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

Problem 1 Part A

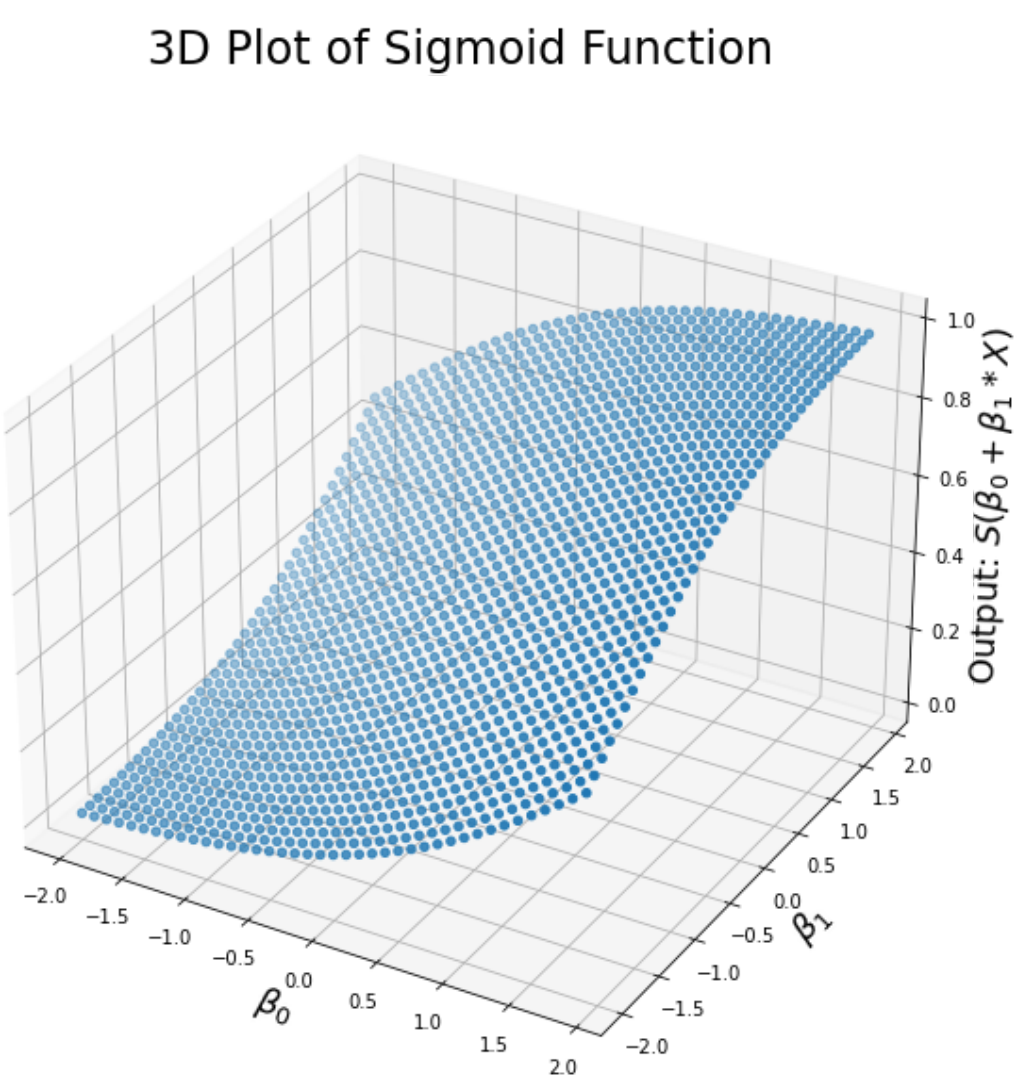
```
def sigmoid(x):
    return 1.0/(1.0 + np.exp(-x))
```

```
beta_0, beta_1 = np.mgrid[-2.0:2.0:0.1, -2.0:2.0:0.1]
```

```
X = 1
sigmoid_input_array = beta_0 + X * beta_1
output_array = sigmoid(sigmoid_input_array)
```

```
plt.rcParams['figure.figsize']=(10, 10)
fig = plt.figure()
ax = fig.add_subplot(projection='3d')
ax.scatter(beta_0, beta_1, output_array)

ax.set_title("3D Plot of Sigmoid Function", fontsize=24)
ax.set_xlabel(r'$\beta_0$', fontsize=18)
ax.set_ylabel(r'$\beta_1$', fontsize=18)
ax.set_zlabel(r'Output: $S(\beta_0 + \beta_1 * X)$', fontsize=18)
plt.savefig("q1_a.jpg")
plt.savefig("q1_a.png")
plt.show()
```



Problem 1 Part B

```
def log_likelihood(beta_0, beta_1, X, Y):
    return -np.log(1 + np.exp(-Y * (beta_0 + beta_1 * X)))
```

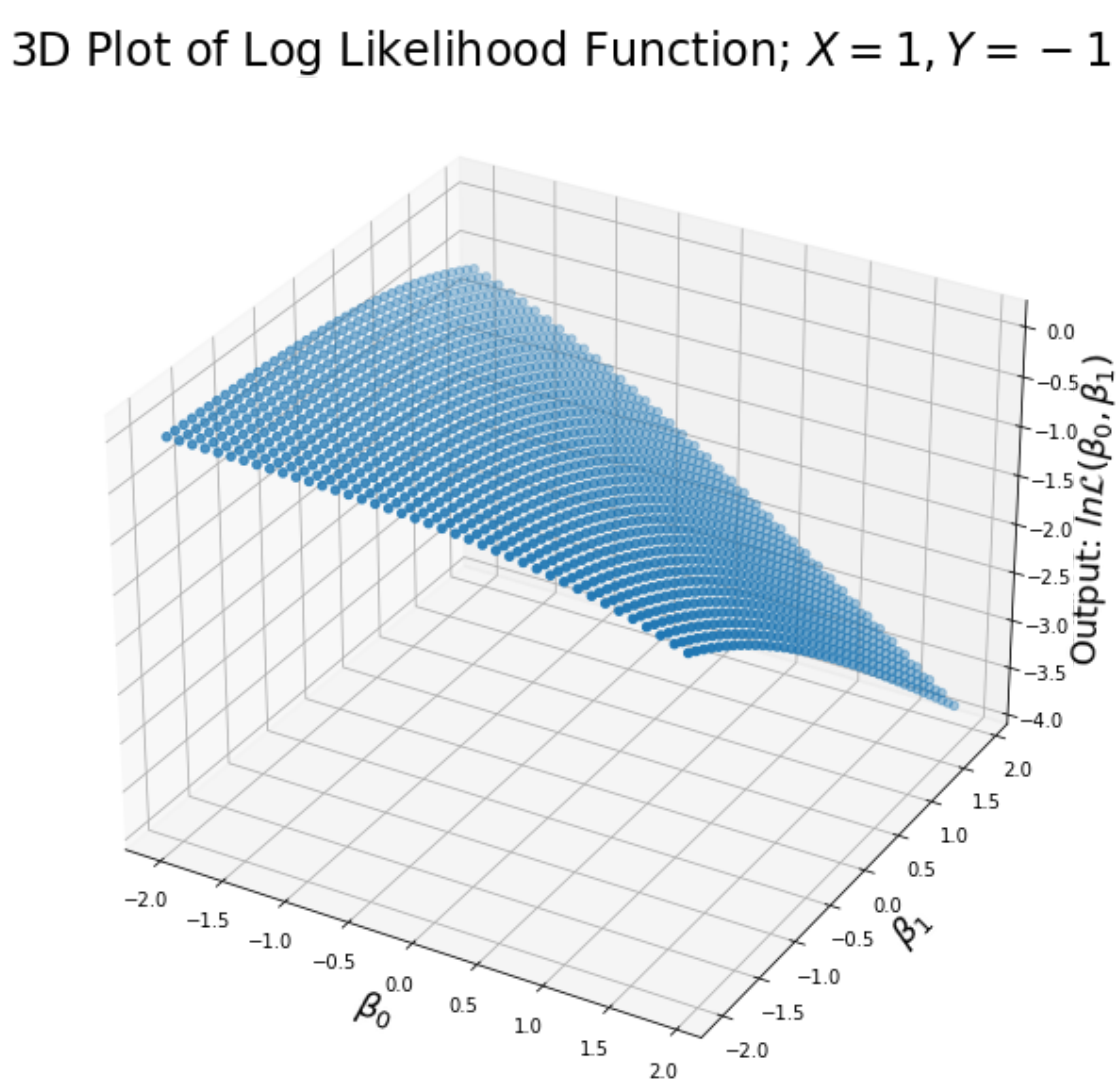
```
beta_0, beta_1 = np.mgrid[-2.0:2.0:0.1, -2.0:2.0:0.1]
```

Case 1: $X = 1, Y = -1$

```
X = 1.0
Y = -1.0
output_array = log_likelihood(beta_0, beta_1, X, Y)

plt.rcParams['figure.figsize']=(10, 10)
fig = plt.figure()
ax = fig.add_subplot(projection='3d')
ax.scatter(beta_0, beta_1, output_array)

ax.set_title(r"3D Plot of Log Likelihood Function; $X = 1, Y = -1$", fontsize=24)
ax.set_xlabel(r'$\beta_0$', fontsize=18)
ax.set_ylabel(r'$\beta_1$', fontsize=18)
ax.set_zlabel(r'Output: $ln \mathcal{L}(\beta_0, \beta_1)$', fontsize=18)
plt.savefig("q1_b1.jpg")
plt.savefig("q1_b1.png")
plt.show()
```

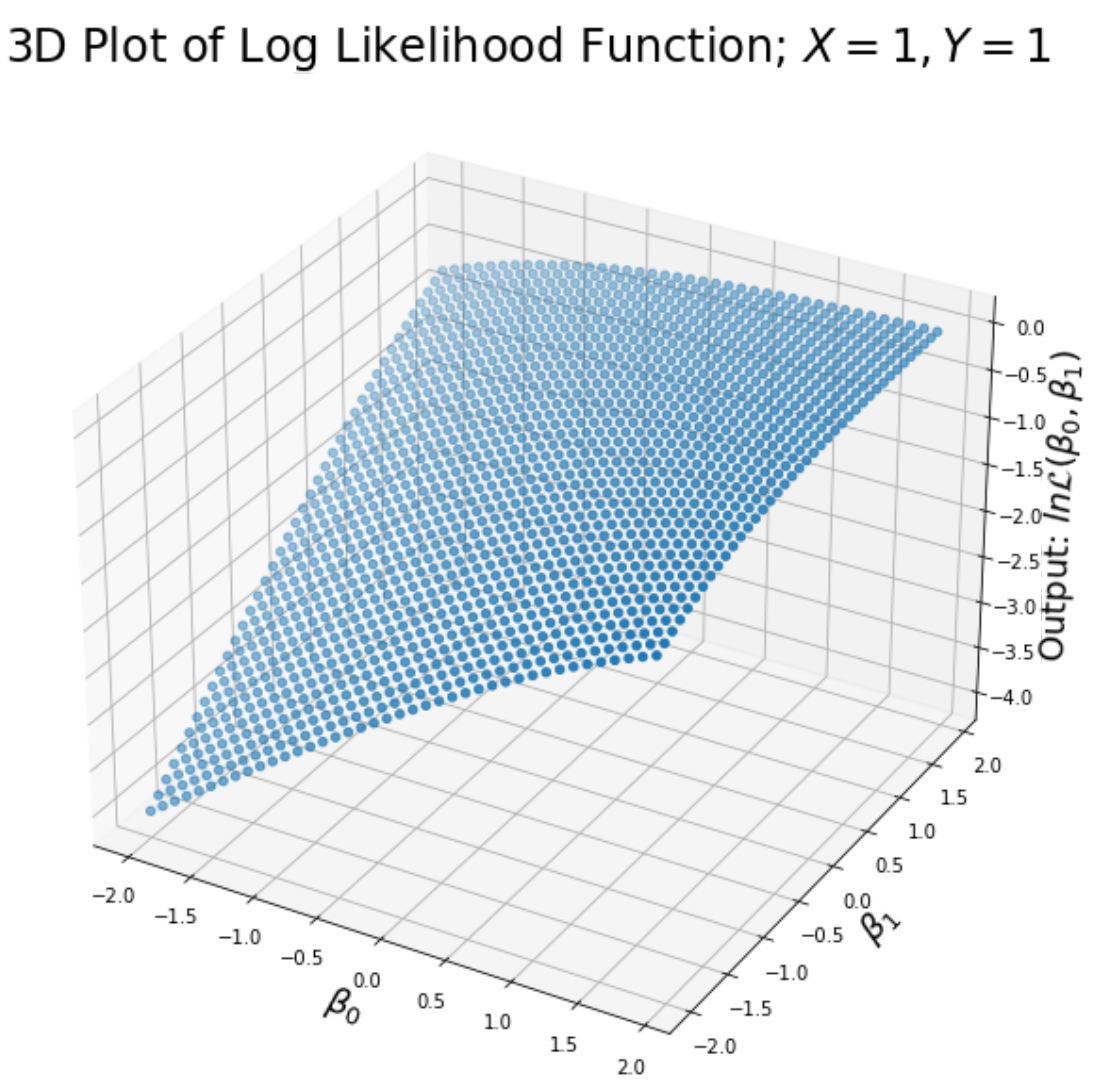


Case 2: $X = 1, Y = 1$

```
X = 1.0
Y = 1.0
output_array = log_likelihood(beta_0, beta_1, X, Y)

plt.rcParams['figure.figsize']=(10, 10)
fig = plt.figure()
ax = fig.add_subplot(projection='3d')
ax.scatter(beta_0, beta_1, output_array)

ax.set_title(r"3D Plot of Log Likelihood Function; $X = 1, Y = 1$", fontsize=24)
ax.set_xlabel(r'$\beta_0$', fontsize=18)
ax.set_ylabel(r'$\beta_1$', fontsize=18)
ax.set_zlabel(r'Output: $ln \mathcal{L}(\beta_0, \beta_1)$', fontsize=18)
plt.savefig("q1_b1.jpg")
plt.savefig("q1_b1.png")
plt.show()
```



Q: Based on the graph, is it possible to maximize this function?

A: Since the asymptote of this graph is not reachable (log likelihood of zero), we cannot truly maximize this function.

However, we do see that as β_0, β_1 approach their upper, the log likelihood increases.