In [36]:
```
from __future__ import division
import numpy as np
import matplotlib.pyplot as plt
```

Problem 1

In [37]:
```
x1,x2,y = np.loadtxt('lms.dat',unpack=True)
x = np.column_stack((x1,x2))
```

Part (a)

In [38]:
```
cov = np.dot(x.T,x)
```

In [172]:
```
beta = np.dot(np.linalg.inv(cov),np.dot(x.T,y))
print 'Parameter Vector'
print beta
```

```
Parameter Vector
[ 5.04203031 -1.40060196]
```

Part (b)

In [174]:
```
eVals,eVecs = np.linalg.eig(cov)
print 'Eigenvalues'
print eVals
print 'Eigenvectors'
print eVecs[0]
print eVecs[1]
```

```
Eigenvalues
[  8.09336026  22.95175814]
Eigenvectors
[-0.84686679  0.53180508]
[-0.53180508 -0.84686679]
```

In [70]:
```
J = lambda b1,b2 : np.sum([(y[ii]-np.dot([b1,b2],x[ii]))**2
                           for ii in xrange(y.shape[0])])/2
```

In [144]:
```
delta = 0.025
```

```
beta1 = np.arange(0, beta[0]+3.0, delta)
beta2 = np.arange(beta[1]-3.0, beta[1]+3.0, delta)
Beta1, Beta2 = np.meshgrid(beta1, beta2)
```

In [153]:
```
costJ = np.array([[J(Beta1[ii,jj],Beta2[ii,jj])
                   for ii in xrange(Beta1.shape[0])]
                   for jj in xrange(Beta1.shape[1])]).T
```

In [195]:
```
plt.figure()
CS = plt.contour(Beta1, Beta2, costJ,30)
plt.clabel(CS, inline=1, fontsize=10)
plt.title('Cost as a function of parameters')
plt.xlabel('Beta1')
plt.ylabel('Beta2')
plt.show()
```

Part (c)

In [200]:
```
iterations = 500
betas = np.zeros((iterations,2))
rho = 1/np.linalg.eigh(cov)[0][-1]/4
for ii in xrange(1,iterations):
    #jj = ii % y.shape[0]
    jj = np.random.randint(y.shape[0])
    betas[ii] = betas[ii-1] +rho*(y[jj]-np.dot(betas[ii-1],x[jj]))*x[jj]
```

In [201]:
```
plt.figure()
CS = plt.contour(Beta1, Beta2, costJ,30)
plt.clabel(CS, inline=1, fontsize=10)
plt.xlabel('Beta1')
plt.ylabel('Beta2')
plt.title('Cost as a function of parameters\n'+'Rho:'+str(rho))
skip = 1
plt.plot(betas[::skip,0],betas[::skip,1])
plt.plot(betas[::skip,0],betas[::skip,1],'bo')
plt.show()
```

In [189]:
```
print beta
print betas[-1]
```

```
[ 5.04203031 -1.40060196]
[ 5.04085023 -1.38851189]
```

In [ ]: