In [12]:
```
import pandas as pd
import tensorflow as tf
import numpy as np
import scipy as sp
from matplotlib import pylab as plt
import sklearn
from scipy import misc
import matplotlib.cm as cm
import imageio
from sklearn.datasets import load_iris
from sklearn.linear_model import LogisticRegression

#%matplotlib inline

labels_train, features_train = [], []
for line in open('./faces/train.txt'):

#   Splits each line in train by "whitespace" (i.e.: the first space), then takes element ZERO (image pixels).
    im = imageio.imread(line.split()[0])

#   Reshapes im objects from 50 x 50 sizes to 2500 flattened vectors (Part b)
    features_train.append(im.reshape(2500,))

#   Splits each line in train by "whitespace" (i.e.: the first space), then takes element ONE (image labels).
    labels_train.append(line.split()[1])

# Creates numpy arrays from lists
features_train, labels_train = np.array(features_train, dtype=float), np.array(labels_train, dtype=int)

# PART (b) Prints the shape of each numpy array.
print (features_train.shape)
plt.imshow(features_train[10, :].reshape(50,50), cmap = cm.Greys_r)
plt.show()

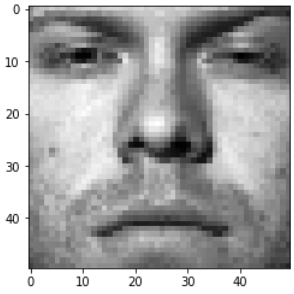
labels_test, features_test = [], []
for line in open('./faces/test.txt'):
    im = imageio.imread(line.split()[0])

    features_test.append(im.reshape(2500,))
    labels_test.append(line.split()[1])

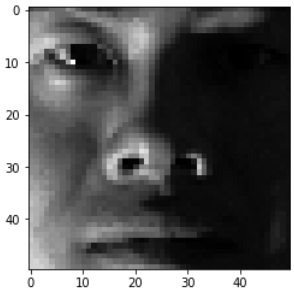
# Creates numpy arrays from lists
features_test, labels_test = np.array(features_test, dtype=float), np.array(labels_test, dtype=int)

print (features_test.shape)
plt.imshow(features_test[10, :].reshape(50,50), cmap = cm.Greys_r)
plt.show()
```

```
(540, 2500)
```




```
(100, 2500)
```

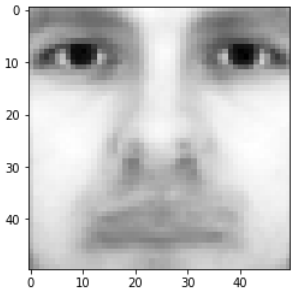


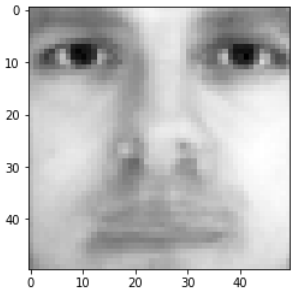
In [13]:
```
average_face_train = np.empty(2500)



average_face_train = (np.sum(features_train, axis = 0)/len(labels_train))
plt.imshow(average_face_train.reshape(50,50), cmap = cm.Greys_r)
plt.show()


average_face_test = np.empty(2500)
average_face_test = (np.sum(features_test, axis = 0)/len(labels_test))
plt.imshow(average_face_test.reshape(50,50), cmap = cm.Greys_r)
plt.show()
```



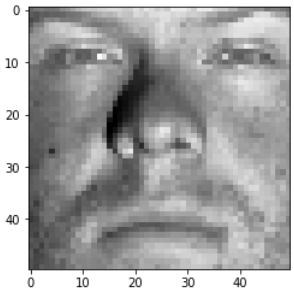


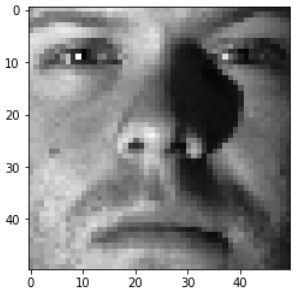
In [14]:
```
features_train_minus_av = np.empty_like(features_train)
features_test_minus_av = np.empty_like(features_test)

for i,j in enumerate(features_train_minus_av):
    features_train_minus_av[i]= features_train[i]-average_face_train

for i,j in enumerate(features_test_minus_av):
    features_test_minus_av[i]= features_test[i]-average_face_test

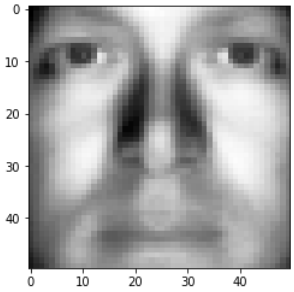
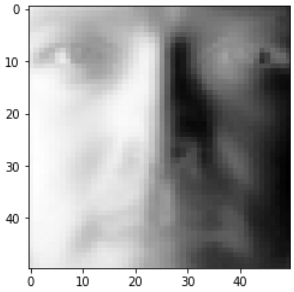
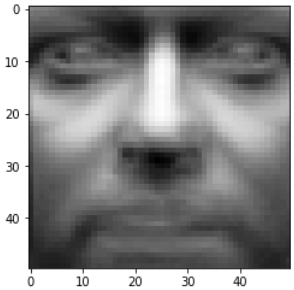
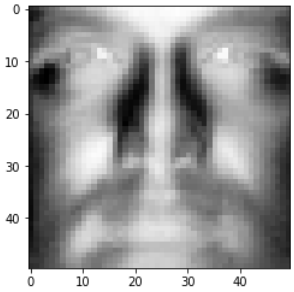
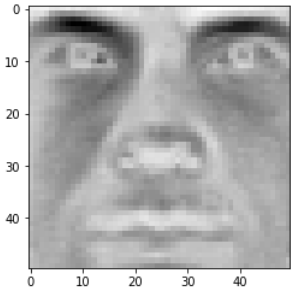
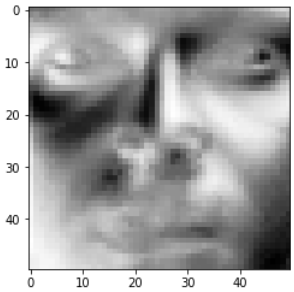
plt.imshow(features_train_minus_av[1].reshape(50,50), cmap = cm.Greys_r)
plt.show()
plt.imshow(features_test[1].reshape(50,50), cmap = cm.Greys_r)
plt.show()
```

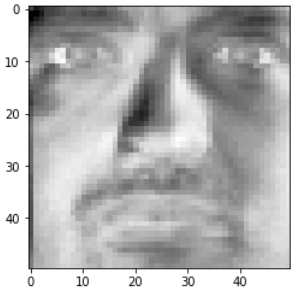
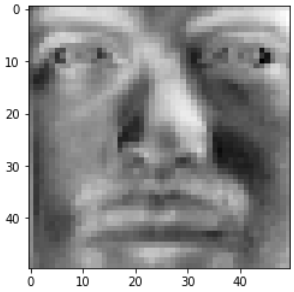
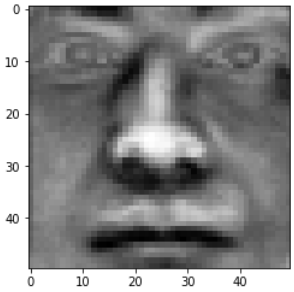
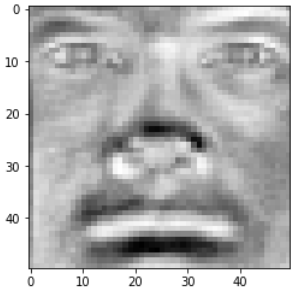
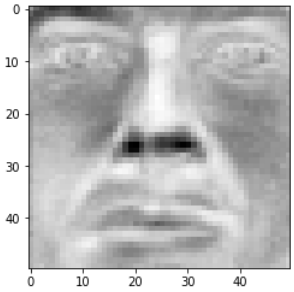




In [15]:
```
# Part 1(e)
u_train, s_train, vh_train = np.linalg.svd(features_train_minus_av) #,compute_uv=True)

for i in range(11):
    plt.imshow(vh_train[i].reshape(50,50), cmap = cm.Greys_r)
    plt.show()
```

In [16]:
```
s_train_diag= np.diag(s_train)
# print (s_train_diag)
```

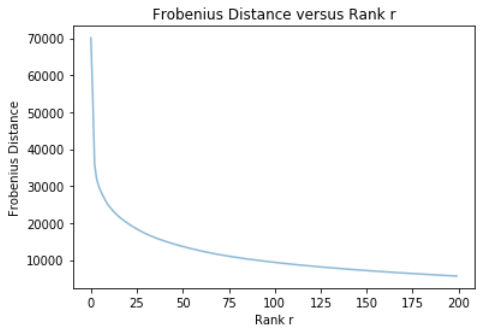
In [17]:
```
r = 200
X_pred_r = np.empty([r,540,2500])
F_dist = np.empty(r)

for i in range(0,r):
    X_pred_r[i] = np.linalg.multi_dot  ([   u_train[:,:i], s_train_diag[:i,:i]  ,  vh_train[:i,:] ])
    F_dist[i] =   np.linalg.norm(features_train_minus_av-X_pred_r[i])

#     plt.imshow(X_pred_r[i].reshape(540,50,50)[0], cmap = cm.Greys_r)
#     plt.show()

# print(F_dist)

plt.plot(np.arange(r),F_dist, alpha=0.5)
plt.title('Frobenius Distance versus Rank r')
plt.xlabel('Rank r')
plt.ylabel('Frobenius Distance')
plt.show()
```



In [18]:
```
print(vh_train.shape)
```

```
(2500, 2500)
```

In [19]:
```
r = 10

F_train = np.dot(features_train_minus_av , np.transpose(vh_train[:r,:]))
print(F_train.shape)

F_test = np.dot(features_test_minus_av , np.transpose(vh_train[:r,:]))
print(F_test.shape)
```

```
(540, 10)
(100, 10)
```

In [20]:
```
print((vh_train[:1,:].shape))
```

```
(1, 2500)
```

In [37]:
```
accu_r = []
for r in range(1,200):

#   This is obtained by multiplying the training feature array by the transpose of the fisrt r rows of vh_train
    F_train = np.dot(features_train_minus_av , np.transpose(vh_train[:r,:]))
    F_test =  np.dot(features_test_minus_av  , np.transpose(vh_train [:r,:]))


    #solver='liblinear',

   # solver : str, {‘newton-cg’, ‘lbfgs’, ‘liblinear’, ‘sag’, ‘saga’}, optional (default=’liblinear’).
    clf = LogisticRegression(solver='lbfgs', multi_class='ovr', max_iter=10000).fit(F_train, labels_train) #labels_train_ovr_face)



    print("For rank equal to",r, "accuracy is",round(clf.score(F_test, labels_test)*100),"%.")
    accu_r.append(clf.score(F_test, labels_test)*100)

accu_r = np.array(accu_r)
plt.plot(np.arange(len(accu_r)),accu_r, alpha=0.5)
plt.title('Model Accuracy versus Rank r')
plt.xlabel('Rank r')
plt.ylabel('Model Accuracy')
plt.show()
```

```
For rank equal to 1 accuracy is 15.0 %.
For rank equal to 2 accuracy is 10.0 %.
For rank equal to 3 accuracy is 14.0 %.
For rank equal to 4 accuracy is 19.0 %.
For rank equal to 5 accuracy is 41.0 %.
For rank equal to 6 accuracy is 38.0 %.
For rank equal to 7 accuracy is 51.0 %.
For rank equal to 8 accuracy is 64.0 %.
For rank equal to 9 accuracy is 72.0 %.
For rank equal to 10 accuracy is 80.0 %.
For rank equal to 11 accuracy is 81.0 %.
For rank equal to 12 accuracy is 82.0 %.
For rank equal to 13 accuracy is 85.0 %.
For rank equal to 14 accuracy is 87.0 %.
For rank equal to 15 accuracy is 90.0 %.
For rank equal to 16 accuracy is 86.0 %.
For rank equal to 17 accuracy is 87.0 %.
For rank equal to 18 accuracy is 88.0 %.
For rank equal to 19 accuracy is 85.0 %.
For rank equal to 20 accuracy is 86.0 %.
For rank equal to 21 accuracy is 87.0 %.
For rank equal to 22 accuracy is 89.0 %.
For rank equal to 23 accuracy is 87.0 %.
For rank equal to 24 accuracy is 91.0 %.
For rank equal to 25 accuracy is 92.0 %.
For rank equal to 26 accuracy is 88.0 %.
For rank equal to 27 accuracy is 91.0 %.
For rank equal to 28 accuracy is 89.0 %.
For rank equal to 29 accuracy is 88.0 %.
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For rank equal to 31 accuracy is 92.0 %.
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```

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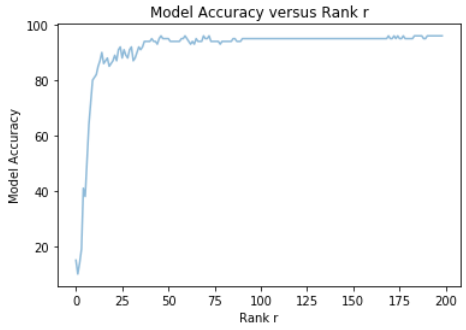
For rank equal to 199 accuracy is 96.0 %.
```



In [ ]: