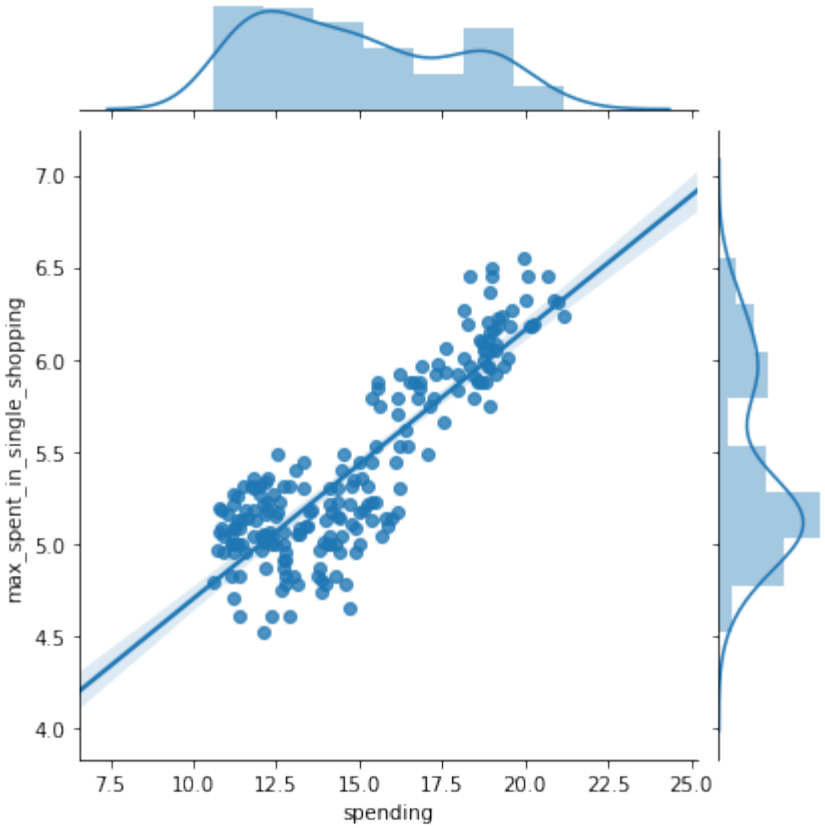
Out[103]: <seaborn.axisgrid.JointGrid at 0x1891cc18278>



In [104]:
```
sns.jointplot(df['spending'],df['max_spent_in_single_shopping'],kind='reg'
```

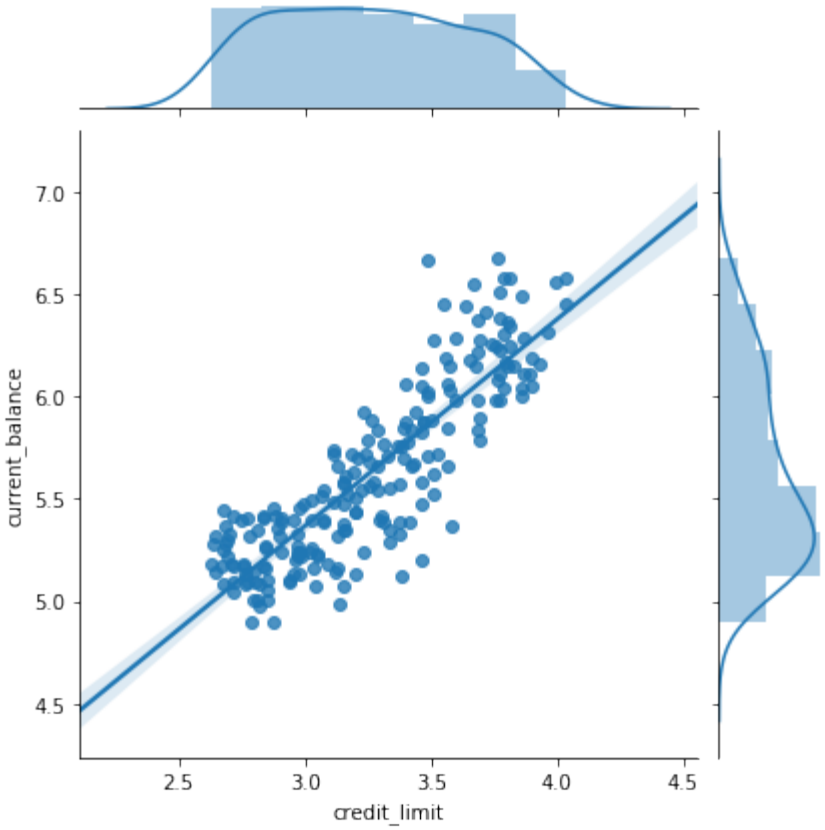
```
)
```

Out[104]: <seaborn.axisgrid.JointGrid at 0x1891cd58208>



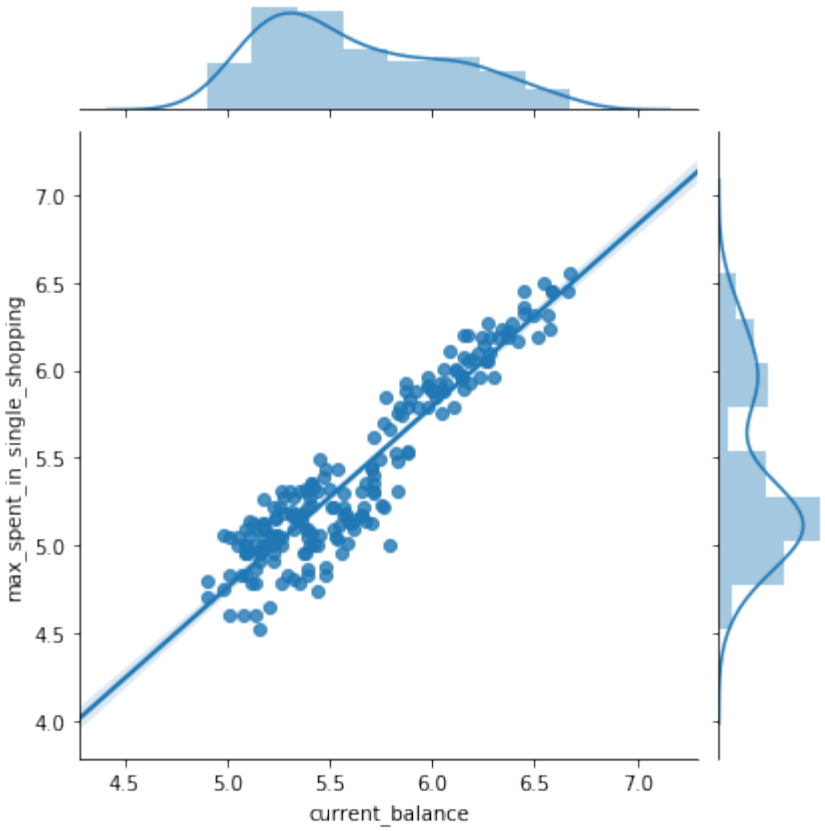
In [105]:
```
sns.jointplot(df['credit_limit'],df['current_balance'],kind='reg')
```

Out[105]: <seaborn.axisgrid.JointGrid at 0x1891ce1c400>



In [106]:
```
sns.jointplot(df['current_balance'],df['max_spent_in_single_shopping'],kind='reg')
```

Out[106]: <seaborn.axisgrid.JointGrid at 0x1891cf8dcc0>



In [107]:
```
df1=df.iloc[:]
```

In [108]:
```
from sklearn.preprocessing import StandardScaler
```

In [109]:
```
sc = StandardScaler()
```

In [110]:
```
df1 = sc.fit_transform(df1)
```

In [111]:
```
df1
```

Out[111]:
```
array([[ 1.75435461,  1.81196782,  0.177628  , ...,  1.33857863,
        -0.29862524,  2.3289982 ],
       [ 0.39358228,  0.25383997,  1.50507052, ...,  0.85823561,
        -0.24229198, -0.53858174],
       [ 1.41330028,  1.42819249,  0.505234  , ...,  1.317348  ,
        -0.22083168,  1.50910692],
       ...,
       [-0.2816364 , -0.30647202,  0.36483143, ..., -0.15287318,
        -1.32804867, -0.83023461],
       [ 0.43836719,  0.33827054,  1.23277462, ...,  0.60081421,
        -0.95718798,  0.07123789],
       [ 0.24889256,  0.45340314, -0.77966228, ..., -0.07325831,
        -0.70905334,  0.96047321]])
```

In [112]:
```
from sklearn.cluster import KMeans
k_means = KMeans(n_clusters = 2)
```

In [113]:
```
k_means.fit(df1)
```

Out[113]:
```
KMeans(algorithm='auto', copy_x=True, init='k-means++', max_iter=300,
       n_clusters=2, n_init=10, n_jobs=None, precompute_distances='auto',
       random_state=None, tol=0.0001, verbose=0)
```

In [114]:
```
k_means.labels_
```

Out[114]:
```
array([0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1,
       0, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 0, 0,
       1, 1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0,
       0, 1, 0, 1, 1, 1, 0, 0, 1, 0, 1, 1, 0, 1, 1, 1, 1, 0, 1, 1, 0, 0,
       0, 1, 1, 0, 1, 1, 1, 0, 0, 0, 1, 0, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0,
       0, 1, 0, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1,
       1, 0, 1, 0, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0,
       1, 1, 1, 1, 1, 0, 0, 1, 0, 0, 0, 1, 0, 1, 1, 1, 0, 1, 1, 0, 0, 0,
       1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 0, 1,
       0, 1, 1, 0, 1, 1, 0, 1, 0, 1, 0, 0])
```

In [115]:
```
k_means.inertia_
```

Out[115]:
```
659.1474009548498
```

In [117]:
```
wss =[]
for i in range(1,11):
    KM = KMeans(n_clusters=i)
    KM.fit(df1)
```

