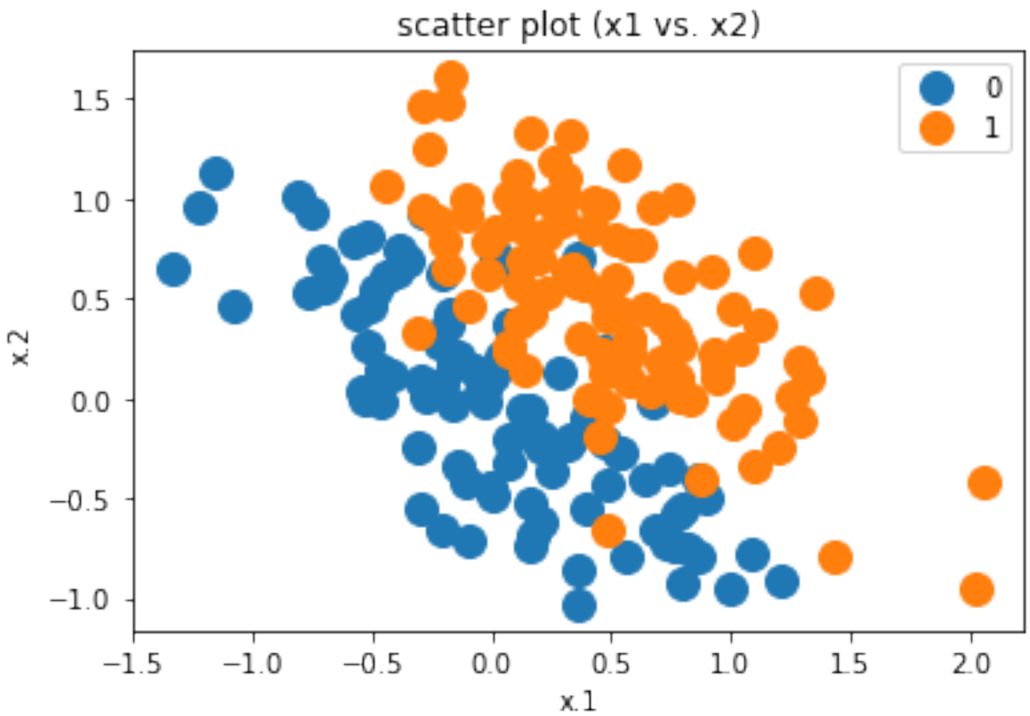
In [209]:

```
import pandas as pd
import numpy as np
%matplotlib inline
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
#read data
df = pd.read_csv("applesOranges.csv")
X = df[["x.1","x.2"]].T
```

1)
a)

In [210]:

```
def datagraph() :
   plt.figure()
   groups = df.groupby('y')
   for name, group in groups:
      plt.plot(group["x.1"], group["x.2"], marker='o', linestyle='', ms=12, label
   plt.xlabel("x.1")
   plt.ylabel("x.2")
   plt.legend()
   plt.title("scatter plot (x1 vs. x2)")
datagraph()
```



b)
for α = 20 (w = [0.93969262 0.34202014]) it is giving the best performance with %76

In [211]:

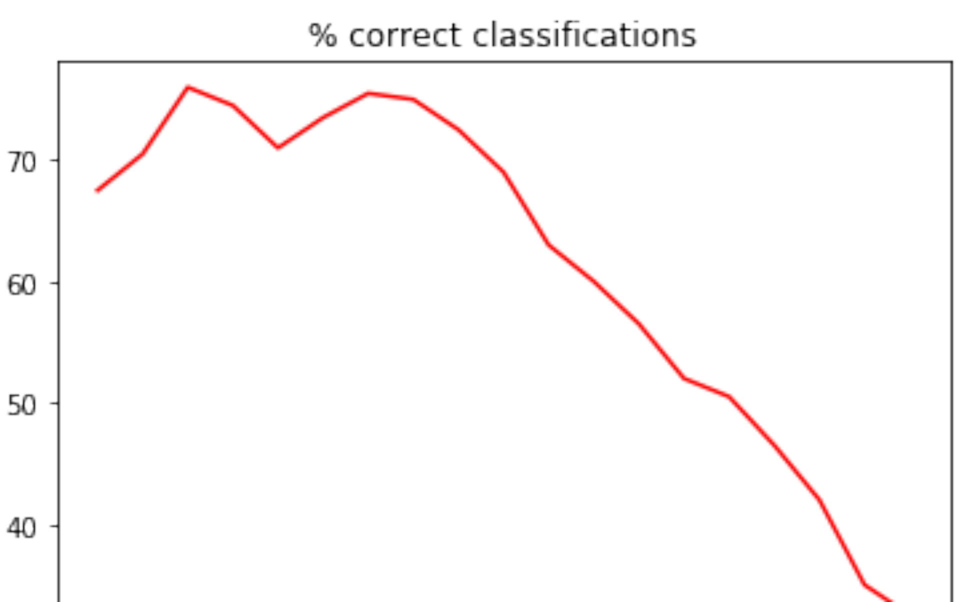
```
def acc_f(weight,X):
     h = np.dot(weight,X)
     h[h == 0] = 1
     h[h < 0] = 0
```

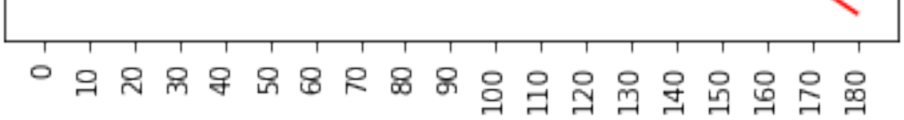
```
    h[h < 0] = 0
    wrong = (np.sign(h) != df["y"]).nonzero()[0]
    return wrong
theta = np.arange(0,190,10)
thetar = theta * (np.pi / 180.0)
weights = np.array(list(zip(np.cos(thetar),np.sin(thetar))))
acc = np.zeros((len(weights)))
ind = 0
for i in weights:
    acc[ind] = (1-(acc_f(i,X).shape[0]/float(df.shape[0])))*100
    ind = ind+1
print(str(acc[np.argmax(acc)])+" best performance")
print(str(weights[np.argmax(acc)])+" weight vector")
print(str(theta[np.argmax(acc)])+" α value")
plt.figure()
plt.plot(theta,acc,color = "r")
plt.title("% correct classifications")
plt.xticks(np.arange(min(theta),max(theta)+10,10.0),rotation=90)
```

```
76.0 best performance
[ 0.93969262  0.34202014] weight vector
20 α value
```

```
Out[211]:
```

```
([<matplotlib.axis.XTick at 0x118f32400>,
  <matplotlib.axis.XTick at 0x118c80b70>,
  <matplotlib.axis.XTick at 0x118f3e358>,
  <matplotlib.axis.XTick at 0x118ed04e0>,
  <matplotlib.axis.XTick at 0x118ed0eb8>,
  <matplotlib.axis.XTick at 0x118ed68d0>,
  <matplotlib.axis.XTick at 0x118edc2e8>,
  <matplotlib.axis.XTick at 0x118edccc0>,
  <matplotlib.axis.XTick at 0x118ee46d8>,
  <matplotlib.axis.XTick at 0x118eea0f0>,
  <matplotlib.axis.XTick at 0x118eeaac8>,
  <matplotlib.axis.XTick at 0x118fd84e0>,
  <matplotlib.axis.XTick at 0x118fd8eb8>,
  <matplotlib.axis.XTick at 0x118fdc8d0>,
  <matplotlib.axis.XTick at 0x118fe42e8>,
  <matplotlib.axis.XTick at 0x118fe4cc0>,
  <matplotlib.axis.XTick at 0x118fec6d8>,
  <matplotlib.axis.XTick at 0x118ff00f0>,
  <matplotlib.axis.XTick at 0x118ff0ac8>],
 <a list of 19 Text xticklabel objects>)
```






```
c)
for bias = -0.146 it is giving the best performance with %80.5 if we use the
weight [ 0.93969262  0.34202014].
```

In [212]:

```python
X1 = np.concatenate((np.ones((1,X.shape[1])), X))
bias = np.arange(-3,3.001,0.001)
weight = weights[np.argmax(acc)]
accb = np.zeros((len(bias)))
ind = 0
for i in bias :
    weight1 = np.insert(weight,0,i)
    accb[ind] = (1-(acc_f(weight1,X1).shape[0]/float(df.shape[0])))*100
    ind =ind +1
print(str(max(accb))+" best performance")
maxind = np.argmax(accb)
maxb = bias[maxind]
print(str(maxb)+" bias")
```

```
80.5 best performance
-0.146 bias
```

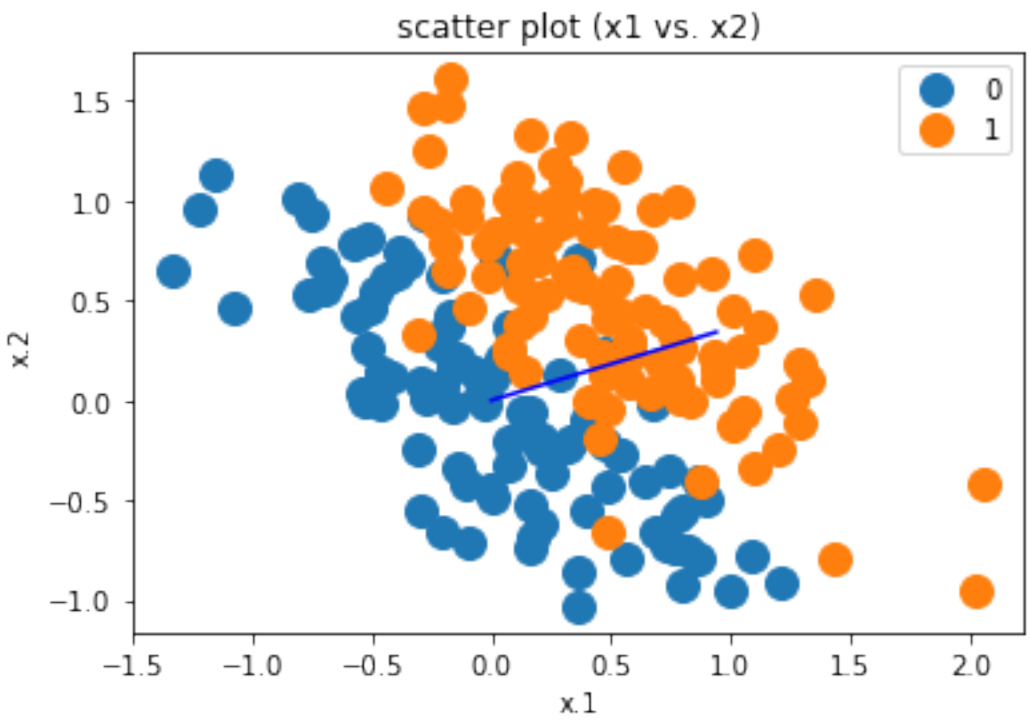
```
#d) There are points that misclassified with this classification.It
nearly gives correct prediction for the data points from the class 1 but for the
values belong class 0 nearly half of them predicted as they belong class 1.It is
not a optimum linear seperator
```

In [213]:

```
datagraph()
plt.plot([0.0,0.93969262 ],[0.0,0.34202014],color = "blue")    # weight
```

Out[213]:

[<matplotlib.lines.Line2D at 0x118ea20b8>]

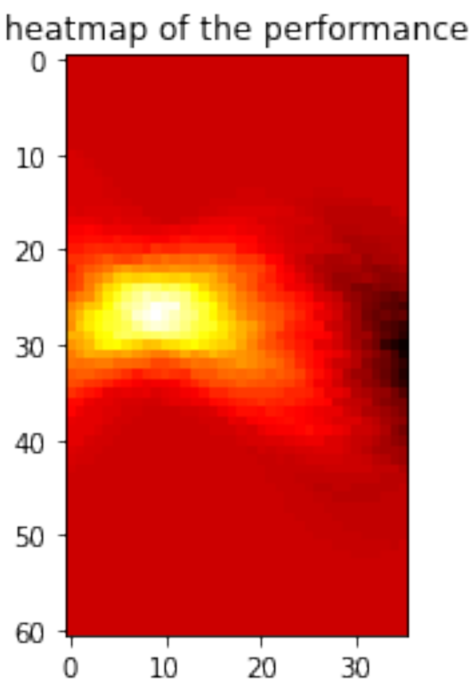


e)If we choose bias -0.3 and α = 45 (w =[0.70710678 0.70710678]) we are getting %91.5 accuracy
It is the best accuracy in the range it is taken.

In [214]:

```
bias = np.arange(-3,3.1,0.1)
thetas = np.arange(0,180,5)
thetas2 = thetas*(np.pi /180. )
weights = np.array(list(zip(np.cos(thetas2),np.sin(thetas2))))
ind = 0
acct = np.zeros((len(bias)*len(weights)))
for i in bias:
    for j in weights :
        weight_last = np.insert(j,0,i)
        acct[ind] = (1-(acc_f(weight_last,X1).shape[0]/float(df.shape[0])))*100
        ind = ind +1

acc = acct.reshape((len(bias),len(weights)))
i,j = np.unravel_index(acc.argmax(), acc.shape)# i bias, j weight
print(str(bias[i])+" bias value")#27   // -0.3
print(str(weights[j])+" weight vector")#9  // [ 0.70710678  0.70710678]
print(str(thetas[j])+" α value") # 45
print(str(acc[i,j])+"best performance")# 91.5
plt.figure()
plt.title("heatmap of the performance")
plt.imshow(acc, cmap='hot', interpolation='nearest')
plt.show()
```

```
-0.3 bias value
[ 0.70710678  0.70710678] weight vector
45 α value
91.5best performance
```



f)It can be problematic for the huge datasets concerning the performance of the code.Moreover if the data is not linearly separable then this method must fail in this case.

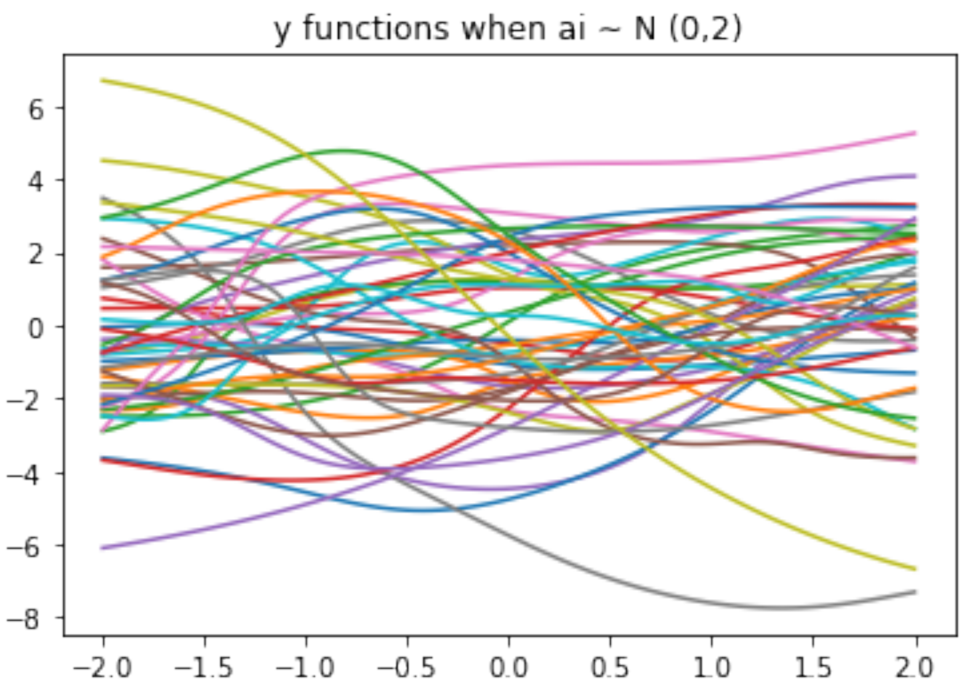
2)
a)

In [215]:

```
def make_func(a,b,w):
    def func(x):
       return np.dot(w,np.tanh(a*(x-b)))
    return func

def g(x):
    return -1*x

def mlp(c,d,ind) :
   ind = 0
   lst = list()
   mse = np.zeros((50))
   plt.figure()
   for i in range(50) :
      w = np.random.normal(0,1, 10)
      b = np.random.uniform(-2,2,10)
      a = np.random.normal(c,np.sqrt(d),10)
      y = make_func(a,b,w)
      lst.append(make_func(a,b,w))
      ax = np.linspace(-2,2,100)
      ly = np.array([y(t) for t in ax])
      lg = np.array([g(t) for t in ax])
      mse_temp = np.dot((ly-lg),(ly-lg))/len(ly)
      mse[ind] = mse_temp
      plt.plot(ax,ly)
      ind = ind +1
   return lst,mse

mlp1,mse1 = mlp(0,2,0)
plt.title("y functions when ai ~ N (0,2)")
```

Out[215]:

```
<matplotlib.text.Text at 0x1192755c0>
```



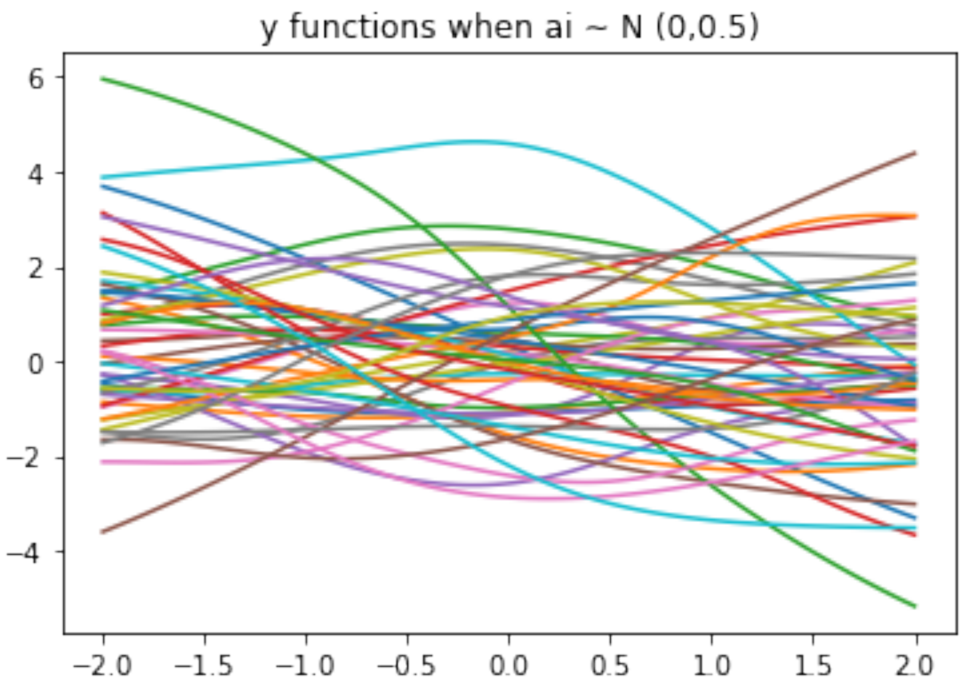
b)The functions with ai ~ N (0,0.5) are more smoother than the first ones.

In [216]:

```
mlp2,mse2 = mlp(0,0.5,50)
plt.title("y functions when ai ~ N (0,0.5)")
```

Out[216]:

```
<matplotlib.text.Text at 0x1193f3ef0>
```



In [ ]:

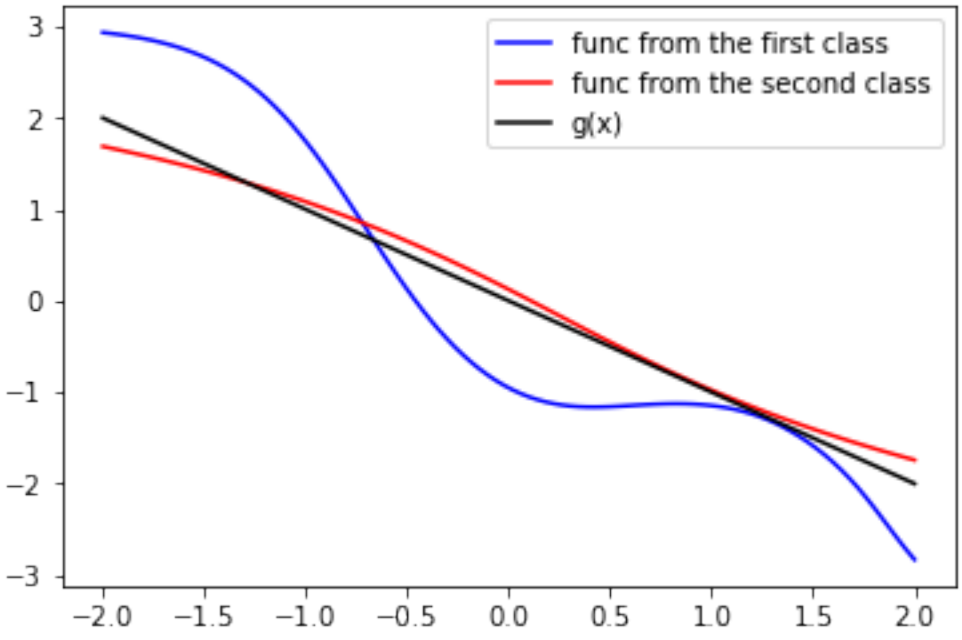
```
c)
```

In [217]:

```
ax = np.linspace(-2,2,100)
ay1 = np.array([mlp1[np.argmin(mse1)](t) for t in ax])
ay2 = np.array([mlp2[np.argmin(mse2)](t) for t in ax])

plt.figure()
plt.plot(ax,ay1,label = "func from the first class",color = "blue")
plt.plot(ax,ay2,label = "func from the second class",color = "red")
plt.plot([-2,2],[2,-2],color = "black",label = "g(x)")
plt.legend()
```

Out[217]:

```
<matplotlib.legend.Legend at 0x1196651d0>
```



In [ ]:

In [ ]:

In [ ]:

In [ ]: