Question 1

Question 1(a):
[[0.49241486 0.75239824 0.67606395]
 [0.50275673 0.37619258 0.00279037]
 [0.80117437 0.48985495 0.57285682]
 [0.40931682 0.56693066 0.04106205]]

Question 1(b):
[[0.43579684]
 [0.60612126]
 [0.17501898]
 [0.84358646]]

Question 1(c):
[[0.49241486 0.75239824 0.67606395 0.50275673 0.37619258 0.00279037]
 [0.80117437 0.48985495 0.57285682 0.40931682 0.56693066 0.04106205]]

Question 1(d):
[[0.9282117 1.18819508 1.11186079]
 [1.10887799 0.98231384 0.60891163]
 [0.97619335 0.66487393 0.7478758]
 [1.25290328 1.41051712 0.88464851]]

Question 1(e):
[0.43579684 0.60612126 0.17501898 0.84358646]

Question 1(f):
[[0.43579684 0.75239824 0.67606395]
 [0.60612126 0.37619258 0.00279037]
 [0.17501898 0.48985495 0.57285682]
 [0.84358646 0.56693066 0.04106205]]

Question 1(g):
[[1.11186079 0.75239824 0.67606395]
 [0.60891163 0.37619258 0.00279037]
 [0.7478758 0.48985495 0.57285682]
 [0.88464851 0.56693066 0.04106205]]

Question 1(h):
[[1.11186079 0.75239824]

```
 [0.60891163 0.37619258]
 [0.7478758  0.48985495]
 [0.88464851 0.56693066]]
```

Question 1(i):
```
[0.60891163 0.37619258 0.00279037]
[0.88464851 0.56693066 0.04106205]
```

Question 1(j):
```
[3.35329674 2.18537643 1.29277319]
```

Question 1(k):
```
[1.11186079 0.60891163 0.7478758  0.88464851]
```

Question 1(l):
```
0.5692871962413104
```

Question 1(m):
```
[[  0.21207001  -0.56897905  -0.7829352 ]
 [ -0.99216426  -1.95530818 -11.76316258]
 [ -0.58103673  -1.4272919   -1.11423895]
 [ -0.24512974  -1.13503655  -6.38534173]]
```

Question 1(n):
```
[[1.73078967]
 [1.11990004]
 [0.43121804]]
```


Question 2 a)

Question 2 b)

Question 2 c) N=200
```
0.00139498710632 seconds for Cube1 using numpy
13.2935760021 seconds for Cube2 using loops
Magnitude of the difference is3.5652192309498787e-10
```

Question 2 c) N=2000

IT TOOK AROUND 2.5 hours!!!

Question 4

Best Fitting Function:
Optimal value of M = 8

Optimal value of w = [[-61.53882763]
[-10549.5556656]
[4063.78680234]
[16096.66588129]
[-6484.81659136]
[1311.64720066]
[9698.18002229]
[-13217.21905889]
[-776.23779436]]

Training Error of Optimal Value of M and w :2.18847416521

Testing Error of Optimal Value of M and w :7.12818038225

Training error is indeed less than test error.

Question 5
Best Fitting Function:
Optimal value of alpha = 0.01

Optimal value of w = [-54.00925081 6.86609108 2.13415301 15.60406784 8.4904623
14.11255525 6.71531265 15.41208278 10.05519171 -1.05068362
5.83225073 16.41405537 18.42321933 18.46844516 5.19156131
2.34580555]

Training Error of Optimal Value of alpha and w :3.8656997219

Validation Error of Optimal Value of alpha and w :6.0118079848

Testing Error of Optimal Value of alpha and w : 10.2899664701

The errors are indeed training error < validation error < test error

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Question 6
Mean of training Errors: 9.02960784771
Mean of Validation Errors: 15.6287508713
Mean Validation Error is indeed greater than the mean training error
Optimal value of alpha: 0.001
Optimal value of w: [-91.32602884 12.41614446 1.87527228 12.64489594 3.97954826
9.94328836 39.91288144 22.96089514 21.41025701 23.28780368
15.03058045 13.24517731 22.55966693 -1.43741966 4.97397645
40.24816179]
Testing Error: 6.90256852305
Training Error: 2.51409788257

Mean Validation Error: 30.3733980352
Question 7

Optimal w:[-54.00923223 6.86608902 2.13415233 15.60406712 8.49046416
 14.11254968 6.71531101 15.41208098 10.05518514 -1.05068938
  5.83223619 16.41404581 18.42321599 18.46844225 5.19156209
  2.34580498]

Training error: 3.8657004454924415

Test Error: 10.289966675669232

w2: [-54.00925081 6.86609108 2.13415301 15.60406784 8.4904623
 14.11255525 6.71531265 15.41208278 10.05519171 -1.05068362
  5.83225073 16.41405537 18.42321933 18.46844516 5.19156131
  2.34580555]

Manitude of the difference: 7.90621829969e-10

Learning Rate: 0.01

Value of alpha: 0.01

Process finished with exit code 0