In [1]:

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from numpy import linalg as LA
import cvxpy as cp
```

In [2]:

```
dataset = pd.read_csv(filepath_or_buffer='Data.csv',header=None,names=['Attribute_1','A
ttribute_2','Label'])
dataset.head()
```

Out[2]:

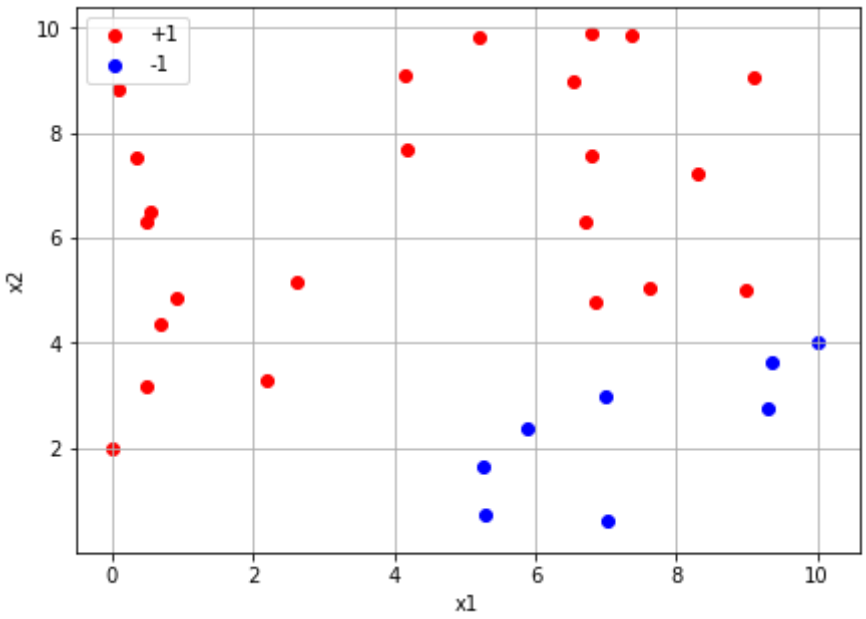
	Attribute_1	Attribute_2	Label
0	2.18960	3.2823	1
1	0.47045	6.3264	1
2	6.78860	7.5641	1
3	6.79300	9.9104	1
4	9.34690	3.6534	-1

Q5(a)

In [3]:

```
x = np.concatenate((dataset['Attribute_1'].values.reshape((dataset.shape[0],1)),dataset
['Attribute_2'].values.reshape((dataset.shape[0],1))),axis=1)
y = dataset['Label'].values

label1 = (y==1)
label2 = (y==-1)
plt.scatter(x[label1,0],x[label1,1],color='red')
plt.scatter(x[label2,0],x[label2,1],color='blue')
plt.xlabel('x1')
plt.ylabel('x2')
plt.legend(('+1','-1'))
plt.grid(True)
fig = plt.gcf()
fig.set_size_inches(7, 5)
plt.show()
```



Q5(b)

In [4]:

```
m = x.shape[0]
d = x.shape[1]

w = cp.Variable(d)
b = cp.Variable()

obj = cp.Minimize((0.5*cp.norm(w,2)))

constraints = [(y[i]*(w.T*x[i] + b) >= 1) for i in range(m)]

prob = cp.Problem(obj,constraints)
prob.solve()
```

Out[4]:

```
0.790569415288356
```

In [5]:

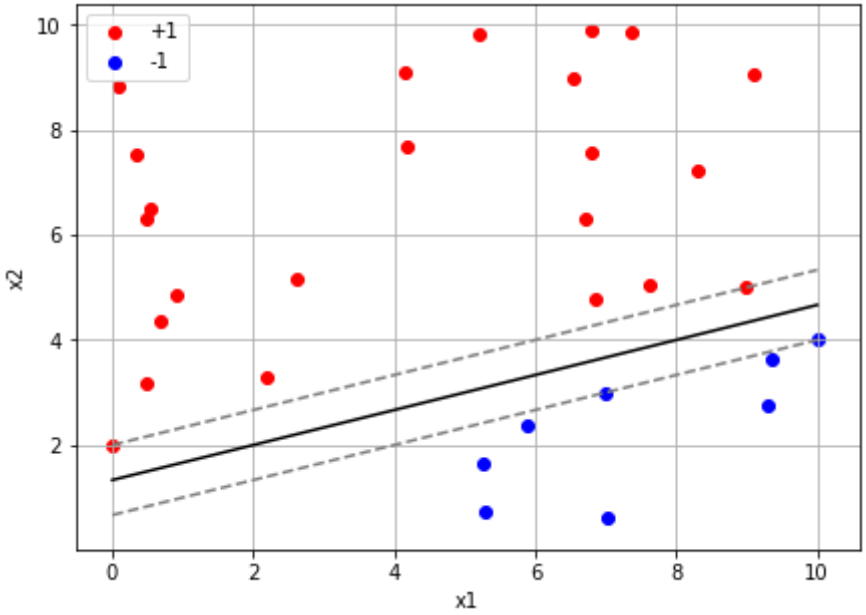
```
def plotClusters(x,y,w,b):
    # Takes in a set of datapoints x and y for two clusters,
    #  the hyperplane separating them in the form a'x -b = 0,
    #  and a slab half-width t
    d1_min = np.min(x[:,0])
    d1_max = np.max(x[:,0])
    # Line form: (-a[0] * x - b ) / a[1]
    d2_atD1min = (-w[0]*d1_min - b ) / w[1]
    d2_atD1max = (-w[0]*d1_max - b ) / w[1]

    sup_up_atD1min = (-w[0]*d1_min - b + 1 ) / w[1]
    sup_up_atD1max = (-w[0]*d1_max - b + 1 ) / w[1]
    sup_dn_atD1min = (-w[0]*d1_min - b - 1 ) / w[1]
    sup_dn_atD1max = (-w[0]*d1_max - b - 1 ) / w[1]

    # Plot the clusters!
    label1 = (y==1)
    label2 = (y==-1)
    plt.scatter(x[label1,0],x[label1,1],color='red')
    plt.scatter(x[label2,0],x[label2,1],color='blue')
    plt.xlabel('x1')
    plt.ylabel('x2')
    plt.legend(('+1','-1'))
    plt.plot([d1_min,d1_max],[d2_atD1min,d2_atD1max],color='black')
    plt.plot([d1_min,d1_max],[sup_up_atD1min,sup_up_atD1max],'--',color='gray')
    plt.plot([d1_min,d1_max],[sup_dn_atD1min,sup_dn_atD1max],'--',color='gray')
    plt.grid(True)
    fig = plt.gcf()
    fig.set_size_inches(7, 5)
    plt.show()
```

In [6]:

```
plotClusters(x,y,w.value,b.value)
```



In [7]:

```
print(1/LA.norm(w.value))
```

```
0.6324555317208284
```

In [8]:

```
print(w.value)
```

```
[-0.5  1.5]
```

In [9]:

```
print(b.value)
```

```
-2.0000000014167476
```

Q5(c)

In [10]:

```
Q = np.multiply(x,y.reshape((y.shape[0],1)))
P = np.matmul(Q,Q.T)
P += 1e-13*np.eye(31)
```

In [11]:

```
m = x.shape[0]
d = x.shape[1]

a = cp.Variable(m)

obj = cp.Maximize((cp.sum(a) - (0.5*cp.quad_form(a,P))))

constraint1 = [0<= a]
constraint2 = [a*y == 0]

constraints = constraint1 + constraint2

prob = cp.Problem(obj,constraints)
prob.solve()
```

Out[11]:

```
1.2499999999998785
```

In [12]:

```
a = a.value
xs = []
ys = []
for i in range(len(a)) :
    if (a[i]<1e-9):
        a[i]=0
    else:
        xs.append(x[i])
        ys.append(y[i])

xs = np.array(xs)
ys = np.array(ys)
print(xs)
```

```
[[ 7.  3.]
 [10.  4.]
 [ 0.  2.]
 [ 9.  5.]]
```

In [13]:

```
print(ys)
```

```
[-1 -1  1  1]
```

In [14]:

```
print(a)
```

```
[0.         0.         0.         0.         0.         0.
 0.         0.         0.         0.         0.         0.
 0.         0.         0.         0.         0.         0.
 0.         0.         0.         0.         0.         0.
 0.         0.         0.         1.03178447 0.21821553 0.26059482
 0.98940518]
```

In [15]:

```
w = np.sum((a.reshape((a.shape[0],1))*Q),axis=0)
print(w)
```

```
[-0.5  1.5]
```

In [ ]:

```
```