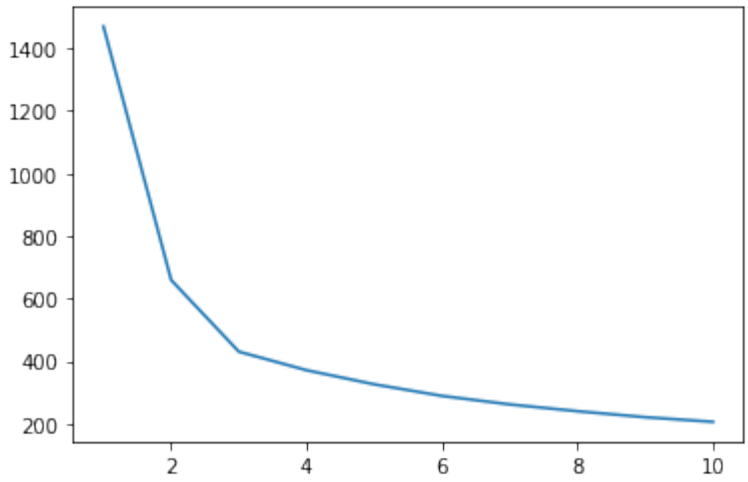
```
    wss.append(KM.inertia_)
```

In [118]:
```
wss
```

Out[118]:
```
[1470.0,
 659.1474009548498,
 430.2984817512229,
 371.0356644664014,
 325.91481424455253,
 288.87262693751563,
 261.70343166701974,
 239.99755307866684,
 220.8312817253219,
 206.0704206856896]
```

In [119]:
```
plt.plot(range(1,11), wss)
```

Out[119]:
```
[<matplotlib.lines.Line2D at 0x1891d106278>]
```



In [120]:
```
k_means = KMeans(n_clusters = 2)
k_means.fit(df1)
labels = k_means.labels_
```

In [121]:
```
df["Clusters"] = labels
df.head(5)
```

Out[121]:

	spending	advance_payments	probability_of_full_payment	current_balance	credit_limit	min_paymen
0	19.94	16.92	0.875200	6.675	3.763	
1	15.99	14.89	0.906400	5.363	3.582	
2	18.95	16.42	0.882900	6.248	3.755	
3	10.83	12.96	0.810588	5.278	2.641	
4	17.99	15.86	0.899200	5.890	3.694	

In [122]:
```
df.Clusters.value_counts().sort_index()
```

Out[122]:
```
0    133
1     77
```

```
Name: Clusters, dtype: int64
```

In [123]:
```
aggdata=df.groupby('Clusters').mean()
aggdata['Freq']=df.Clusters.value_counts().sort_index()
aggdata
```

Out[123]:

Clusters	spending	advance_payments	probability_of_full_payment	current_balance	credit_limit	min_
0	12.930602	13.693459	0.863619	5.339699	3.025917	
1	18.158571	16.054805	0.883817	6.127429	3.660519	

In [55]:
```
from sklearn.metrics import silhouette_samples, silhouette_score
silhouette_score(df,labels)
```

Out[55]:
```
0.530650791509288
```

In [56]:
```
sil_width = silhouette_samples(df,labels)
```

In [57]:
```
df["sil_width"] = sil_width
df.head(5)
```

Out[57]:

	spending	advance_payments	probability_of_full_payment	current_balance	credit_limit	min_paymen
0	19.94	16.92	0.875200	6.675	3.763	
1	15.99	14.89	0.906400	5.363	3.582	
2	18.95	16.42	0.882900	6.248	3.755	
3	10.83	12.96	0.810588	5.278	2.641	
4	17.99	15.86	0.899200	5.890	3.694	

In [58]:
```
silhouette_samples(df,labels).min()
```

Out[58]:
```
-0.11093475637165014
```

In [59]:
```
df[df['sil_width']<0].count()
```

Out[59]:
```
spending                      2
advance_payments              2
probability_of_full_payment   2
current_balance               2
credit_limit                  2
min_payment_amt               2
max_spent_in_single_shopping  2
Clus_kmeans                   2
sil_width                     2
dtype: int64
```

In [60]:
```
df3=pd.read_csv('bank_marketing_part1_Data.csv')
```

In [61]:
```
df4=df3.iloc[:]
```

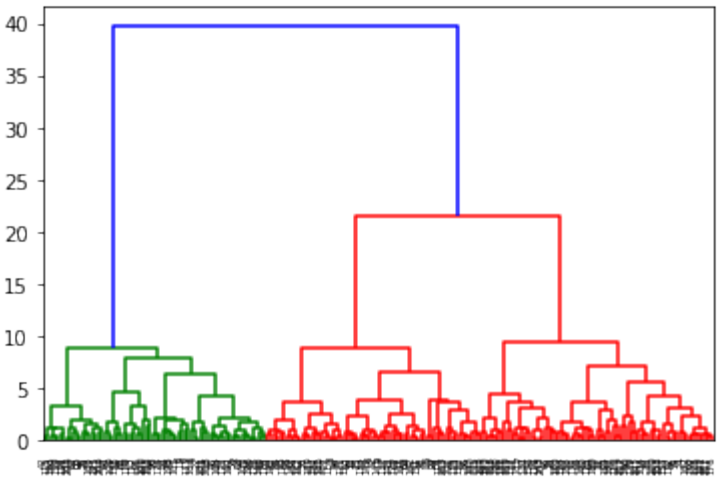
In [62]:
```
sc = StandardScaler()
```

In [63]:
```
df4 = sc.fit_transform(df4)
```

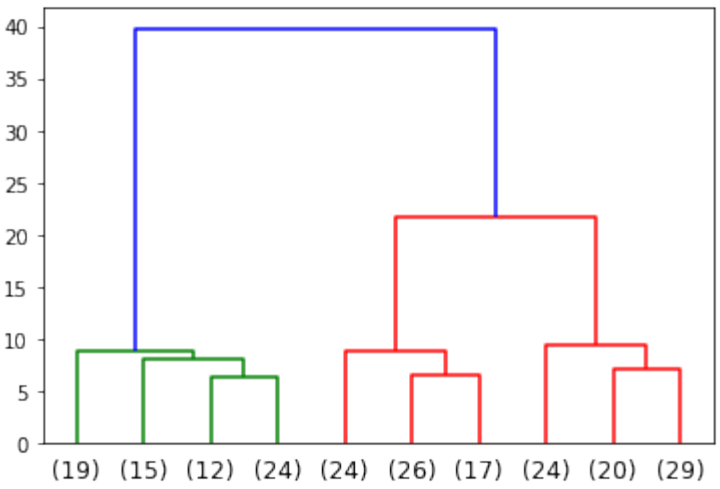
In [64]:
```
from scipy.cluster.hierarchy import dendrogram, linkage
```

In [65]:
```
wardlink = linkage(df4, method = 'ward')
```

In [66]:
```
dend = dendrogram(wardlink)
```



In [67]:
```
dend = dendrogram(wardlink,
                  truncate_mode='lastp',
                  p = 10,
                  )
```



In [69]:
```
from scipy.cluster.hierarchy import fcluster
```

In [70]:
```
clusters = fcluster(wardlink,2, criterion='maxclust')
clusters
```

Out[70]:
```
array([1, 2, 1, 2, 1, 2, 2, 2, 1, 2, 1, 2, 2, 1, 2, 2, 2, 2, 2, 2, 2, 2,
       1, 2, 2, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 1, 1, 2, 1, 1,
```

```
2, 2, 2, 1, 1, 1, 2, 1, 1, 1, 1, 1, 2, 2, 2, 1, 2, 2, 2, 2, 2, 1,
1, 2, 1, 2, 2, 2, 1, 1, 2, 1, 2, 2, 1, 2, 2, 2, 2, 1, 2, 2, 2, 1,
1, 2, 2, 1, 2, 2, 2, 1, 1, 1, 2, 1, 2, 1, 2, 1, 2, 1, 1, 2, 2, 1,
2, 2, 1, 2, 2, 1, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2,
2, 1, 2, 1, 1, 2, 1, 2, 2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 1, 1, 2, 1, 1, 1, 2, 1, 2, 2, 2, 2, 2, 2, 1, 1, 1,
2, 2, 1, 2, 2, 2, 2, 2, 1, 1, 2, 2, 2, 2, 2, 2, 2, 1, 2, 1, 1, 2,
1, 2, 2, 1, 2, 2, 1, 2, 1, 2, 1, 2], dtype=int32)
```

In [71]:
```
df3["Clusters"] = clusters
df3.head(5)
```

Out[71]:

	spending	advance_payments	probability_of_full_payment	current_balance	credit_limit	min_paymen
0	19.94	16.92	0.8752	6.675	3.763	
1	15.99	14.89	0.9064	5.363	3.582	
2	18.95	16.42	0.8829	6.248	3.755	
3	10.83	12.96	0.8099	5.278	2.641	
4	17.99	15.86	0.8992	5.890	3.694	

In [72]:
```
df3.Clusters.value_counts().sort_index()
```

Out[72]:
```
1     70
2    140
Name: Clusters, dtype: int64
```

In [73]:
```
aggdata=df3.groupby('Clusters').mean()
aggdata['Freq']=df3.Clusters.value_counts().sort_index()
aggdata
```

Out[73]:

Clusters	spending	advance_payments	probability_of_full_payment	current_balance	credit_limit	min_
1	18.371429	16.145429	0.884400	6.158171	3.684629	
2	13.085571	13.766214	0.864298	5.363714	3.045593	

In [145]:
```
df5=pd.read_csv('insurance_part2_data.csv')
```

In [146]:
```
df5.head()
```

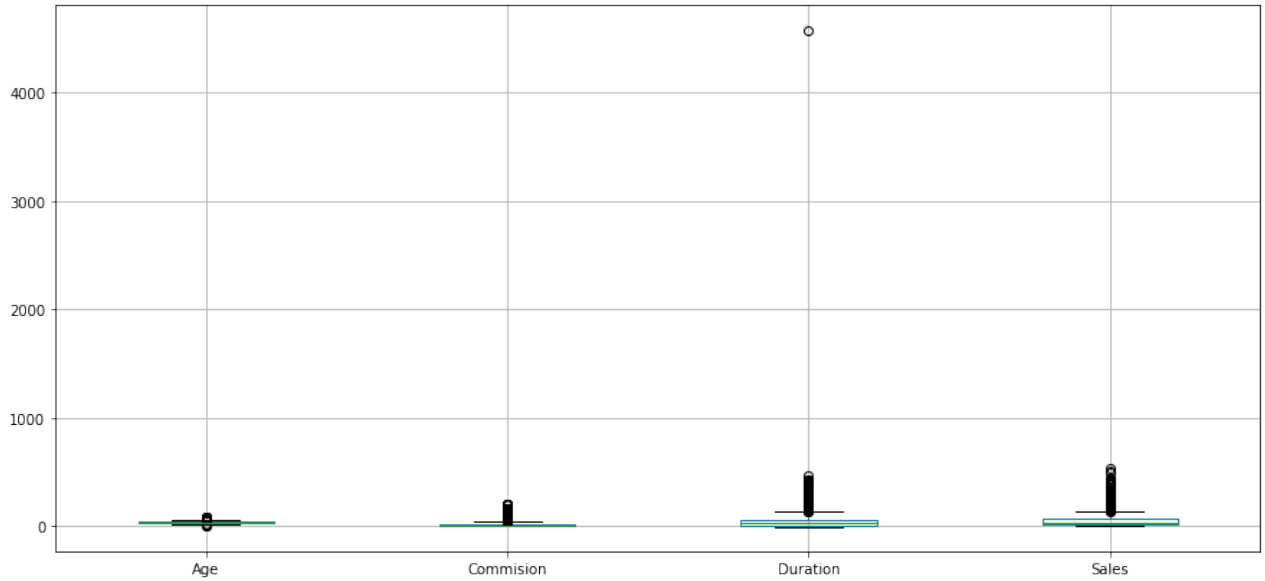
Out[146]:

	Age	Agency_Code	Type	Claimed	Commision	Channel	Duration	Sales	Product Name	Destinati
0	48	C2B	Airlines	No	0.70	Online	7	2.51	Customised Plan	AS
1	36	EPX	Travel Agency	No	0.00	Online	34	20.00	Customised Plan	AS
2	39	CWT	Travel Agency	No	5.94	Online	3	9.90	Customised Plan	Americ
3			Travel						Cancellation	

	36	EPX	Agency	No	0.00	Online	4	26.00	Plan	AS
4	33	JZI	Airlines	No	6.30	Online	53	18.00	Bronze Plan	AS

In [147]:
```
plt.figure(figsize=(15,7))
df5.boxplot()
```

Out[147]: <matplotlib.axes._subplots.AxesSubplot at 0x25e36bec4a8>



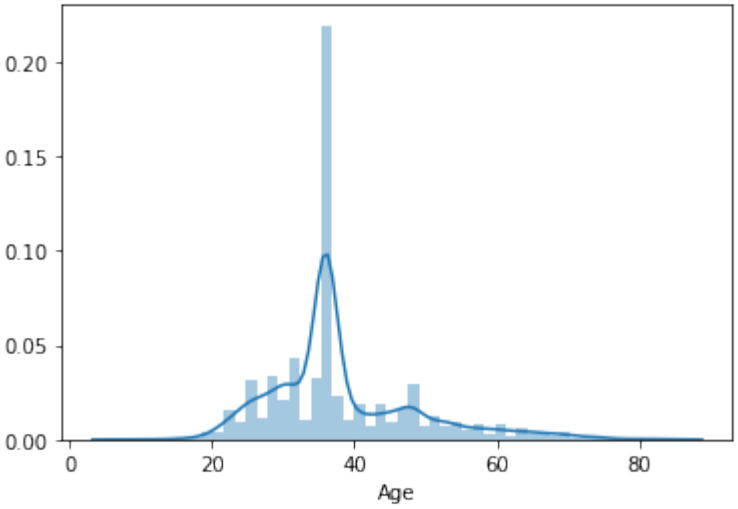
In [148]:
```
df5.corr()
```

Out[148]:

	Age	Commision	Duration	Sales
Age	1.000000	0.067717	0.030425	0.039455
Commision	0.067717	1.000000	0.471389	0.766505
Duration	0.030425	0.471389	1.000000	0.558930
Sales	0.039455	0.766505	0.558930	1.000000

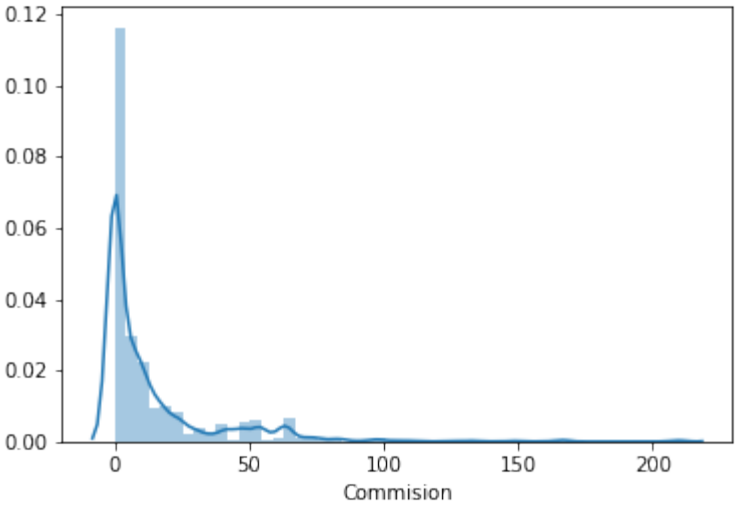
In [149]:
```
sns.distplot(df5['Age'])
```

Out[149]: <matplotlib.axes._subplots.AxesSubplot at 0x25e36c85978>



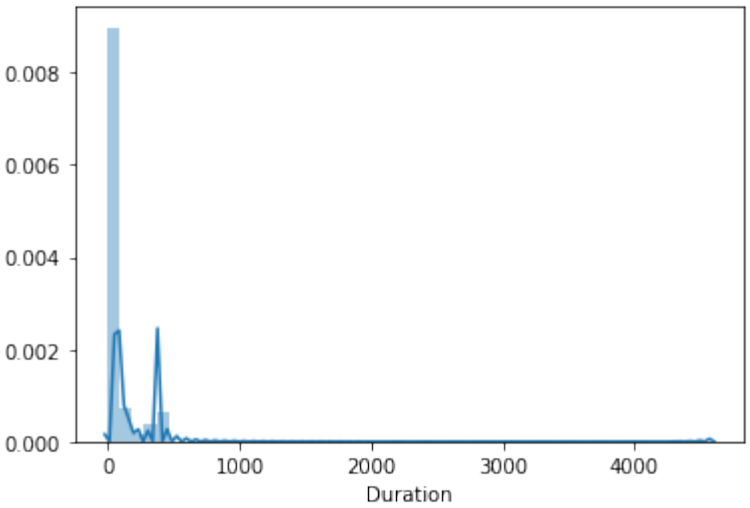
In [150]:
```
sns.distplot(df5['Commision'])
```

Out[150]: <matplotlib.axes._subplots.AxesSubplot at 0x25e36b9a208>



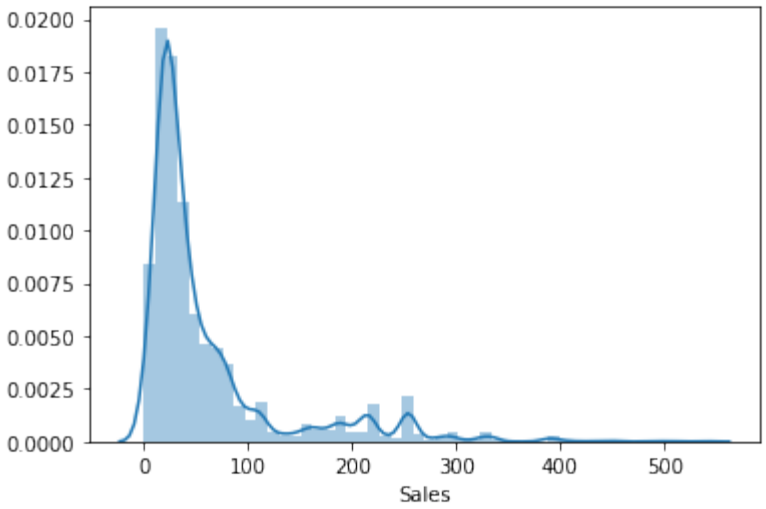
In [151]:
```
sns.distplot(df5['Duration'])
```

Out[151]: <matplotlib.axes._subplots.AxesSubplot at 0x25e2efca1d0>



In [152]:
```
sns.distplot(df5['Sales'])
```

Out[152]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x25e359e4470>
```



In [160]:
```
df6 = df5.iloc[:,2:]
```

In [161]:
```
df6.head()
```

Out[161]:

	Type	Claimed	Commision	Channel	Duration	Sales	Product Name	Destination
0	Airlines	No	0.70	Online	7	2.51	Customised Plan	ASIA
1	Travel Agency	No	0.00	Online	34	20.00	Customised Plan	ASIA
2	Travel Agency	No	5.94	Online	3	9.90	Customised Plan	Americas
3	Travel Agency	No	0.00	Online	4	26.00	Cancellation Plan	ASIA
4	Airlines	No	6.30	Online	53	18.00	Bronze Plan	ASIA

In [162]:
```
df6.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3000 entries, 0 to 2999
Data columns (total 8 columns):
Type            3000 non-null object
Claimed         3000 non-null object
Commision       3000 non-null float64
Channel         3000 non-null object
Duration        3000 non-null int64
Sales           3000 non-null float64
Product Name    3000 non-null object
Destination     3000 non-null object
dtypes: float64(2), int64(1), object(5)
memory usage: 187.6+ KB
```

In [163]:
```
df6.isnull().sum()
```

Out[163]:
```
Type            0
Claimed         0
Commision       0
Channel         0
```

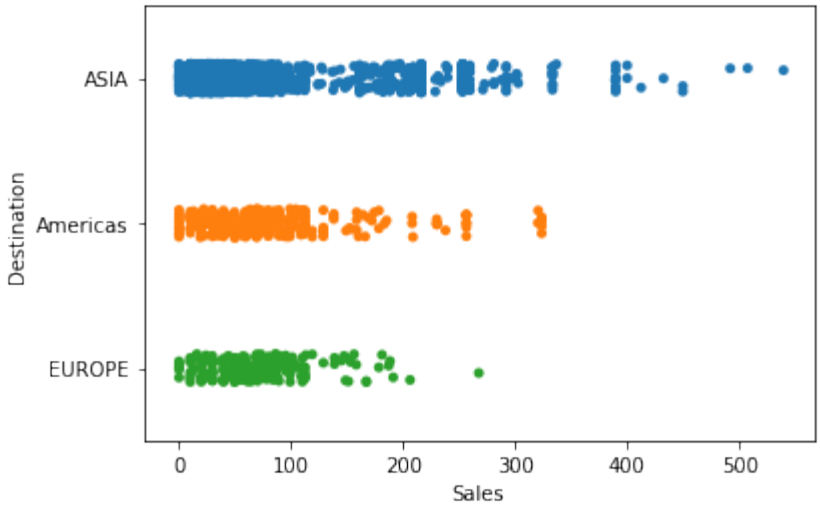
```
Duration        0
Sales           0
Product Name    0
Destination     0
dtype: int64
```

In [164]:
```
for feature in df6.columns:
    if df6[feature].dtype == 'object':
        df6[feature] = pd.Categorical(df6[feature]).codes
```

In [165]:
```
from scipy.stats import zscore
for i in df6[['Commision','Sales','Duration']]:
    df6[[i]] = df6[[i]].apply(zscore)
    df6[[i]]=np.where(df6[[i]]>3,3,df6[[i]])
    df6[[i]]=np.where(df6[[i]]<-3,-3,df6[[i]])
```

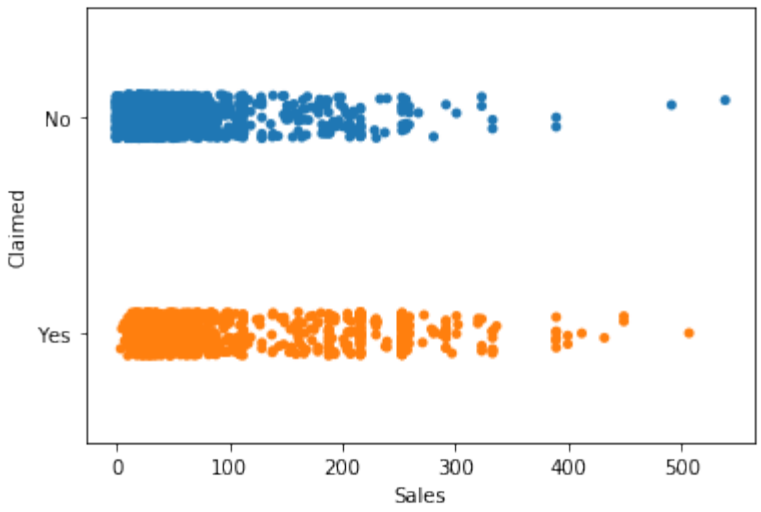
In [170]:
```
sns.stripplot(df5['Sales'],df5['Destination'])
```

Out[170]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x25e39a2f4e0>
```



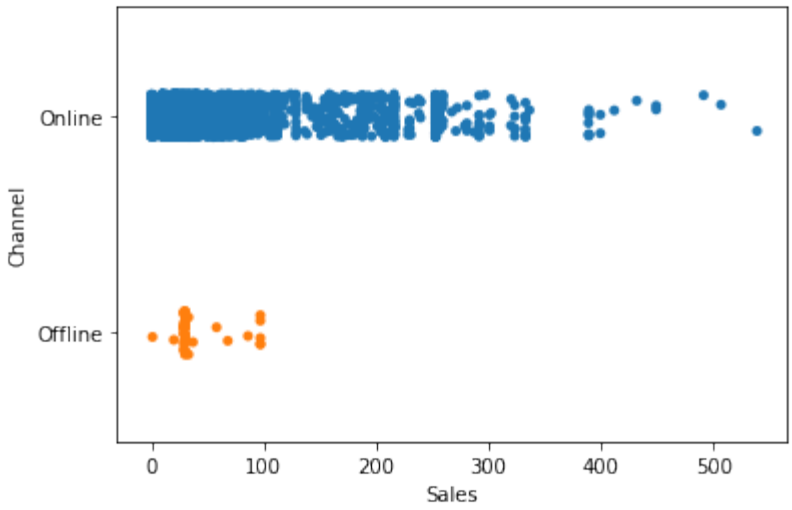
In [167]:
```
sns.stripplot(df5['Sales'],df5['Claimed'])
```

Out[167]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x25e36de07f0>
```



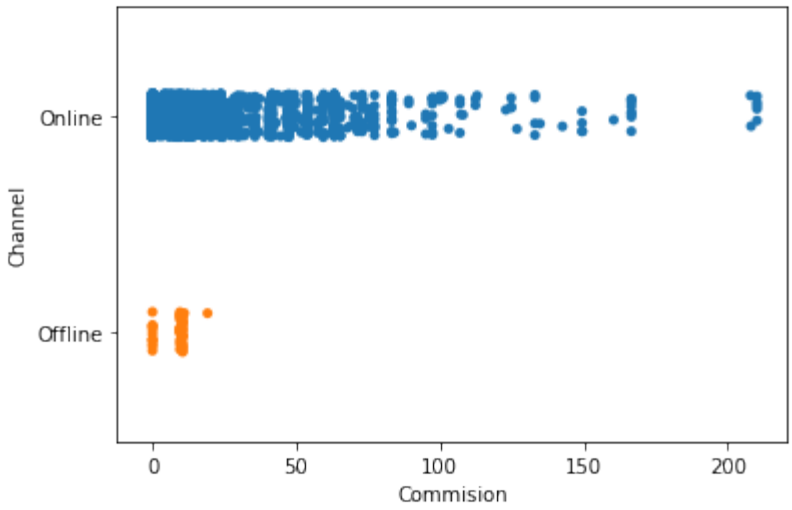
In [172]:
```
sns.stripplot(df5['Sales'],df5['Channel'])
```

Out[172]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x25e39a289b0>
```



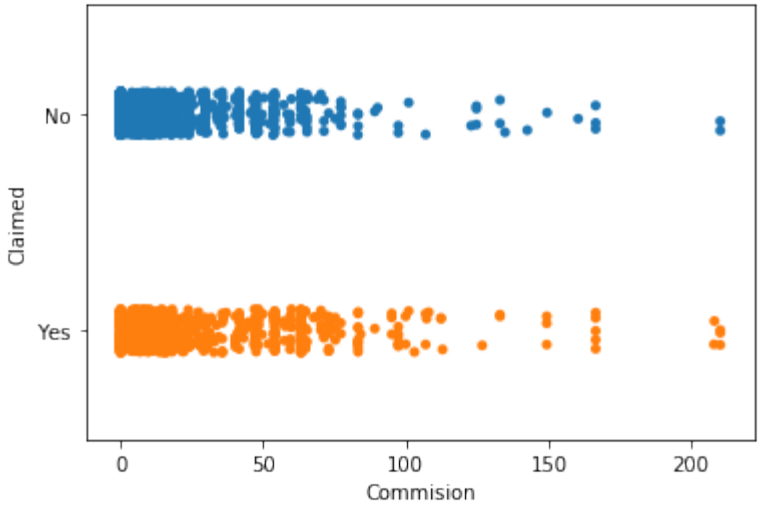
In [174]:
```
sns.stripplot(df5['Commision'],df5['Channel'])
```

Out[174]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x25e39b09b38>
```



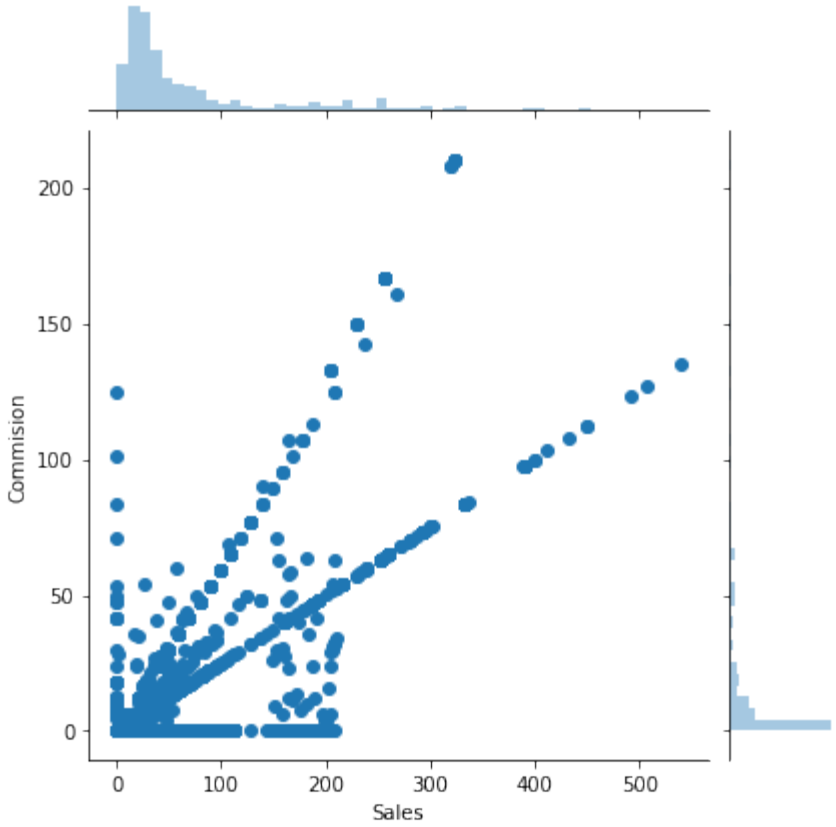
In [175]:
```
sns.stripplot(df5['Commision'],df5['Claimed'])
```

Out[175]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x25e39b5ac18>
```



In [177]:
```
sns.jointplot(df5['Sales'],df5['Commision'])
```

Out[177]:
```
<seaborn.axisgrid.JointGrid at 0x25e39afc4e0>
```



In [163]:
```
df6.head()
```

Out[163]:

	Type	Claimed	Commision	Channel	Duration	Sales	Product Name	Destination
0	0	0	-0.542807	1	-0.470051	-0.816433	2	0
1	1	0	-0.570282	1	-0.268605	-0.569127	2	0
2	1	0	-0.337133	1	-0.499894	-0.711940	2	1
3	1	0	-0.570282	1	-0.492433	-0.484288	1	0

4	0	0	-0.323003	1	-0.126846	-0.597407	0	0

In [166]:
```
x = df6.drop("Claimed",axis=1)
y = df6.pop("Claimed")
```

In [167]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, train_labels, test_labels = train_test_split(x, y, test_s
ize=.30, random_state=1)
```

In [188]:
```
X_train.shape
```

Out[188]:
```
(2100, 7)
```

In [168]:
```
from sklearn.tree import DecisionTreeClassifier
dt_model = DecisionTreeClassifier(criterion = 'gini')
```

In [169]:
```
dt_model.fit(X_train, train_labels)
```

Out[169]:
```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=None,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
```

In [170]:
```
from sklearn import tree

train_char_label = ['No', 'Yes']
Credit_Tree_File = open('C:\\Users\\edhrsur\\Desktop\\GL\\Week 18,19 - Pro
ject\\credit_tree.dot','w')
dot_data = tree.export_graphviz(dt_model, out_file=Credit_Tree_File, featu
re_names = list(X_train), class_names = list(train_char_label))

Credit_Tree_File.close()
```

In [171]:
```
print (pd.DataFrame(dt_model.feature_importances_, columns = ["Imp"], inde
x = X_train.columns))
```

```
                Imp
Type       0.001260
Commision  0.185024
Channel    0.011485
Duration   0.360768
Sales      0.218912
Product Name  0.196854
Destination   0.025698
```

In [172]:
```
y_predict = dt_model.predict(X_test)
```

In [173]:
```
y_predict.shape
```

Out[173]:
```
(900,)
```

In [176]:
```
from sklearn.model_selection import GridSearchCV
```

```
param_grid = {
    'max_depth': [8,9,10],
    'min_samples_leaf': [8,10,11,13,14],
    'min_samples_split': [13,17,20]
}

dt_model = DecisionTreeClassifier()

grid_search = GridSearchCV(estimator = dt_model, param_grid = param_grid,
cv = 5)
```

In [177]:
```
grid_search.fit(X_train, train_labels)
```

Out[177]:
```
GridSearchCV(cv=5, error_score='raise-deprecating',
             estimator=DecisionTreeClassifier(class_weight=None,
                                              criterion='gini', max_depth=Non
e,
                                              max_features=None,
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=0.0,
                                              presort=False, random_state=Non
e,
                                              splitter='best'),
             iid='warn', n_jobs=None,
             param_grid={'max_depth': [7, 8, 9, 10],
                         'min_samples_leaf': [8, 10, 11, 13, 14],
                         'min_samples_split': [13, 17, 20]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring=None, verbose=0)
```

In [178]:
```
grid_search.best_params_
```

Out[178]:
```
{'max_depth': 7, 'min_samples_leaf': 10, 'min_samples_split': 13}
```

In [179]:
```
best_grid = grid_search.best_estimator_
```

In [180]:
```
ytrain_predict = best_grid.predict(X_train)
ytest_predict = best_grid.predict(X_test)
```

In [181]:
```
from sklearn.metrics import classification_report
```

In [182]:
```
print(classification_report(train_labels,ytrain_predict))
```

```
              precision    recall  f1-score   support

           0       0.82      0.93      0.87      1471
           1       0.75      0.53      0.62       629

    accuracy                           0.81      2100
   macro avg       0.79      0.73      0.74      2100
```

```
weighted avg       0.80      0.81      0.79      2100
```

In [183]:
```
print(classification_report(test_labels,ytest_predict))
```

```
              precision    recall  f1-score   support

           0       0.77      0.92      0.83       605
           1       0.71      0.42      0.53       295

    accuracy                           0.76       900
   macro avg       0.74      0.67      0.68       900
weighted avg       0.75      0.76      0.74       900
```

In [184]:
```
reg_dt_model = DecisionTreeClassifier(criterion = 'gini', max_depth = 7,mi
n_samples_leaf=10,min_samples_split=13)
reg_dt_model.fit(X_train, train_labels)
```

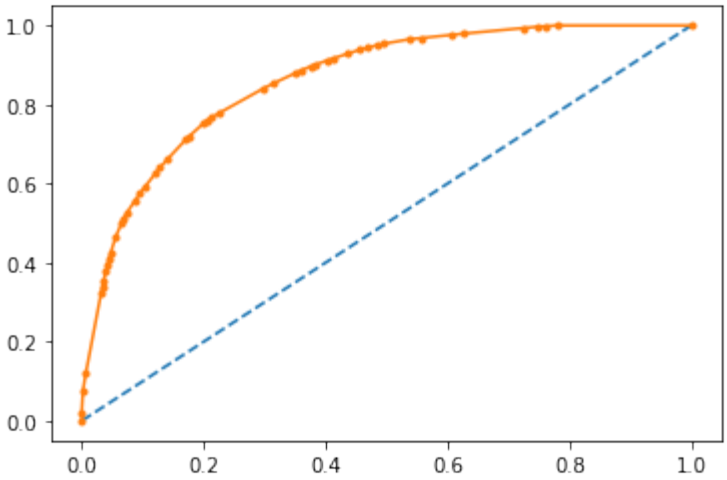
Out[184]:
```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=7,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=10, min_samples_split=13,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
```

In [185]:
```
credit_tree_regularized = open('C:\\Users\\edhrsur\\Desktop\\GL\\Week 18,1
9 - Project\\credit_tree_regularized.dot','w')
dot_data = tree.export_graphviz(reg_dt_model, out_file= credit_tree_regula
rized , feature_names = list(X_train), class_names = list(train_char_label
))

credit_tree_regularized.close()

print (pd.DataFrame(reg_dt_model.feature_importances_, columns = ["Imp"],
index = X_train.columns))
```

```
                 Imp
Type        0.003871
Commision   0.277088
Channel     0.000000
Duration    0.063073
Sales       0.173671
Product Name  0.475031
Destination   0.007266
```

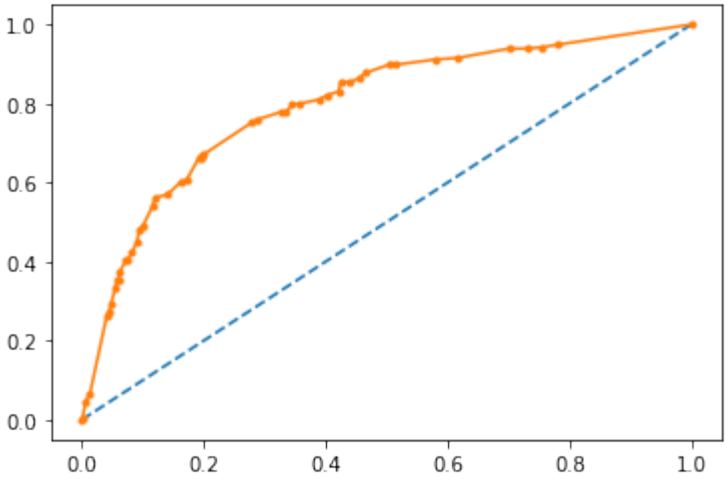
In [186]:
```
probs = reg_dt_model.predict_proba(X_train)
probs = probs[:, 1]
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(train_labels, probs)
print('AUC: %.3f' % auc)
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(train_labels, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr, tpr, marker='.')
plt.show()
```

