Question 1

Question 1(a):

[[8. 1. 9. 6.]

[8. 9. 7. 0.]

[6. 0. 7. 5.]]

Question 1(b):

[[1. 3. 9. 2.]]

Question 1(c):

[[8. 1.]

[9. 6.]

[8. 9.]

[7. 0.]

[6. 0.]

[7. 5.]]

Question 1(d):

[[9. 4. 18. 8.]

[9. 12. 16. 2.]

[7. 3. 16. 7.]]

Question 1(e):

[1. 3. 9. 2.]

Question 1(f):

[[1. 3. 9. 2.]

[8. 9. 7. 0.]

[6. 0. 7. 5.]]

Question 1(g):

[[1. 3. 9. 2.]

[5. -3. -2. 3.]

[6. 0. 7. 5.]]

Question 1(h):

[[1. 3. 9.]

[5. -3. -2.]

[6. 0. 7.]]

Question 1(i):

[[1. 9.]

[5. -2.]

[6. 7.]]

Question 1(j):

-3.0

Question 1(k):

[3.75 0.75 4.5]

Question 1(l):

[[0.54030231 -0.9899925 -0.91113026 -0.41614684]

[0.28366219 -0.9899925 -0.41614684 -0.9899925]

[0.96017029 1.   0.75390225 0.28366219]]

Question 1(m):

[144. 0. 196. 100.]

Question 1(n):

[[95. -16. 79.]

 [-16. 47. 31.]

 [79. 31. 110.]]

Question 1(o):

52.666666666666664

Question 2

Question 2(d):

Running mymeasure(200, 400)

Execution time of custom multiply: 7.96399998665

Execution time of numpy.matmul: 0.00699996948242

Magnitude of the difference matrix: 1.92478182726e-07

Running mymeasure(1000, 2000)

Execution time of custom multiply: 995.598999977

Execution time of numpy.matmul: 0.0490000247955

Magnitude of the difference matrix: 5.01945905853e-05

Question 4

Question 4(b):

6 basis functions

Question 4(e):

Fit a function to training data using 5 basis functions

err_train

3.7636572180389933

err_test

6.170547828093

Question 4(f):

Fit a function to training data using 12 basis functions

err_train

1.9591614236322783

err_test

7.227975525385414

Question 4(g):

Fit a function to training data using 19 basis functions

err_train

1.3948000525377007e-06

err_test

137.8902697195645

Question 5

Question 5(b):

Fit a function to training data using gamma = 10^-9 and 19 basis functions

err_train

2.310121252531775

err_val

5.425038261828897

err_test

5.443698582591634

Question 5(c):

Fit a function to training data using gamma = 0 and 19 basis functions

err_train

7.587993218891775e-07

err_val

10.184466774501317

err_test

13.447253516886988

Question 5(d):

Find the best gamma value

optimal value of gamma:

0.0001

optimal value of w_0:

19.560254440103737

err_train for the optimal values of gamma and w:

3.906186529946704

err_val for the optimal values of gamma and w:

4.152462251834987

err_test for the optimal values of gamma and w:

5.976882149326241

Question 6

Question 6(d):

Fit a function to data with least squares regression based on gradient descent

final training error:

5.248250157293745

final testing error:

9.92920111521361

training and test errors for myfit_reg:

386.509740291545

400.62906202367424

difference in training errors for gradient descent and myfit_reg:

381.26149013425123

difference in testing errors for gradient descent and myfit_reg:

390.6998609084606

learning rate:

0.001