In this post I will show you how to calculate and plot the Spehrical Bessel Functions ($j_n(z)$) of the first kind using C and Gnuplot.

We will use the following information:

$$j_0(z) = \frac{\sin z}{z}$$
$$j_1(z) = \frac{\sin z}{z^2} - \frac{\cos z}{z}$$

and the recurrence relation:

$$j_{n-1}(z) + j_{n+1}(z) = (2n+1)\frac{j_n(z)}{z}$$

We will create a program that calculates the values of the Bessel Function at various z values and for different n and store these values in a txt file. Then just plot it using Gnuplot.

We will create two functions called 'b0' and 'b1', that contain the definition of $j_0(z), j_1(z)$ respectively. Then we will create a function 'bn' that will use the first two functions and recursion to find the value of Bessel function for different z,n.
NOTE: I am using a slightly modified form of the recurrence relation. To get the form I am using, just replace n by n-1.

C PROGRAM:

```
/*********************************************
**********SPHERICAL BESSEL FUNCTIONS***********
*********************************************/
#include<stdio.h>
#include<math.h>

/*Define j0(z) */
double b0(double z){
        return sin(z)/z;
}

/*Define j1(z) */
double b1(double z){
        return sin(z)/(z*z)-cos(z)/z;
}

/*Define jn(z) */
double bn(double z,int n){
        double out;
        if (n==0){
                out = b0(z);
        }
        else if(n==1){
                out = b1(z);
        }
        /*using recurrence relation */
        else{
                out = (2*n-1)*bn(z,n-1)/z-bn(z,n-2);
        }
        return out;
}
main(){
        double z;
        int n;
        FILE *fp=NULL;
        fp=fopen("bessel.txt","w");
        for(z=0.01;z<=20;z=z+0.01){
                //fprintf(fp,"%lf\t%lf\n",z,bn(z,3));
fprintf(fp,"%lf\t%lf\t%lf\t%lf\t%lf\t%lf\t%lf\n",z,bn(z,0),bn(z,1),bn(z,2),bn(z,3),bn(z
,4),bn(z,5));
        }
}
```

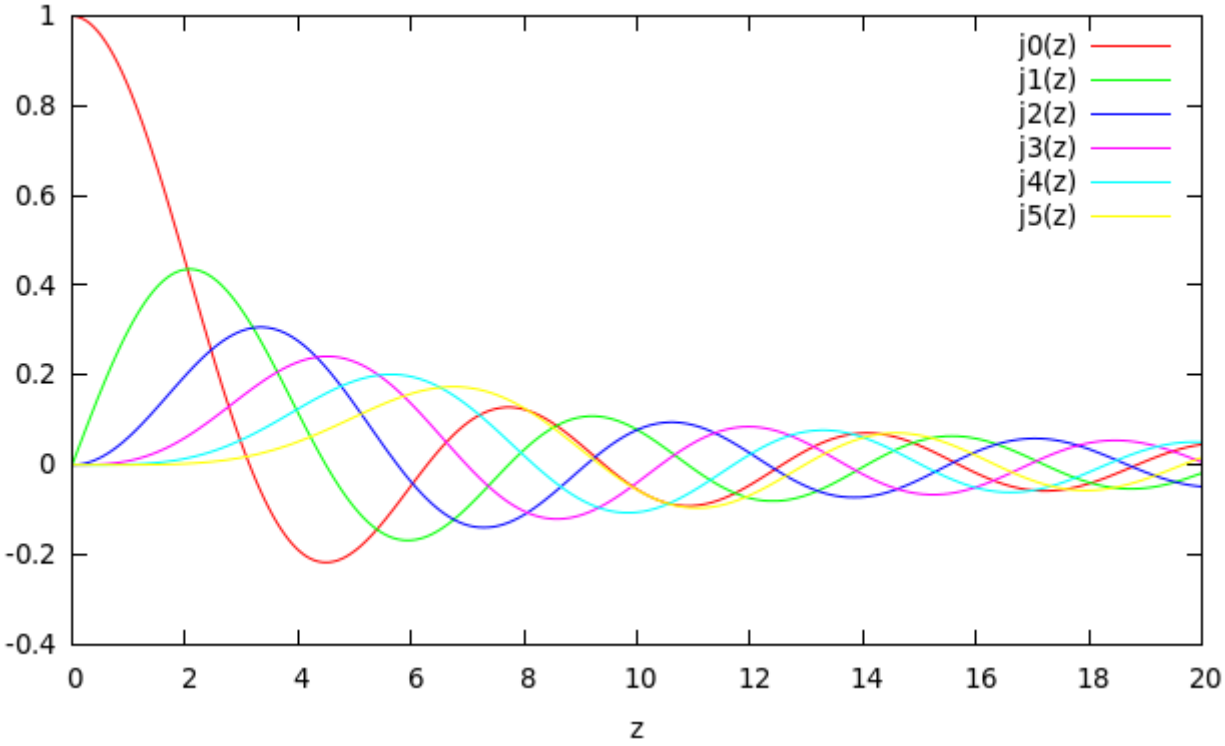
When you run the above C, it will generate a file called ‘bessel.txt’ which would contain 7 columns of data-points. The first column contains the ‘z’ values and the rest of them are for $j_0(z), j_1(z), \ldots$.