```
AUC: 0.862
```

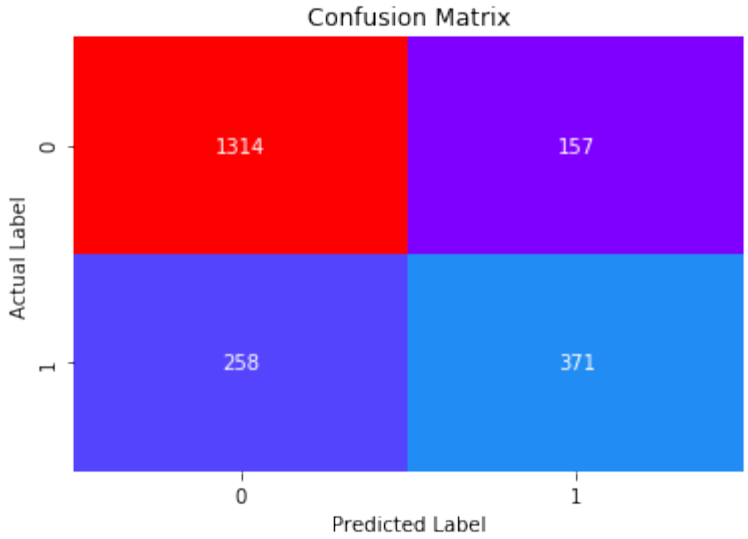


In [187]:
```
probs = reg_dt_model.predict_proba(X_test)
probs = probs[:, 1]
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(test_labels, probs)
print('AUC: %.3f' % auc)
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(test_labels, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr, tpr, marker='.')
plt.show()
```

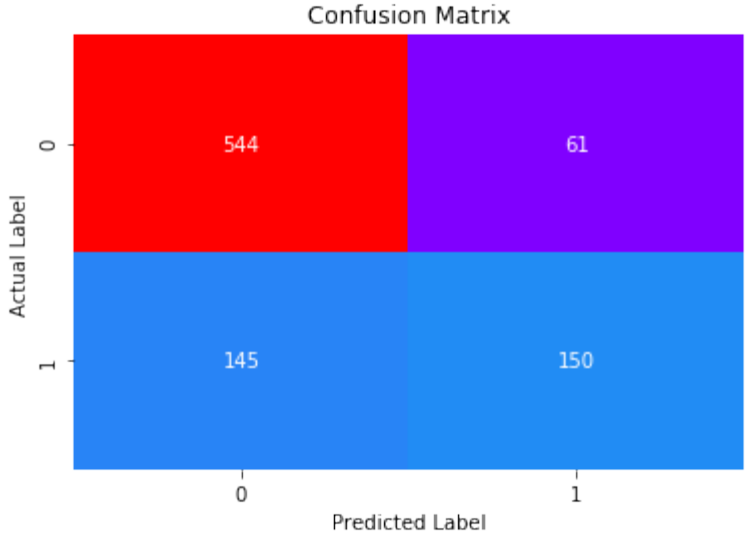
```
AUC: 0.797
```



In [131]:
```
# Get the confusion matrix on the train data
from sklearn.metrics import confusion_matrix,classification_report
confusion_matrix(train_labels,ytrain_predict)
sns.heatmap(confusion_matrix(train_labels,ytrain_predict),annot=True, fmt=
'd',cbar=False, cmap='rainbow')
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
plt.title('Confusion Matrix')
plt.show()
```



In [132]:
```
confusion_matrix(test_labels,ytest_predict)
sns.heatmap(confusion_matrix(test_labels,ytest_predict),annot=True, fmt='d
',cbar=False, cmap='rainbow')
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
plt.title('Confusion Matrix')
plt.show()
```



In [88]:
```
df5=pd.read_csv('insurance_part2_data.csv')
```

In [89]:
```
df5.head()
```

Out[89]:

	Age	Agency_Code	Type	Claimed	Commision	Channel	Duration	Sales	Product Name	Destinati
0	48	C2B	Airlines	No	0.70	Online	7	2.51	Customised Plan	AS
1	36	EPX	Travel Agency	No	0.00	Online	34	20.00	Customised Plan	AS
2	39	CWT	Travel Agency	No	5.94	Online	3	9.90	Customised Plan	Americ

3	36		EPX	Travel Agency	No	0.00	Online	4	26.00	Cancellation Plan	AS
4	33		JZI	Airlines	No	6.30	Online	53	18.00	Bronze Plan	AS

In [90]:
```
df5 = df5.iloc[:,2:]
```

In [91]:
```
df5.head()
```

Out[91]:

	Type	Claimed	Commision	Channel	Duration	Sales	Product Name	Destination
0	Airlines	No	0.70	Online	7	2.51	Customised Plan	ASIA
1	Travel Agency	No	0.00	Online	34	20.00	Customised Plan	ASIA
2	Travel Agency	No	5.94	Online	3	9.90	Customised Plan	Americas
3	Travel Agency	No	0.00	Online	4	26.00	Cancellation Plan	ASIA
4	Airlines	No	6.30	Online	53	18.00	Bronze Plan	ASIA

In [92]:
```
for feature in df5.columns:
    if df5[feature].dtype == 'object':
        df5[feature] = pd.Categorical(df5[feature]).codes
```

In [93]:
```
df5.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3000 entries, 0 to 2999
Data columns (total 8 columns):
Type            3000 non-null int8
Claimed         3000 non-null int8
Commision       3000 non-null float64
Channel         3000 non-null int8
Duration        3000 non-null int64
Sales           3000 non-null float64
Product Name    3000 non-null int8
Destination     3000 non-null int8
dtypes: float64(2), int64(1), int8(5)
memory usage: 85.0 KB
```

In [94]:
```
from scipy.stats import zscore
```

In [95]:
```
for i in df5[['Commision','Sales','Duration']]:
    df5[[i]] = df5[[i]].apply(zscore)
    df5[[i]]=np.where(df5[[i]]>3,3,df5[[i]])
    df5[[i]]=np.where(df5[[i]]<-3,-3,df5[[i]])
```

In [96]:
```
df5.head()
```

Out[96]:

	Type	Claimed	Commision	Channel	Duration	Sales	Product Name	Destination
0	0	0	-0.542807	1	-0.470051	-0.816433	2	0
1	1	0	-0.570282	1	-0.268605	-0.569127	2	0

2	1	0	-0.337133	1	-0.499894	-0.711940	2	1
3	1	0	-0.570282	1	-0.492433	-0.484288	1	0
4	0	0	-0.323003	1	-0.126846	-0.597407	0	0

In [97]:
```
x = df5.drop("Claimed",axis=1)
y = df5.pop("Claimed")
```

In [98]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, train_labels, test_labels = train_test_split(x, y, test_s
ize=.30, random_state=1)
```

In [99]:
```
from sklearn.ensemble import RandomForestClassifier
rfcl = RandomForestClassifier(n_estimators = 501)
rfcl = rfcl.fit(X_train, train_labels)
```

In [100]:
```
rfcl
```

Out[100]:
```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
                       max_depth=None, max_features='auto', max_leaf_nodes=N
one,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=501,
                       n_jobs=None, oob_score=False, random_state=None,
                       verbose=0, warm_start=False)
```

In [101]:
```
ytrain_predict = rfcl.predict(X_train)
ytest_predict = rfcl.predict(X_test)
```

In [102]:
```
from sklearn.metrics import confusion_matrix,classification_report
```

In [103]:
```
print(classification_report(train_labels,ytrain_predict))
```

```
              precision    recall  f1-score   support

           0       0.98      0.98      0.98      1471
           1       0.95      0.95      0.95       629

    accuracy                           0.97      2100
   macro avg       0.96      0.96      0.96      2100
weighted avg       0.97      0.97      0.97      2100
```

In [104]:
```
print(classification_report(test_labels,ytest_predict))
```

```
              precision    recall  f1-score   support

           0       0.77      0.85      0.81       605
           1       0.61      0.48      0.54       295

    accuracy                           0.73       900
   macro avg       0.69      0.67      0.67       900
weighted avg       0.72      0.73      0.72       900
```

In [105]:
```
from sklearn.model_selection import GridSearchCV

param_grid = {
    'max_depth': [7, 10],
    'max_features': [5,6,7],
    'min_samples_leaf': [13,15,17],
    'min_samples_split': [20,30,40],
    'n_estimators': [301, 501]
}

rfcl = RandomForestClassifier()

grid_search = GridSearchCV(estimator = rfcl, param_grid = param_grid, cv =
5)
```

In [106]:
```
grid_search.fit(X_train, train_labels)
```

Out[106]:
```
GridSearchCV(cv=5, error_score='raise-deprecating',
             estimator=RandomForestClassifier(bootstrap=True, class_weight=N
one,
                                              criterion='gini', max_depth=Non
e,
                                              max_features='auto',
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=0.0,
                                              n_estimators='warn', n_jobs=Non
e,
                                              oob_score=False,
                                              random_state=None, verbose=0,
                                              warm_start=False),
             iid='warn', n_jobs=None,
             param_grid={'max_depth': [7, 10], 'max_features': [5, 6, 7],
                         'min_samples_leaf': [13, 15, 17],
                         'min_samples_split': [20, 30, 40],
                         'n_estimators': [301, 501]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring=None, verbose=0)
```

In [108]:
```
grid_search.best_params_
```

Out[108]:
```
{'max_depth': 10,
 'max_features': 7,
 'min_samples_leaf': 15,
 'min_samples_split': 20,
 'n_estimators': 301}
```

In [109]:
```
best_grid = grid_search.best_estimator_
```

In [110]:
```
ytrain_predict = best_grid.predict(X_train)
```

```
ytest_predict = best_grid.predict(X_test)
```

In [111]:
```
print(classification_report(train_labels,ytrain_predict))
```

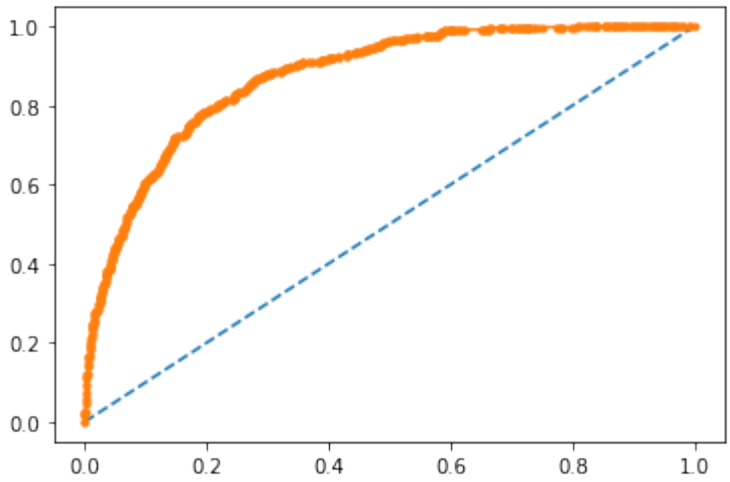
```
              precision    recall  f1-score   support

           0       0.84      0.90      0.87      1471
           1       0.72      0.60      0.66       629

    accuracy                           0.81      2100
   macro avg       0.78      0.75      0.76      2100
weighted avg       0.81      0.81      0.81      2100
```

In [112]:
```
print(classification_report(test_labels,ytest_predict))
```

```
              precision    recall  f1-score   support

           0       0.79      0.90      0.84       605
           1       0.71      0.50      0.59       295

    accuracy                           0.77       900
   macro avg       0.75      0.70      0.71       900
weighted avg       0.76      0.77      0.76       900
```

In [113]:
```
probs = best_grid.predict_proba(X_train)
probs = probs[:, 1]
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(train_labels, probs)
print('AUC: %.3f' % auc)
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(train_labels, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr, tpr, marker='.')
plt.show()
```

