Question 3

Question 3 part a and b

```
import numpy as np
import matplotlib.pyplot as plt

gauss = np.random.multivariate_normal(np.zeros(3), np.eye(3), size=10000); gauss
```

```
array([[-0.35055601,  1.0027236 ,  1.0417066 ],
       [ 0.61468679, -0.89185592, -0.75633552],
       [ 0.36373892, -0.6392462 ,  1.18210459],
       ...,
       [-0.53036724, -2.61728161,  1.78560162],
       [ 0.9046675 ,  0.79831417,  0.75105474],
       [ 2.36443303,  0.30009514, -1.08709845]])
```

```
gauss.shape
```

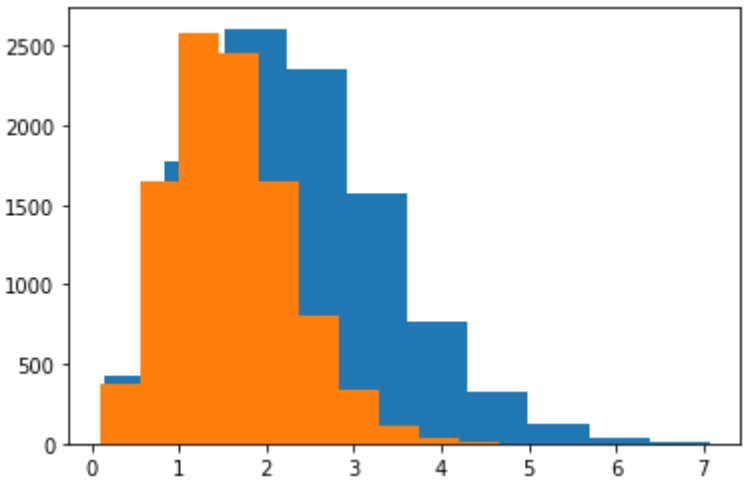
```
(10000, 3)
```

```
l1_norms = list()
l2_norms = list()
for i in range(0, 10000):
  vec = gauss[i]
  l1 = np.linalg.norm(vec, 1)
  l2 = np.linalg.norm(vec, 2)
  l1_norms.append(l1)
  l2_norms.append(l2)

print(l1_norms)
print(len(l1_norms))
print(l2_norms)
print(len(l2_norms))


```

```
[2.3949862130821806, 2.2628782282461373, 2.185089710401776, 0.7118649284592974, 1.206
10000
[1.4877825023577225, 1.3210943368544905, 1.3922330855321816, 0.4226718024134472, 0.80
10000
```

```
plt.hist(l1_norms)
plt.hist(l2_norms)
```

```
(array([ 378., 1643., 2581., 2457., 1648.,  806.,  340.,  111.,   29.,
          7.]),
 array([0.09186081, 0.54846765, 1.00507448, 1.46168132, 1.91828815,
        2.37489498, 2.83150182, 3.28810865, 3.74471549, 4.20132232,
        4.65792916]),
 <a list of 10 Patch objects>)
```




```
l1_norm_mean = np.mean(l1_norms)
l2_norm_mean = np.mean(l2_norms)

l1_norm_std = np.std(l1_norms)
l2_norm_std = np.std(l2_norms)
```

```
print(l1_norm_mean)
print(l2_norm_mean)
print(l1_norm_std)
print(l2_norm_std)
```

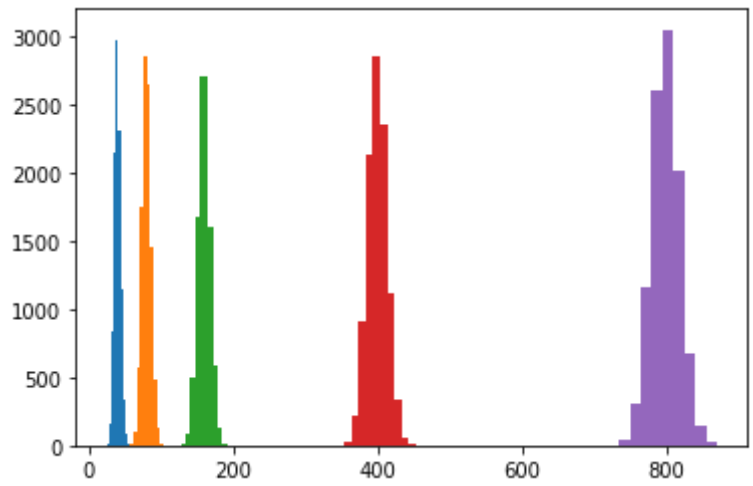
```
2.3930708541699315
1.593065365605574
1.050126995542834
0.6793944281492451
```

Question 3 part c

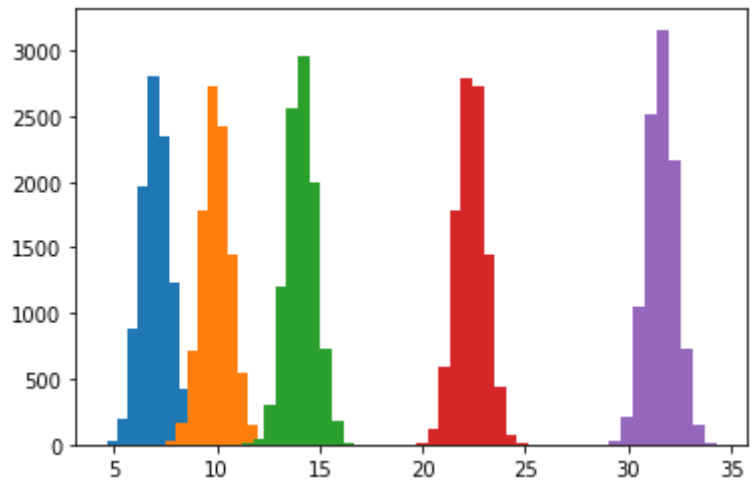
```
d_values = [50, 100, 200, 500, 1000]
all_l1_norms = list()
all_l2_norms = list()
for i in d_values:
  gauss = np.random.multivariate_normal(np.zeros(i), np.eye(i), size=10000)
  l1_norms = list()
  l2_norms = list()
  for i in range(0, 10000):
    vec = gauss[i]
    l1 = np.linalg.norm(vec, 1)
    l2 = np.linalg.norm(vec, 2)
    l1_norms.append(l1)
    l2_norms.append(l2)

  all_l1_norms.append(l1_norms)
```

```
15   all_l1_norms.append(l1_norms)
16   all_l2_norms.append(l2_norms)
17
```

```
1 for i in all_l1_norms:
2   plt.hist(i)
```




```
1 for i in all_l2_norms:
2   plt.hist(i)
```

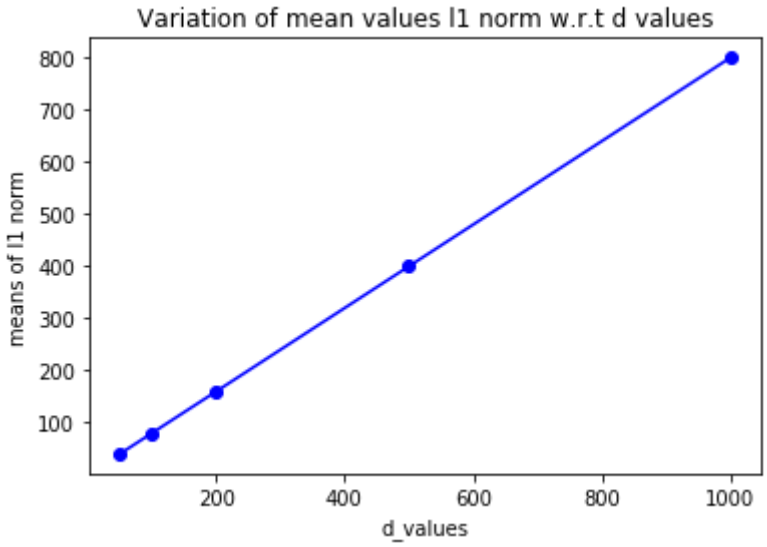



```
1 all_l1_norm_means = list()
2 all_l2_norm_means = list()
3 all_l1_norm_std = list()
4 all_l2_norm_std = list()
5
6 for i in all_l1_norms:
7   all_l1_norm_means.append(np.mean(i))
8   all_l1_norm_std.append(np.std(i))
9
10 for i in all_l2_norms:
11   all_l2_norm_means.append(np.mean(i))
12   all_l2_norm_std.append(np.std(i))
```

```
1 # plt.scatter(d_values, all_l1_norm_means)
2 plt.plot(d_values, all_l1_norm_means,'bo-',markevery=1)
3 plt.title('Variation of mean values l1 norm w.r.t d values')
```

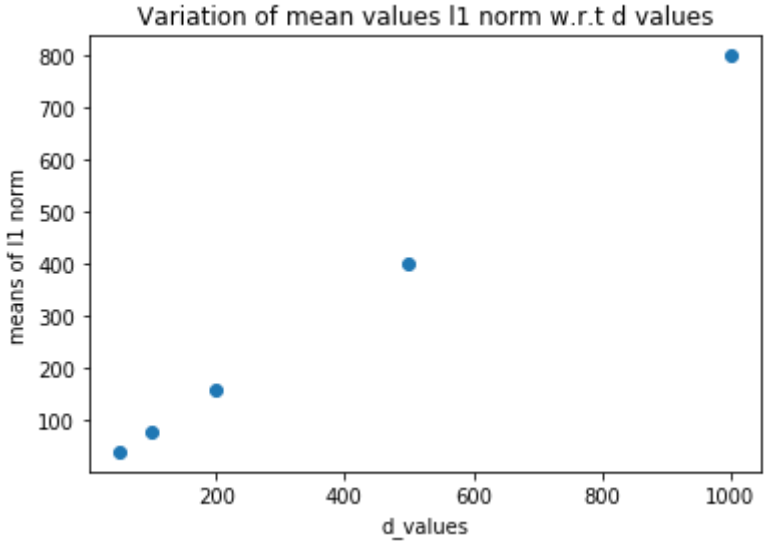
```
plt.title('Variation of mean values l1 norm w.r.t d values')
plt.xlabel('d_values')
plt.ylabel('means of l1 norm')
```

```
Text(0, 0.5, 'means of l1 norm')
```



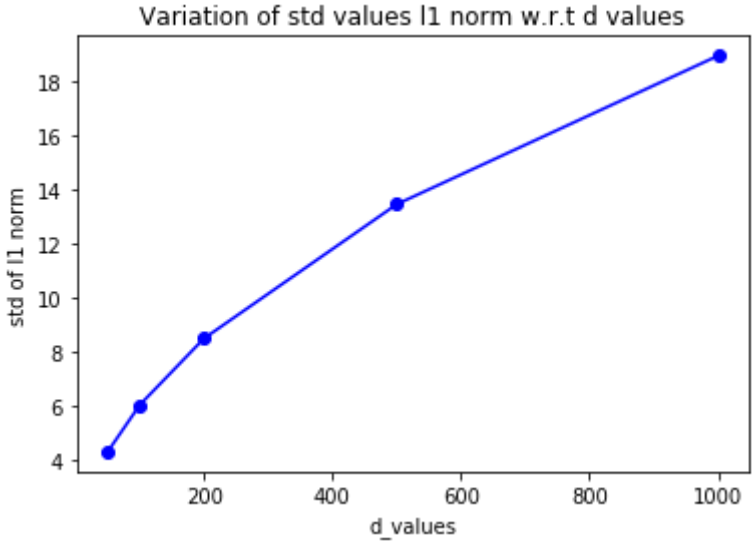

```
plt.scatter(d_values, all_l1_norm_means)
# plt.plot(d_values, all_l1_norm_means,'bo-',markevery=1)
plt.title('Variation of mean values l1 norm w.r.t d values')
plt.xlabel('d_values')
plt.ylabel('means of l1 norm')
```

```
Text(0, 0.5, 'means of l1 norm')
```



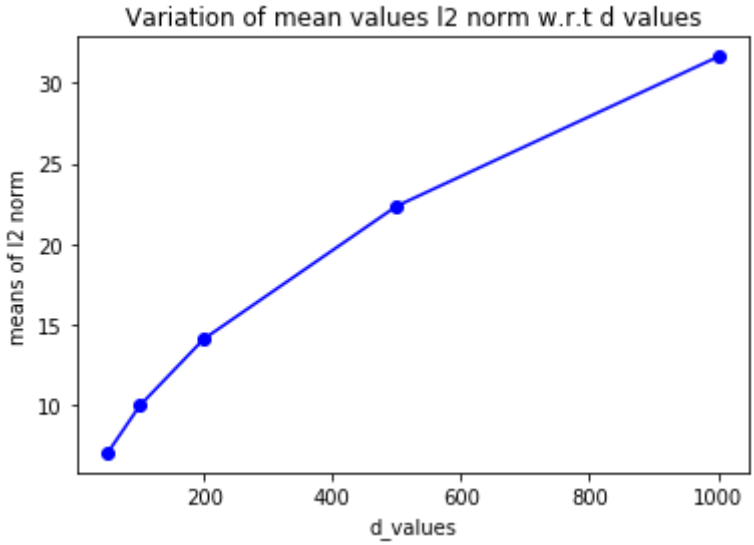

```
# plt.scatter(d_values, all_l1_norm_std)
plt.plot(d_values, all_l1_norm_std,'bo-',markevery=1)
plt.title('Variation of std values l1 norm w.r.t d values')
plt.xlabel('d_values')
plt.ylabel('std of l1 norm')
```

```
Text(0, 0.5, 'std of l1 norm')
```



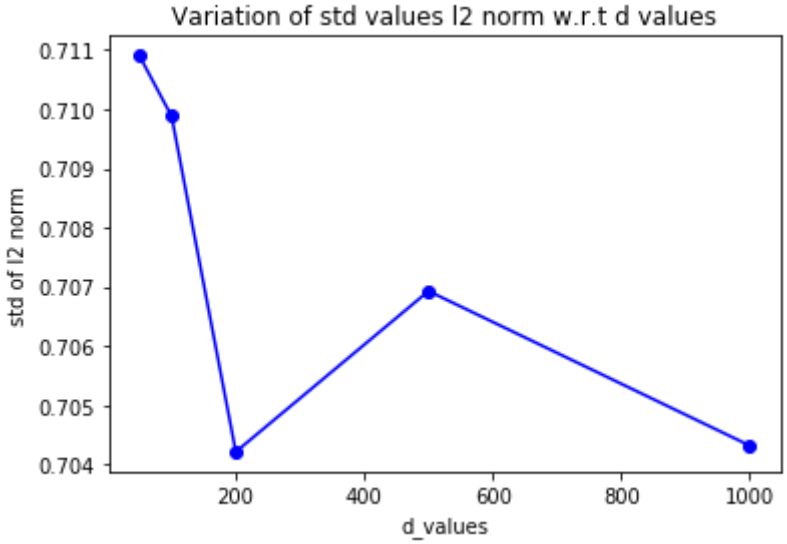

```
1 # plt.scatter(d_values, all_l2_norm_means)
2 plt.plot(d_values, all_l2_norm_means,'bo-',markevery=1)
3 plt.title('Variation of mean values l2 norm w.r.t d values')
4 plt.xlabel('d_values')
5 plt.ylabel('means of l2 norm')
```

```
Text(0, 0.5, 'means of l2 norm')
```



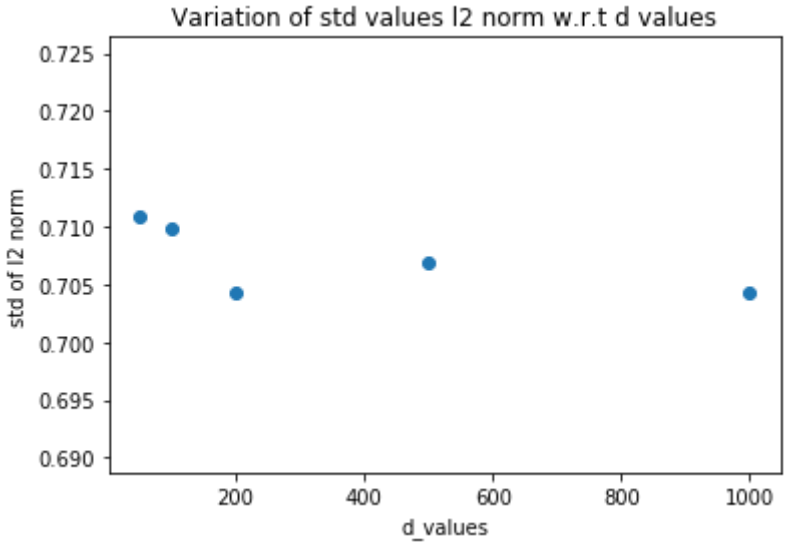

```
1 # plt.scatter(d_values, all_l2_norm_std)
2 plt.plot(d_values, all_l2_norm_std,'bo-',markevery=1)
3 plt.title('Variation of std values l2 norm w.r.t d values')
4 plt.xlabel('d_values')
5 plt.ylabel('std of l2 norm')
```

```
Text(0, 0.5, 'std of l2 norm')
```




```
1 plt.scatter(d_values, all_l2_norm_std)
2 # plt.plot(d_values, all_l2_norm_std,'bo-',markevery=1)
3 plt.title('Variation of std values l2 norm w.r.t d values')
4 plt.xlabel('d_values')
5 plt.ylabel('std of l2 norm')
```

```
Text(0, 0.5, 'std of l2 norm')
```



Part d

From the plots of part c we can conclude the following, 1) Mean of L1 norm varies linearly w.r.t inc
norm varies almost linearly w.r.t increase in d values 3) Mean of L2 norm varies almost linearly w.r
of L2 norm does not vary much with the increase in d values. Which means even if the number of
norm do not vary by a significant amount.

1