These can be easily plotted using Gnuplot by using the following commands:

Gnuplot Command:

```
->set xlabel "z"
->plot 'bessel.txt' u 1:2 w l t "j0(z)", '' u 1:3 w l t "j1(z)", '' u 1:4 w l t "j2(z)", '' u 1:5 w l t "j3(z)", '' u 1:6 w l t "j4(z)", '' u 1:7 w l t "j5(z)"
```

OUTPUT (Gnuplot):



Spherical Bessel Functions
Jn(z) from n=0 to 5

YouTube Tutorial:

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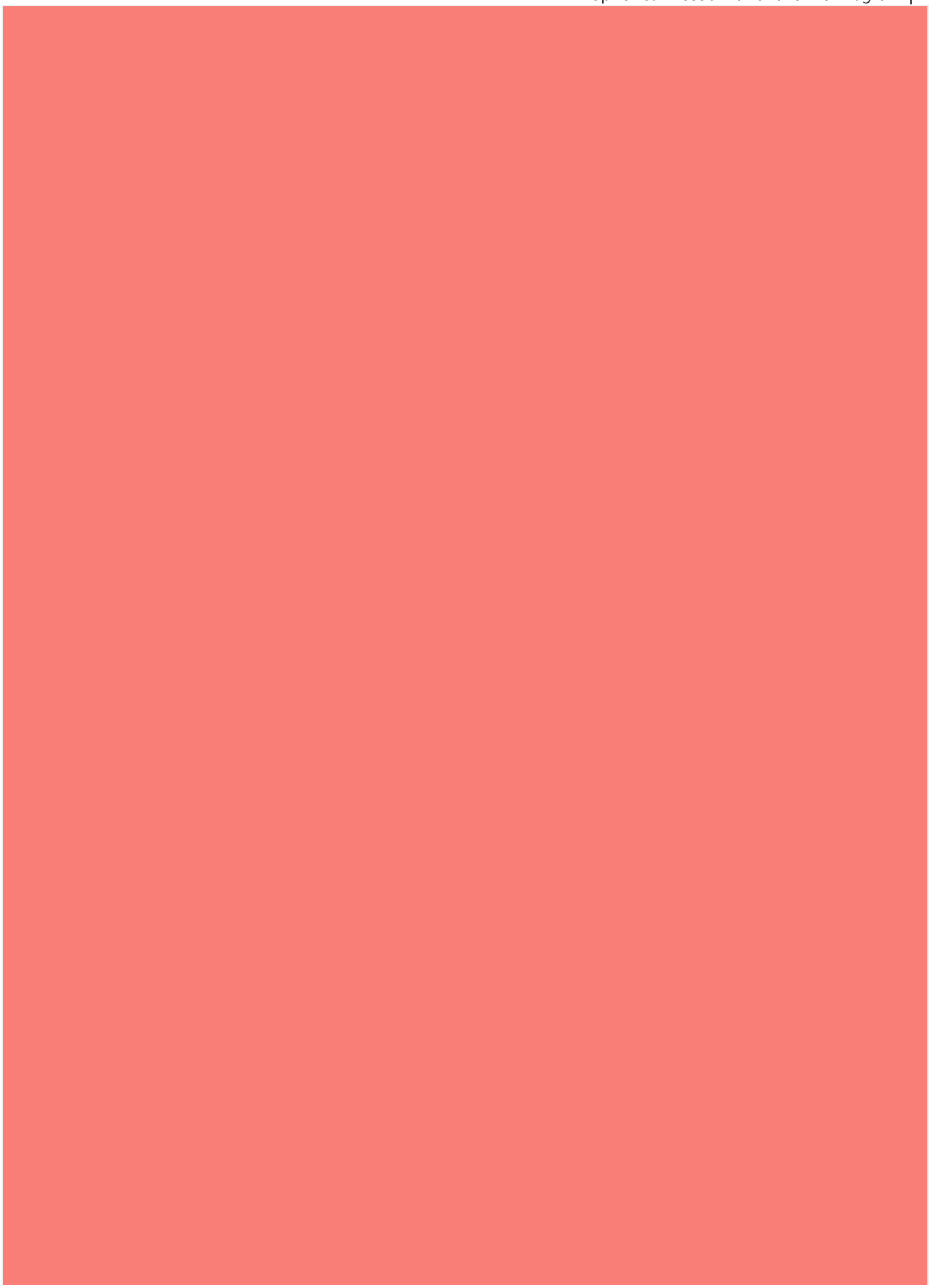

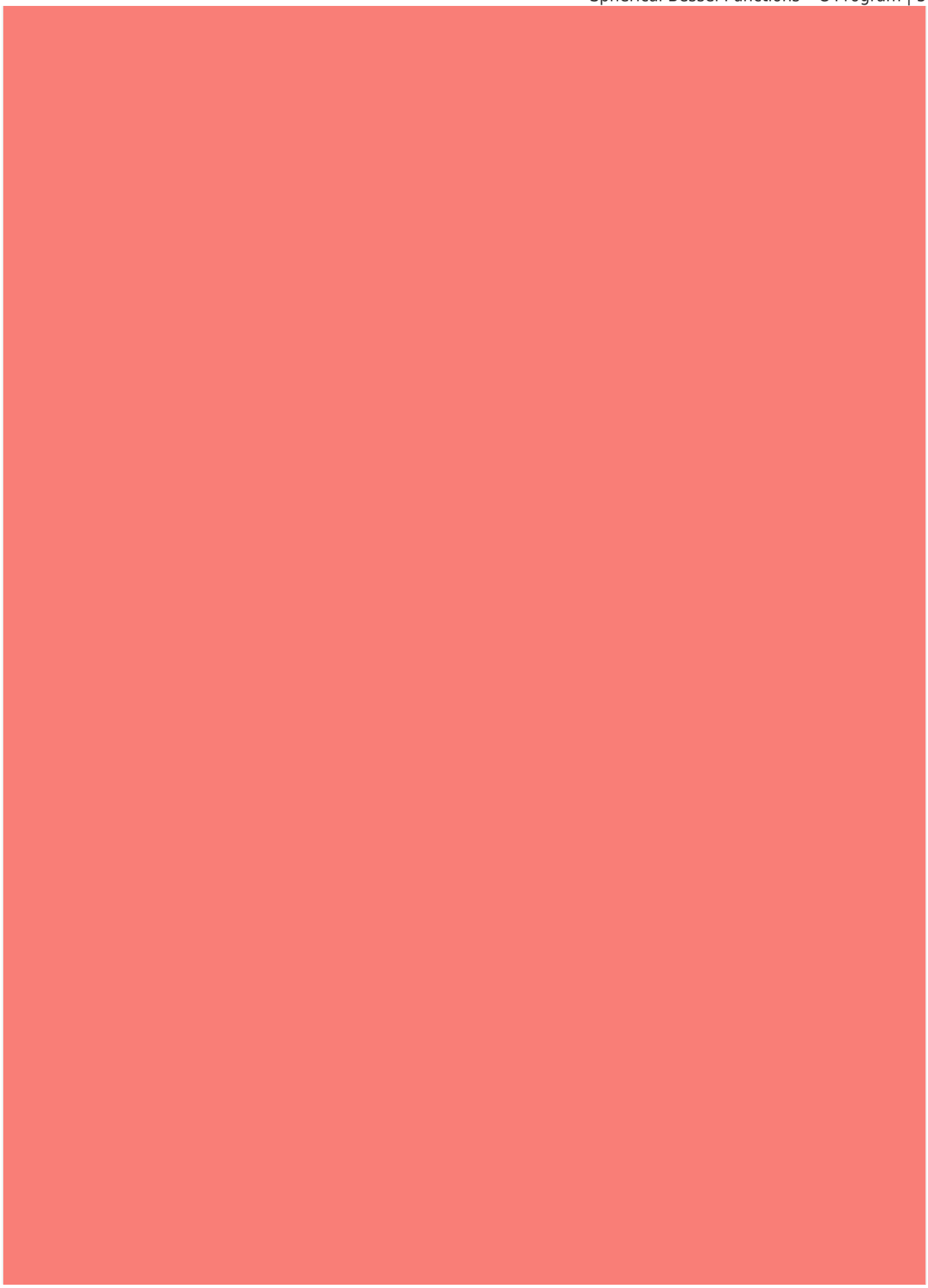

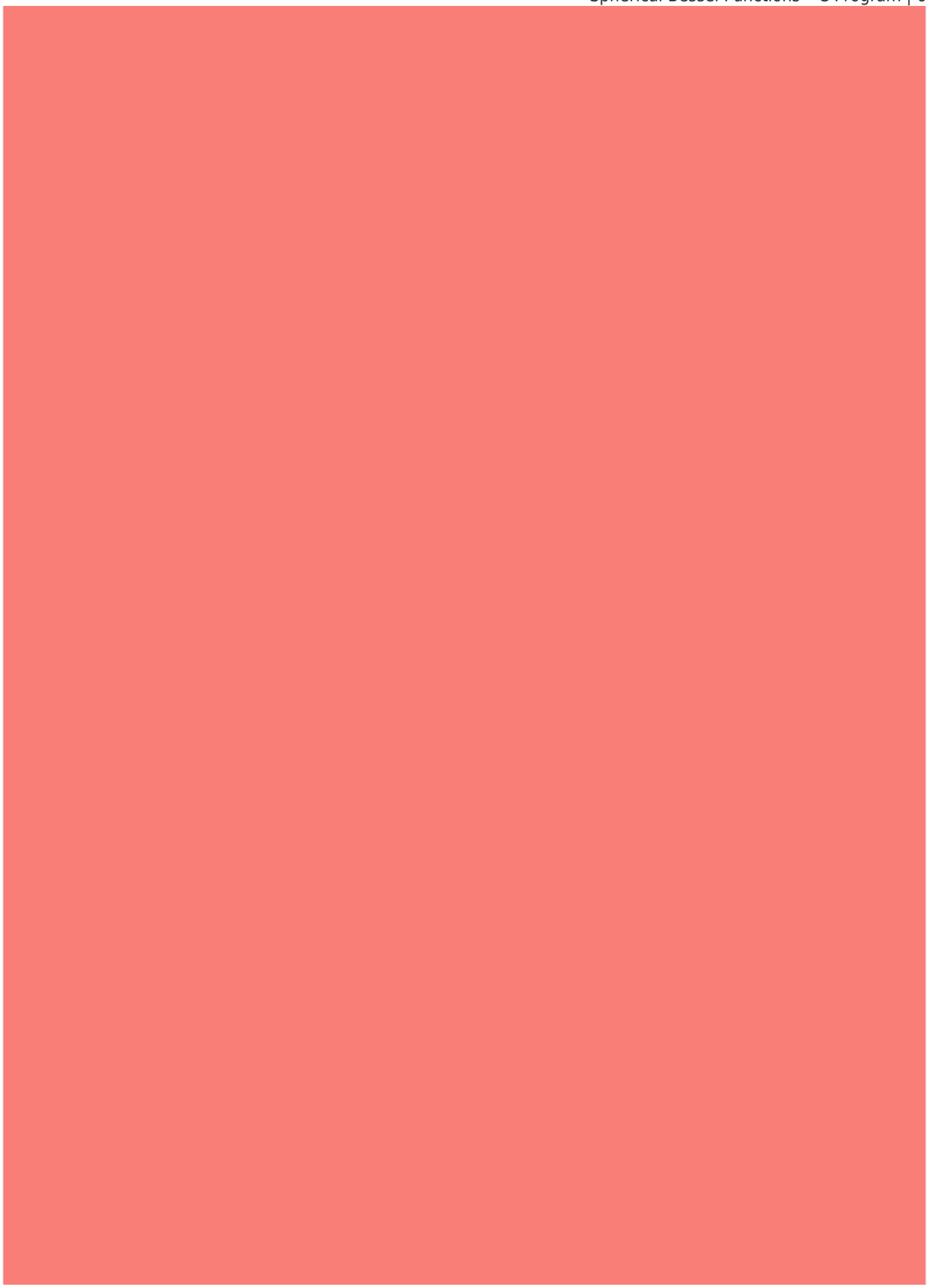

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