QUIZ-2, ECON425

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Ans1.

When we take learning rate = 0.1 and maximum iteration = 1000, the Scikit model is the best performer with the accuracy score of 0.9090. Meanwhile, the model developed using method-2 with biased term is the worst with the score of 0.8181. This could be because of overfitting problem. The model with biased term has better accuracy score on training data because the biased term allows the entire activation curve to shift (left and right) to fit the data better. But, the high accuracy score on training data set does not confirm the score on testing set will be high given having overfitting problem.

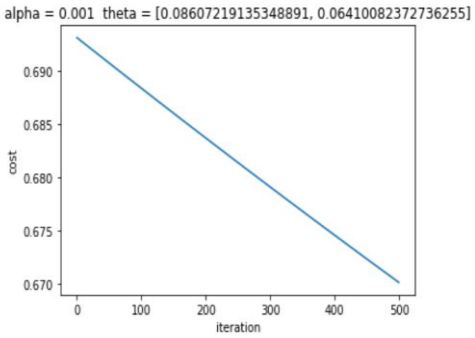
Note that the accuracy score of Scikit model, the model developed using method -2 with and without bias term is: 0.90909090, 0.8181818181 and 0.87878787 respectively.

Ans2:

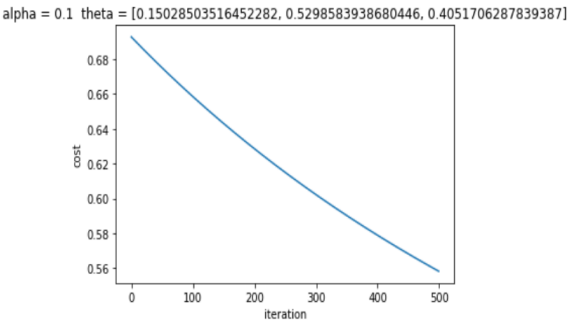
For this part, I applied different value of hyper-parameters (that is learning rate and iteration). The best model or the model with the highest accuracy score **(without the biased term)** is obtained taking learning rate equal to 0.001 and maximum iterations equal to 500. The best model or the model with the highest accuracy score **(with the biased term)** is obtained taking learning rate equal to 0.007 and maximum iterations equal to 500. Note that the best model obtained from method-2 with biased term has higher accuracy score, 0.96 as compared to the one without the biased term, 0.90. The reason for the same could be attributed to the fact that the model with biased term is less fit and hence can solve the overfitting problem when we use testing data.

The learning rate and iteration is very small, 0.007 and 500; the coefficient is largely different from the scikit-lean model using the formula for solving maximization.

Convergence curve of Best model without biased term

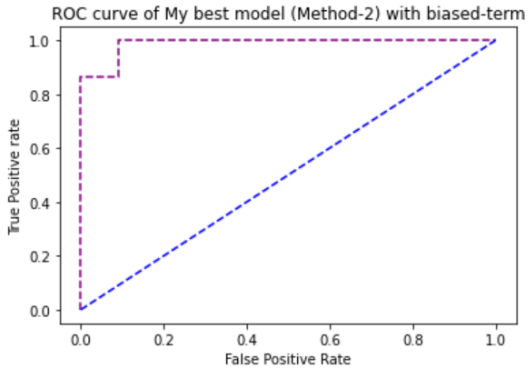


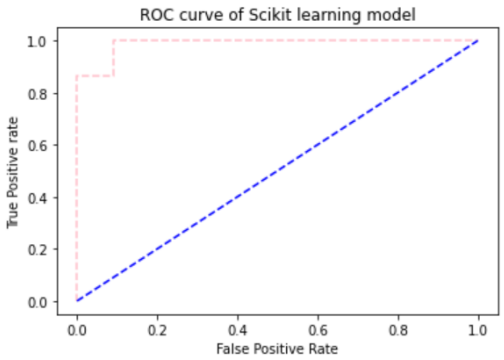
Convergence curve of Best Model with Biased term

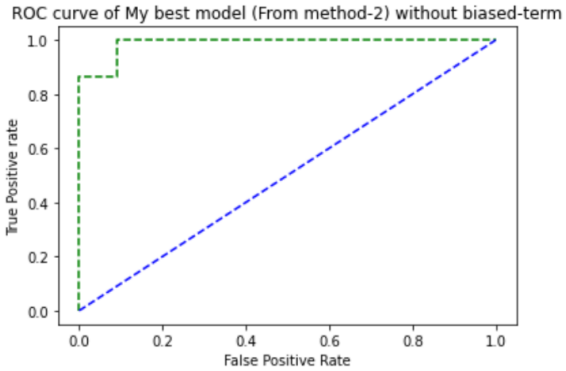


Ans 3:

Note that the AUC score and ROC curve obtained for all the three models are the same the reason for which could be that they are not very different in accuracy score and also the fact that the training set is small. The accuracy score might be a better metric for model evaluation in this case when the splitting data is very well balanced between y = 0 and y =1 (as can be seen in the figure below). However, this results might vary due to different value of random_state So, cross-validation should be applied.







Appendix: Codes

Anshika Sharma, UCLA ID:(305488635)

In [1]:
```
#In the first step, we import all the functions:
import math
import numpy as np
import pandas as pd

from pandas import DataFrame
from sklearn import preprocessing
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
from numpy import loadtxt, where
from pylab import scatter, show, legend, xlabel, ylabel

#Now, we import self-defined functions:
from util import Cost_Function, Gradient_Descent, Cost_Function_Derivative, Co
st_Function, Prediction, Sigmoid
```

Step: pre-processing the data

In [2]:
```
# scale data to be between -1,1

min_max_scaler = preprocessing.MinMaxScaler(feature_range=(-1,1))
df = pd.read_csv("data.csv", header=0)

# clean up data
df.columns = ["grade1","grade2","label"]

x = df["label"].map(lambda x: float(x.rstrip(';')))

# formats the input data into two arrays, one of independant variables
# and one of the dependant variable
X = df[["grade1","grade2"]]
X = np.array(X)
X = min_max_scaler.fit_transform(X)
Y = df["label"].map(lambda x: float(x.rstrip(';')))
Y = np.array(Y)

print(X.shape)
print(Y.shape)
```

```
(100, 2)
(100,)
```

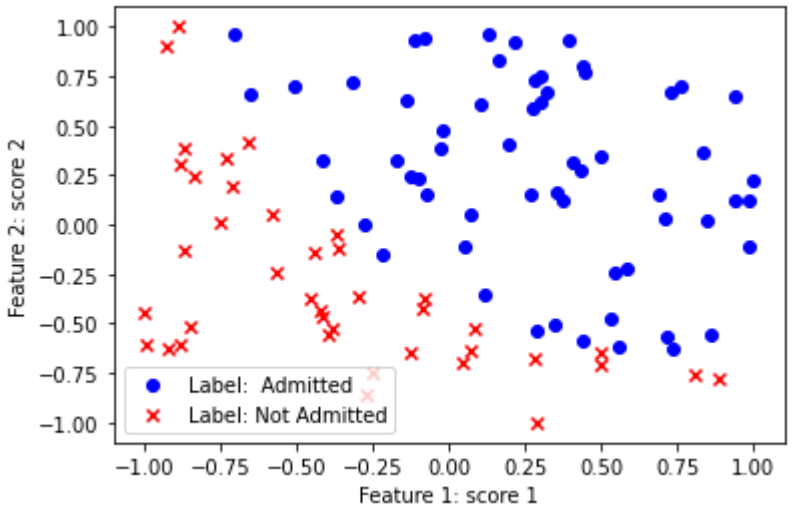
Splitting the data

In [3]:
```
# split the dataset into two subsets: testing and training
X_train,X_test,Y_train,Y_test = train_test_split(X,Y,test_size=0.33, random_st
ate = 0)
```

Step: training and testing using sklearn

In [4]:
```
# use sklearn class
clf = LogisticRegression()
# call the function fit() to train the class instance
clf.fit(X_train,Y_train)
# scores over testing samples
print(clf.score(X_test,Y_test))

# visualize data using functions in the library pylab
pos = where(Y == 1)
neg = where(Y == 0)
scatter(X[pos, 0], X[pos, 1], marker='o', c='b')
scatter(X[neg, 0], X[neg, 1], marker='x', c='r')
xlabel('Feature 1: score 1')
ylabel('Feature 2: score 2')
legend(['Label:  Admitted', 'Label: Not Admitted'])
show()
```

```
0.9090909090909091
```



Step-4: training and testing using self-developed model Without bias term

In [5]:
```
#Without bias term
thetao = [0,0] #initial model parameters
alpha = 0.1 # learning rates
max_iteration = 1000 # maximal iterations

m = len(Y_test) # number of samples

for x in range(max_iteration):
        # call the functions for gradient descent method
        new_theta = Gradient_Descent(X_test,Y_test,thetao,m,alpha)
        thetao = new_theta
        if x % 200 == 0:
                # calculate the cost function with the present theta
                Cost_Function(X_test,Y_test,thetao,m)
                print('theta ', thetao)
                print('cost is ', Cost_Function(X_test,Y_test,thetao,m))
print("coefficeint of model without biase term: ", thetao)
```

```
theta  [0.012183693210473964, 0.016040785552839887]
cost is  0.6891034524191488
theta  [1.595668382380516, 1.7623296121264824]
cost is  0.3849535321655342
theta  [2.432575630119286, 2.433733975181813]
cost is  0.32597924734364025
theta  [2.9986243664794237, 2.8233699189624857]
cost is  0.3021317059133413
theta  [3.421196870900459, 3.0958366189533053]
cost is  0.2894222938558452
coefficeint of model without biase term:  [3.752559821674534, 3.3048645289645
21]
```

Step: training and testing using self-developed model with biased term

In [6]:
```
thetab = [0,0,0] #initial model parameters
alphab = 0.1  # learning rates
max_iteration = 1000 # maximal iterations

xValuesb = np.ones((len(Y_train) , 3)) #create array(60,3) of 1
xValuesb[:, 1:3] = X_train[:, 0:2] # split training and testing data set
yValuesb = Y_train

m = len(Y_train) # number of samples
total_c = []
for x in range(max_iteration):
    # call the functions for gradient descent method
    new_theta = Gradient_Descent(xValuesb ,yValuesb,thetab,m,alphab)
    thetab = new_theta
    cost = Cost_Function(xValuesb,yValuesb,thetab,m)
    total_c.append(cost)
    if x % 200 == 0:
        # calculate the cost function with the present theta
        print('theta ', thetab)
        print('cost is ', cost)
res = [thetab]
print('theta of final model:',res)
print('cost:', cost)
import matplotlib.pyplot as plt
```

```
theta  [0.006716417910447761, 0.017594552563821805, 0.013041079056435988]
cost is  0.6879260076519823
theta  [0.27230486977806295, 1.8509744247713953, 1.5674058687026597]
cost is  0.35925358125923335
theta  [0.32685205876981677, 2.609236302445539, 2.3413727258185757]
cost is  0.29915571234895694
theta  [0.3755935061558235, 3.0990384653909016, 2.860323652288471]
cost is  0.27336158485525913
theta  [0.4173426458352523, 3.4656190942199743, 3.24944381587512]
cost is  0.2589192974933075
theta of final model: [[0.4527981227294301, 3.75774790761984, 3.5581748294928
905]]
cost: 0.24975187267122004
```

In [7]:
```
scoreo = 0
scoreb = 0

# accuracy for sklearn
scikit_score = clf.score(X_test,Y_test)
length = len(X_test)
#model without bias term
for i in range(length):
        predictiono = round(Prediction(X_test[i],thetao))
        answero = Y_test[i]
        if predictiono == answero:
                scoreo += 1
my_scoreo = float(scoreo) / float(length)

for i in range(length):
        predictionb = round(Prediction(X_test[i],thetab))
        answero = Y_test[i]
        if predictionb == answero:
                scoreb += 1
my_scoreb = float(scoreb) / float(length)

print('The score of Scikit model: ', scikit_score)
print('The score of model without biased term : ', my_scoreo)
print('The score of model with biased term: ', my_scoreb)
```

```
The score of Scikit model:  0.9090909090909091
The score of model without biased term :  0.8787878787878788
The score of model with biased term:  0.8181818181818182
```

Changing hyperparameters, learning rate and max_iteration

1 - Self developed model without biased term (Developed using Method-2 of Logistic reg)

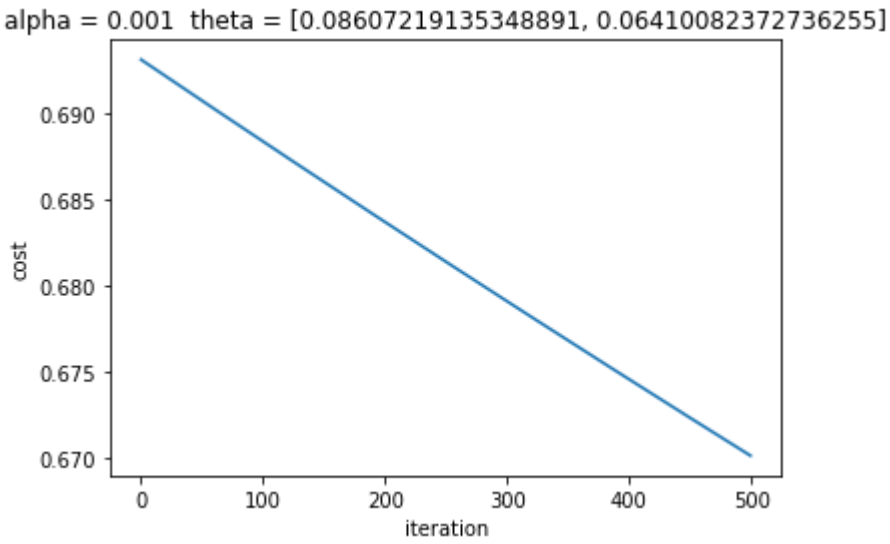
In [8]:
```
##### training and testing using self-developed model without biased term ####
#

# Change alpha and iteration

def logisticreg(xValues ,yValues,theta,m,alpha,testXValues,Y_test,max_iteratio
n):
    for x in range(max_iteration):
    # call the functions for gradient descent method
        new_theta = Gradient_Descent(xValues ,yValues,theta,m,alpha)
        theta = new_theta
        Cost_Function(xValues,yValues,theta,m)
    #evaluate model
    score = 0
    length = len(testXValues)
    for i in range(length):
        prediction = round(Prediction(testXValues[i],theta))
        answer = Y_test[i]
        if prediction == answer:
            score += 1
    my_score = float(score) / float(length)
    res = [my_score]
    res.extend(theta)
    return res

alphar = [0.0001, 0.0007,0.001, 0.007,0.01, 0.07,0.1,0.7 ]
#Initialize the dataframe to store coefficients
col = ['max_iteration']+ ['testing_score'] + ['coef_x_%d'%i for i in range(1,
3)]
ind = ['alpha_%.2g'%alphar[i] for i in range(0,8)]
#ind = a+a+a
coef_matrix_logisw = pd.DataFrame(index=ind, columns=col)

thetaw = [0,0] #initial model parameters
xValuesw = X_train # split training and testing data set
yValuesw = Y_train

m = len(Y_train) # number of samples

testXValues2 = X_test
max_iterationr = [500,1000,10000]
total =  []
for j in range (3):
#Iterate through all powers and assimilate results
    for i in range(8):
        coef_matrix_logisw.iloc[i,0] = max_iterationr[j]
        coef_matrix_logisw.iloc[i,1:] = logisticreg(xValuesw ,yValuesw,thetaw,
m,alphar[i],testXValues2,Y_test,max_iterationr[j])
    print(coef_matrix_logisw)
```

	max_iteration	testing_score	coef_x_1	coef_x_2
alpha_0.0001	500	0.909091	0.008778	0.006509
alpha_0.0007	500	0.909091	0.060645	0.045101
alpha_0.001	500	0.909091	0.086072	0.064101
alpha_0.007	500	0.878788	0.531343	0.406472
alpha_0.01	500	0.878788	0.715914	0.554428
alpha_0.07	500	0.878788	2.448603	2.163067
alpha_0.1	500	0.878788	2.860257	2.592435
alpha_0.7	500	0.878788	5.163595	4.983767
	max_iteration	testing_score	coef_x_1	coef_x_2
alpha_0.0001	1000	0.909091	0.017518	0.012996
alpha_0.0007	1000	0.909091	0.119456	0.089131
alpha_0.001	1000	0.909091	0.168453	0.126042
alpha_0.007	1000	0.878788	0.931351	0.732320
alpha_0.01	1000	0.878788	1.203986	0.966156
alpha_0.07	1000	0.878788	3.263809	3.017084
alpha_0.1	1000	0.878788	3.704772	3.479285
alpha_0.7	1000	0.878788	5.684622	5.515084
	max_iteration	testing_score	coef_x_1	coef_x_2
alpha_0.0001	10000	0.909091	0.168447	0.126038
alpha_0.0007	10000	0.878788	0.931174	0.732203
alpha_0.001	10000	0.878788	1.203707	0.965961
alpha_0.007	10000	0.878788	3.262625	3.015857
alpha_0.01	10000	0.878788	3.703382	3.477836
alpha_0.07	10000	0.878788	5.683376	5.513817
alpha_0.1	10000	0.878788	5.824896	5.657776
alpha_0.7	10000	0.878788	5.915152	5.749518

1.1 - My self developed best model without biased term (Developed using Method-2 of Logistic reg)

In [9]:
```
#plotting the convergence curve

#######training and testing using self-developed model biased term (best mode
l)##

thetaw = [0 , 0] #initial model parameters
alphaw = 0.001  # learning rates
max_iteration = 500 # maximal iterations

xValuesw = X_train # split training and testing data set
yValuesw = Y_train

m = len(Y_train) # number of samples
total_cw = []
for x in range(max_iteration):
    # call the functions for gradient descent method
    new_thetaw = Gradient_Descent(xValuesw ,yValuesw,thetaw,m,alphaw)
    thetaw = new_thetaw
    costw = Cost_Function(xValuesw,yValuesw,thetaw,m)
    total_cw.append(costw)
    if x % 200 == 0:
        # calculate the cost function with the present theta
        print('theta ', thetaw)
        print('cost is ', costw)
resw = [thetaw]
print('theta of final model:',resw)
print('cost:', costw)
import matplotlib.pyplot as plt

plt.plot(range(0,len(total_cw)),total_cw);
plt.xlabel('iteration')
plt.ylabel('cost')
plt.title('alpha = {}  theta = {}'.format(alphaw, thetaw))
plt.show()
```

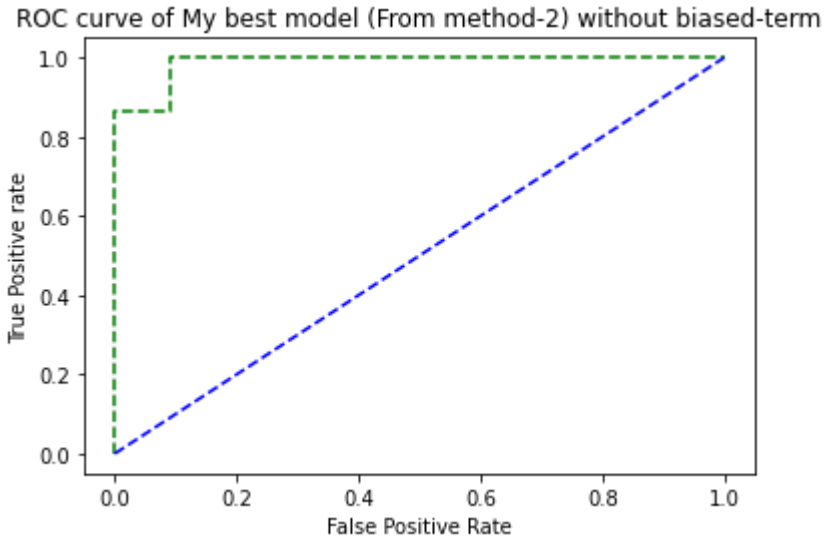
```
theta  [0.00017594552563821806, 0.00013041079056435987]
cost is  0.6930992187021833
theta  [0.03505604153083156, 0.026033346305702698]
cost is  0.6836614760174738
theta  [0.06932861224176784, 0.05158294473360511]
cost is  0.6745246882615417
theta of final model: [[0.08607219135348891, 0.06410082372736255]]
cost: 0.670110249585646
```



In [10]:
```
# ROC, AUC
from sklearn.metrics import roc_auc_score
from sklearn.metrics import auc
from sklearn.metrics import roc_curve
pred4 = []
pred4 = []
Ytest4 = []
thetaob =   thetaw
print(thetaob)
length = len(X_test)
score = 0
for i in range(length):
        prediction = round(Prediction(X_test[i],thetaob))
        answer = Y_test[i]
        if prediction == answer:
                score += 1
my_scoreob = float(score) / float(length)

prop4 =[]
for i in range(length):
    prop4 = Prediction(X_test[i],thetaob)
    pred4.append(prop4)

pred_prob4 = np.array(pred4)
fpr4, tpr4, thresh4 = roc_curve(Y_test, pred_prob4, pos_label=1)
print('Score of my best model without biased term:', my_scoreob)
print('The AUC score is: ', roc_auc_score(Y_test, pred_prob4))

random_probs = [0 for i in range(len(Y_test))]
p_fpr, p_tpr, _ = roc_curve(Y_test, random_probs, pos_label=1)
```

```
[0.08607219135348891, 0.06410082372736255]
Score of my best model without biased term: 0.9090909090909091
The AUC score is:  0.9876033057851239
```

In [11]:
```
# plot roc curves
plt.plot(fpr4, tpr4, linestyle='--',color='green', label='my own-model without
biased-term')
#plt.plot(fpr2, tpr2, linestyle='--',color='green', label='My own model')
plt.plot(p_fpr, p_tpr, linestyle='--', color='blue')
# title
plt.title('ROC curve of My best model (From method-2) without biased-term')
# x label
plt.xlabel('False Positive Rate')
# y label
plt.ylabel('True Positive rate')

#plt.legend(loc='best')
#plt.savefig('ROC',dpi=300)
plt.show()
```



2 - My Self developed model with biased term (Developed using Method-2 of Logistic reg)

In [12]:
```
###############training and testing using self-developed model biased term#####
########

# Change iteration and learning rate, alpha

def logisticreg(xValuesl ,yValuesl,thetal,m,alpha,testXValues1,Y_test,max_iter
ation):
    for x in range(max_iteration):
    # call the functions for gradient descent method
        new_theta = Gradient_Descent(xValuesl ,yValuesl,thetal,m,alpha)
        thetal = new_theta
        Cost_Function(xValuesl,yValuesl,thetal,m)
    #evaluate model
    scorel = 0
    length = len(testXValues1)
    for i in range(length):
        predictionl = round(Prediction(testXValues1[i],thetal))
        answerl = Y_test[i]
        if predictionl == answerl:
            scorel += 1
    my_scorel = float(scorel) / float(length)
    res = [my_scorel]
    res.extend(thetal)
    return res

alphar = [0.0001, 0.0007,0.001, 0.007,0.01, 0.07,0.1,0.7 ]
#Initialize the dataframe to store coefficients
col = ['max_iteration']+ ['testing_score'] + ['coef_x_%d'%i for i in range(0,
3)]
ind = ['alpha_%.2g'%alphar[i] for i in range(0,8)]
#ind = a+a+a
coef_matrix_logis = pd.DataFrame(index=ind, columns=col)

thetal = [0,0,0] #initial model parameters
xValuesl = np.ones((len(Y_train) , 3)) #create array(60,3) of 1
xValuesl[:, 1:3] = X_train[:, 0:2] # split training and testing data set
yValuesl = Y_train

m = len(Y_train) # number of samples

testXValues1 = np.ones((len(X_test), 3))
testXValues1[:, 1:3] = X_test[:, 0:2]
max_iterationr = [500,1000,10000]
total =  []
for j in range (3):
#Iterate through all powers and assimilate results
    for i in range(8):
        #print(logisticreg(xValuesl ,yValuesl,thetal,m,alphar[i],testXValues1,
Y_test,max_iteration))
        coef_matrix_logis.iloc[i,0] = max_iterationr[j]
        coef_matrix_logis.iloc[i,1:] = logisticreg(xValuesl ,yValuesl,thetal,m
,alphar[i],testXValues1,Y_test,max_iterationr[j])
    print(coef_matrix_logis)
```

	max_iteration	testing_score	coef_x_0	coef_x_1	coef_x_2
alpha_0.0001	500	0.909091	0.003335	0.008777	0.006509
alpha_0.0007	500	0.909091	0.022403	0.060621	0.045079
alpha_0.001	500	0.909091	0.031357	0.086023	0.064058
alpha_0.007	500	0.969697	0.150285	0.529858	0.405171
alpha_0.01	500	0.939394	0.181938	0.713593	0.552421
alpha_0.07	500	0.878788	0.313333	2.451184	2.175861
alpha_0.1	500	0.909091	0.351853	2.872300	2.619482
alpha_0.7	500	0.878788	0.666873	5.405140	5.278819
	max_iteration	testing_score	coef_x_0	coef_x_1	coef_x_2
alpha_0.0001	1000	0.909091	0.006624	0.017515	0.012995
alpha_0.0007	1000	0.909091	0.042724	0.119361	0.089048
alpha_0.001	1000	0.939394	0.058631	0.168268	0.125881
alpha_0.007	1000	0.939394	0.209280	0.928139	0.729663
alpha_0.01	1000	0.939394	0.233524	1.199981	0.963270
alpha_0.07	1000	0.909091	0.397036	3.291243	3.064524
alpha_0.1	1000	0.909091	0.452798	3.757748	3.558175
alpha_0.7	1000	0.878788	0.754692	6.081940	5.980664
	max_iteration	testing_score	coef_x_0	coef_x_1	coef_x_2
alpha_0.0001	10000	0.939394	0.058624	0.168262	0.125877
alpha_0.0007	10000	0.939394	0.209215	0.927962	0.729546
alpha_0.001	10000	0.939394	0.233460	1.199703	0.963075
alpha_0.007	10000	0.909091	0.396902	3.290033	3.063260
alpha_0.01	10000	0.909091	0.452621	3.756305	3.556657
alpha_0.07	10000	0.878788	0.754480	6.080283	5.978949
alpha_0.1	10000	0.878788	0.781804	6.294769	6.200965
alpha_0.7	10000	0.878788	0.804247	6.472737	6.385026

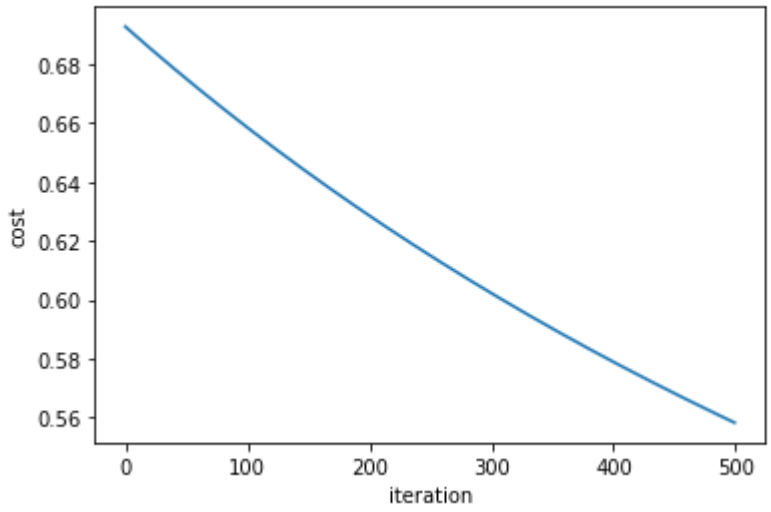
2.1 - My Self Developed best model without biased term

In [16]:
```
###############training and testing using self-developed model biased term (bes
t model)#########

thetab = [0,0,0] #initial model parameters
alphab = 0.007  # learning rates
max_iteration = 500 # maximal iterations

xValuesb = np.ones((len(Y_train) , 3)) #create array(60,3) of 1
xValuesb[:, 1:3] = X_train[:, 0:2] # split training and testing data set
yValuesb = Y_train

m = len(Y_train) # number of samples
total_c = []
for x in range(max_iteration):
    # call the functions for gradient descent method
    new_theta = Gradient_Descent(xValuesb ,yValuesb,thetab,m,alphab)
    thetab = new_theta
    cost = Cost_Function(xValuesb,yValuesb,thetab,m)
    total_c.append(cost)
    if x % 200 == 0:
        # calculate the cost function with the present theta
        print('theta ', thetab)
        print('cost is ', cost)
reso = [thetab]
print('theta of final model:',reso)
print('cost:', cost)
import matplotlib.pyplot as plt
```

```
theta  [0.0004701492537313433, 0.0012316186794675264, 0.0009128755339505191]
cost is  0.6927799856769551
theta  [0.07823476128470279, 0.23262427788394754, 0.1746606609056328]
cost is  0.6285517031961659
theta  [0.13084505877234584, 0.4372129540578281, 0.332355619310598]
cost is  0.5788554335203299
theta of final model: [[0.15028503516452282, 0.5298583938680446, 0.4051706287
839387]]
cost: 0.5582733025767725
```

In [17]:
```
#visualize the convergence curve
plt.plot(range(0,len(total_c)),total_c);
plt.xlabel('iteration')
plt.ylabel('cost')
plt.title('alpha = {}  theta = {}'.format(alpha, thetab))
plt.show()
```

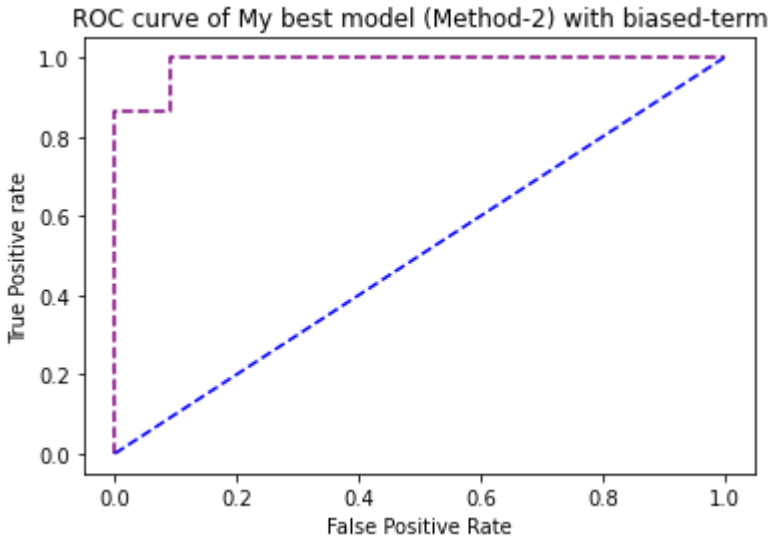
```
alpha = 0.1  theta = [0.15028503516452282, 0.5298583938680446, 0.4051706287839387]
```



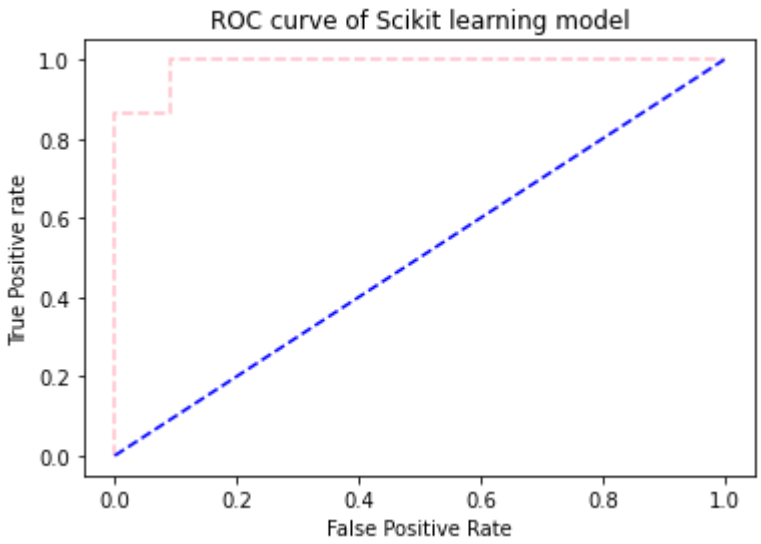
In [18]:
```
# ROC, AUC
from sklearn.metrics import roc_auc_score
from sklearn.metrics import auc
from sklearn.metrics import roc_curve
pred1 = []
pred1 = []
Ytest1 = []
thetaob = thetab
print(thetaob)
length = len(X_test)
scoreb = 0

# My best model
testXValues1 = np.ones((len(X_test), 3))
testXValues1[:, 1:3] = X_test[:, 0:2]
for i in range(length):
        predictionb = round(Prediction(testXValues1[i],thetaob))
        answerb = Y_test[i]
        if predictionb == answerb:
                scoreb += 1

my_scoreob = float(scoreb) / float(length)

for i in range(length):
    prop1 = Prediction(testXValues1[i],thetaob)
    pred1.append(prop1)
pred_prob2 = np.array(pred1)
fpr2, tpr2, thresh2 = roc_curve(Y_test, pred_prob2, pos_label=1)
print('Score of my best model with biased term : ', my_scoreob)
print('AUC score', roc_auc_score(Y_test, pred_prob2))
```

```
[0.15028503516452282, 0.5298583938680446, 0.4051706287839387]
Score of my best model with biased term :  0.9696969696969697
AUC score 0.9876033057851239
```

In [19]:
```
# plot roc curves
#plt.plot(fpr4, tpr4, linestyle='--',color='orange', label='Using Scikit-Learn
ing')
plt.plot(fpr2, tpr2, linestyle='--',color='purple', label='My own model')
plt.plot(p_fpr, p_tpr, linestyle='--', color='blue')
# title
plt.title('ROC curve of My best model (Method-2) with biased-term')
# x label
plt.xlabel('False Positive Rate')
# y label
plt.ylabel('True Positive rate')

#plt.legend(loc='best')
#plt.savefig('ROC',dpi=300)
plt.show()
```



In [20]:
```
# Scikit learning

pred_prob1 = clf.predict_proba(X_test)
# roc curve for models
fpr1, tpr1, thresh1 = roc_curve(Y_test, pred_prob1[:,1], pos_label=1)

#plot roc curves
plt.plot(fpr1, tpr1, linestyle='--',color='pink', label='Using Scikit-Learnin
g')
#plt.plot(fpr2, tpr2, linestyle='--',color='green', label='My own model')
plt.plot(p_fpr, p_tpr, linestyle='--', color='blue')
# title
plt.title('ROC curve of Scikit learning model')
# x label
plt.xlabel('False Positive Rate')
# y label
plt.ylabel('True Positive rate')

#plt.legend(loc='best')
#plt.savefig('ROC',dpi=300)
plt.show()
```



In [21]:
```
Y_test.mean()
```

Out[21]: 0.6666666666666666

In [22]:
```
Y_train.mean()
```

Out[22]: 0.5671641791044776