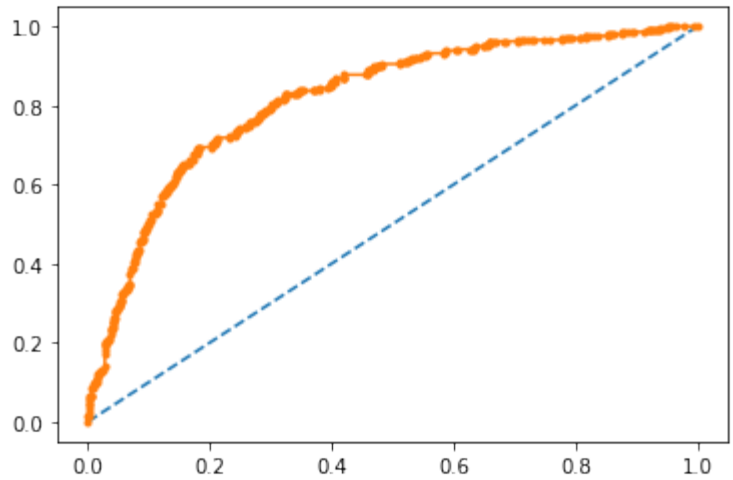
```
AUC: 0.875
```



In [114]:
```
probs = best_grid.predict_proba(X_test)
probs = probs[:, 1]
```

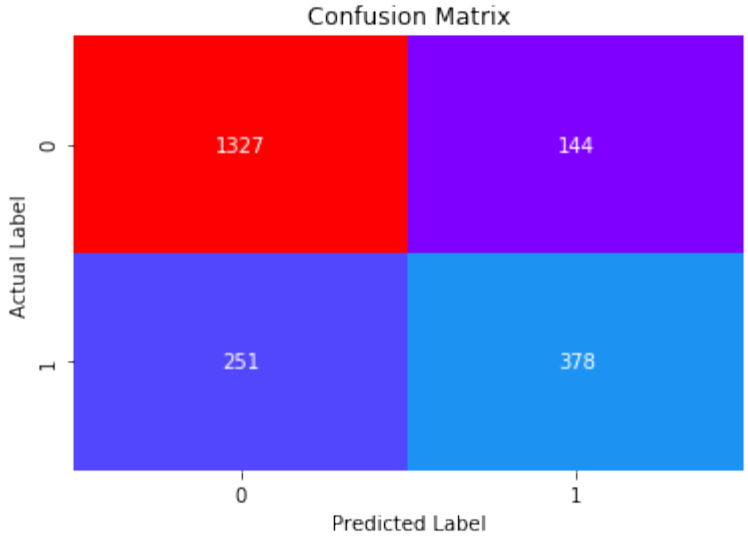
```
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(test_labels, probs)
print('AUC: %.3f' % auc)
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(test_labels, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr, tpr, marker='.')
plt.show()
```

```
AUC: 0.817
```



In [115]:

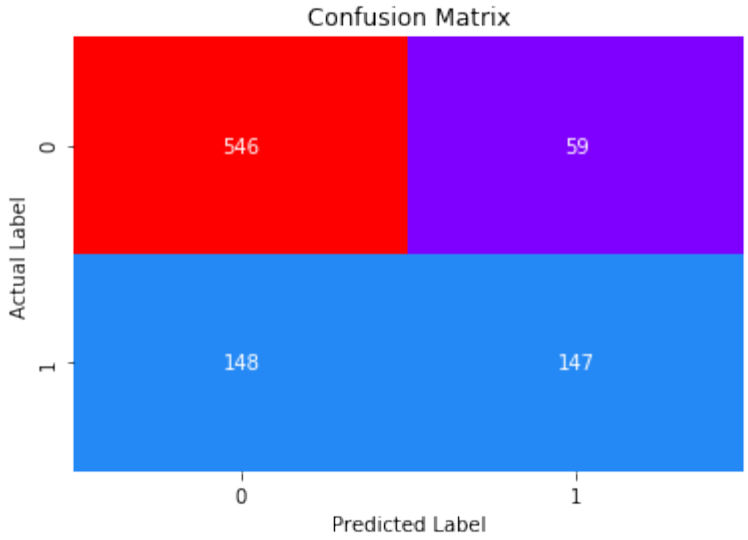
```
confusion_matrix(train_labels,ytrain_predict)
sns.heatmap(confusion_matrix(train_labels,ytrain_predict),annot=True, fmt=
'd',cbar=False, cmap='rainbow')
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
plt.title('Confusion Matrix')
plt.show()
```



In [116]:

```
confusion_matrix(test_labels,ytest_predict)
sns.heatmap(confusion_matrix(test_labels,ytest_predict),annot=True, fmt='d
',cbar=False, cmap='rainbow')
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
```

```
plt.title('Confusion Matrix')
plt.show()
```



In [117]:
```
print (pd.DataFrame(best_grid.feature_importances_, columns = ["Imp"], ind
ex = X_train.columns))
```

```
                  Imp
Type         0.016116
Commision    0.179400
Channel      0.000110
Duration     0.112876
Sales        0.205144
Product Name 0.474707
Destination  0.011647
```

In [120]:
```
df6=pd.read_csv('insurance_part2_data.csv')
```

In [121]:
```
df6 = df6.iloc[:,2:]
```

In [122]:
```
df6.head()
```

Out[122]:

	Type	Claimed	Commision	Channel	Duration	Sales	Product Name	Destination
0	Airlines	No	0.70	Online	7	2.51	Customised Plan	ASIA
1	Travel Agency	No	0.00	Online	34	20.00	Customised Plan	ASIA
2	Travel Agency	No	5.94	Online	3	9.90	Customised Plan	Americas
3	Travel Agency	No	0.00	Online	4	26.00	Cancellation Plan	ASIA
4	Airlines	No	6.30	Online	53	18.00	Bronze Plan	ASIA

In [123]:
```
for feature in df6.columns:
    if df6[feature].dtype == 'object':
        df6[feature] = pd.Categorical(df6[feature]).codes
```

In [124]:
```
df6.info()
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 3000 entries, 0 to 2999
Data columns (total 8 columns):
Type            3000 non-null int8
Claimed         3000 non-null int8
Commision       3000 non-null float64
Channel         3000 non-null int8
Duration        3000 non-null int64
Sales           3000 non-null float64
Product Name    3000 non-null int8
Destination     3000 non-null int8
dtypes: float64(2), int64(1), int8(5)
memory usage: 85.0 KB
```

In [125]:
```
x = df6.drop("Claimed",axis=1)
y = df6.pop("Claimed")
```

In [126]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, train_labels, test_labels = train_test_split(x, y, test_s
ize=.30, random_state=21)
```

In [127]:
```
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X_trains = sc.fit_transform(X_train)
X_tests = sc.transform (X_test)
```

In [128]:
```
from sklearn.neural_network import MLPClassifier
clf = MLPClassifier(hidden_layer_sizes=100, max_iter=5000,
                    solver='sgd', verbose=True,  random_state=21,tol=0.000
1)
```

In [129]:
```
clf.fit(X_train, train_labels)
```

```
Iteration 1, loss = inf
Iteration 2, loss = inf
Iteration 3, loss = inf
Iteration 4, loss = 1.04699356
Iteration 5, loss = 1.07758050
Iteration 6, loss = 0.99826489
Iteration 7, loss = 0.88993018
Iteration 8, loss = 0.77958363
Iteration 9, loss = 0.77947769
Iteration 10, loss = 0.74045522
Iteration 11, loss = 0.64398655
Iteration 12, loss = 0.72900595
Iteration 13, loss = 0.81410197
Iteration 14, loss = 0.64538502
Iteration 15, loss = 0.62266799
Iteration 16, loss = 0.62098727
Iteration 17, loss = 0.56825307
Iteration 18, loss = 0.58031036
Iteration 19, loss = 0.58929718
Iteration 20, loss = 0.58273975
Iteration 21, loss = 0.56827748
Iteration 22, loss = 0.55889542
Iteration 23, loss = 0.62093717
```

```
Iteration 24, loss = 0.54906911
Iteration 25, loss = 0.58699587
Iteration 26, loss = 0.57339316
Iteration 27, loss = 0.57886858
Iteration 28, loss = 0.55811030
Iteration 29, loss = 0.54342103
Iteration 30, loss = 0.58533801
Iteration 31, loss = 0.56124092
Iteration 32, loss = 0.55770650
Iteration 33, loss = 0.57548663
Iteration 34, loss = 0.55462551
Iteration 35, loss = 0.55780973
Iteration 36, loss = 0.55122681
Iteration 37, loss = 0.54921608
Iteration 38, loss = 0.57078649
Iteration 39, loss = 0.54216556
Iteration 40, loss = 0.55264024
Iteration 41, loss = 0.54180276
Iteration 42, loss = 0.55059583
Iteration 43, loss = 0.54213110
Iteration 44, loss = 0.55101596
Iteration 45, loss = 0.54307317
Iteration 46, loss = 0.55567322
Iteration 47, loss = 0.55487627
Iteration 48, loss = 0.53787818
Iteration 49, loss = 0.54100757
Iteration 50, loss = 0.53643637
Iteration 51, loss = 0.55496423
Iteration 52, loss = 0.54486554
Iteration 53, loss = 0.53627919
Iteration 54, loss = 0.54891550
Iteration 55, loss = 0.52772767
Iteration 56, loss = 0.53860419
Iteration 57, loss = 0.53481931
Iteration 58, loss = 0.53015238
Iteration 59, loss = 0.52851635
Iteration 60, loss = 0.53008394
Iteration 61, loss = 0.54016502
Iteration 62, loss = 0.54623533
Iteration 63, loss = 0.55150096
Iteration 64, loss = 0.53786683
Iteration 65, loss = 0.52947678
Iteration 66, loss = 0.53040841
Training loss did not improve more than tol=0.000100 for 10 consecutive epo
chs. Stopping.
```

Out[129]:
```
MLPClassifier(activation='relu', alpha=0.0001, batch_size='auto', beta_1=0.
9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=100, learning_rate='constant',
              learning_rate_init=0.001, max_iter=5000, momentum=0.9,
              n_iter_no_change=10, nesterovs_momentum=True, power_t=0.5,
              random_state=21, shuffle=True, solver='sgd', tol=0.0001,
              validation_fraction=0.1, verbose=True, warm_start=False)
```

In [130]:
```
y_predict = clf.predict(X_train)
```

In [131]:
```
from sklearn.metrics import confusion_matrix,classification_report
print(classification_report(train_labels, y_predict))
```

```
              precision    recall  f1-score   support

           0       0.77      0.94      0.85      1432
           1       0.74      0.41      0.53       668

    accuracy                           0.77      2100
   macro avg       0.76      0.67      0.69      2100
weighted avg       0.76      0.77      0.74      2100
```

In [132]:
```
ytest_predict = clf.predict(X_test)
```

In [133]:
```
print(classification_report(test_labels, ytest_predict))
```

```
              precision    recall  f1-score   support

           0       0.79      0.93      0.85       644
           1       0.68      0.39      0.50       256

    accuracy                           0.77       900
   macro avg       0.74      0.66      0.68       900
weighted avg       0.76      0.77      0.75       900
```

In [134]:
```
from sklearn.model_selection import GridSearchCV

param_grid = {
    'hidden_layer_sizes': [100,200,300],
    'max_iter': [5000,6000,7000],
    'solver': ['sgd','adam'],
    'tol': [0.001,0.00001,0.000001],
}

nncl = MLPClassifier()

grid_search = GridSearchCV(estimator = nncl, param_grid = param_grid, cv = 5)
```

In [135]:
```
grid_search.fit(X_train, train_labels)
```

Out[135]:
```
GridSearchCV(cv=5, error_score='raise-deprecating',
             estimator=MLPClassifier(activation='relu', alpha=0.0001,
                                     batch_size='auto', beta_1=0.9,
                                     beta_2=0.999, early_stopping=False,
                                     epsilon=1e-08, hidden_layer_sizes=(100,)
,
                                     learning_rate='constant',
                                     learning_rate_init=0.001, max_iter=200,
                                     momentum=0.9, n_iter_no_change=10,
                                     nesterovs_momentum=True, power_t=0.5,
                                     random_state=None, shuffle=True,
                                     solver='adam', tol=0.0001,
                                     validation_fraction=0.1, verbose=False,
```

```
                                warm_start=False),
             iid='warn', n_jobs=None,
             param_grid={'hidden_layer_sizes': [100, 200, 300],
                         'max_iter': [5000, 6000, 7000],
                         'solver': ['sgd', 'adam'],
                         'tol': [0.001, 1e-05, 1e-06]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring=None, verbose=0)
```

In [136]:
```
grid_search.best_params_
```

Out[136]:
```
{'hidden_layer_sizes': 100, 'max_iter': 7000, 'solver': 'adam', 'tol': 1e-0
6}
```

In [137]:
```
best_grid = grid_search.best_estimator_
```

In [138]:
```
ytrain_predict = best_grid.predict(X_train)
ytest_predict = best_grid.predict(X_test)
```

In [139]:
```
print(classification_report(train_labels,ytrain_predict))
```

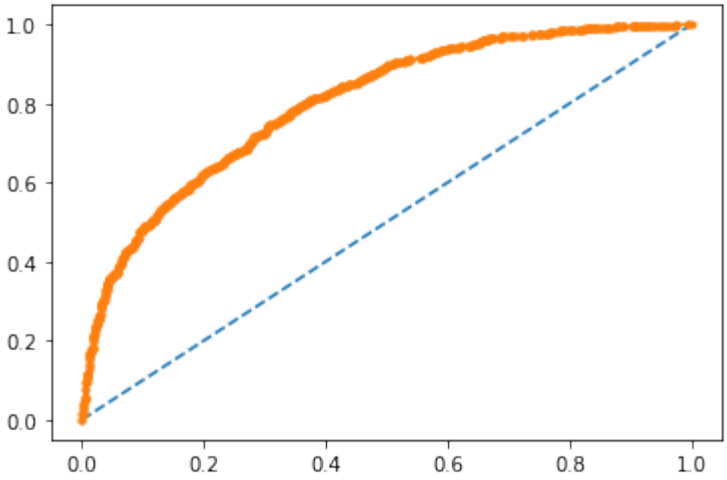
```
              precision    recall  f1-score   support

           0       0.78      0.92      0.84      1432
           1       0.72      0.43      0.54       668

    accuracy                           0.76      2100
   macro avg       0.75      0.68      0.69      2100
weighted avg       0.76      0.76      0.75      2100
```

In [140]:
```
print(classification_report(test_labels,ytest_predict))
```

```
              precision    recall  f1-score   support

           0       0.80      0.90      0.85       644
           1       0.63      0.43      0.52       256

    accuracy                           0.77       900
   macro avg       0.72      0.67      0.68       900
weighted avg       0.75      0.77      0.75       900
```

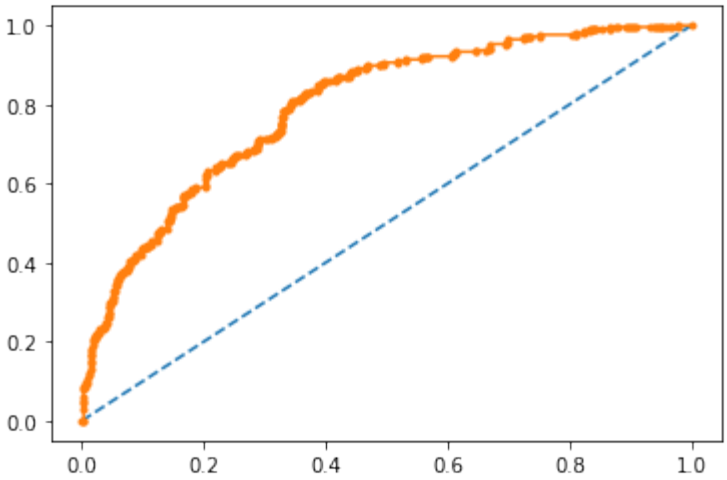
In [141]:
```
probs = best_grid.predict_proba(X_train)
probs = probs[:, 1]
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(train_labels, probs)
print('AUC: %.3f' % auc)
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(train_labels, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr, tpr, marker='.')
plt.show()
```

```
AUC: 0.803
```

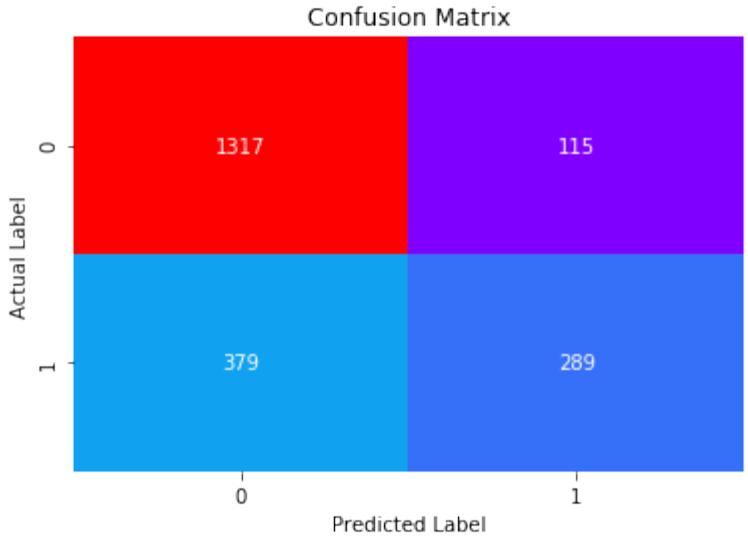


In [142]:
```
probs = best_grid.predict_proba(X_test)
probs = probs[:, 1]
from sklearn.metrics import roc_auc_score
auc = roc_auc_score(test_labels, probs)
print('AUC: %.3f' % auc)
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(test_labels, probs)
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr, tpr, marker='.')
plt.show()
```

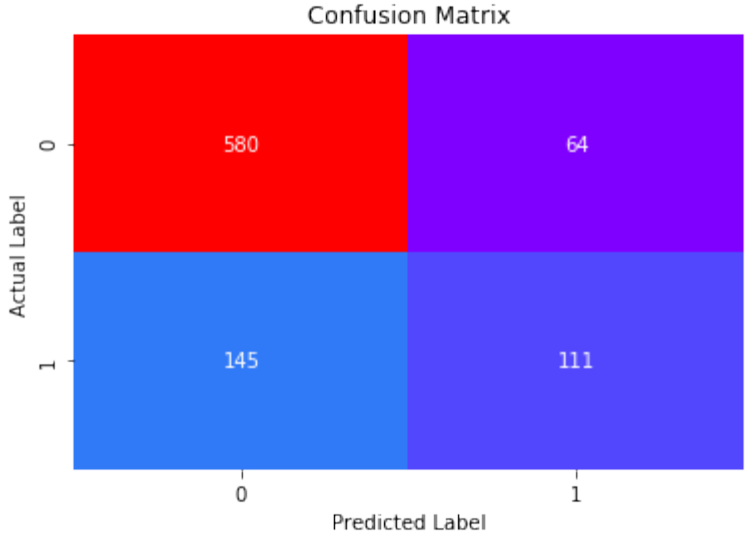
```
AUC: 0.796
```



In [143]:
```
confusion_matrix(train_labels,ytrain_predict)
sns.heatmap(confusion_matrix(train_labels,ytrain_predict),annot=True, fmt=
'd',cbar=False, cmap='rainbow')
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
plt.title('Confusion Matrix')
plt.show()
```



In [144]:
```
confusion_matrix(test_labels,ytest_predict)
sns.heatmap(confusion_matrix(test_labels,ytest_predict),annot=True, fmt='d
',cbar=False, cmap='rainbow')
plt.xlabel('Predicted Label')
plt.ylabel('Actual Label')
plt.title('Confusion Matrix')
plt.show()
```



In [ ]:

In [ ]:

In [ ]: