In [1]:
```
# Kaushal Banthia
# 19CS10039
# Question 3
```

In [2]:
```
import numpy as np
import matplotlib.pyplot as plt
import random
```

In [3]:
```
points = 10000
```

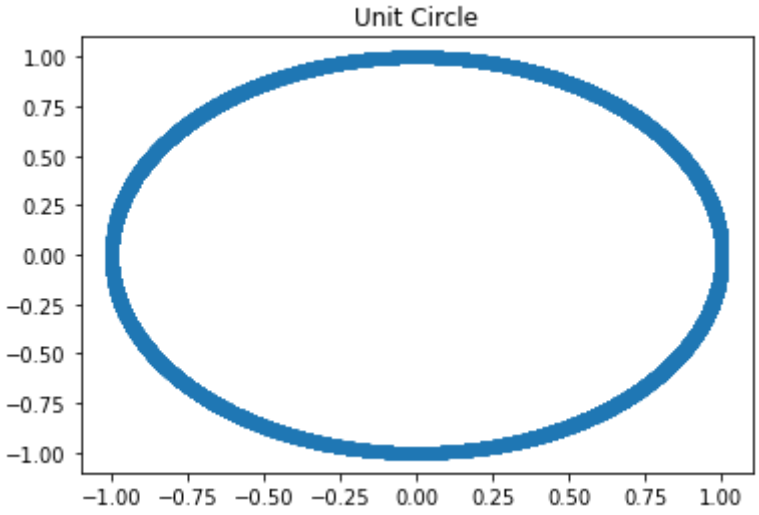
In [4]:
```
def plot_3_dimensions(A, title, x):
    b = np.matmul(A, x) # this is the ellipsoid
    ax = plt.axes(projection ='3d')
    ax.set_title(title)
    ax.scatter(b[0], b[1], b[2])
    plt.show()
```

In [5]:
```
def plot_2_dimensions(A, title, x):
    b = np.matmul(A, x) # this is the ellipsoid
    plt.plot(b[0], b[1], 'o')
    plt.title(title)
    plt.show()
```

In [15]:
```
def cond(A):
    return np.linalg.cond(A)

def determinant(A):
    return np.linalg.det(A)
```

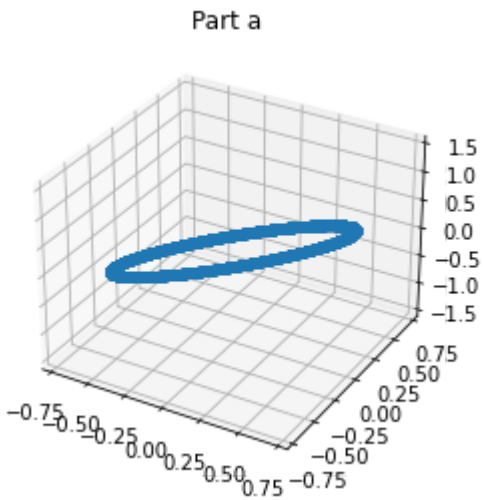
In [7]:
```
# Unit Circle
x = np.ndarray((2,points),dtype = np.float64)

pi = np.pi

for i in range(points):
    angle = random.uniform(0,2*pi)
    x[0][i] = np.cos(angle)
    x[1][i] = np.sin(angle)

print("x-coordinates:")
print(x[0])
print("y-coordinates:")
print(x[1])

plt.plot(x[0], x[1], 'o')
plt.title('Unit Circle')
plt.show()
```

```
x-coordinates:
[ 0.64255723 -0.99462456  0.90241063 ... -0.95829686  0.69911591
  0.20757907]
y-coordinates:
[-0.76623769 -0.10354702  0.43087709 ...  0.28577461 -0.71500835
 -0.97821824]
```



In [17]:

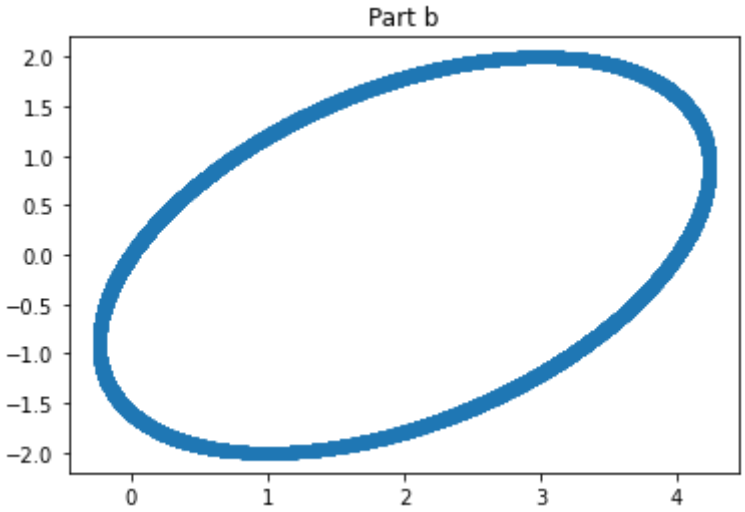
```
# a

# Rectangle Matrix (m != n)
A = np.array([
    [-1/np.sqrt(2),0],
    [0,-1/np.sqrt(2)],
    [-1,1]
])
plot_3_dimensions(A, "Part a", x)

print("Condition Number of matrix: ", cond(A))
```




```
Condition Number of matrix:  2.23606797749979
```

In [11]:

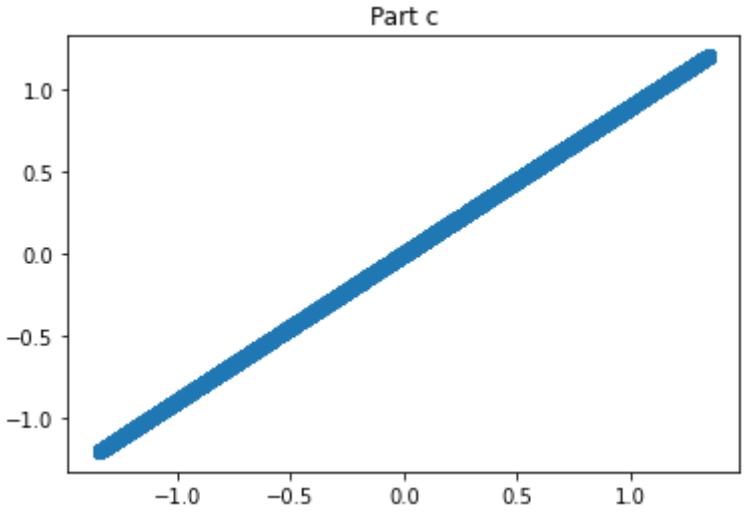
```
# b

# Rectangle Matrix (m != n)
B = np.array([
    [-2,1,2],
    [0,2,0]
])

x = np.vstack((x,np.ones((1,int(points)))))

plot_2_dimensions(B, "Part b", x)
x = np.delete(x,2,axis = 0)

print("Condition Number of matrix: ", cond(B))
```




```
Condition Number of matrix:  1.715010090561728
```

In [22]:

```
# c

# Square Matrix (m = n)
C = np.array([
    [1,0.9],
    [0.9,0.8]
])
plot_2_dimensions(C, "Part c", x)

print("Condition Number of matrix: ", cond(C))
print("Determinant of matrix: ", determinant(C))
if (determinant(C) == 0):
    print("Non Invertible Matrix")
else:
    print("Invertible Matrix")
```

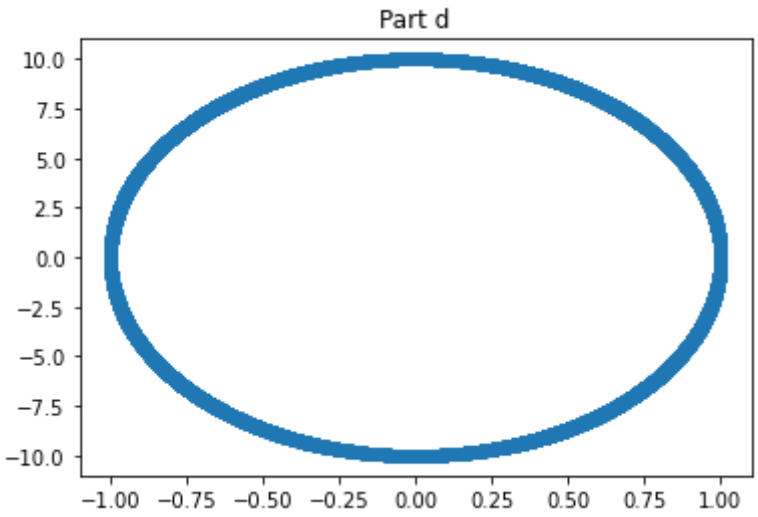



```
Condition Number of matrix:  325.99693248647924
Determinant of matrix:  -0.010000000000000004
Invertible Matrix
```

In [28]:

```
# d

# Square Matrix (m = n)
D = np.array([
    [1,0],
    [0,-10]
])
plot_2_dimensions(D, "Part d", x)
```

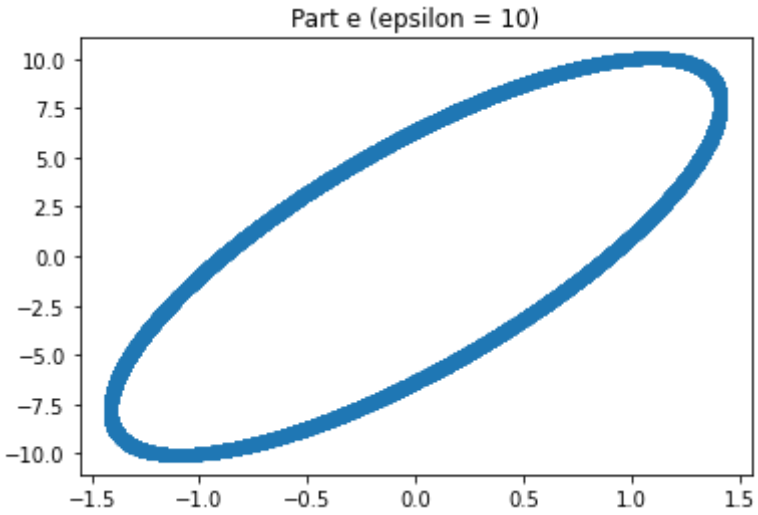
```
print("Condition Number of matrix: ", cond(D))
print("Determinant of matrix: ", determinant(D))
if (determinant(D) == 0):
    print("Non Invertible Matrix")
else:
    print("Invertible Matrix")
```




```
Condition Number of matrix:  10.0
Determinant of matrix:  -10.000000000000002
Invertible Matrix
```

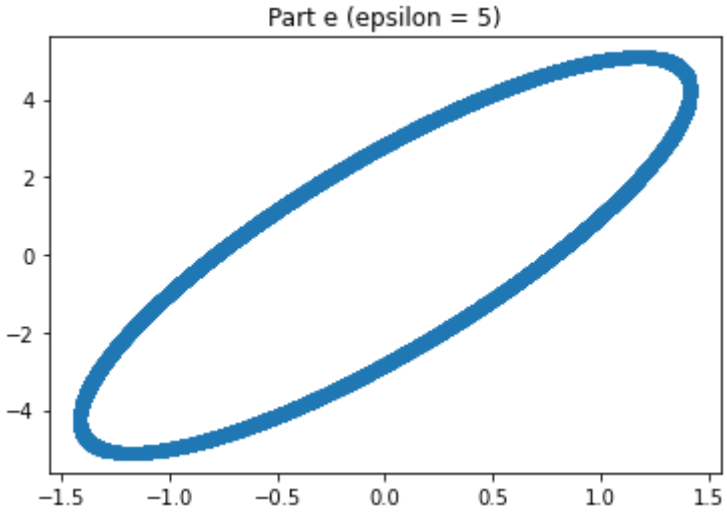
In [26]:

```
# e

epsilon = [10, 5, 1, 10**-1, 10**-2, 10**-4, 0]
for e in epsilon:
    # Square Matrix (m = n)
    E = np.array([
        [1,1],
        [1,e]
    ])
    plot_2_dimensions(E,"Part e (epsilon = "+str(e) + ")" , x)

    print("Condition Number of matrix: ", cond(E))
    print("Determinant of matrix: ", determinant(E))
    if (determinant(E) == 0):
        print("Non Invertible Matrix")
    else:
        print("Invertible Matrix")
```

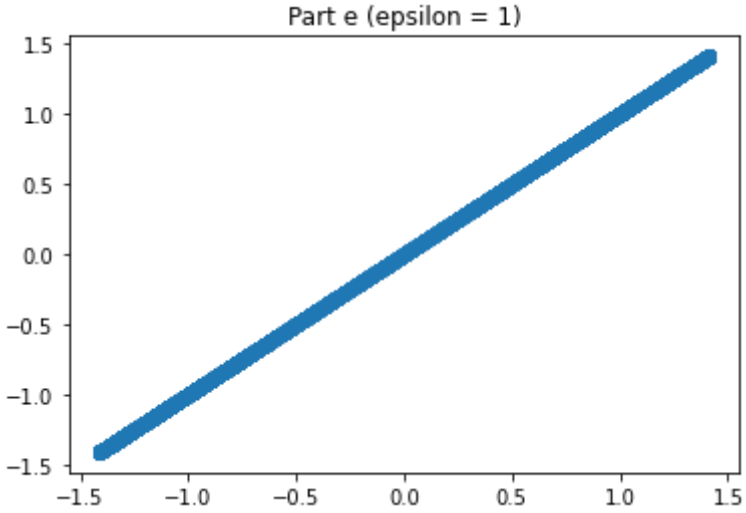



```
Condition Number of matrix:  11.35638827945676
```

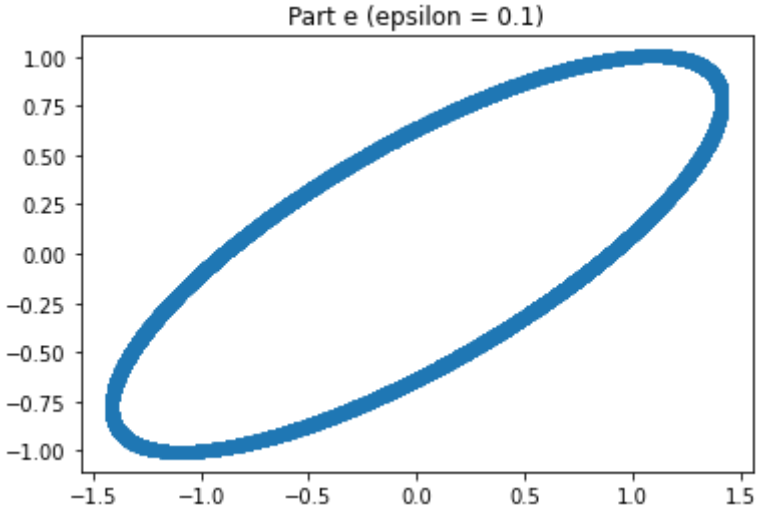
```
Determinant of matrix:  9.000000000000002
Invertible Matrix
```



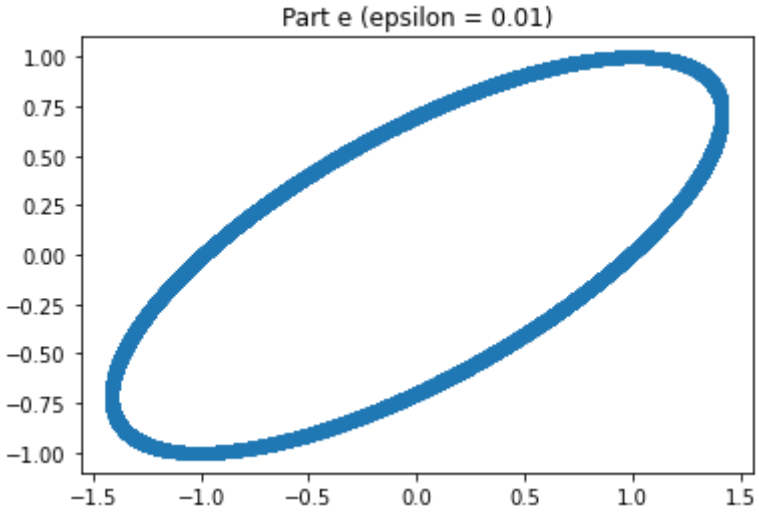

```
Condition Number of matrix:  6.854101966249685
Determinant of matrix:  4.0
Invertible Matrix
```



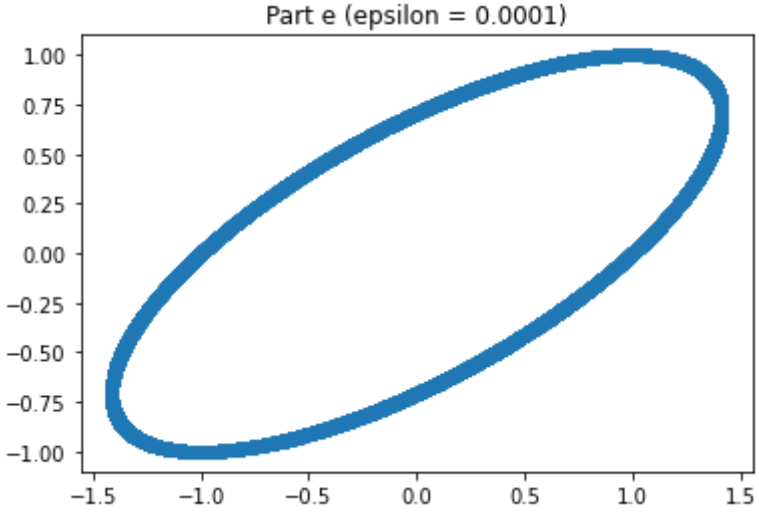

```
Condition Number of matrix:  inf
Determinant of matrix:  0.0
Non Invertible Matrix
```



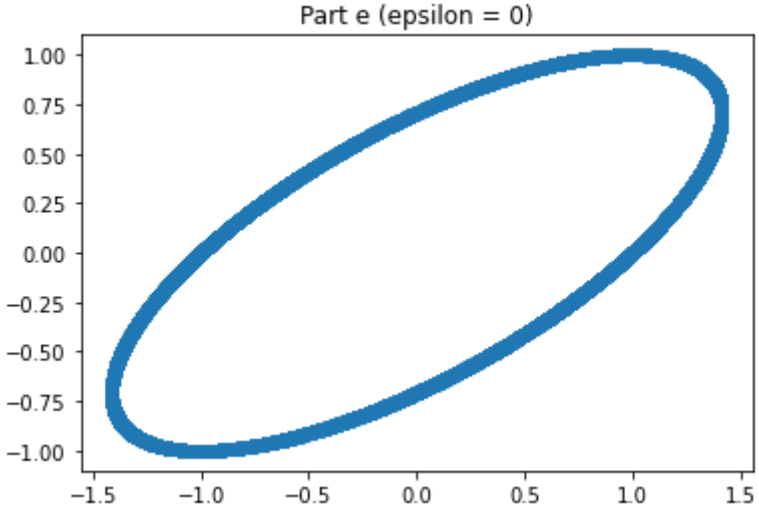

```
Condition Number of matrix:  3.0124935233004138
Determinant of matrix:  -0.9
Invertible Matrix
```




```
Condition Number of matrix:  2.6535504563252847
Determinant of matrix:  -0.99
Invertible Matrix
```




```
Condition Number of matrix:  2.618385273654826
Determinant of matrix:  -0.9999
Invertible Matrix
```




```
Condition Number of matrix:  2.6180339887498953
Determinant of matrix:  -1.0
Invertible Matrix
```

In [30]:
```
print("Yes there is a relation between the condition number and the determinant. Whe
```

```
Yes there is a relation between the condition number and the determinant. When the d
eterminant is 0, i.e, the matrix is non-invertible, then the condition number is inf
inite. Otherwise it is finite
```