Class Ex.3 by Matan Porat and Rotem Tsalisher

Guidlines:

- All functions are implemented in the notebook
- Names of functions are determined by the question number
- All functions are called in the main function (last function in the notebook)

In [4]:
```
import numpy as np
import matplotlib.pyplot as plt
import math
```

In [5]:
```
def calcGaussian(x,mu,sigma,pi = 1):
    # Calculate the denominator of the Gaussian distribution
    denominator = np.sqrt(2 * np.pi * sigma**2)

    # Calculate the exponent term
    exponent = -0.5 * ((x - mu) / sigma) ** 2

    # Calculate the Gaussian distribution
    gaussian = (1 / denominator) * np.exp(exponent)

    return pi*gaussian
```

In [6]:
```
def plotGaussian(x,gauss,N=1000):

    plt.plot(x,gauss)
    plt.grid(visible=True)
    plt.xlabel("x")
    plt.ylabel("p(x)")

    return
```

In [7]:
```
def calcParams(D):
    muML = np.mean(D)
    sigmaML = np.mean((D-muML)**2)
    return muML,sigmaML;
```

In [8]:
```
def calcQDAParams(D):
    x = D[:,0]; # samples
    y = D[:,1]; # classification
    params0 = calcParams(x[y==0]);
    params1 = calcParams(x[y==1]);
    pi1 = sum(y)/len(y)
    pi0 = 1-pi1

    mu = np.array([params0[0], params1[0]]);
    sig = np.sqrt(np.array([params0[1], params1[1]]));
    pi = np.array([pi0,pi1]);

    return mu,sig,pi
```

In [9]:
```
def calcBayes(x0,mu,sig,pi):
    #apply Bayes formula:
    px0_y0 = calcGaussian(x0,mu[0],sig[0],pi[0]);
    px0_y1 = calcGaussian(x0,mu[1],sig[1],pi[1]);
    p0 = (pi[0]*px0_y0)/(pi[0]*px0_y0 + pi[1]*px0_y1);
```

```
    return p0;
```

In [10]:
```
def q3(mu,sig,pi):
    a = 4;
    N = 1000;
    gauss = np.zeros((3,N));
    x = np.linspace(min(mu-a*sig),max(mu+a*sig),N);
    for i in range(2):
        gauss[i] = calcGaussian(x,mu[i],sig[i],pi[i]);
        plotGaussian(x,gauss[i])

    gauss[2] = np.sum(gauss,axis=0)
    plotGaussian(x,gauss[2])
    plt.title("Graphs of N1(%.1f,%.1f),N2(%.1f,%.1f),N1+N2"%(mu[0],sig[0],mu[1],sig
    plt.legend(labels = ("N(mu0,sig0): pi0 = %.2f" %pi[0], "N(mu1,sig1): pi1 = %.2f
    return
```

In [11]:
```
def q4(x0,mu,sig,pi):

    p0 = calcBayes(x0,mu,sig,pi)
    #p1 = calcBayes(x0,mu[::-1], sig[::-1], pi[::-1]);
    print("Answer for q4: the probability for p(y11 = 0 | x11 = 0.41) = %.3f" %p0);

    plt.plot(x0,p0,marker="x");
    plt.title("Probability of p(y11=0|x11=0.41)");
    plt.text(x0 - .6, p0+1, "{x0 = %.2f\n p(y0=0|x0) = %.4f}"%(x0,p0))
    return
```

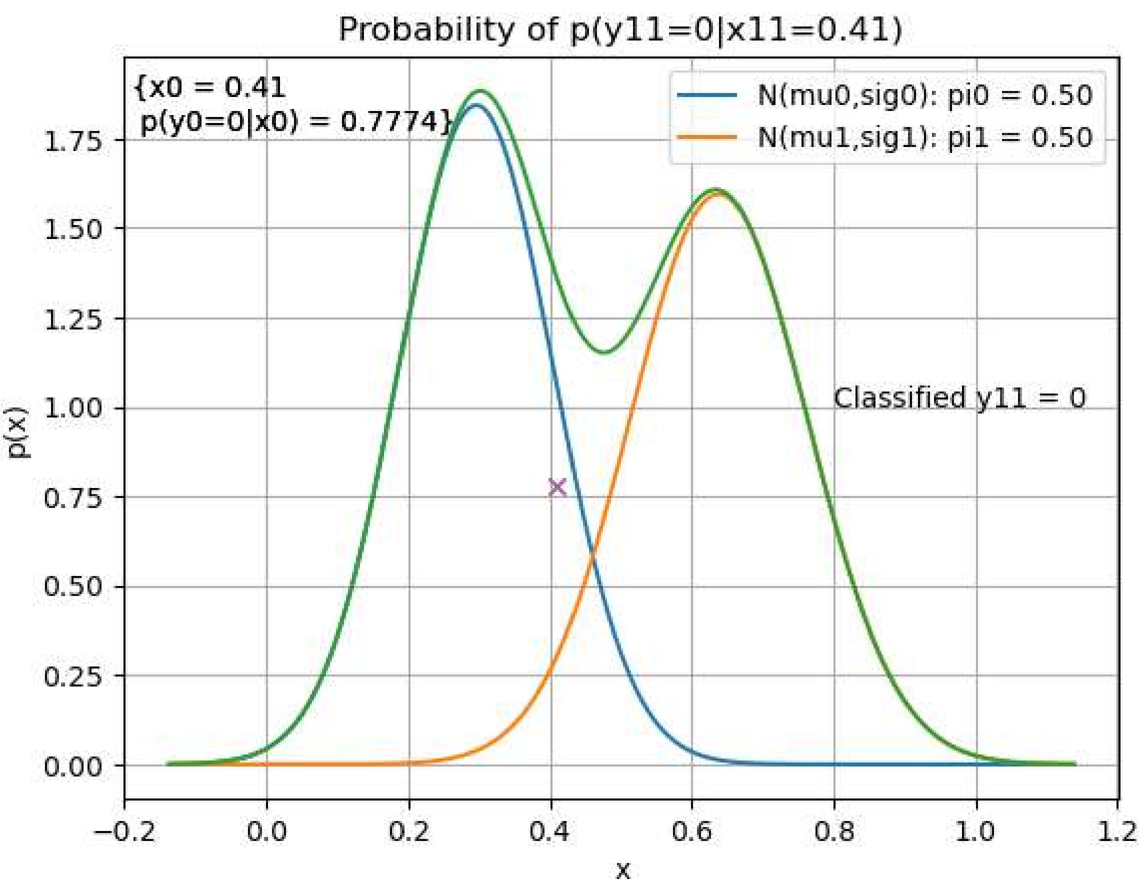
In [12]:
```
def q5(x0,mu,sig,pi):

    p0 = calcBayes(x0,mu,sig,pi)
    p1 = calcBayes(x0,mu[::-1], sig[::-1], pi[::-1]);

    plt.plot(x0,p0,marker="x");
    plt.title("Probability of p(y11=0|x11=0.41)");
    plt.text(x0 - .6, p0+1, "{x0 = %.2f\n p(y0=0|x0) = %.4f}"%(x0,p0))

    print("Answer for q5: the probability for p(y11 = 0 | x11 = 0.41) = %.3f" %p0);
    print("Answer for q5: the probability for p(y11 = 1 | x11 = 0.41) = %.3f" %p1);


    return (x0,np.argmax(np.array([p0,p1])))
```

In [13]:
```
def main(D):

    # q2
    #D = np.array([(0.44,0),(0.12,0),(0.26,0),(0.37,0),(0.29,0),(0.64,1),(0.55,1),(
    mu,sig,pi = calcQDAParams(D);

    # q3:
    q3(mu,sig,pi);

    # q4:

    x11 = 0.41;
    q4(x11,mu,sig,pi)
    print("\n");

    # q5
    (x11,y11) = q5(x11,mu,sig,pi);
```

```
    print("Classify y11 as y11 = %d" %(y11))
    print("\n")
    plt.text(0.8,1,"Classified y11 = %d"%(y11))
    return
```

In [14]:
```
D = np.array([(0.44,0),(0.12,0),(0.26,0),(0.37,0),(0.29,0),(0.64,1),(0.55,1),(0.62,
plt.figure()
print("============================")
print("First set of Classified Data")
print("============================")
main(D)
```

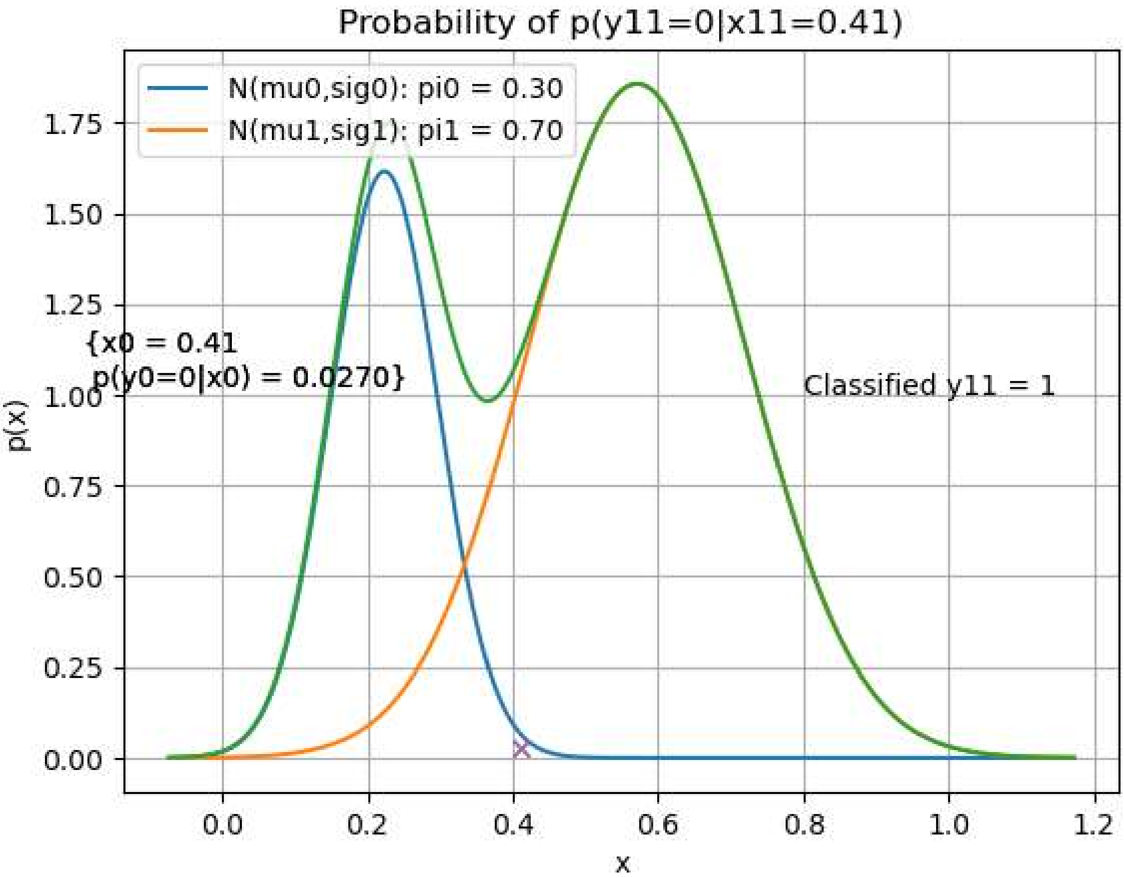
```
============================
First set of Classified Data
============================
Answer for q4: the probability for p(y11 = 0 | x11 = 0.41) = 0.777


Answer for q5: the probability for p(y11 = 0 | x11 = 0.41) = 0.777
Answer for q5: the probability for p(y11 = 1 | x11 = 0.41) = 0.223
Classify y11 as y11 = 0
```



Q6:

In [15]:
```
D_ = np.array([(0.44,1),(0.12,0),(0.26,0),(0.37,1),(0.29,0),(0.64,1),(0.55,1),(0.62
plt.figure()
print("============================")
print("Second set of Classified Data")
print("============================")
main(D_)
```

```
============================
Second set of Classified Data
============================
Answer for q4: the probability for p(y11 = 0 | x11 = 0.41) = 0.027


Answer for q5: the probability for p(y11 = 0 | x11 = 0.41) = 0.027
Answer for q5: the probability for p(y11 = 1 | x11 = 0.41) = 0.973
Classify y11 as y11 = 1
```



In [ ]:

In [ ]: