Yating Liao

In [86]:
```python
# Import the libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import warnings #to remove the warnings
warnings.filterwarnings('ignore')
```

In [87]:
```python
# Import the dataset
Test1_1 = pd.read_csv(r'D:\Caroline\Documents\Graduate\ISE 530 Optimizaton for Anal
print(Test1_1.head(10))
```

```
   Sample code number  Clump Thickness  Uniformity of Cell Size  \
0             1000025                5                        1
1             1002945                5                        4
2             1015425                3                        1
3             1016277                6                        8
4             1017023                4                        1
5             1017122                8                       10
6             1018099                1                        1
7             1018561                2                        1
8             1033078                2                        1
9             1033078                4                        2

   Uniformity of Cell Shape  Marginal Adhesion  Single Epithelial Cell Size  \
0                         1                  1                            2
1                         4                  5                            7
2                         1                  1                            2
3                         8                  1                            3
4                         1                  3                            2
5                        10                  8                            7
6                         1                  1                            2
7                         2                  1                            2
8                         1                  1                            2
9                         1                  1                            2

   Bare Nuclei  Bland Chromatin  Normal Nucleoli  Mitoses  Class
0            1                3                1        1      2
1           10                3                2        1      2
2            2                3                1        1      2
3            4                3                7        1      2
4            1                3                1        1      2
5           10                9                7        1      4
6           10                3                1        1      2
7            1                3                1        1      2
8            1                1                1        5      2
9            1                2                1        1      2
```

In [88]:

```python
# Remove the first column which is Sample Code Number
Test1_1.drop('Sample code number', axis=1, inplace=True)

X = Test1_1.iloc[:,:-1].values # get columns except for the last one.
print("Data of X:",X)
Y = Test1_1.iloc[:,-1].values # get the last one column which is class.
print("Data of Y:",Y)
```

```
Data of X: [[ 5  1  1 ...  3  1  1]
 [ 5  4  4 ...  3  2  1]
 [ 3  1  1 ...  3  1  1]
 ...
 [ 5 10 10 ...  8 10  2]
 [ 4  8  6 ... 10  6  1]
 [ 4  8  8 ... 10  4  1]]
Data of Y: [2 2 2 2 2 4 2 2 2 2 2 2 4 2 4 4 2 2 4 2 4 4 2 2 4 2 2 2 2 2 2 4 2 2 2
4 2
 4 4 4 4 4 4 2 4 2 2 4 4 4 4 4 4 4 4 4 4 4 4 2 4 4 2 4 2 4 4 2 2 4 2 4 4 2
 2 2 2 2 2 2 2 2 4 4 4 4 2 2 2 2 2 2 2 2 2 2 4 4 4 4 2 4 4 4 4 4 2 4 2 4 4
 4 2 2 2 4 2 2 2 2 4 4 4 2 4 2 4 2 2 2 4 2 2 2 2 2 2 2 2 4 2 2 4 2 2 4 2 4
 4 2 2 4 2 2 4 4 2 2 2 2 4 4 2 2 2 2 2 4 4 4 2 4 2 4 2 2 2 4 4 2 4 4 4 2 4
 4 2 2 2 2 2 2 2 2 4 4 2 2 2 4 4 2 2 2 4 4 2 4 4 4 2 2 4 2 2 4 4 4 4 2 4 4
 2 4 4 4 2 4 2 4 4 4 4 2 2 2 2 2 2 4 4 2 2 4 2 4 4 4 2 2 2 2 4 4 4 4 4 2 4
 4 4 2 4 2 4 4 2 2 2 2 4 2 2 4 4 4 4 4 2 4 4 2 2 4 4 2 2 4 4 2 4 2 4 4 2 2
 4 2 2 2 4 2 2 4 4 2 2 4 2 4 2 2 4 2 4 4 4 2 2 4 4 2 4 2 2 4 4 2 2 2 4 2 2
 2 4 4 2 2 2 4 2 2 4 4 4 4 4 4 2 2 2 2 4 4 2 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2
 2 2 4 2 2 2 2 4 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2 2 2 2 2 4 2 4 2 4 2 2 2 2 4
 2 2 2 4 2 4 2 2 2 2 2 2 2 4 4 2 2 2 4 2 2 2 2 2 2 2 2 4 2 2 2 4 2 4 4 4 2
 2 2 2 2 2 2 4 4 4 2 2 2 2 2 2 2 2 2 2 2 4 2 2 4 4 2 2 2 4 4 4 2 4 2 4 2 2
 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2 2 2 4 4 2 2 2 4 2 2 4 4 2 2 2 2 2 2 4 2 2
 2 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 4 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 4 4
 4 4 2 2 4 2 2 2 2 2 2 4 4 2 2 2 4 2 4 2 4 4 4 2 4 2 2 2 2 2 2 2 2 4 4 4 2
 2 4 2 4 4 4 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2 4 2 2 4 2 2 2 2 2 2 2 2
 2 2 2 4 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2 2 2 2 4 4 4 2 2 2 2 2 2 2 2 2 4 4
 2 2 2 2 2 2 2 2 2 4 2 2 2 2 4 4 4]
```

In [89]:

```python
# We don't need to encode the dataset because the data size is similar

# Spliting the dataset into training and testing set
from sklearn.model_selection import train_test_split
X_train, X_test, Y_train, Y_test = train_test_split(X,Y, test_size = 0.2, random_s
```

In [90]:

```
# Feature Scaling--Normalization
# I choose the normalization meathod

from sklearn.preprocessing import MinMaxScaler
# Create an instance of MinMaxScaler
scaler = MinMaxScaler()
X_train_normal = scaler.fit_transform(X_train)
X_test_normal = scaler.fit_transform(X_test)
X_train_normal = pd.DataFrame(X_train_normal)
X_test_normal = pd.DataFrame(X_test_normal)
print("Normalized X train:", X_train_normal.head(10))
print("Normalized X test:",X_test_normal.head(10))
```

```
Normalized X train:            0         1         2         3         4
5         6  \
0  1.000000  0.000000  0.000000  0.000000  0.111111  1.000000  0.444444
1  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.222222
2  0.444444  0.000000  0.000000  0.000000  0.111111  0.000000  0.222222
3  0.222222  0.000000  0.111111  0.000000  0.111111  0.000000  0.111111
4  0.777778  0.111111  0.222222  0.000000  0.555556  0.222222  0.666667
5  0.000000  0.000000  0.000000  0.000000  0.111111  0.000000  0.222222
6  0.111111  0.000000  0.000000  0.000000  0.111111  0.000000  0.222222
7  0.333333  0.000000  0.000000  0.222222  0.000000  0.000000  0.111111
8  0.444444  0.666667  0.666667  0.000000  0.444444  0.777778  0.222222
9  0.777778  1.000000  1.000000  0.777778  0.555556  0.888889  0.222222

          7    8
0  0.333333  0.0
1  0.000000  0.0
2  0.000000  0.0
3  0.000000  0.0
4  0.000000  0.0
```

Training the Logistic Regression model on the Training Set

In [91]:

```
# Training the Logistic Regression model on the Training Set
from sklearn.linear_model import LogisticRegression
modelLogistic = LogisticRegression(random_state = 0)
modelLogistic.fit(X_train_normal, Y_train)
#print the regression coefficients
print("The intercept b0= ", modelLogistic.intercept_)
print("The coefficient b1= ", modelLogistic.coef_)
```

```
The intercept b0=  [-4.98497464]
The coefficient b1=  [[2.31479863 1.46611995 1.60077767 1.37726984 1.35613885 2.7
6471853
  1.92988752 1.80420999 0.74381706]]
```

Predicting the Test set results

In [92]:

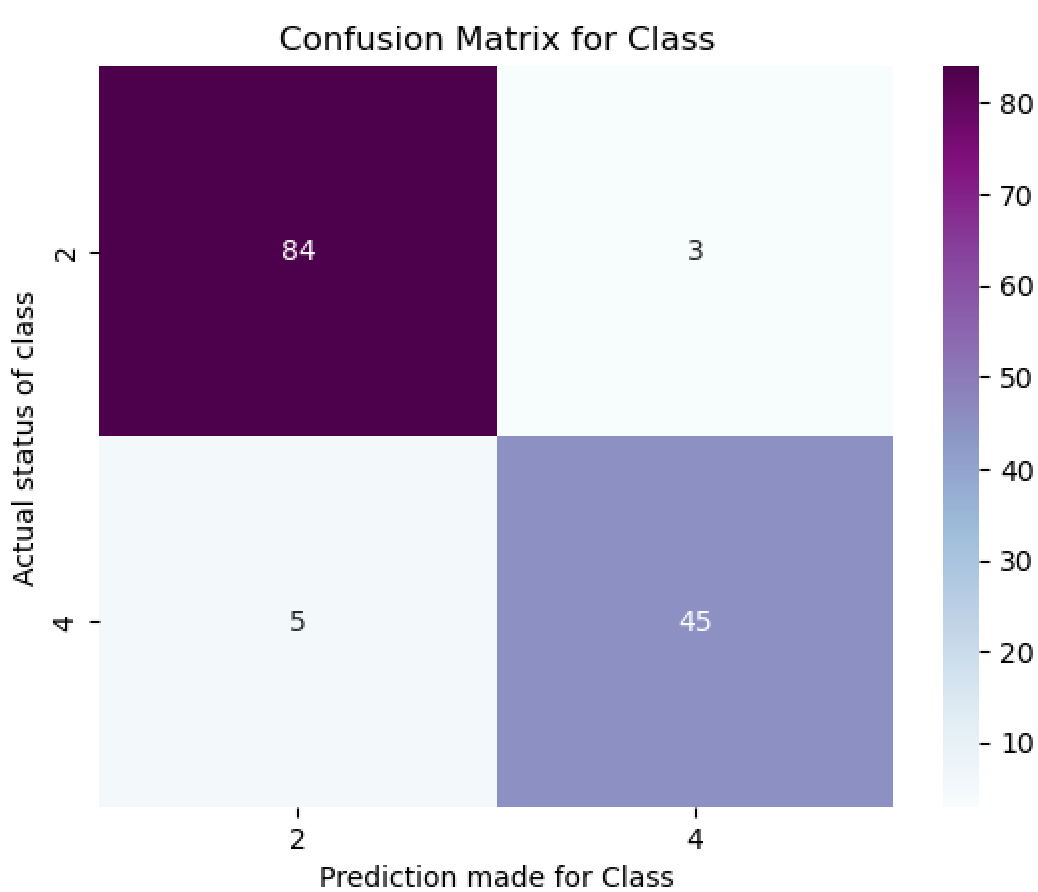
```
y_test_pred = modelLogistic.predict(X_test_normal)
print(y_test_pred)
print(np.concatenate((y_test_pred.reshape(len(y_test_pred),1),Y_test.reshape(len(Y_
```

```
[2 2 4 4 2 2 2 4 2 2 4 2 4 2 2 2 4 4 4 2 2 2 4 2 4 4 2 2 2 4 2 4 4 2 2 2 4
 4 2 4 2 2 2 2 2 2 2 4 2 2 4 2 4 2 2 2 4 4 2 4 2 2 2 2 2 2 2 2 4 4 2 2 2 2
 2 2 4 2 2 2 4 2 4 2 2 4 2 4 4 2 4 2 4 2 2 4 4 4 2 2 2 2 4 4 2 2 4 2 2 2 4
 2 2 4 2 2 2 2 2 2 2 4 2 2 4 4 2 4 2 4 2 2 4 2 2 4 2]
[[2 2]
 [2 2]
 [4 4]
 [4 4]
 [2 2]
 [2 2]
 [2 2]
 [4 4]
 [2 2]
 [2 2]
 [4 4]
 [2 2]
 [4 4]
 [2 2]
 [2 2]
```

In [98]:

```
# Confusion Matrix
from sklearn.metrics import confusion_matrix, accuracy_score
ConfusionMatrix = confusion_matrix(Y_test, y_test_pred)
print(ConfusionMatrix)
ax = sns.heatmap(ConfusionMatrix,annot=True,cmap='BuPu')
ax.set_title('Confusion Matrix for Class');
ax.set_xlabel('Prediction made for Class')
ax.set_ylabel('Actual status of class');
## Ticket labels - List must be in alphabetical order
ax.xaxis.set_ticklabels(['2','4'])
ax.yaxis.set_ticklabels(['2','4'])
## Display the visualization of the Confusion Matrix.
plt.show()
```

```
[[84  3]
 [ 5 45]]
```



In [99]:

```python
print(accuracy_score(Y_test, y_test_pred))
```

```
0.9416058394160584
```

The accuracy rate of 94.16% is very high, meaning the logistic regression model is the good and fitted model.

Try Standardization

In [94]:

```python
# Try Standardization
from sklearn.preprocessing import StandardScaler
scaler2 = StandardScaler()
X_train_stand = scaler2.fit_transform(X_train)
X_test_stand = scaler2.fit_transform(X_test)
X_train_stand = pd.DataFrame(X_train_stand)
X_test_stand = pd.DataFrame(X_test_stand)
print("Standized X train:", X_train_stand.head(10))
print("Standized X test:",X_test_stand.head(10))
```

```
Standized X train:          0         1         2         3         4         5  \
6  \
0  1.988395 -0.697811 -0.741526 -0.633637 -0.548720  1.815536  0.619074
1 -1.224684 -0.697811 -0.741526 -0.633637 -0.997897 -0.682796 -0.188607
2  0.203351 -0.697811 -0.741526 -0.633637 -0.548720 -0.682796 -0.188607
3 -0.510666 -0.697811 -0.404973 -0.633637 -0.548720 -0.682796 -0.592447
4  1.274378 -0.372444 -0.068420 -0.633637  1.247988 -0.127611  1.426754
5 -1.224684 -0.697811 -0.741526 -0.633637 -0.548720 -0.682796 -0.188607
6 -0.867675 -0.697811 -0.741526 -0.633637 -0.548720 -0.682796 -0.188607
7 -0.153658 -0.697811 -0.741526  0.075309 -0.997897 -0.682796 -0.592447
8  0.203351  1.254392  1.277791 -0.633637  0.798811  1.260351 -0.188607
9  1.274378  2.230493  2.287450  1.847676  1.247988  1.537943 -0.188607

          7         8
0  0.345321 -0.338637
1 -0.621578 -0.338637
2 -0.621578 -0.338637
3 -0.621578 -0.338637
4 -0.621578 -0.338637
5 -0.621578 -0.338637
6 -0.621578 -0.338637
7 -0.621578 -0.338637
8  0.345321 -0.338637
9  2.279119  4.765854
Standized X test:          0         1         2         3         4         5  \
6  \
0 -1.208343 -0.720172 -0.743031 -0.663180 -0.583582  0.296005 -1.012067
1 -0.515694 -0.720172 -0.743031 -0.663180 -0.583582 -0.764196 -0.582800
2  0.176954  0.604171  0.570456 -0.331590  0.779214  1.621257  0.275733
3 -0.169370  1.266343  1.555572  0.000000  0.324949  1.621257  2.422067
4 -1.208343 -0.720172 -0.743031 -0.663180 -0.583582 -0.764196 -1.012067
5 -0.515694 -0.058000 -0.743031 -0.663180 -0.583582 -0.764196 -1.012067
6  0.176954 -0.058000 -0.743031 -0.331590 -0.583582 -0.764196 -0.582800
7  1.215927  2.259601  2.212316  2.321129  1.687745  0.296005  0.275733
8 -1.208343 -0.720172 -0.743031  0.000000 -1.037847 -0.234096 -1.012067
9 -1.208343 -0.720172 -0.743031 -0.663180 -0.583582 -0.764196 -0.582800

          7         8
0 -0.579728 -0.392731
1 -0.579728 -0.392731
2  0.129403 -0.392731
3 -0.579728 -0.392731
4 -0.579728 -0.392731
5 -0.579728 -0.392731
6 -0.579728 -0.392731
7  1.902231  3.361046
8 -0.579728 -0.392731
9 -0.579728 -0.392731
```

In [95]:

```
# Training the Logistic Regression model on the Standized Training Set
from sklearn.linear_model import LogisticRegression
modelLogistic2 = LogisticRegression(random_state = 0)
modelLogistic2.fit(X_train_stand, Y_train)
#print the regression coefficients
print("The intercept b0= ", modelLogistic2.intercept_)
print("The coefficient b1= ", modelLogistic2.coef_)
```

```
The intercept b0=  [-1.15196112]
The coefficient b1=  [[1.14397509 0.19849412 0.58494288 0.64708178 0.51186677 1.3
058281
  0.98532234 0.78902716 0.43939809]]
```

In [96]:

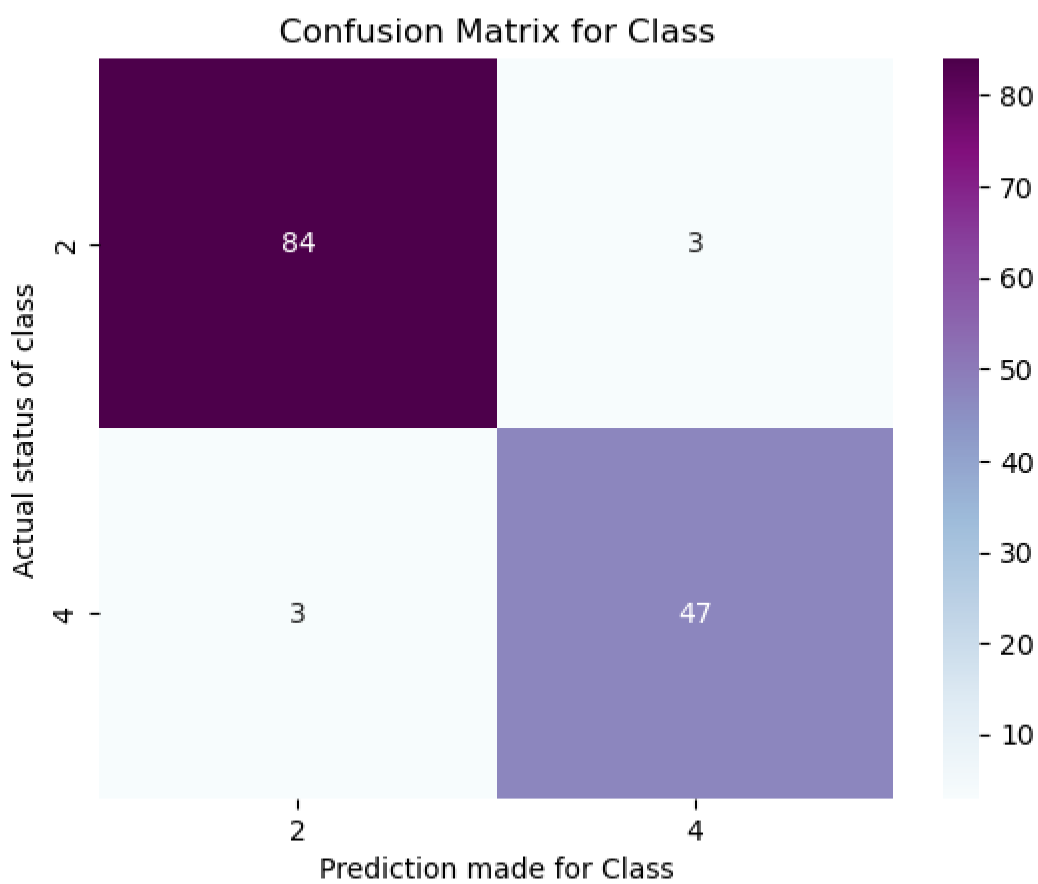
```
y_test_pred2 = modelLogistic2.predict(X_test_stand)
print(y_test_pred2)
print(np.concatenate((y_test_pred2.reshape(len(y_test_pred2),1),Y_test.reshape(len(
```

```
[2 2 4 4 2 2 2 4 2 2 4 2 4 2 2 2 4 4 4 2 2 2 4 2 4 4 2 2 2 4 2 4 4 2 2 2 4
 4 2 4 2 2 2 2 2 2 2 4 2 2 4 2 4 2 2 2 4 4 2 4 2 2 2 2 2 2 2 2 4 4 2 2 2 2
 2 2 4 2 2 2 4 2 4 2 2 4 2 4 4 2 4 2 4 4 2 4 4 4 4 2 2 2 4 4 2 2 4 2 2 2 4
 2 2 4 2 2 2 2 2 2 2 4 2 2 4 4 2 4 2 4 2 2 4 2 2 4 2]
[[2 2]
 [2 2]
 [4 4]
 [4 4]
 [2 2]
 [2 2]
 [2 2]
 [4 4]
 [2 2]
 [2 2]
 [4 4]
 [2 2]
 [4 4]
 [2 2]
 [2 2]
```

In [100]:

```
# Confusion Matrix2
from sklearn.metrics import confusion_matrix, accuracy_score
CM2 = confusion_matrix(Y_test, y_test_pred2)
print(CM2)
ax = sns.heatmap(CM2,annot=True,cmap='BuPu')
ax.set_title('Confusion Matrix for Class');
ax.set_xlabel('Prediction made for Class')
ax.set_ylabel('Actual status of class');
## Ticket labels - List must be in alphabetical order
ax.xaxis.set_ticklabels(['2','4'])
ax.yaxis.set_ticklabels(['2','4'])
## Display the visualization of the Confusion Matrix.
plt.show()
```

```
[[84  3]
 [ 3 47]]
```



In [101]:

```
print(accuracy_score(Y_test, y_test_pred2))
```

```
0.9562043795620438
```

After standization, the accurcacy rate is higer than the normalization data, meaning the standardization is better than the normalization. (There are other possible factors that influence on the result, but I am not going to analyze so deeply here.)