In [3]:
```python
import tensorflow.compat.v1 as tf
tf.disable_v2_behavior()
import random
import math
import csv
import numpy as np
from matplotlib import pyplot as plt
from matplotlib import patches as mpatches
from sklearn import preprocessing
#import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.callbacks import TensorBoard
import keras.backend as K
```

```
WARNING:tensorflow:From C:\Anaconda\lib\site-packages\tensorflow\python\compat\v2_compat.py:96: disable_resource_variables (from tensorflow.python.ops.variable_scope) is deprecated and will be removed in a future version.
Instructions for updating:
non-resource variables are not supported in the long term
```

In [4]:
```python
linkLength = 2

Q1 = []
Q2 = []
Q3 = []
posX = []
posY = []
titaEnd = []
samples = 2000
```

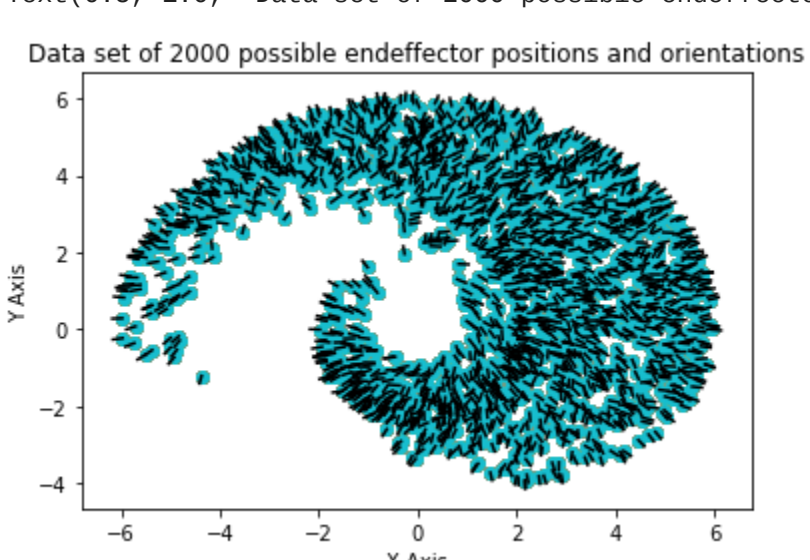
In [7]:
```python
def Xe (a,b,c):                 # return the X,Y,Tita for a given 2 joint angles
    return linkLength*math.cos(a)+linkLength*math.cos(a+b)+linkLength*math.cos(a+b+c)
def Ye (e,f,g):
    return linkLength*math.sin(e) + linkLength*math.sin(e + f) + linkLength*math.sin(e + f + g)
def tita (h,i,j):
    return math.degrees(h)+math.degrees(i)+math.degrees(j)
```

In [8]:
```python
def customloss (yTrue,yPred):
    return K.sum((yTrue - yPred)**2)


def build_model():              # NN Model
    model = keras.Sequential()
    model.add(keras.layers.Dense(3))
    #model.add(keras.layers.Dense(100,use_bias=True, activation='relu'))
    #model.add(keras.layers.Dense(100, use_bias=True, activation='relu'))
    model.add(keras.layers.Dense(100,use_bias=True, activation='relu'))
    model.add(keras.layers.Dense(50,use_bias=True, activation='relu'))
    model.add(keras.layers.Dense(25,use_bias=True, activation='relu'))
    model.add(keras.layers.Dense(3,use_bias=True, activation='linear'))
    model.compile(optimizer=tf.train.AdamOptimizer(0.01), loss=customloss, metrics=['accuracy'])  # mean squared error
    return model
```

In [9]:
```python
file = open ("traing_data.csv","w")                             # Data Set Creation
for i in range (0,samples):
    q1= round(random.uniform(0,math.pi),2)
    q2= round(random.uniform(-math.pi,0),2)
    q3= round(random.uniform(-math.pi/2, math.pi/2), 2)

    Q1.append(q1)
    file.write(str(q1))
    file.write(",")

    Q2.append(q2)
    file.write(str(q2))
    file.write(",")

    Q3.append(q3)
    file.write(str(q3))
    file.write(",")

    X = Xe(q1,q2,q3)
    posX.append(X)
    file.write(str(round(X, 2)))
    file.write(",")

    Y =Ye(q1,q2,q3)
    posY.append(Y)
    file.write(str(round(Y, 2)))
    file.write(",")

    T = tita(q1,q2,q3)
    titaEnd.append(T)
    file.write(str(round(T, 2)))
    file.write("\n")

file.close()
```

In [14]:
```python
for i in range(0,len(posX)):
    plt.plot([posX[i],posX[i]+0.2*math.cos(math.radians(titaEnd[i]))],[posY[i],posY[i]+0.2*math.sin(math.radians(titaEnd[i]))],'k-')
    plt.scatter(posX,posY)                              #Plotting the data set

plt.xlabel("X Axis")
plt.ylabel("Y Axis")
plt.title("Data set of 2000 possible endeffector positions and orientations")
```

Out[14]: `Text(0.5, 1.0, 'Data set of 2000 possible endeffector positions and orientations')`



In [10]:
```python
dataMat =np.c_[Q1,Q2,Q3,posX,posY,titaEnd]          # Augmenting to the data marix

for i in range (0,samples):                         # Removing duplicated end effeector positions
    check1 = dataMat[i,3]
    check2 = dataMat[i,4]
    check3 = dataMat[i,5]
    for j in range (0,samples):
        if i != j:
            #print(i,j,'checking..')
            if (dataMat[j,3] == check1 and dataMat[j,4] == check2 and dataMat[j,5] == check3):
                print(i,j,dataMat[j,3],dataMat[j,4],dataMat[j,5])
```

```
1291 1556 4.511551809575435 2.1076857876216626 -20.053522829578803
1556 1291 4.511551809575435 2.1076857876216626 -20.053522829578803
```

In [11]:
```python
data =dataMat[:,[3,4,5]] #X,Y,Tita
output =dataMat[:,[0,1,2]]  # Q1,Q2,Q3

train_input = data[0:int(0.7*samples),:]                              #Separate data set in to Train, Test And Validation
train_output = output[0:int(0.7*samples),:]

test_input = data[int(0.7*samples):int(0.85*samples),:]
test_output = output[int(0.7*samples):int(0.85*samples),:]

validate_input = data[int(0.85*samples):int(samples),:]
validate_output = output[int(0.85*samples):int(samples),:]

print("Train INPUT---------------------")
print(np.shape(train_input))
print(train_input)
print("OUTPUT--------------------")
print(np.shape(output))
print(output)
```

```
Train INPUT---------------------
(1400, 3)
[[  -0.9391886     4.35367827  107.71606548]
 [   2.59982349    0.19221537  -56.14986392]
 [   3.17188899   -0.64199706  -34.37746771]
 ...
 [  -1.62020541   -1.14218422 -158.13635146]
 [  -2.48693856    5.33926192  115.16451682]
 [   4.85883363   -1.3829172    -6.30253575]]
OUTPUT--------------------
(2000, 3)
[[ 2.61 -1.81  1.08]
 [ 1.83 -1.87 -0.94]
 [ 1.47 -2.32  0.25]
 ...
 [ 2.77 -1.61 -0.51]
 [ 1.64 -2.16 -0.44]
 [ 0.42 -1.5   1.5 ]]
```

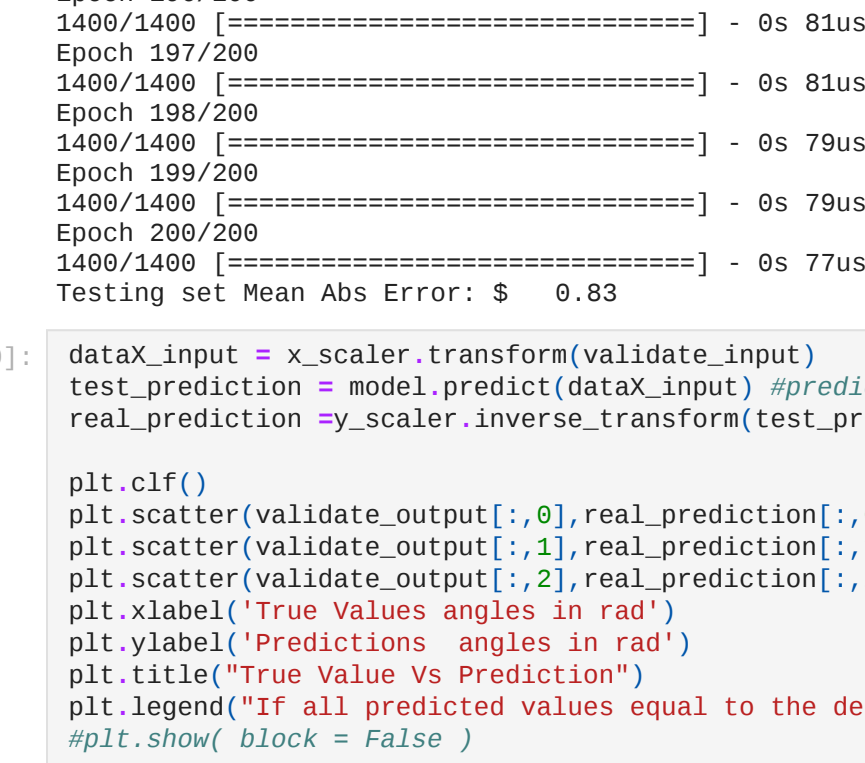
In [12]:
```python
x_scaler = preprocessing.MinMaxScaler(feature_range=(-1,1))
y_scaler = preprocessing.MinMaxScaler(feature_range=(-1,1))
x_scaler_test = preprocessing.MinMaxScaler(feature_range=(-1,1))
y_scaler_test = preprocessing.MinMaxScaler(feature_range=(-1,1))
x_scaler_eva = preprocessing.MinMaxScaler(feature_range=(-1,1))
y_scaler_eva = preprocessing.MinMaxScaler(feature_range=(-1,1))

dataX = x_scaler.fit_transform(train_input)
dataY = y_scaler.fit_transform(train_output)
dataX_test = x_scaler_test.fit_transform(test_input)
dataY_test = y_scaler_test.fit_transform(test_output)
dataX_eva = x_scaler_eva.fit_transform(validate_input)
dataY_eva = y_scaler_eva.fit_transform(validate_output)
```

In [25]:
```python
model =  build_model()                                          # Building the model
history = model.fit(dataX,dataY, nb_epoch=200)    #train the model
[loss,mae] =model.evaluate(dataX_test,dataY_test,verbose=0)        #evaluation
print("Testing set Mean Abs Error: ${:7.2f}".format(mae))
```

```
WARNING:tensorflow:The `nb_epoch` argument in `fit` has been renamed `epochs`.
Train on 1400 samples
Epoch 1/200
1400/1400 [==============================] - 0s 73us/sample - loss: 15.1219 - acc: 0.5957
Epoch 2/200
1400/1400 [==============================] - 0s 76us/sample - loss: 4.7960 - acc: 0.7921
Epoch 3/200
1400/1400 [==============================] - 0s 77us/sample - loss: 3.0017 - acc: 0.8350
Epoch 4/200
1400/1400 [==============================] - 0s 77us/sample - loss: 2.2918 - acc: 0.8500
Epoch 5/200
1400/1400 [==============================] - 0s 75us/sample - loss: 2.2836 - acc: 0.8479
Epoch 6/200
1400/1400 [==============================] - 0s 82us/sample - loss: 1.5585 - acc: 0.8664
Epoch 7/200
1400/1400 [==============================] - 0s 80us/sample - loss: 2.0229 - acc: 0.8614
Epoch 8/200
1400/1400 [==============================] - 0s 76us/sample - loss: 1.4532 - acc: 0.8757
Epoch 9/200
1400/1400 [==============================] - 0s 76us/sample - loss: 1.3036 - acc: 0.8714
Epoch 10/200
1400/1400 [==============================] - 0s 78us/sample - loss: 1.2154 - acc: 0.8814
Epoch 11/200
1400/1400 [==============================] - 0s 79us/sample - loss: 1.1569 - acc: 0.8914
Epoch 12/200
1400/1400 [==============================] - 0s 79us/sample - loss: 1.3525 - acc: 0.8843
Epoch 13/200
1400/1400 [==============================] - 0s 79us/sample - loss: 1.4327 - acc: 0.8879
Epoch 14/200
1400/1400 [==============================] - 0s 78us/sample - loss: 1.6400 - acc: 0.8607
Epoch 15/200
1400/1400 [==============================] - 0s 78us/sample - loss: 1.3395 - acc: 0.8829
Epoch 16/200
1400/1400 [==============================] - 0s 79us/sample - loss: 1.3132 - acc: 0.8871
Epoch 17/200
1400/1400 [==============================] - 0s 77us/sample - loss: 1.2688 - acc: 0.8821
Epoch 18/200
1400/1400 [==============================] - 0s 77us/sample - loss: 1.5594 - acc: 0.8664
Epoch 19/200
1400/1400 [==============================] - 0s 75us/sample - loss: 1.0509 - acc: 0.8964
Epoch 20/200
1400/1400 [==============================] - 0s 80us/sample - loss: 0.8716 - acc: 0.9043
Epoch 21/200
1400/1400 [==============================] - 0s 86us/sample - loss: 0.9953 - acc: 0.8986
Epoch 22/200
1400/1400 [==============================] - 0s 81us/sample - loss: 0.8402 - acc: 0.8993
Epoch 23/200
1400/1400 [==============================] - 0s 78us/sample - loss: 0.8770 - acc: 0.8921
Epoch 24/200
1400/1400 [==============================] - 0s 81us/sample - loss: 0.9505 - acc: 0.8957
Epoch 25/200
1400/1400 [==============================] - 0s 79us/sample - loss: 1.1928 - acc: 0.8929
Epoch 26/200
1400/1400 [==============================] - 0s 79us/sample - loss: 1.2430 - acc: 0.8771
Epoch 27/200
1400/1400 [==============================] - 0s 78us/sample - loss: 1.2026 - acc: 0.8993
Epoch 28/200
1400/1400 [==============================] - 0s 74us/sample - loss: 1.0175 - acc: 0.8964
Epoch 29/200
1400/1400 [==============================] - 0s 78us/sample - loss: 0.8602 - acc: 0.9071
Epoch 30/200
1400/1400 [==============================] - 0s 79us/sample - loss: 1.1001 - acc: 0.8936
Epoch 31/200
1400/1400 [==============================] - 0s 81us/sample - loss: 1.1055 - acc: 0.8943
Epoch 32/200
1400/1400 [==============================] - 0s 81us/sample - loss: 1.0795 - acc: 0.8986
Epoch 33/200
1400/1400 [==============================] - 0s 81us/sample - loss: 1.0053 - acc: 0.9007
Epoch 34/200
1400/1400 [==============================] - 0s 81us/sample - loss: 0.9095 - acc: 0.8929
Epoch 35/200
1400/1400 [==============================] - 0s 80us/sample - loss: 1.1590 - acc: 0.8964
Epoch 36/200
1400/1400 [==============================] - 0s 80us/sample - loss: 0.9063 - acc: 0.9157
Epoch 37/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.8147 - acc: 0.9100
Epoch 38/200
1400/1400 [==============================] - 0s 78us/sample - loss: 0.8559 - acc: 0.9036
Epoch 39/200
1400/1400 [==============================] - 0s 74us/sample - loss: 0.8287 - acc: 0.9043
Epoch 40/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.9327 - acc: 0.8907
Epoch 41/200
1400/1400 [==============================] - 0s 78us/sample - loss: 0.5846 - acc: 0.9043
Epoch 42/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.4969 - acc: 0.9229
Epoch 43/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.8625 - acc: 0.8914
Epoch 44/200
1400/1400 [==============================] - 0s 78us/sample - loss: 1.1014 - acc: 0.8814
Epoch 45/200
1400/1400 [==============================] - 0s 76us/sample - loss: 1.1018 - acc: 0.8971
Epoch 46/200
1400/1400 [==============================] - 0s 75us/sample - loss: 0.6249 - acc: 0.9229
Epoch 47/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.7291 - acc: 0.9086
Epoch 48/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.6533 - acc: 0.9071
Epoch 49/200
1400/1400 [==============================] - 0s 80us/sample - loss: 0.5702 - acc: 0.9164
Epoch 50/200
1400/1400 [==============================] - 0s 79us/sample - loss: 1.3549 - acc: 0.8900
Epoch 51/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.6867 - acc: 0.9071
Epoch 52/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.6927 - acc: 0.9007
Epoch 53/200
1400/1400 [==============================] - 0s 78us/sample - loss: 0.8902 - acc: 0.9014
Epoch 54/200
1400/1400 [==============================] - 0s 82us/sample - loss: 1.2992 - acc: 0.8936
Epoch 55/200
1400/1400 [==============================] - 0s 82us/sample - loss: 1.0730 - acc: 0.8864
Epoch 56/200
1400/1400 [==============================] - 0s 76us/sample - loss: 1.4112 - acc: 0.8800
Epoch 57/200
1400/1400 [==============================] - 0s 76us/sample - loss: 1.1745 - acc: 0.8793
Epoch 58/200
1400/1400 [==============================] - 0s 77us/sample - loss: 1.0367 - acc: 0.8850
Epoch 59/200
1400/1400 [==============================] - 0s 76us/sample - loss: 0.8227 - acc: 0.9107
Epoch 60/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.6218 - acc: 0.9157
Epoch 61/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.6942 - acc: 0.9000
Epoch 62/200
1400/1400 [==============================] - 0s 77us/sample - loss: 1.3262 - acc: 0.8793
Epoch 63/200
1400/1400 [==============================] - 0s 80us/sample - loss: 0.8349 - acc: 0.8993
Epoch 64/200
1400/1400 [==============================] - 0s 80us/sample - loss: 0.5768 - acc: 0.9129
Epoch 65/200
1400/1400 [==============================] - 0s 80us/sample - loss: 1.2561 - acc: 0.8686
Epoch 66/200
1400/1400 [==============================] - 0s 82us/sample - loss: 1.0073 - acc: 0.9029
Epoch 67/200
1400/1400 [==============================] - 0s 98us/sample - loss: 0.8280 - acc: 0.9064
Epoch 68/200
1400/1400 [==============================] - 0s 134us/sample - loss: 1.0023 - acc: 0.9036
Epoch 69/200
1400/1400 [==============================] - 0s 135us/sample - loss: 0.6320 - acc: 0.9121
Epoch 70/200
1400/1400 [==============================] - 0s 133us/sample - loss: 0.8152 - acc: 0.8957
Epoch 71/200
1400/1400 [==============================] - 0s 129us/sample - loss: 0.5505 - acc: 0.9179
Epoch 72/200
1400/1400 [==============================] - 0s 133us/sample - loss: 0.7154 - acc: 0.9029
Epoch 73/200
1400/1400 [==============================] - 0s 137us/sample - loss: 0.9886 - acc: 0.8986
Epoch 74/200
1400/1400 [==============================] - 0s 139us/sample - loss: 0.9983 - acc: 0.8843
Epoch 75/200
1400/1400 [==============================] - 0s 131us/sample - loss: 0.6034 - acc: 0.9164
Epoch 76/200
1400/1400 [==============================] - 0s 140us/sample - loss: 0.7110 - acc: 0.9257
Epoch 77/200
1400/1400 [==============================] - 0s 131us/sample - loss: 1.0063 - acc: 0.8929
Epoch 78/200
1400/1400 [==============================] - 0s 141us/sample - loss: 0.6265 - acc: 0.9150
Epoch 79/200
