# CS 5720: Design and Analysis of Algorithms
# Project#0 Report

Raja Kantheti

September 15, 2024

## 1 Introduction

**This project0 is made from Scratch.**
The goal is to get a visual proof of the orderr of growths of several functions through plotting the functions from smaller values to larger values and. by performing a limit test on functions, $f(x)$ and $g(x)$ and plotting the resultant to observe where the curve flattens out thus confirming the same order of growth.

## 2 About the code:

The code is written is Rust using the *plotly* library. The code is available in github in the src directory. The submitted source code is dependent on the plotly library and the binary works on x86_darwin architecture. Let me know if anyother architecture binary is needed and I can cross-compile it for you. If you can handle this yourself, you are welcome to clone the repository at the github link and compile and run using the following commands in terminal after navigating into *project0* directory.
See the following command :

```
$ cargo build && cargo run
```

## 3 Deliverable : 1

### 3.1 Functions:

$$f(n) = \frac{1}{2}n(n-1) + 10, g(n) = n^2$$

### 3.2 Results of plotting and how I Interpreted them:

Although it is not obvious with the smaller values of $n$, the plot of $f(n)$ and $g(n)$ for $n$ ranging from 1 to 10, as shown in Figure 1, shows that $f(n)$ and $g(n)$ has same rates of growth. when we plot the functions for $n$ ranging from 1 to

$10^6$, as shown in Figure 2, we can see that the functions have the same rate of growth as $n$ increases.

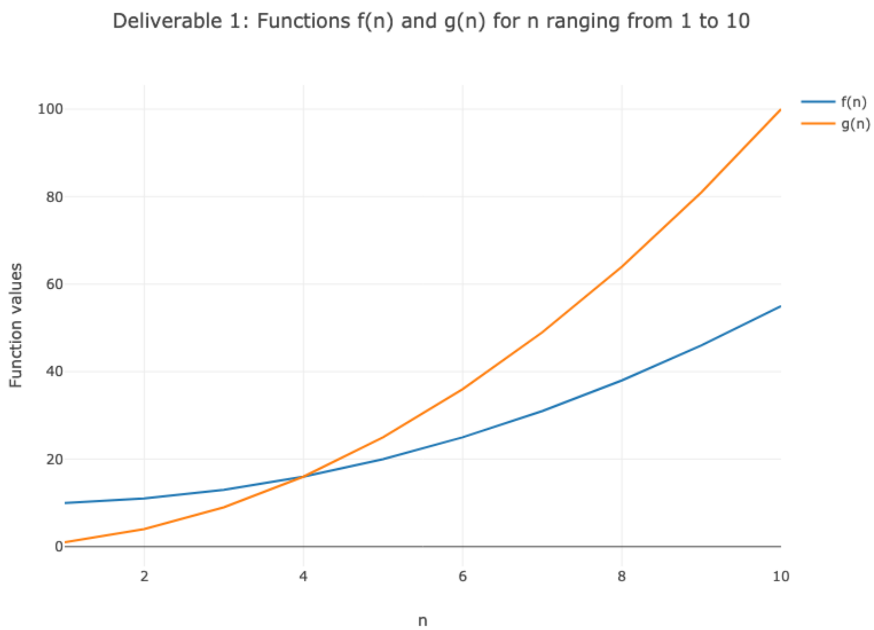


Figure 1: Plot of $f(n)$ and $g(n)$ for $n$ ranging from 1 to 10.

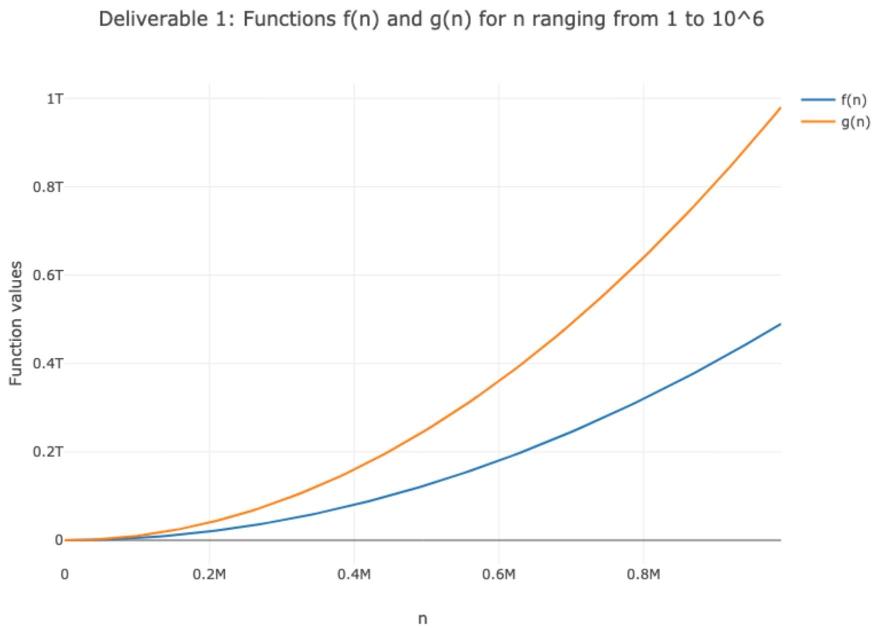


Figure 2: Plot of $f(n)$ and $g(n)$ for $n$ ranging from 1 to $10^6$.

# 4 Deliverable : 2(Limit Test over Deliverable 1:)

## 4.1 Functions:

$$f(n) = \frac{1}{2}n(n-1) + 10, g(n) = n^2$$

## 4.2 Results of plotting and how I Interpreted them:

I understand the limit test as how the ratio of the function scales as we approach infinity or a very large value.

It is limitedly obvious in the Figure 3 to see the curve flattening out. However, the plot of the ratio of $f(n)$ and $g(n)$ for $n$ ranging from 1 to $10^6$, as shown in Figure 4, For large values of $n$, or as $n$ approaches infinity, the values of the ratio flattens out which means the $\lim_{n\to\infty} \frac{f(n)}{g(n)}$ is a positive constant indicating the same order of growth for two functions.

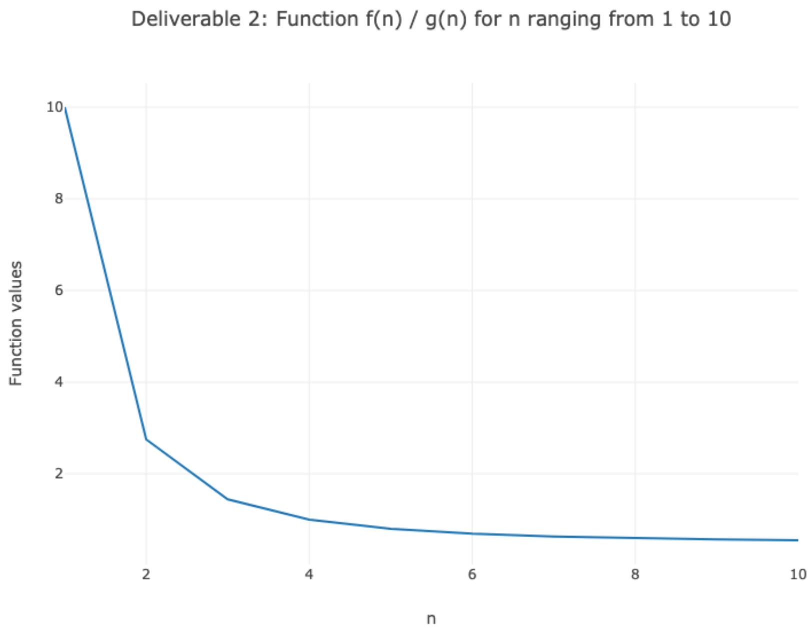


Figure 3: Plot of $\frac{f(n)}{g(n)}$ for $n$ ranging from 1 to 10.

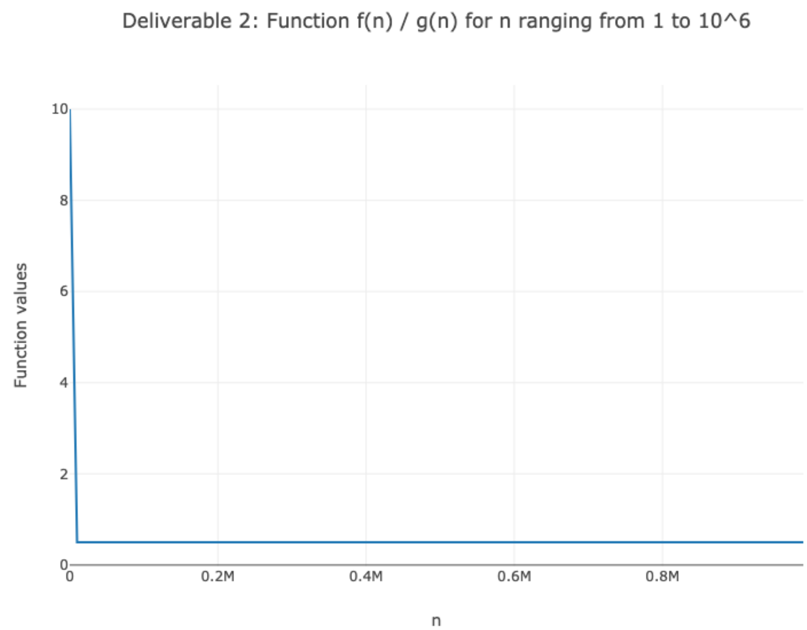


Figure 4: Plot of $\frac{f(n)}{g(n)}$ for $n$ ranging from 1 to $10^6$.

# 5 Deliverable : 3

## 5.1 Functions:

$f(n) = \sqrt{n^2 + 3n + 1}, g(n) = 5n^2$

## 5.2 Results of plotting and how I Interpreted them:

The function $g(n)$ grows faster than $f(n)$ as we can see in the Figure 5 and Figure 6. It is not clear in the graph that has the values from $1 to 10^6$ as I took the logarithmic scale along the axes to show the full scale.

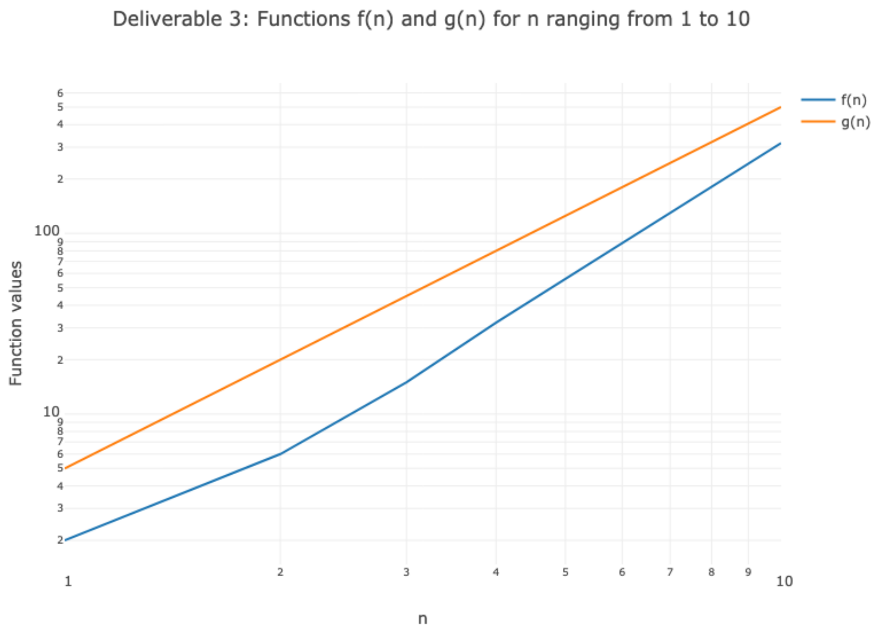


Figure 5: Plot of $f(n)$ and $g(n)$ for $n$ ranging from 1 to 10.

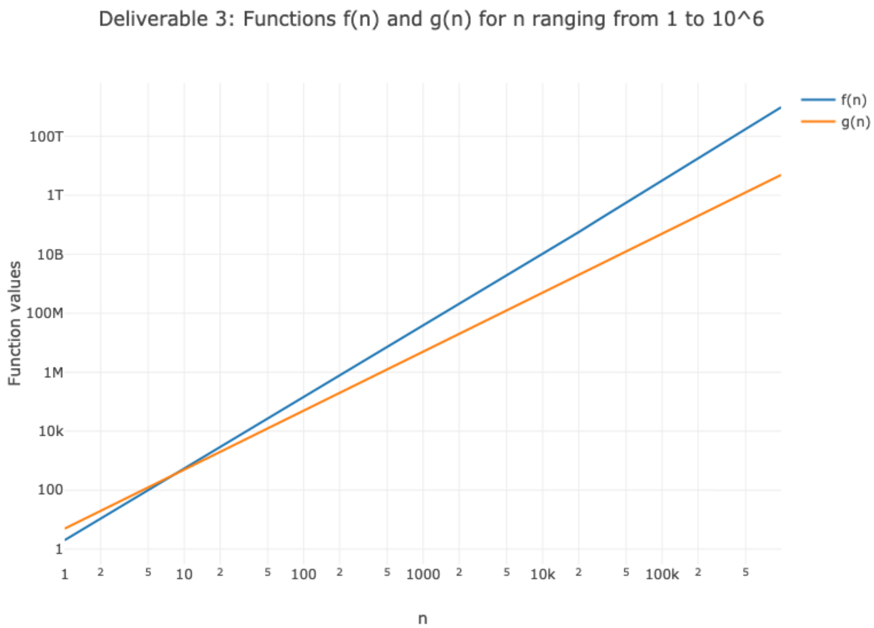


Figure 6: Plot of $f(n)$ and $g(n)$ for $n$ ranging from 1 to $10^6$.

## 5.3 Limit Test of Deliverable 3:

The limit test proved that the functions $f(n)$ and $g(n)$ have the different orders of growth. The ratio as we can see in the Figure 7 and Figure 8 the ratio keeps growing as the value of $n$ increases. This indicates that the functions have different orders of growth as $\Theta(n^{2.5}) and \Theta(n^2)$ respectively.

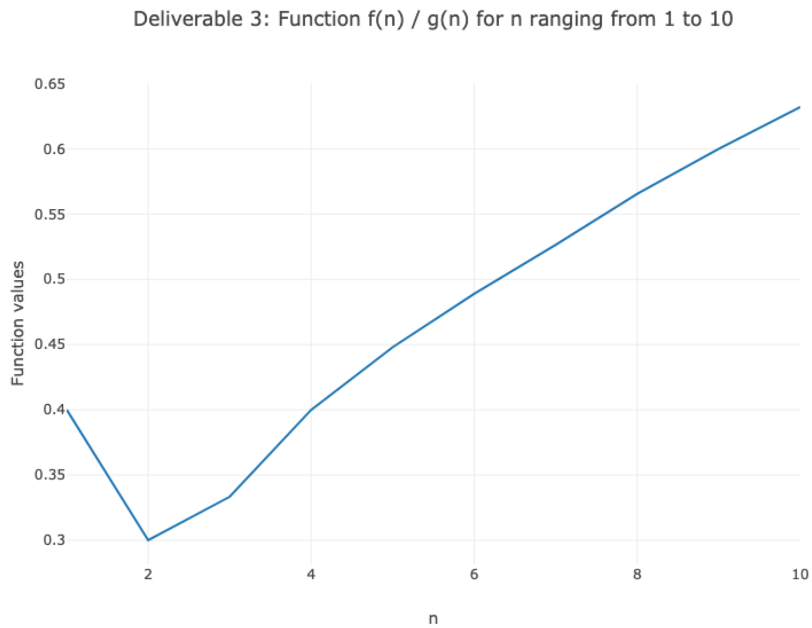


Figure 7: Plot of $\frac{f(n)}{g(n)}$ for $n$ ranging from 1 to 10.

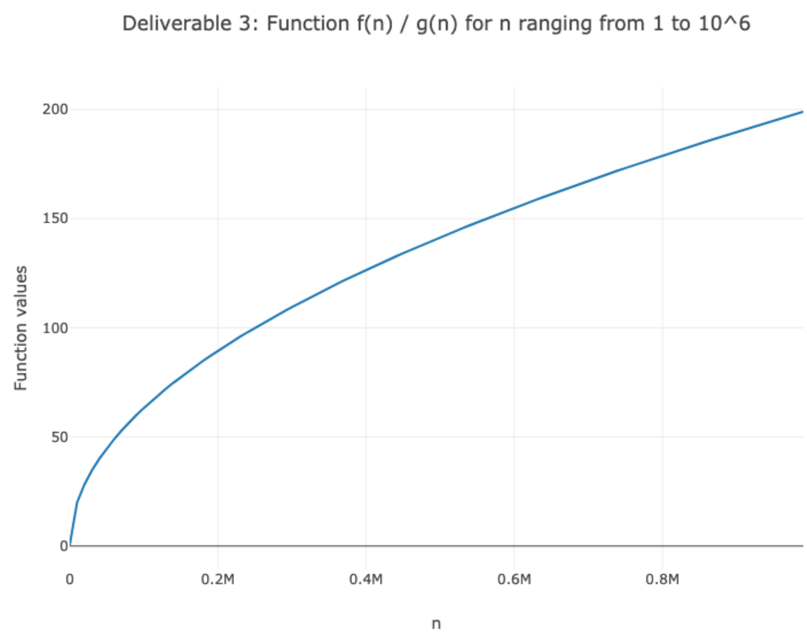


Figure 8: Plot of $\frac{f(n)}{g(n)}$ for $n$ ranging from 1 to $10^6$.

# 6 Deliverable 4:

## 6.1 Functions:

$$f(n) = \log(n), g(n) = \sqrt{n}$$

## 6.2 Results of plotting and how I Interpreted them:

Although there is a noticeble difference in the the plots of $f(n) and g(n)$ for smaller values of $n$ in the Figure9, we can see the difference in the growths of the fuctions for larger values of $n$ inn the figure10

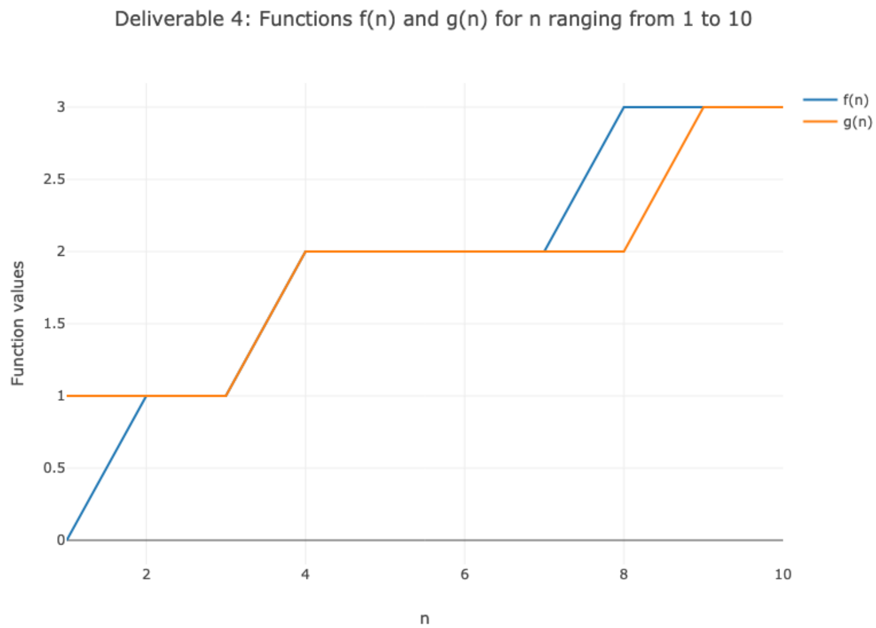


Figure 9: Plot of $f(n)$ and $g(n)$ for $n$ ranging from 1 to 10.

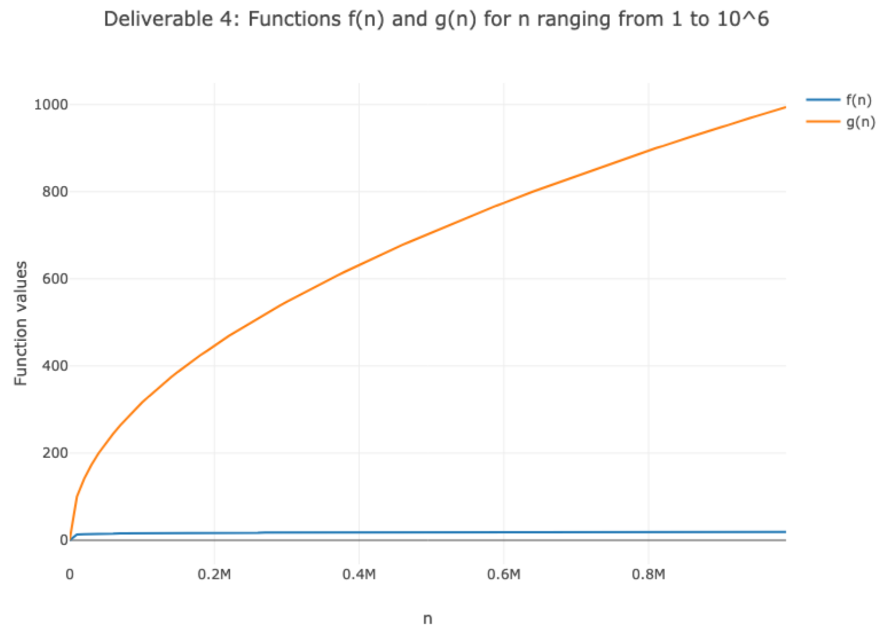


Figure 10: Plot of $f(n)$ and $g(n)$ for $n$ ranging from 1 to $10^6$.

### 6.3 Limit Test of Deliverable 4:

The Limit test proves the same that the function $f(n)$ has a significantly slower rate of growth than the function $g(n)$, as we can see in the Figure 11 and, very clearly, in the Figure 12 seems to be approaching 0 as the $n$ tends to $\infty$.Hence these two functions has different Orders of growth.

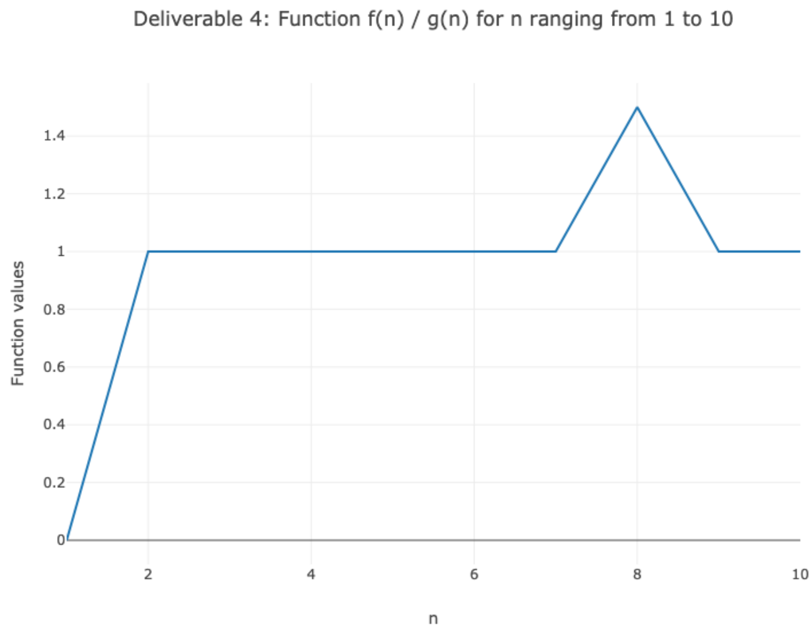


Figure 11: Plot of $\frac{f(n)}{g(n)}$ for $n$ ranging from 1 to 10.

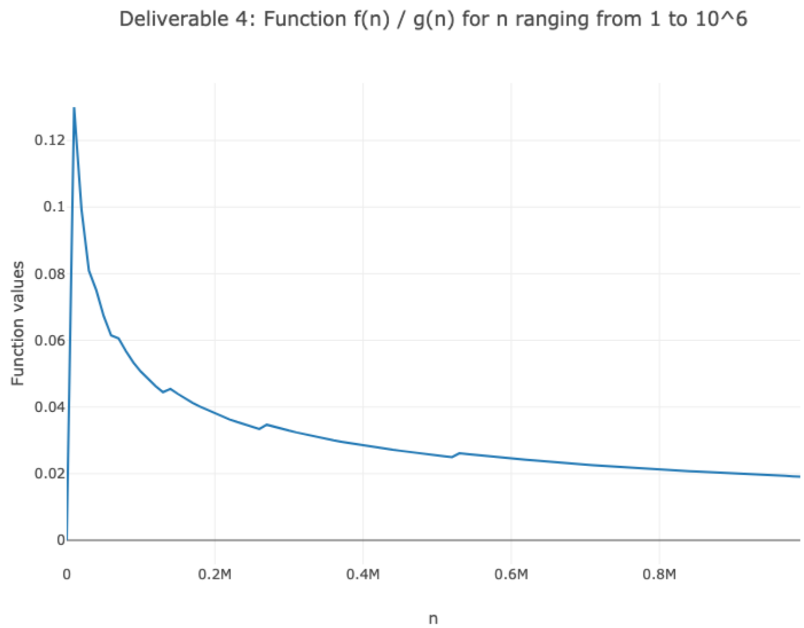


Figure 12: Plot of $\frac{f(n)}{g(n)}$ for $n$ ranging from 1 to $10^6$.

# 7 Deliverable 5:

## 7.1 Functions:

$$f(n) = \log_2 n, g(n) = \log_{10} n$$

## 7.2 Results of plotting and how I Interpreted them:

The order of growth would be confusing wiht the logarithmic functions, for smaller values of $n$, we can see a different plots seems to be never in sync. The plots become more alike with the larger values of $n$ as we can see in the Figure 13 and Figure 14

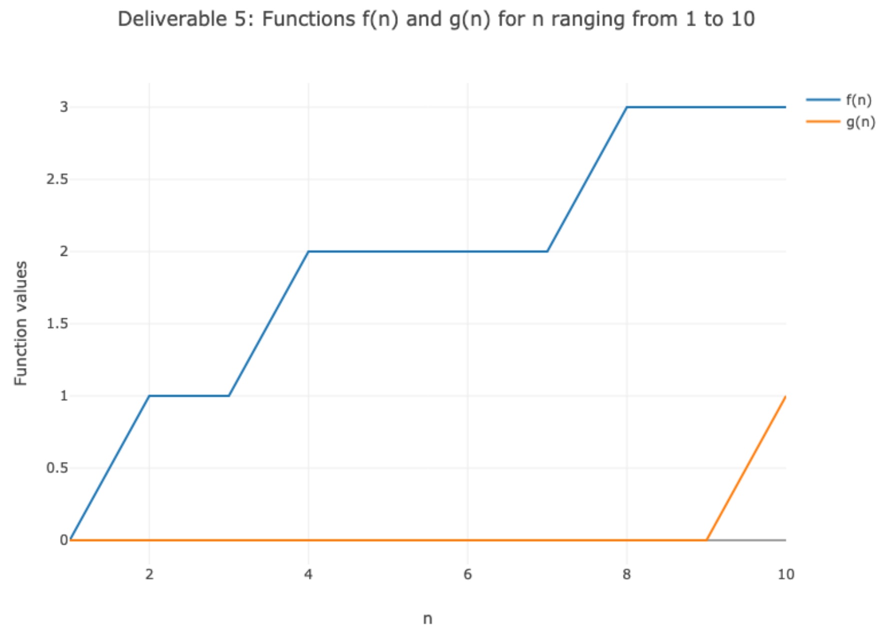


Figure 13: Plot of $f(n)$ and $g(n)$ for $n$ ranging from 1 to 10.

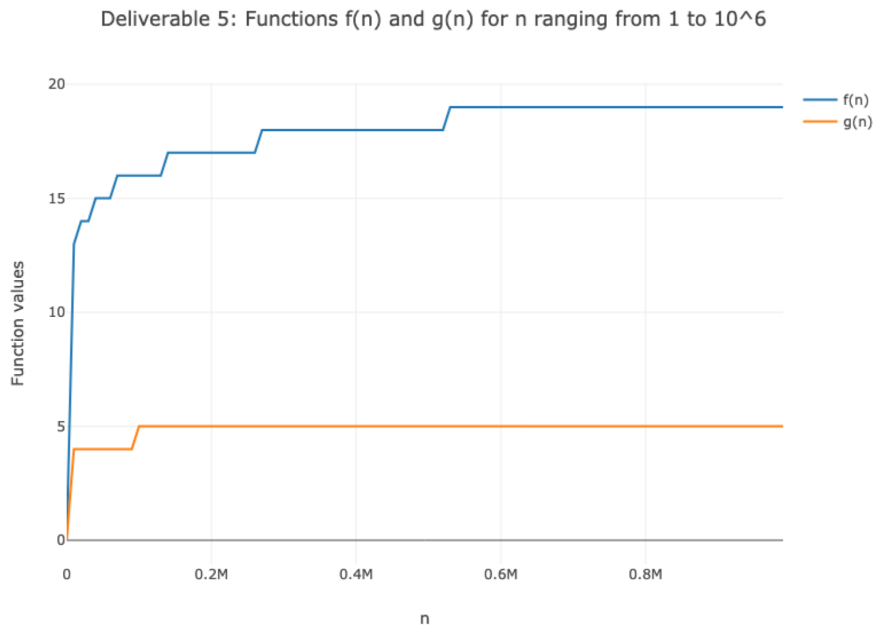


Figure 14: Plot of $f(n)$ and $g(n)$ for $n$ ranging from 1 to $10^6$.

### 7.3 Limit test of Deliverable 5:

Although the plot of the ratio varies alot for the smaller values of $n$ we can see $n \to \infty$, the pot flattens out on some positive value which indicates that $f(n) and g(n)$ has the same order of growth.

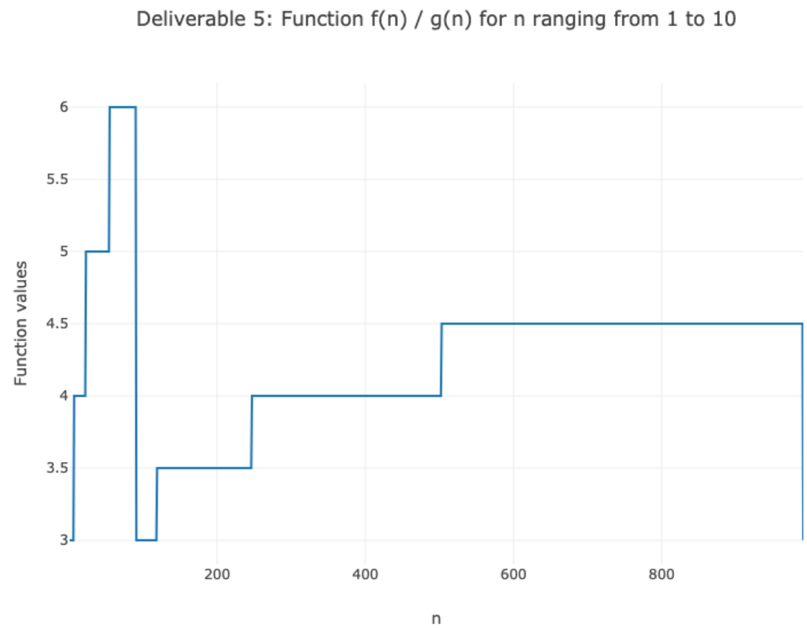


Figure 15: Plot of $\frac{f(n)}{g(n)}$ for $n$ ranging from 1 to 10.

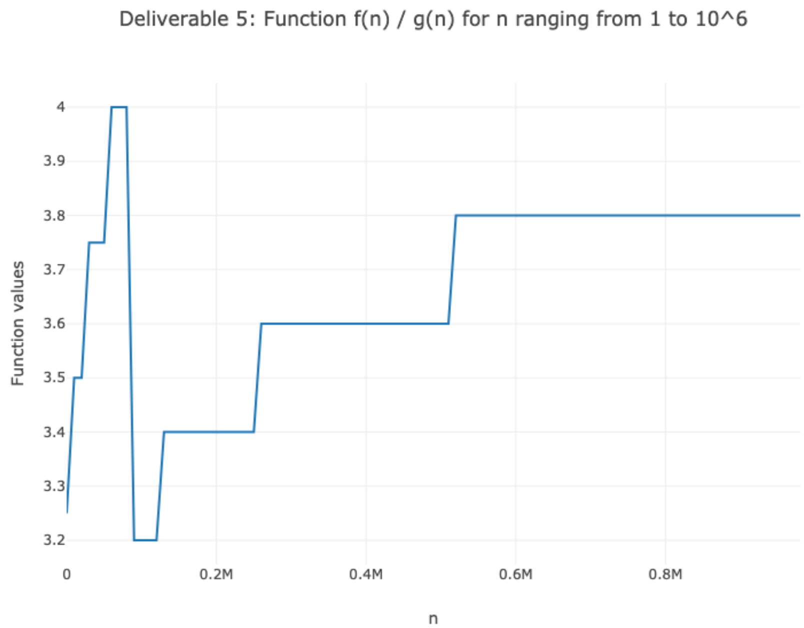


Figure 16: Plot of $\frac{f(n)}{g(n)}$ for $n$ ranging from 1 to $10^6$.