

LAB 7 : Regression Part 2

In this Lab we will look into the shortcomings of Linear Regression and see how those problems can be solved using Logistic Regression. We will also explore Polynomial Regression

1. Polynomial Regression
2. Linear Regression on a specific pattern of data to observe shortcomings
3. Logistic Regression to solve those problems

```
In [ ]: import numpy as np
import matplotlib.pyplot as plt
```

Polynomial Regression

1. Generate data using relation $y = 0.25x^3 + 1.25x^2 - 3x - 3$
2. Corrupt y by adding random noise (uniformly sampled)
3. Fit the generated curve using different polynomial order. (Using matrix inversion and gradient descent)

```
In [ ]: ## Use the Regression class defined in the previous Lab
class regression:
    # Constructor
    def __init__(self, name='reg'):
        self.name = name # Create an instance variable

    def grad_update(self,w_old,lr,y,x):
        w = w_old + (2*lr/x.shape[1]) * (x @ (y - (x.T @ w_old)))
        return w

    def error(self,w,y,x):
        return np.mean(np.power((y - x.T @ w), 2))

    def mat_inv(self,y,x_aug):
        return np.linalg.pinv((x_aug @ x_aug.T)) @ x_aug @ y # w_opt, basically

    # By Gradient descent

    def Regression_grad_des(self, x, y, lr, w_choose):
        err_arr = np.array([])
        if w_choose == 0:
            w_init = np.random.uniform(-1, 1, (x.shape[0],1))
        else:
            # w_init = np.random.uniform(-2, 2, (x.shape[0],1))
            w_init = np.array([[0], [-3], [1], [0], [0]])
            # for degree 4, some local minima may exist for cost function, so we place initial point in
            # middle
        w_prev = w_init
        w_curr = w_init
        temp = 0
        for i in range(5000):

            w_curr = self.grad_update(w_curr, lr, y, x)
            err = self.error(w_curr, y, x)
            err_prev = self.error(w_prev, y, x)
            # err_arr.concatenate(err_arr, err)
            dev = np.abs(err - err_prev)
            w_prev = w_curr
            temp = err
```

```

# print(err)
if dev<=0.000001:
    break

w_pred = w_curr
# err_arr = np.concatenate(err_arr)
# print(err_arr)
# err = err_arr

err = temp
return w_pred, err

```

```

In [ ]: ## Data generation

x=np.linspace(-6, 6, 100)
x=x[:,np.newaxis,:]

w = np.array([[[-3], [-3], [1.25], [0.25]]]) ## Define Weights as per the given equation

## Function to transform the data into polynomial
def data_transform(X,degree):
    ## Write your code here
    X_new = []

    for i in range(degree+1):
        X_new.append(np.power(X, i)) # append X^i to list
        # print(X_new)
        # print(np.power(X,i))
    X_new = np.concatenate(X_new) # concat list of arrays
    return X_new

X = data_transform(x,3)
# print(X)
y = X.T @ w

y = y+5*np.random.uniform(0,1,y.shape)

# plt.plot(x.T,y, '.')
reg=regression()

# By computation

# Code for degree 0 polynomial fitting

degree = 0
X_0 = data_transform(x,degree)
w_mat=reg.mat_inv(y,X_0)
y_pred=X_0.T @ w_mat
plt.figure()
plt.plot(x.T,y, '.')
plt.plot(x.T,y_pred)
plt.title('0-Degree Polynomial')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()

# Write the code for degree 1 polynomial fitting

degree = 1
X_1 = data_transform(x,degree)
w_mat=reg.mat_inv(y,X_1)
y_pred=X_1.T @ w_mat
plt.figure()

```

```

plt.plot(x.T,y, '.')
plt.plot(x.T,y_pred)
plt.title('1-Degree Polynomial')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()

# Write the code for degree 2 polynomial fitting

degree = 2
X_2 = data_transform(x,degree)
w_mat=reg.mat_inv(y,X_2)
y_pred=X_2.T @ w_mat
plt.figure()
plt.plot(x.T,y, '.')
plt.plot(x.T,y_pred)
plt.title('2-Degree Polynomial')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()

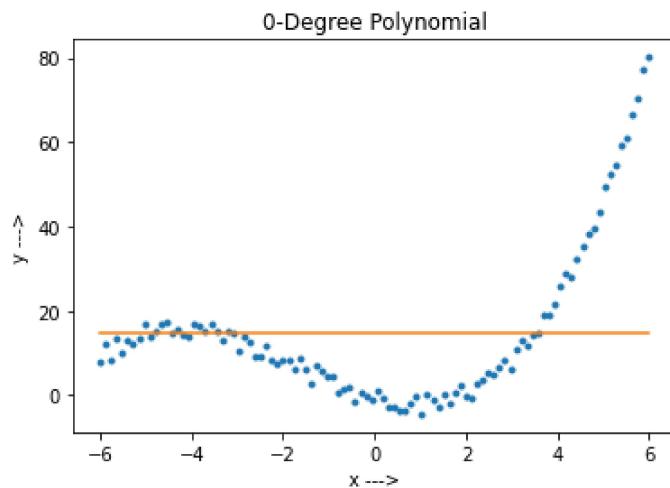
# Write the code for degree 3 polynomial fitting

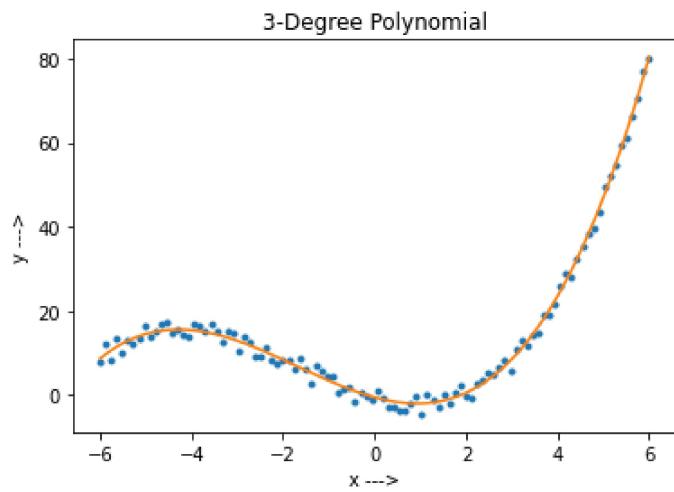
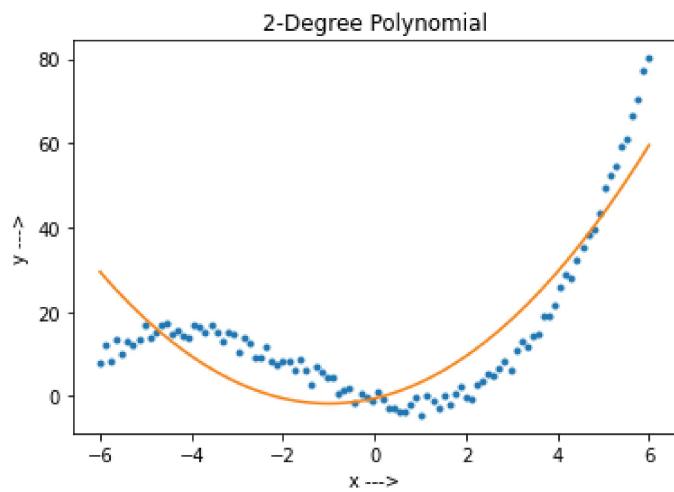
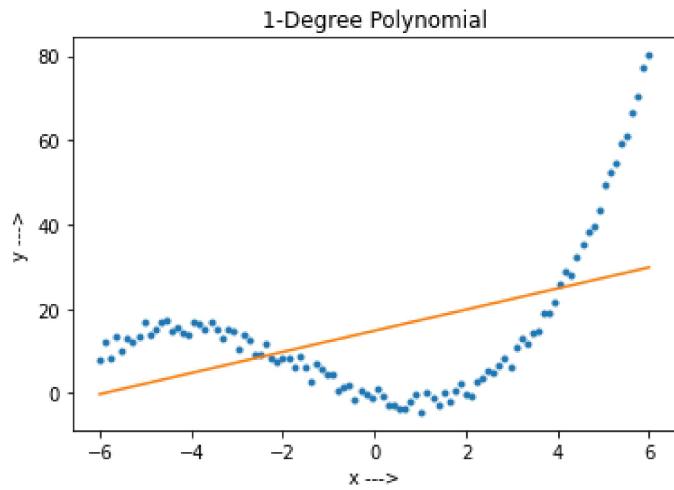
degree = 3
X_3 = data_transform(x,degree)
w_mat=reg.mat_inv(y,X_3)
y_pred=X_3.T @ w_mat
plt.figure()
plt.plot(x.T,y, '.')
plt.plot(x.T,y_pred)
plt.title('3-Degree Polynomial')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()

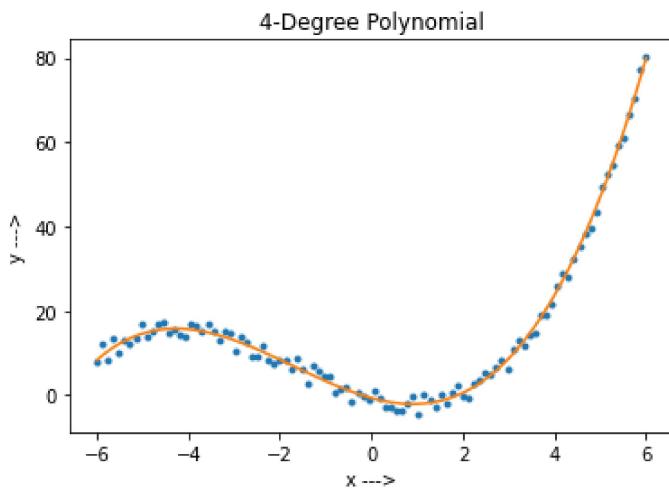
# Write the code for degree 4 polynomial fitting

degree = 4
X_4 = data_transform(x,degree)
w_mat=reg.mat_inv(y,X_4)
y_pred=X_4.T @ w_mat
plt.figure()
plt.plot(x.T,y, '.')
plt.plot(x.T,y_pred)
plt.title('4-Degree Polynomial')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()

```







```
In [ ]: # By Gradient Descent

## Write your code here

reg=regression()

# Code for degree 0 polynomial fitting

degree = 0
lr = 1
X_0 = data_transform(x,degree)
w_mat, _ = reg.Regression_grad_des(X_0, y, lr, 0)
# print(w_mat)
# print(X_0)
y_pred=X_0.T @ w_mat
plt.figure()
plt.plot(x.T,y,'.')
plt.plot(x.T,y_pred)
plt.title('0-Degree Polynomial')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()

# Write the code for degree 1 polynomial fitting

degree = 1
lr = 0.05
X_1 = data_transform(x,degree)
w_mat, _ = reg.Regression_grad_des(X_1, y, lr, 0)
# print(w_mat)
# print(X_1)
y_pred=X_1.T @ w_mat
plt.figure()
plt.plot(x.T,y,'.')
plt.plot(x.T,y_pred)
plt.title('1-Degree Polynomial')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()

# Write the code for degree 2 polynomial fitting

degree = 2
lr = 0.001
X_2 = data_transform(x,degree)
w_mat, _ = reg.Regression_grad_des(X_2, y, lr, 0)
```

```

# print(w_mat)
# print(X_2)
y_pred=X_2.T @ w_mat
plt.figure()
plt.plot(x.T,y,'.')
plt.plot(x.T,y_pred)
plt.title('2-Degree Polynomial')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()

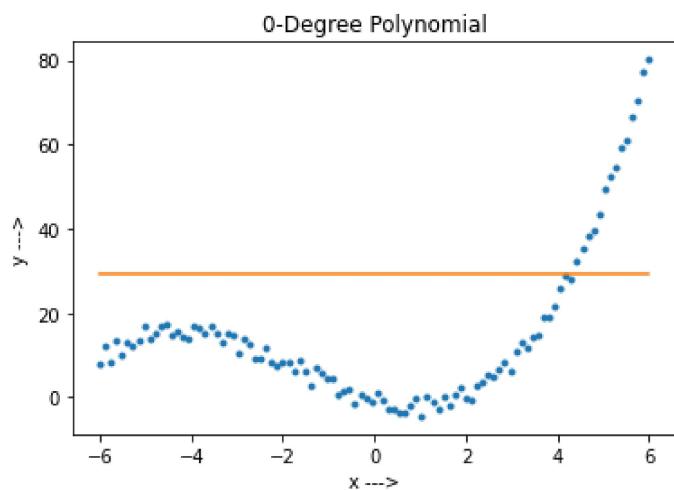
# Write the code for degree 3 polynomial fitting

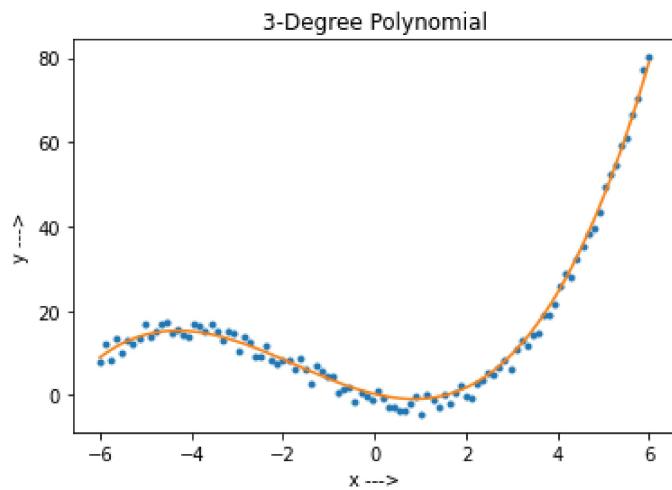
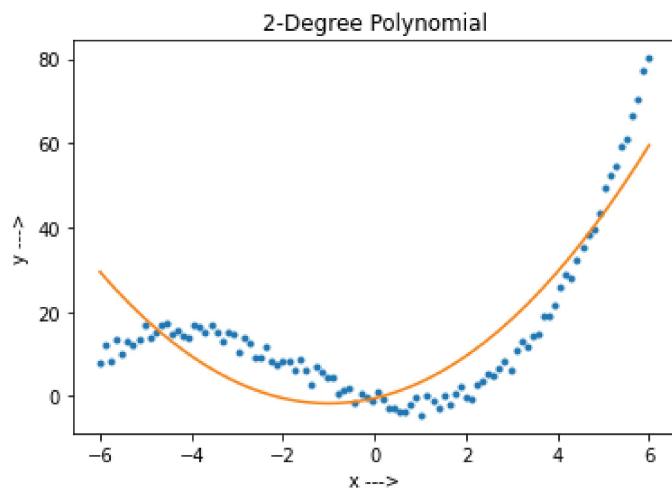
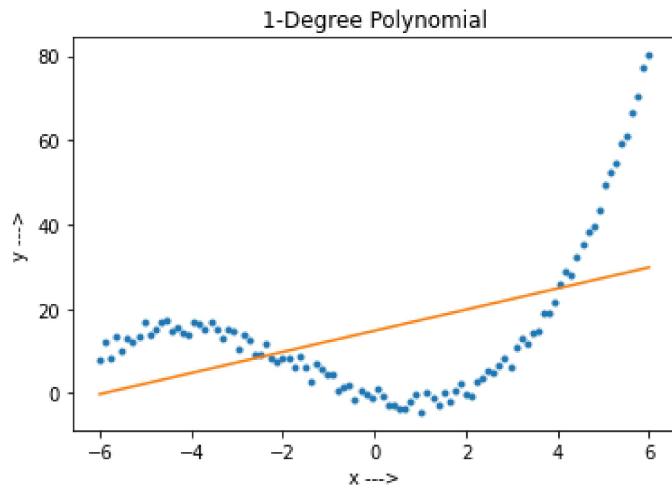
degree = 3
lr = 0.0001
X_3 = data_transform(x,degree)
w_mat, _ = reg.Regression_grad_des(X_3, y, lr, 0)
# print(w_mat)
# print(X_3)
y_pred=X_3.T @ w_mat
plt.figure()
plt.plot(x.T,y,'.')
plt.plot(x.T,y_pred)
plt.title('3-Degree Polynomial')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()

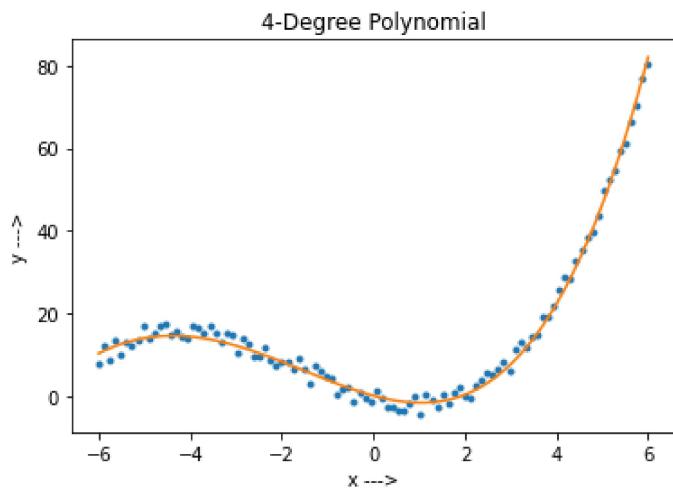
# Write the code for degree 4 polynomial fitting

degree = 4
lr = 0.00000075
X_4 = data_transform(x,degree)
w_mat, err = reg.Regression_grad_des(X_4, y, lr, 1)
# print(w_mat)
# print(X_4)
y_pred=X_4.T @ w_mat
plt.figure()
plt.plot(x.T,y,'.')
plt.plot(x.T,y_pred)
plt.title('4-Degree Polynomial')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()

```







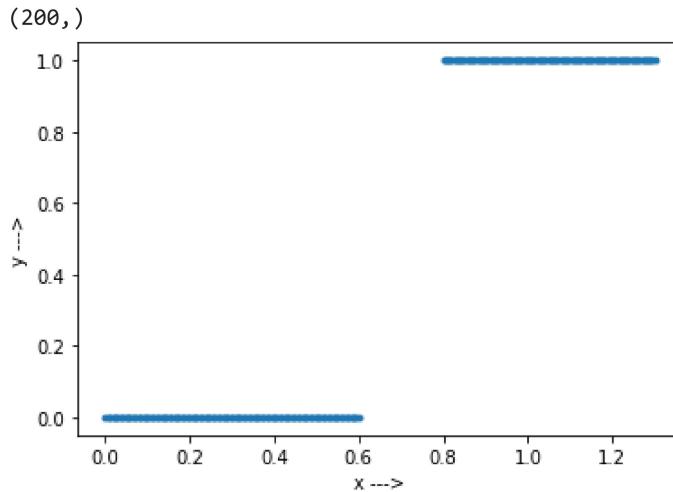
Linear Regression (Prelude to Drawbacks)

Generate the data as shown in the figure below

```
In [ ]: ## Write your code here
x_low = np.linspace(0, 0.6, 100)
y_low = np.zeros(x_low.shape)
x_high = np.linspace(0.8, 1.3, 100)
y_high = np.ones(x_high.shape)

x = np.concatenate((x_low, x_high))
y = np.concatenate((y_low, y_high))

plt.figure()
print(x.shape)
plt.plot(x, y, '.')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()
```



Use the Regression class defined in the previous lab to fit the curve

```
In [ ]: ## Write your Code here
class linearRegression:
    # Contructor
    def __init__(self, name='linreg'):
        self.name = name # Create an instance variable
```

```

def grad_update(self,w_old,lr,y,x):
    w = w_old + (2*lr/x.shape[1]) * (x @ (y - (x.T @ w_old)))
    return w

def error(self,w,y,x):
    return np.mean(np.power((y - x.T @ w), 2))

def mat_inv(self,y,x_aug):
    return np.linalg.pinv((x_aug @ x_aug.T)) @ x_aug @ y      # w_opt, basically

# By Gradient descent

def Regression_grad_des(self, x, y, lr):
    err_arr = []
    w_init = np.random.uniform(-1, 1, (x.shape[0],1))
    w_prev = w_init
    w_curr = w_init
    for i in range(5000):

        w_curr = self.grad_update(w_curr, lr, y, x)
        err = self.error(w_curr, y, x)
        err_prev = self.error(w_prev, y, x)
        # print("err = ", err)
        # print("err_arr = ", err_arr)
        err_arr.append(err)
        dev = np.abs(err - err_prev)
        w_prev = w_curr
        # print(err)
        if dev<=0.000001:
            break

    w_pred = w_curr
    # err_arr = np.concatenate(err_arr)
    # print(err_arr)
    err = err_arr
    return w_pred, err

```

Augment the Data and generate optimal weights

```

In [ ]: ## Write your Code here
x_new = x[:, np.newaxis].T                      # FVs are vertical
print(x_new.shape)
x_ones = np.ones((1, x_new.shape[1]))
x_aug = np.concatenate((x_ones, x_new))
print(x_aug.shape)
y_new = y[:, np.newaxis]

linreg = linearRegression()
w = linreg.mat_inv(y_new, x_aug)
print("Optimal Weights using Matrix inversion,\n w = \n", w)

linreg = linearRegression()
lr = 0.01
w, err_list = linreg.Regression_grad_des(x_aug, y_new, lr)
print("Optimal Weights using Gradient Descent,\n w = \n", w)

```

```
(1, 200)
(2, 200)
Optimal Weights using Matrix inversion,
w =
[[-0.25988351]
 [ 1.12575335]]
Optimal Weights using Gradient Descent,
w =
[[-0.23254963]
 [ 1.08971934]]
```

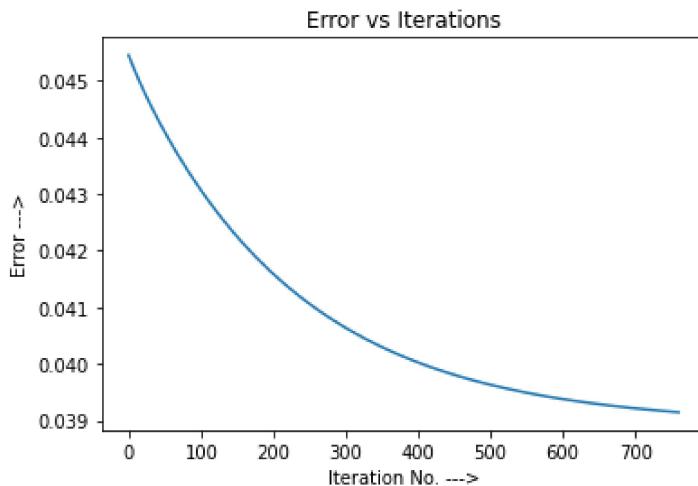
Using the optimal weights, fit the curve

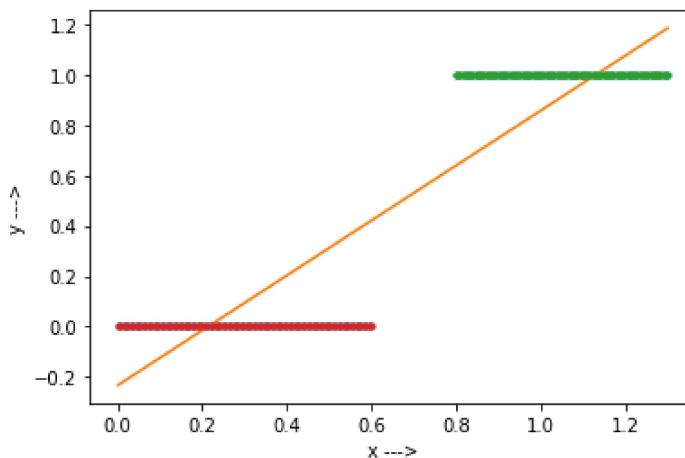
```
In [ ]: ## Write your Code here
plt.figure()
plt.title('Error vs Iterations')
plt.xlabel('Iteration No. --->')
plt.ylabel('Error --->')
plt.plot(err_list)
plt.show()

y_out = x_aug.T @ w
# plt.figure()
# plt.plot(x.T, y, '.')
# plt.plot(x.T, y_out)
# plt.xlabel('x --->')
# plt.ylabel('y --->')
# plt.show()

class_0 = []
class_1 = []
for i in range(len(x.T)):
    if y_out[i]>=0.5:
        class_1.append(x.T[i])
    else:
        class_0.append(x.T[i])

plt.figure()
plt.plot(x.T, y, '.')
plt.plot(x.T, y_out)
plt.plot(class_1, np.ones(len(class_1)), '.')
plt.plot(class_0, np.zeros(len(class_0)), '.')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()
```





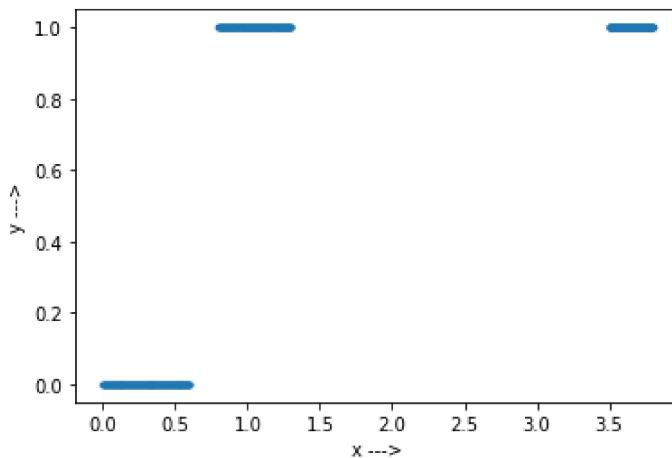
Drawback of Linear regression based Classificaton

Generate the Data as shown in the figure and follow the same steps as above to fit a curve using regression class

```
In [ ]: ## Write your code here
x1 = np.linspace(0,0.6,100)
y1 = np.zeros(x1.shape)
x2 = np.linspace(0.8,1.3,100)
y2 = np.ones(x2.shape)
x3 = np.linspace(3.5,3.8,100)
y3 = np.ones(x3.shape)

x = np.concatenate((x1, x2, x3))
y = np.concatenate((y1, y2, y3))

plt.figure()
plt.plot(x.T, y, '.')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()
```



```
In [ ]: ## Write your code here
x_new = x[:, np.newaxis].T # FVs are vertical
print(x_new.shape)
x_ones = np.ones((1, x_new.shape[1]))
x_aug = np.concatenate((x_ones, x_new))
print(x_aug.shape)
y_new = y[:, np.newaxis]
```

```

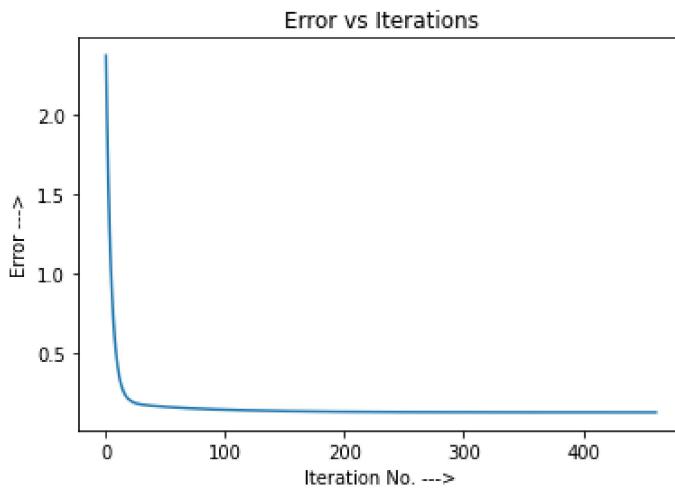
linreg = linearRegression()
w = linreg.mat_inv(y_new, x_aug)
print("Optimal Weights using Matrix inversion,\n w = \n", w)

linreg = linearRegression()
lr = 0.01
w, err_list = linreg.Regession_grad_des(x_aug, y_new, lr)
print("Optimal Weights using Gradient Descent,\n w = \n", w)

plt.figure()
plt.title('Error vs Iterations')
plt.xlabel('Iteration No. --->')
plt.ylabel('Error --->')
plt.plot(err_list)
plt.show()

(1, 300)
(2, 300)
Optimal Weights using Matrix inversion,
w =
[[0.3017071]
 [0.21897574]]
Optimal Weights using Gradient Descent,
w =
[[0.31397636]
 [0.21440968]]

```



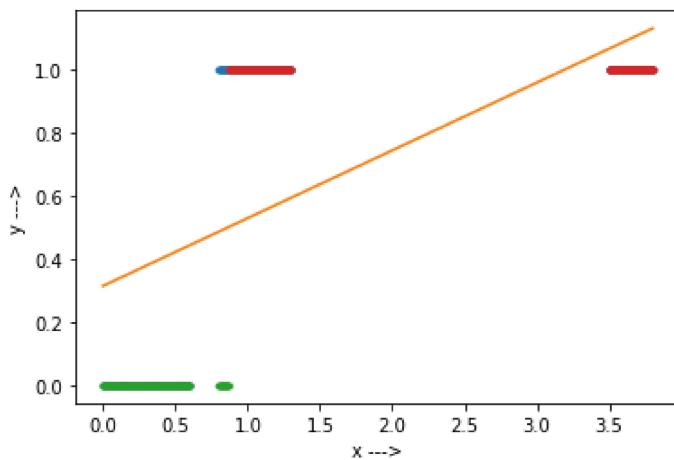
```

In [ ]: y_out = x_aug.T @ w

class_0 = []
class_1 = []
for i in range(len(x.T)):
    if y_out[i]>=0.5:
        class_1.append(x.T[i])
    else:
        class_0.append(x.T[i])

plt.figure()
plt.plot(x.T, y, '.')
plt.plot(x.T, y_out)
plt.plot(class_0, np.zeros(len(class_0)), '.')
plt.plot(class_1, np.ones(len(class_1)), '.')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()

```



Logistic regression

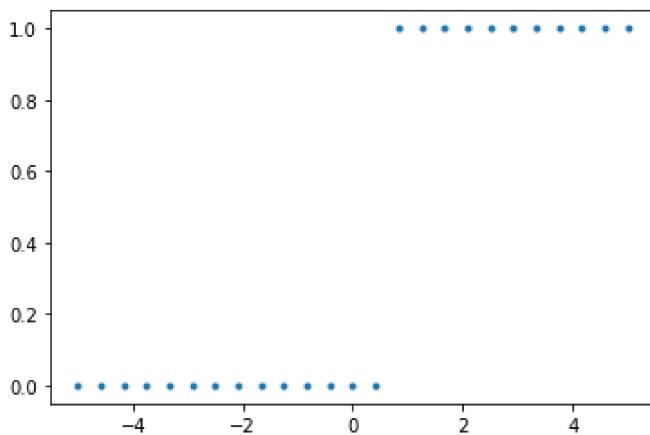
Error Surface (Comparison between Logistic Loss and Mean Squared Error)

```
In [ ]: import numpy as np
import matplotlib.pyplot as plt

x=np.linspace(-5,5,25)
y=np.zeros(x.shape)
y[np.where(x>0.7314)]=1

plt.plot(x,y, '.')
```

Out[]: [<matplotlib.lines.Line2D at 0x236b89d1190>]



1. $\text{MSE} = \frac{1}{2N} \sum_{i=1}^N (y_i^p - y_i)^2$, where $y^p = \frac{1}{1+e^{-w^T x}}$
2. $\text{Logistic loss} = -\frac{1}{N} \sum_{i=1}^N y_i \log(y_i^p) + (1 - y_i) \log(1 - y_i^p)$

```
In [ ]: # search space (only w1 is searched, where as w0 is fixed)
w1_in=10/(x[1]-x[0])
w0=-w1_in*0.7314
w1=np.linspace(-w1_in,4*w1_in,100)

cost_fn_mse=[]
cost_fn_logis=[]
for i in range(w1.shape[0]):
```

```
# Compute Mean square error and Logistic Loss using cost function
# Write your code here
z = w0 + w1[i]*x
yp = 1/(1 + np.exp(-z))

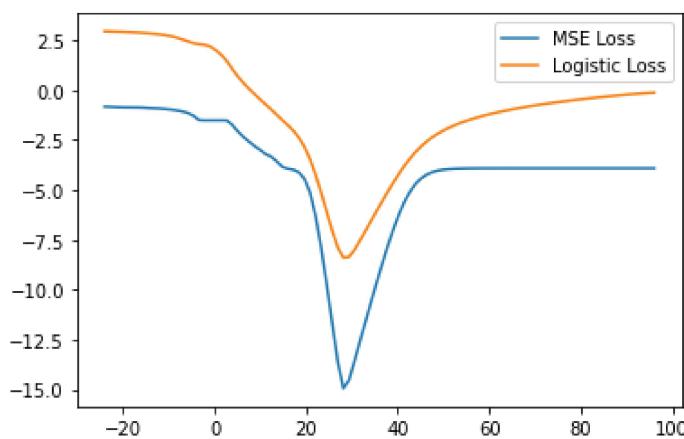
cost_mse = np.sum((yp - y)**2)/(2*x.shape[0])
cost_fn_mse.append(cost_mse)

dc = 10**(-10)
cost_logis = -np.sum(y*np.log(yp+dc) + (1-y)*np.log(1-yp+dc))/(x.shape[0])
cost_fn_logis.append(cost_logis)
```

In []: # Plotting of error surface

```
plt.figure()
plt.plot(w1,np.log(cost_fn_mse),label='MSE Loss')
plt.plot(w1,np.log(cost_fn_logis),label = 'Logistic Loss')
plt.legend()
```

Out[]: <matplotlib.legend.Legend at 0x236b8c1bac0>



Solving the Outlier Issue

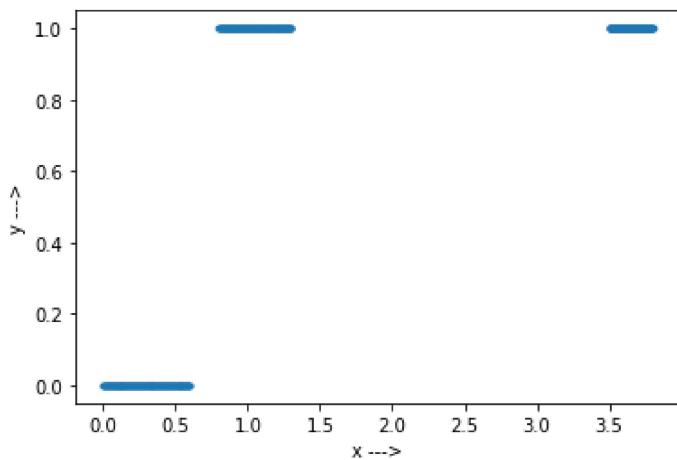
Generate the Data as shown in the figure

In []: ## Write your Code here

```
x1 = np.linspace(0,0.6,100)
y1 = np.zeros(x1.shape)
x2 = np.linspace(0.8,1.3,100)
y2 = np.ones(x2.shape)
x3 = np.linspace(3.5,3.8,100)
y3 = np.ones(x3.shape)

x = np.concatenate((x1, x2, x3))
y = np.concatenate((y1, y2, y3))

plt.figure()
plt.plot(x.T, y,'.')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()
```



Define a Logistic Regression class

Recall:

1. $\text{MSE} = \frac{1}{2N} \sum_{i=1}^N (y_i^p - y_i)^2$, where $y^p = \frac{1}{1+e^{-w^T x}}$
2. Logistic loss = $-\frac{1}{N} \sum_{i=1}^N (y_i \log(y_i^p) + (1-y_i) \log(1-y_i^p))$

```
In [ ]: class logis_regression:
    # Constructor
    def __init__(self, name='reg'):
        self.name = name # Create an instance variable

    def logis(self,x,w_old):
        # write code here
        op = 1/(1 + np.exp(-(x.T @ w_old)))
        return op

    def grad_update(self,w_old,lr,y,x):
        # write code here
        w = w_old + (lr/x.shape[1])*(x @ (y - (self.logis(x, w_old))))
        return w

    def error(self,w,y,x):
        g = self.logis(x, w)
        return -np.mean(y*np.log(g + 10**(-10)) + (1-y)*np.log(1-g + 10**(-10)))

    def Regression_grad_des(self,x,y,lr):
        err_arr = []
        w_init = np.random.uniform(-1, 1, (x.shape[0],1))
        w_prev = w_init
        w_curr = w_init
        for i in range(1000):
            w_curr = self.grad_update(w_curr, lr, y, x)
            # print(w_curr)
            err = self.error(w_curr, y, x)
            err_prev = self.error(w_prev, y, x)
            # print("err = ", err)
            # print("err_arr = ", err_arr)
            err_arr.append(err)
            dev=np.abs(err - err_prev)
            w_prev = w_curr
            if dev<=10**(-20):
                break
        w_pred = w_curr
        err = err_arr
        # err.pop(0)
        return w_pred,err
```

Augment the data and fit the curve by obtaining optimal weights (Using Gradient Descent)

```
In [ ]: ## Write your code here

x_new = x[:, np.newaxis].T # FVs are vertical
# print(x_new.shape)
x_ones = np.ones((1, x_new.shape[1]))
x_aug = np.concatenate((x_ones, x_new))
# print(x_aug.shape)
y_new = y[:, np.newaxis]

reg = logis_regression()
lr = 0.1
w, err_list = reg.Regession_grad_des(x_aug, y_new, lr)
print("Optimal Weights using Gradient Descent,\n w = \n", w)
```

Optimal Weights using Gradient Descent,

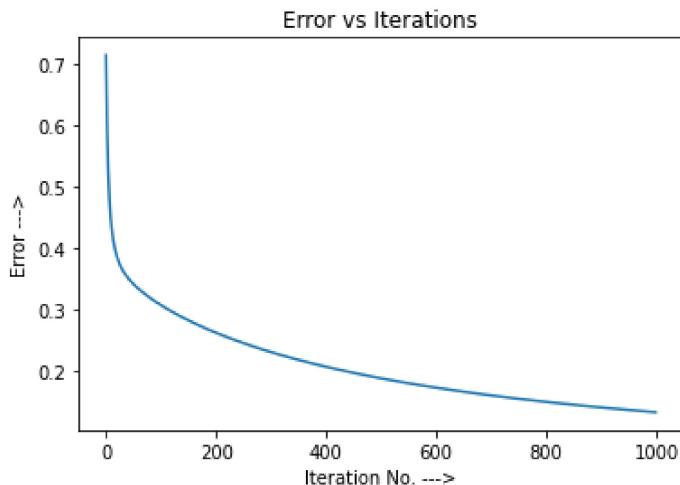
```
w =
[-3.00182249]
[ 4.66398208]
```

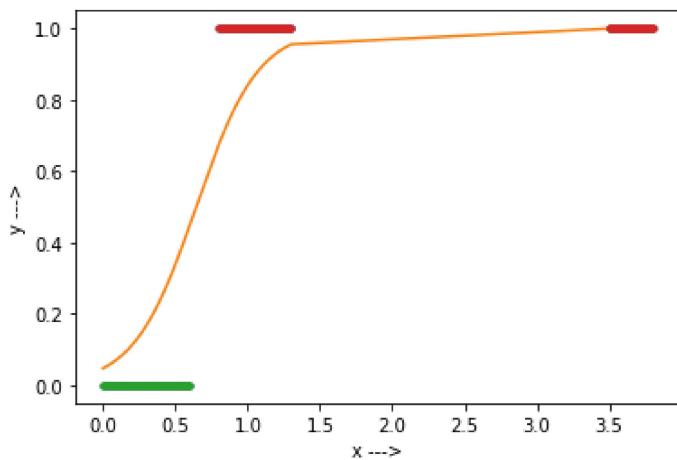
```
In [ ]: plt.figure()
plt.title('Error vs Iterations')
plt.xlabel('Iteration No. --->')
plt.ylabel('Error --->')
plt.plot(err_list)
plt.show()

y_out = 1/(1 + np.exp(-(x_aug.T @ w)))

class_0 = []
class_1 = []
for i in range(len(x.T)):
    if y_out[i]>=0.5:
        class_1.append(x.T[i])
    else:
        class_0.append(x.T[i])

plt.figure()
plt.plot(x.T, y, '.')
plt.plot(x.T, y_out)
plt.plot(class_0, np.zeros(len(class_0)), '.')
plt.plot(class_1, np.ones(len(class_1)), '.')
plt.xlabel('x --->')
plt.ylabel('y --->')
plt.show()
```

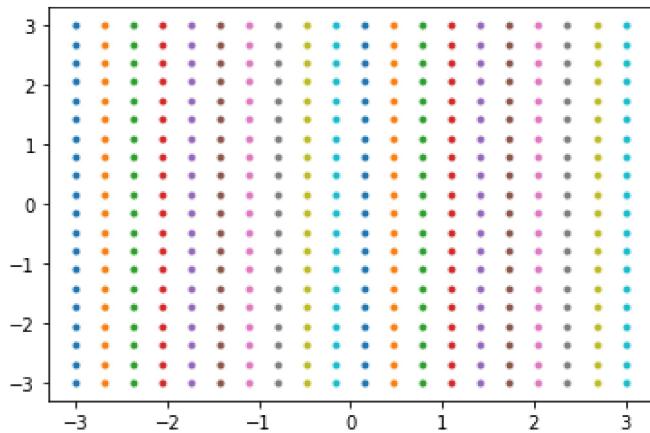




Classification of circularly separated data using logistic regression

```
In [ ]: x1=np.linspace(-3,3,20)
x2=np.linspace(-3,3,20)

x11,x22=np.meshgrid(x1,x2)
plt.plot(x11,x22,'.')
plt.show()
```



Using the above data generate circular data

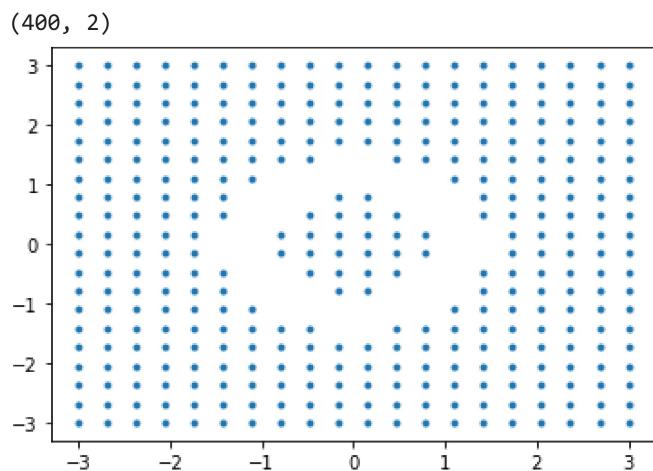
```
In [ ]: # Write code here
x1 = x11.flatten()
x1 = x1[:, np.newaxis]
x2 = x22.flatten()          # 2d -> 1d
x2 = x2[:, np.newaxis]
x = np.concatenate((x1, x2), axis=1) # create all ordered pairs
print(x.shape)

in_pt_ind = np.where((x[:,0]**2 + x[:,1]**2) <= 0.8)
out_pt_ind = np.where((x[:,0]**2 + x[:,1]**2) >= 2.2)
# print(in_pt_ind[0])
x_in = x[in_pt_ind[0], :]
x_out = x[out_pt_ind[0], :]

x = np.concatenate((x_in, x_out)) # our dataset

plt.figure()
```

```
plt.plot(x[:,0], x[:,1], '.')
plt.show()
```

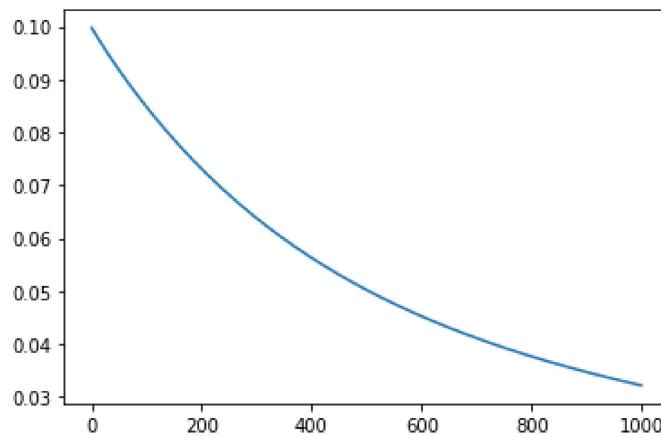


As in case of circularly separated data, the boundary is nonlinear, so squared feature is taken.

```
In [ ]: # perform Logistic regression
y_in = np.zeros((x_in.shape[0]))
y_out = np.ones((x_out.shape[0]))
y = np.concatenate((y_in, y_out))
y_new = y[:, np.newaxis]

x_sq = (x.T)**2
x_ones = np.ones((1, x.shape[0]))
x_aug = np.concatenate((x_ones, x_sq), axis=0)

reg = logis_regression()
lr = 0.1
w_pred, err = reg.Regession_grad_des(x_aug, y_new, lr)
plt.figure()
plt.plot(err)
plt.show()
```



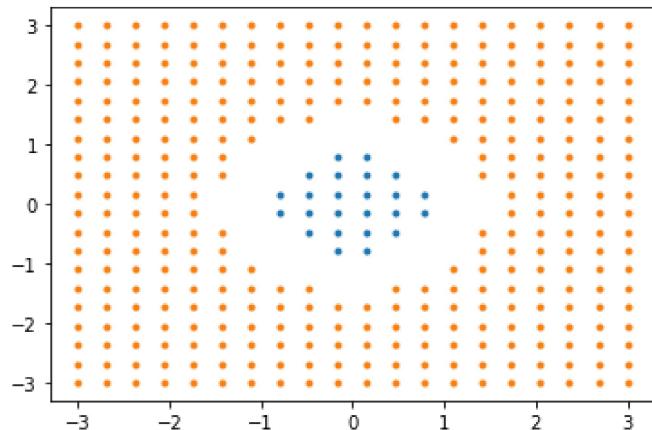
Plot classification using 0.5 as threshold

```
In [ ]: #write code here
y_pred = reg.logis(x_aug,w_pred)

in_pred, _ = np.where(y_pred < 0.5)
out_pred, _ = np.where(y_pred >= 0.5)

x_in_pred = x[in_pred,:]
x_out_pred = x[out_pred,:]
```

```
plt.figure()
plt.plot(x_in_pred[:,0], x_in_pred[:,1], '.')
plt.plot(x_out_pred[:,0], x_out_pred[:,1], '.')
plt.show()
```



Multiclass logistic regression

1. Generate 1D data with 3 classes

One vs rest classification

1. Let's take a polynomial of order 2 (by seeing the data distribution)

```
In [ ]: ## Write your code here

import numpy as np
import matplotlib.pyplot as plt

x1=np.linspace(0,0.6,100)
x2=np.linspace(1.1,2.7,100)
x3=np.linspace(3.5,3.8,100)

x=np.concatenate((x1,x2,x3))
print(x.shape)

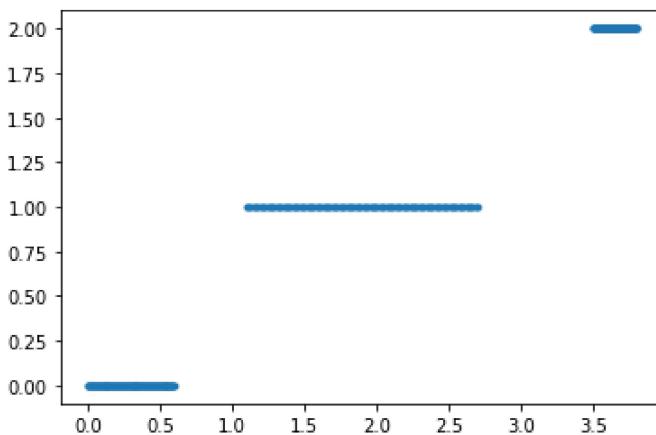
y1=np.zeros(x1.shape)
y2=np.ones(x2.shape)
y3=np.tile([2],x3.shape)

y=np.concatenate((y1,y2,y3))

plt.figure()
plt.plot(x,y, '.')
```

(300,)

Out[]: [`<matplotlib.lines.Line2D at 0x236b8fd3730>`]



```
In [ ]: # def data_transform(X,degree):
#   X_new=[]
#   for i in range(degree +1):
#     # write code here to generate a polynomial

def data_transform(X,degree):
    X_new=[]
    for i in range(degree +1):
        X_new.append(X**i)
    X_new = np.concatenate(X_new)
    return X_new

x_aug=data_transform(x[np.newaxis,:,:],2)
# x_aug
```

```
In [ ]: # plot for classification
def plot_op(x,y_pred):

    ind0,_=np.where(y_pred<0.5)
    ind1,_=np.where(y_pred>=0.5)
    x0=x[ind0,:]
    x1=x[ind1,:]
    plt.plot(x0,np.zeros((x0).shape), 'o',color='y')
    plt.plot(x1,np.ones((x1).shape), 'x',color='r')
```

```
In [ ]: def IsClassNum(num, y):
    yi = np.zeros(y.shape)
    for i in range(len(y)):
        if y[i] == num:
            yi[i] = 0
        else:
            yi[i] = 1
    return yi
```

Using the above function for plotting, plot the curve using different configurations

```
In [ ]: # take class 0 as '0' and other to '1'
## Write your code here
y0 = IsClassNum(0, y)
y0_new = y0[:,np.newaxis]

reg0 = logis_regression()
lr = 0.1

w_pred, err = reg.Regession_grad_des(x_aug, y0_new, lr)
print(w_pred)
```

```

plt.figure()
plt.plot(err)
plt.show()

y0_pred = reg.logis(x_aug, w_pred)

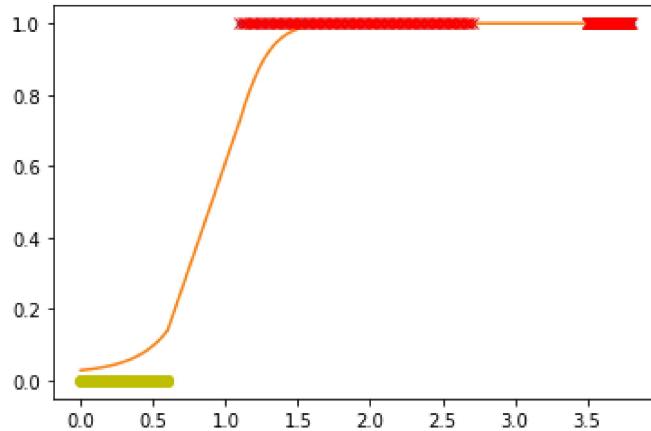
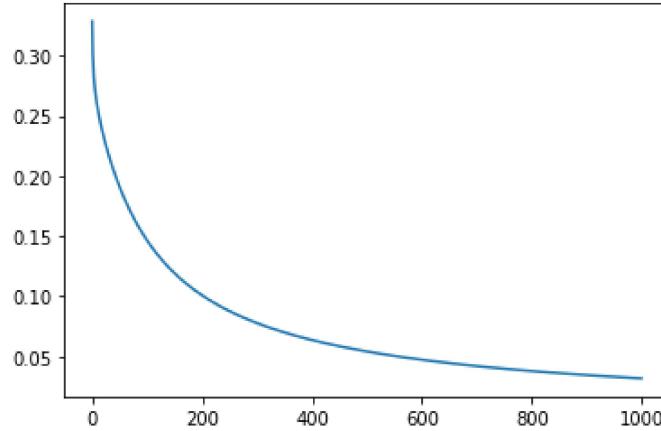
plt.figure()
plt.plot(x, y0_new, '.')
plt.plot(x, y0_pred[:,0])
plot_op(x[:,np.newaxis], y0_pred)
plt.show()

```

```

[[-3.52944986]
 [ 1.36215153]
 [ 2.49471983]]

```



```

In [ ]: # take class 1 as '0' and other to '1'
## Write your code here
y1 = IsClassNum(1, y)
y1_new = y1[:,np.newaxis]

reg1 = logis_regression()
lr = 0.1

w_pred, err = reg.Regession_grad_des(x_aug, y1_new, lr)
print(w_pred)

plt.figure()
plt.plot(err)
plt.show()

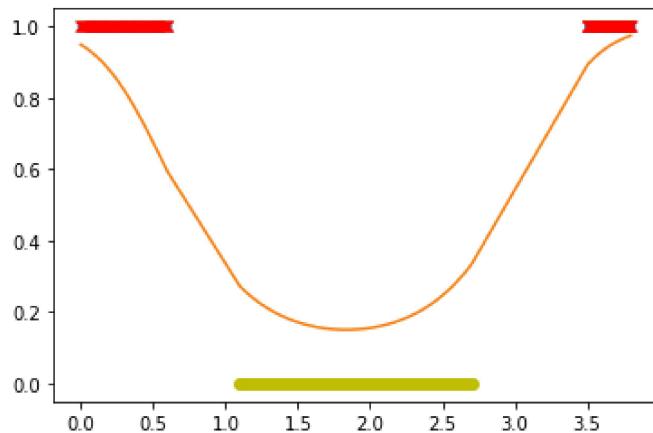
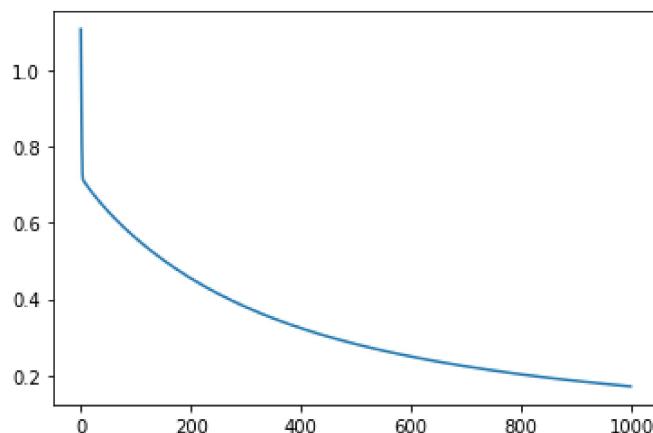
y1_pred = reg.logis(x_aug, w_pred)

plt.figure()
plt.plot(x, y1_new, '.')
plt.plot(x, y1_pred[:,0])

```

```
plot_op(x[:,np.newaxis], y1_pred)
plt.show()
```

```
[[ 2.92155722]
 [-5.0740148 ]
 [ 1.38334031]]
```



```
In [ ]: # Take class 2 as '0' and other to '1'
## Write your code here
y2 = IsClassNum(2, y)
y2_new = y2[:,np.newaxis]

reg2 = logis_regression()
lr = 0.1

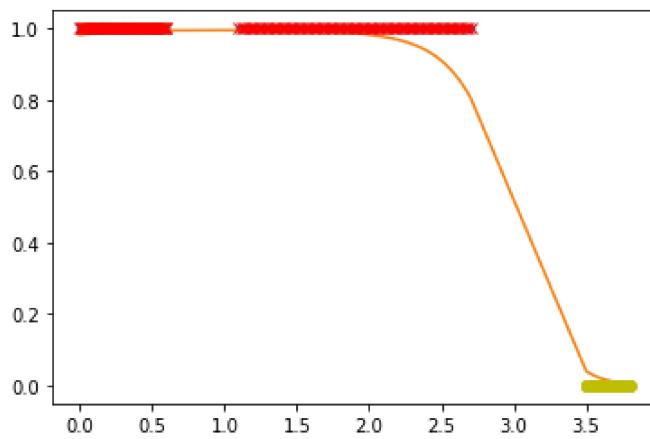
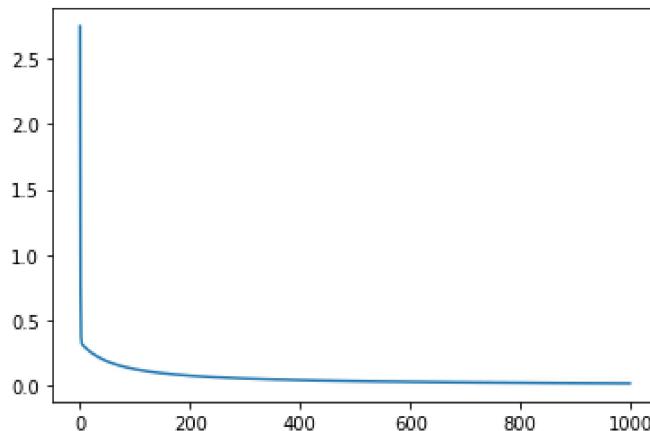
w_pred, err = reg.Regession_grad_des(x_aug, y2_new, lr)
print(w_pred)

plt.figure()
plt.plot(err)
plt.show()

y2_pred = reg.logis(x_aug, w_pred)

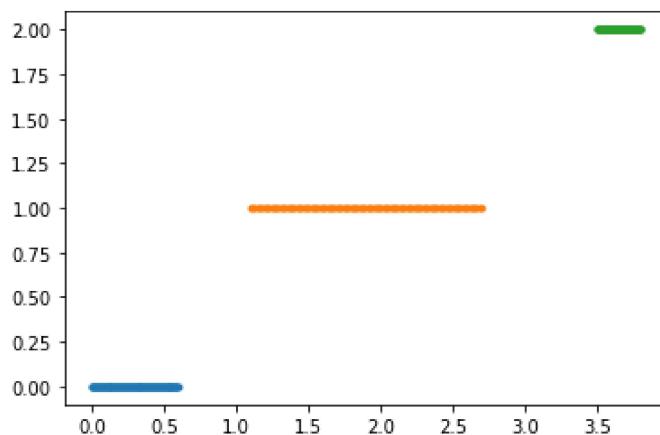
plt.figure()
plt.plot(x, y2_new, '.')
plt.plot(x, y2_pred[:,0])
plot_op(x[:,np.newaxis], y2_pred)
plt.show()
```

```
[[ 3.99266718]
 [ 2.75882408]
 [-1.37394493]]
```



```
In [ ]: # final classification
## Write your code here
index_pred0, _ = np.where(y0_pred<0.5)
x_0 = x[index_pred0]
index_pred1, _ = np.where(y1_pred<0.5)
x_1 = x[index_pred1]
index_pred2, _ = np.where(y2_pred<0.5)
x_2 = x[index_pred2]

plt.figure()
plt.plot(x_0, np.zeros(x_0.shape), '.')
plt.plot(x_1, np.ones(x_1.shape), '.')
plt.plot(x_2, np.tile([2], x_2.shape), '.')
plt.show()
```



```
In [ ]:
```