1400/1400 [==============================] - 0s 142us/sample - loss: 0.7200 - acc: 0.9179
Epoch 80/200
1400/1400 [==============================] - 0s 137us/sample - loss: 0.5303 - acc: 0.9221
Epoch 81/200
1400/1400 [==============================] - 0s 127us/sample - loss: 0.5964 - acc: 0.8943
Epoch 82/200
1400/1400 [==============================] - 0s 125us/sample - loss: 0.7158 - acc: 0.8964
Epoch 83/200
1400/1400 [==============================] - 0s 124us/sample - loss: 0.8733 - acc: 0.8964
Epoch 84/200
1400/1400 [==============================] - 0s 122us/sample - loss: 0.7266 - acc: 0.9100
Epoch 85/200
1400/1400 [==============================] - 0s 126us/sample - loss: 0.5078 - acc: 0.9321
Epoch 86/200
1400/1400 [==============================] - 0s 122us/sample - loss: 0.6415 - acc: 0.9050
Epoch 87/200
1400/1400 [==============================] - 0s 123us/sample - loss: 0.9287 - acc: 0.8943
Epoch 88/200
1400/1400 [==============================] - 0s 121us/sample - loss: 1.0486 - acc: 0.8929
Epoch 89/200
1400/1400 [==============================] - 0s 128us/sample - loss: 0.5172 - acc: 0.9257
Epoch 90/200
1400/1400 [==============================] - 0s 126us/sample - loss: 0.4955 - acc: 0.9271
Epoch 91/200
1400/1400 [==============================] - 0s 125us/sample - loss: 0.6266 - acc: 0.9186
Epoch 92/200
1400/1400 [==============================] - 0s 124us/sample - loss: 0.7770 - acc: 0.9036
Epoch 93/200
1400/1400 [==============================] - 0s 127us/sample - loss: 0.7316 - acc: 0.9157
Epoch 94/200
1400/1400 [==============================] - 0s 123us/sample - loss: 0.6981 - acc: 0.9150
Epoch 95/200
1400/1400 [==============================] - 0s 121us/sample - loss: 0.7577 - acc: 0.9021
Epoch 96/200
1400/1400 [==============================] - 0s 111us/sample - loss: 0.6477 - acc: 0.9214
Epoch 97/200
1400/1400 [==============================] - 0s 113us/sample - loss: 0.6840 - acc: 0.9114
Epoch 98/200
1400/1400 [==============================] - 0s 112us/sample - loss: 0.6549 - acc: 0.9121
Epoch 99/200
1400/1400 [==============================] - 0s 113us/sample - loss: 0.6051 - acc: 0.9243
Epoch 100/200
1400/1400 [==============================] - 0s 113us/sample - loss: 0.5235 - acc: 0.9164
Epoch 101/200
1400/1400 [==============================] - 0s 117us/sample - loss: 0.6841 - acc: 0.9171
Epoch 102/200
1400/1400 [==============================] - 0s 116us/sample - loss: 0.6472 - acc: 0.9250
Epoch 103/200
1400/1400 [==============================] - 0s 112us/sample - loss: 0.4636 - acc: 0.9221
Epoch 104/200
1400/1400 [==============================] - 0s 109us/sample - loss: 0.4729 - acc: 0.9214
Epoch 105/200
1400/1400 [==============================] - 0s 113us/sample - loss: 0.4828 - acc: 0.9279
Epoch 106/200
1400/1400 [==============================] - 0s 113us/sample - loss: 0.4279 - acc: 0.9336
Epoch 107/200
1400/1400 [==============================] - 0s 113us/sample - loss: 0.2924 - acc: 0.9393
Epoch 108/200
1400/1400 [==============================] - 0s 113us/sample - loss: 0.4869 - acc: 0.9279
Epoch 109/200
1400/1400 [==============================] - 0s 112us/sample - loss: 0.7068 - acc: 0.9329
Epoch 110/200
1400/1400 [==============================] - 0s 110us/sample - loss: 0.5025 - acc: 0.9186
Epoch 111/200
1400/1400 [==============================] - 0s 111us/sample - loss: 0.9400 - acc: 0.9057
Epoch 112/200
1400/1400 [==============================] - 0s 115us/sample - loss: 0.8298 - acc: 0.8914
Epoch 113/200
1400/1400 [==============================] - 0s 122us/sample - loss: 0.8541 - acc: 0.9043
Epoch 114/200
1400/1400 [==============================] - 0s 125us/sample - loss: 0.6890 - acc: 0.9143
Epoch 115/200
1400/1400 [==============================] - 0s 124us/sample - loss: 0.9194 - acc: 0.9079
Epoch 116/200
1400/1400 [==============================] - 0s 125us/sample - loss: 1.2522 - acc: 0.8807
Epoch 117/200
1400/1400 [==============================] - 0s 117us/sample - loss: 0.8917 - acc: 0.9043
Epoch 118/200
1400/1400 [==============================] - 0s 124us/sample - loss: 0.6064 - acc: 0.9214
Epoch 119/200
1400/1400 [==============================] - 0s 118us/sample - loss: 0.7358 - acc: 0.9093
Epoch 120/200
1400/1400 [==============================] - 0s 132us/sample - loss: 0.8037 - acc: 0.9021
Epoch 121/200
1400/1400 [==============================] - 0s 125us/sample - loss: 0.8359 - acc: 0.8957
Epoch 122/200
1400/1400 [==============================] - 0s 126us/sample - loss: 0.6356 - acc: 0.9193
Epoch 123/200
1400/1400 [==============================] - 0s 120us/sample - loss: 0.7813 - acc: 0.9093
Epoch 124/200
1400/1400 [==============================] - 0s 123us/sample - loss: 0.6299 - acc: 0.9114
Epoch 125/200
1400/1400 [==============================] - 0s 132us/sample - loss: 0.7317 - acc: 0.9071
Epoch 126/200
1400/1400 [==============================] - 0s 116us/sample - loss: 0.8341 - acc: 0.9021
Epoch 127/200
1400/1400 [==============================] - 0s 123us/sample - loss: 0.7573 - acc: 0.8993
Epoch 128/200
1400/1400 [==============================] - 0s 118us/sample - loss: 0.4671 - acc: 0.9250
Epoch 129/200
1400/1400 [==============================] - 0s 123us/sample - loss: 0.5116 - acc: 0.9286
Epoch 130/200
1400/1400 [==============================] - 0s 122us/sample - loss: 0.4713 - acc: 0.9329
Epoch 131/200
1400/1400 [==============================] - 0s 116us/sample - loss: 0.7005 - acc: 0.9193
Epoch 132/200
1400/1400 [==============================] - 0s 130us/sample - loss: 1.0058 - acc: 0.8929
Epoch 133/200
1400/1400 [==============================] - 0s 120us/sample - loss: 0.7267 - acc: 0.9243
Epoch 134/200
1400/1400 [==============================] - 0s 95us/sample - loss: 0.6538 - acc: 0.9143
Epoch 135/200
1400/1400 [==============================] - 0s 82us/sample - loss: 0.7635 - acc: 0.9164
Epoch 136/200
1400/1400 [==============================] - 0s 83us/sample - loss: 1.1602 - acc: 0.8950
Epoch 137/200
1400/1400 [==============================] - 0s 87us/sample - loss: 0.4703 - acc: 0.9314
Epoch 138/200
1400/1400 [==============================] - 0s 94us/sample - loss: 0.5260 - acc: 0.9257
Epoch 139/200
1400/1400 [==============================] - 0s 81us/sample - loss: 0.5819 - acc: 0.9271
Epoch 140/200
1400/1400 [==============================] - 0s 91us/sample - loss: 0.7247 - acc: 0.9100
Epoch 141/200
1400/1400 [==============================] - 0s 164us/sample - loss: 0.6193 - acc: 0.9186
Epoch 142/200
1400/1400 [==============================] - 0s 93us/sample - loss: 0.9654 - acc: 0.9043
Epoch 143/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.5983 - acc: 0.9200
Epoch 144/200
1400/1400 [==============================] - 0s 81us/sample - loss: 0.5054 - acc: 0.9293
Epoch 145/200
1400/1400 [==============================] - 0s 81us/sample - loss: 0.4667 - acc: 0.9229
Epoch 146/200
1400/1400 [==============================] - 0s 83us/sample - loss: 0.5520 - acc: 0.9243
Epoch 147/200
1400/1400 [==============================] - 0s 82us/sample - loss: 0.4880 - acc: 0.9236
Epoch 148/200
1400/1400 [==============================] - 0s 82us/sample - loss: 1.3263 - acc: 0.8993
Epoch 149/200
1400/1400 [==============================] - 0s 82us/sample - loss: 0.9131 - acc: 0.9014
Epoch 150/200
1400/1400 [==============================] - 0s 132us/sample - loss: 0.8887 - acc: 0.9029
Epoch 151/200
1400/1400 [==============================] - 0s 145us/sample - loss: 0.5943 - acc: 0.9193
Epoch 152/200
1400/1400 [==============================] - 0s 129us/sample - loss: 0.5195 - acc: 0.9179
Epoch 153/200
1400/1400 [==============================] - 0s 130us/sample - loss: 0.6697 - acc: 0.9214
Epoch 154/200
1400/1400 [==============================] - 0s 131us/sample - loss: 0.6755 - acc: 0.9164
Epoch 155/200
1400/1400 [==============================] - 0s 84us/sample - loss: 0.5934 - acc: 0.9057
Epoch 156/200
1400/1400 [==============================] - 0s 100us/sample - loss: 0.5298 - acc: 0.9286
Epoch 157/200
1400/1400 [==============================] - 0s 129us/sample - loss: 0.4397 - acc: 0.9357
Epoch 158/200
1400/1400 [==============================] - 0s 117us/sample - loss: 0.5370 - acc: 0.9321
Epoch 159/200
1400/1400 [==============================] - 0s 122us/sample - loss: 0.6055 - acc: 0.9207
Epoch 160/200
1400/1400 [==============================] - 0s 119us/sample - loss: 0.5120 - acc: 0.9257
Epoch 161/200
1400/1400 [==============================] - 0s 117us/sample - loss: 0.6647 - acc: 0.9157
Epoch 162/200
1400/1400 [==============================] - 0s 118us/sample - loss: 0.7743 - acc: 0.9057
Epoch 163/200
1400/1400 [==============================] - 0s 112us/sample - loss: 0.6213 - acc: 0.9221
Epoch 164/200
1400/1400 [==============================] - 0s 120us/sample - loss: 0.4355 - acc: 0.9307
Epoch 165/200
1400/1400 [==============================] - 0s 111us/sample - loss: 0.7893 - acc: 0.9221
Epoch 166/200
1400/1400 [==============================] - 0s 114us/sample - loss: 0.5897 - acc: 0.9257
Epoch 167/200
1400/1400 [==============================] - 0s 118us/sample - loss: 0.3236 - acc: 0.9357
Epoch 168/200
1400/1400 [==============================] - 0s 101us/sample - loss: 0.4493 - acc: 0.9450
Epoch 169/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.4834 - acc: 0.9293
Epoch 170/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.7126 - acc: 0.9136
Epoch 171/200
1400/1400 [==============================] - 0s 84us/sample - loss: 0.7004 - acc: 0.9121
Epoch 172/200
1400/1400 [==============================] - 0s 80us/sample - loss: 0.5961 - acc: 0.9271
Epoch 173/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.7945 - acc: 0.9093
Epoch 174/200
1400/1400 [==============================] - 0s 80us/sample - loss: 0.4833 - acc: 0.9236
Epoch 175/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.4576 - acc: 0.9271
Epoch 176/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.4709 - acc: 0.9314
Epoch 177/200
1400/1400 [==============================] - 0s 76us/sample - loss: 0.9107 - acc: 0.9107
Epoch 178/200
1400/1400 [==============================] - 0s 79us/sample - loss: 1.0913 - acc: 0.8936
Epoch 179/200
1400/1400 [==============================] - 0s 78us/sample - loss: 0.5092 - acc: 0.9279
Epoch 180/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.6811 - acc: 0.9314
Epoch 181/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.3785 - acc: 0.9386
Epoch 182/200
1400/1400 [==============================] - 0s 76us/sample - loss: 0.5048 - acc: 0.9300
Epoch 183/200
1400/1400 [==============================] - 0s 90us/sample - loss: 0.4207 - acc: 0.9350
Epoch 184/200
1400/1400 [==============================] - 0s 82us/sample - loss: 0.4915 - acc: 0.9207
Epoch 185/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.5241 - acc: 0.9314
Epoch 186/200
1400/1400 [==============================] - 0s 78us/sample - loss: 0.6630 - acc: 0.9157
Epoch 187/200
1400/1400 [==============================] - 0s 80us/sample - loss: 0.6302 - acc: 0.9157
Epoch 188/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.5999 - acc: 0.9079
Epoch 189/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.5607 - acc: 0.9164
Epoch 190/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.3786 - acc: 0.9371
Epoch 191/200
1400/1400 [==============================] - 0s 84us/sample - loss: 0.4246 - acc: 0.9264
Epoch 192/200
1400/1400 [==============================] - 0s 80us/sample - loss: 0.5576 - acc: 0.9236
Epoch 193/200
1400/1400 [==============================] - 0s 77us/sample - loss: 1.1005 - acc: 0.9021
Epoch 194/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.8419 - acc: 0.8936
Epoch 195/200
1400/1400 [==============================] - 0s 78us/sample - loss: 0.8795 - acc: 0.9014
Epoch 196/200
1400/1400 [==============================] - 0s 81us/sample - loss: 0.5177 - acc: 0.9279
Epoch 197/200
1400/1400 [==============================] - 0s 81us/sample - loss: 0.5482 - acc: 0.9221
Epoch 198/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.8486 - acc: 0.9114
Epoch 199/200
1400/1400 [==============================] - 0s 79us/sample - loss: 0.9345 - acc: 0.9164
Epoch 200/200
1400/1400 [==============================] - 0s 77us/sample - loss: 0.8286 - acc: 0.9114
Testing set Mean Abs Error: $   0.83
```

In [20]:
```python
dataX_input = x_scaler.transform(validate_input)
test_prediction = model.predict(dataX_input) #predict
real_prediction =y_scaler.inverse_transform(test_prediction)

plt.clf()
plt.scatter(validate_output[:,0],real_prediction[:,0],c='b')              # Plotting Actual angles( x: desired output(Joint angles used to genarate Xe,Ye nd Titae,y: output from pr
plt.scatter(validate_output[:,1],real_prediction[:,1],c='g')
plt.scatter(validate_output[:,2],real_prediction[:,2],c='r')
plt.xlabel('True Values angles in rad')
plt.ylabel('Predictions  angles in rad')
plt.title("True Value Vs Prediction")
plt.legend("If all predicted values equal to the desired(true) value, this will be lie on 45 degree line")
#plt.show( block = False )
```

Out[20]: `<matplotlib.legend.Legend at 0x26d492d5640>`



In [30]:
```python
plt.savefig('True Value Vs Prediction.png')

#_Tensor Board
#tensorboard --logdir=logs/
print("*********************************")
print(validate_input[100,0]," ",validate_input[100,1])
print(Xe(real_prediction[100,0],real_prediction[100,1],real_prediction[100,2])," ",Ye(real_prediction[100,0],real_prediction[100,1],real_prediction[100,2]) )
print("*********************************")
```

```
*********************************
2.7762071937488724   1.2390796503099544
2.743028565762362   1.1906972985494644
*********************************
<Figure size 432x288 with 0 Axes>
```

In [31]:
```python
single_data_1 = np.array([[5, 2, 60]])
single_data = x_scaler.transform(single_data_1)
single_prediction = model.predict(single_data)
single_real_prediction = y_scaler.inverse_transform(single_prediction)

print(single_data_1[0,0]," ",single_data_1[0,1])
print(Xe(single_real_prediction[0,0],single_real_prediction[0,1],single_real_prediction[0,2])," ",Ye(single_real_prediction[0,0],single_real_prediction[0,1],single_real_prediction[
print("*********************************")
```

```
5   2
4.790735226042725   2.0810691858973818
*********************************
```

In [45]:
```python
model.evaluate(dataX_test,dataY_test)
```

Out[45]: `[3.3232549158732096, 0.82666665]`

In [ ]:

In [ ]: