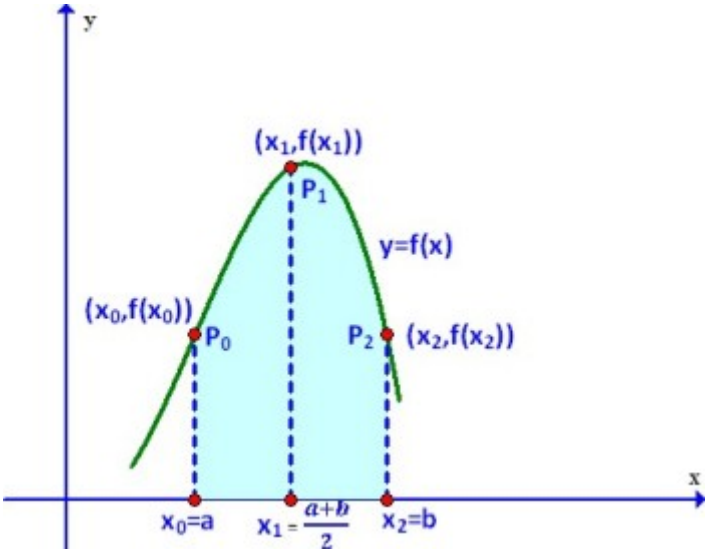
Simpson’s Rule is a Numerical technique to find the definite integral of a function within a given interval.

The function is divided into many sub-intervals and each interval is approximated by a quadratic curve. And the area is then calculated to find the integral. The more is the number of sub-intervals used, the better is the approximation.

NOTE: The no. of sub-intervals should be EVEN.



Formula Used:

$$\int_a^b f(x)dx \approx \frac{h}{3}(f(a)+4f(a+h)+2f(a+2h)+4f(a+3h)+2f(a+4h)+....+f(b))$$

$$\implies \int_a^b f(x)dx \approx \frac{h}{3}(f(a)+4f(x_1)+2f(x_2)+4f(x_3)+2f(x_4)+...+f(b))$$

where $x_i = a + ih$ for $i = 1, 2, ...n-1$ and $h = (b-a)/n$

The following C Program uses the Simpson’s 1/3 Rule to find the definite integral of a function.

Users, will have to change the function f in the following program to the function whose integral they want to find.

PROGRAM (Simple Version):

```
/*********************************
 *******SIMPSON'S 1/3 RULE********
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 *********************************/
#include<stdio.h>
#include<math.h>

/* Define the function to be integrated here: */
double f(double x){
  return x*x;
}

/*Program begins*/
main(){
  int n,i;
  double a,b,h,x,sum=0,integral;
  /*Ask the user for necessary input */
  printf("\nEnter the no. of sub-intervals(EVEN): ");
  scanf("%d",&n);
  printf("\nEnter the initial limit: ");
  scanf("%lf",&a);
  printf("\nEnter the final limit: ");
  scanf("%lf",&b);
  /*Begin Simpson's Procedure: */
  h=fabs(b-a)/n;
  for(i=1;i<n;i++){
    x=a+i*h;
    if(i%2==0){
      sum=sum+2*f(x);
    }
    else{
      sum=sum+4*f(x);
    }
  }
  integral=(h/3)*(f(a)+f(b)+sum);
   /*Print the answer */
  printf("\nThe integral is: %lf\n",integral);
}
```
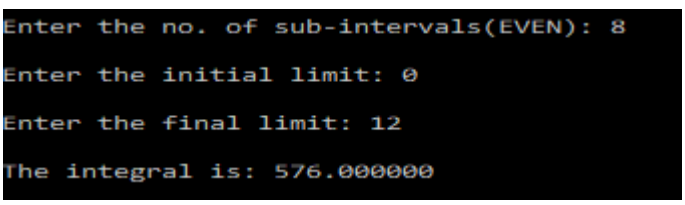

OUTPUT:

For x^2:



The above program returns a better approximation to the interval as the number of sub-intervals is increased. This might work for some applications, however, sometimes one might not want to deal with the number of sub-

intervals, but rather the accuracy upto a certain decimal places. What I mean by accuracy is that sometimes you might just want the approximate value of integral upto a few decimal place. So you will have to keep on increasing the number of sub-intervals and check the value of the integral. If the integral for two subsequent no. of sub-intervals is within the accuracy/tolerance limit given by the user(or set by you) then the integral should be printed out.

The following program illustrates the process of achieving what I just explained and also uses a function called ‘simpsons’ that handles the integration part.

PROGRAM (Better Version):

```
/***********************************************
 *******SIMPSON'S 1/3 RULE USING FUNCTION********
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 ***********************************************/
#include<stdio.h>
#include<math.h>

/* Define the function to be integrated here: */
double f(double x){
  return x*x;
}

/*Function definition to perform integration by Simpson's 1/3rd Rule */
double simpsons(double f(double x),double a,double b,int n){
  double h,integral,x,sum=0;
  int i;
  h=fabs(b-a)/n;
  for(i=1;i<n;i++){
    x=a+i*h;
    if(i%2==0){
      sum=sum+2*f(x);
    }
    else{
      sum=sum+4*f(x);
    }
  }
  integral=(h/3)*(f(a)+f(b)+sum);
  return integral;
}

/*Program begins*/
main(){
  int n,i=2;
  double a,b,h,x,sum=0,integral,eps,integral_new;
  /*Ask the user for necessary input */
  printf("\nEnter the initial limit: ");
  scanf("%lf",&a);
  printf("\nEnter the final limit: ");
  scanf("%lf",&b);
  printf("\nEnter the desired accuracy: ");
```

```
  scanf("%lf",&eps);
  integral_new=simpsons(f,a,b,i);

  /* Perform integration by simpson's 1/3rd for different number of sub-intervals until
they converge to the given accuracy:*/
  do{
    integral=integral_new;
    i=i+2;
    integral_new=simpsons(f,a,b,i);
  }while(fabs(integral_new-integral)>=eps);
  /*Print the answer */
  printf("\nThe integral is: %lf for %d sub-intervals.\n",integral_new,i);
}
```

OUTPUT:

For x^2:

```
Enter the initial limit: 0

Enter the final limit: 12

Enter the desired accuracy: 0.01

The integral is: 576.000000 for 4 sub-intervals.
```

Web App

I have also created this web app so that you can try out the different numerical integration techniques online. You can also open this link to go full screen.

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Manas Sharma

I'm a physicist specializing in computational material science with a PhD in Physics from Friedrich-Schiller University Jena, Germany. I write efficient codes for simulating light-matter interactions at atomic scales. I like to develop Physics, DFT, and Machine Learning related apps and software from time to time. Can code in most of the popular languages. I like to share my knowledge in Physics and applications using this Blog and a YouTube channel.

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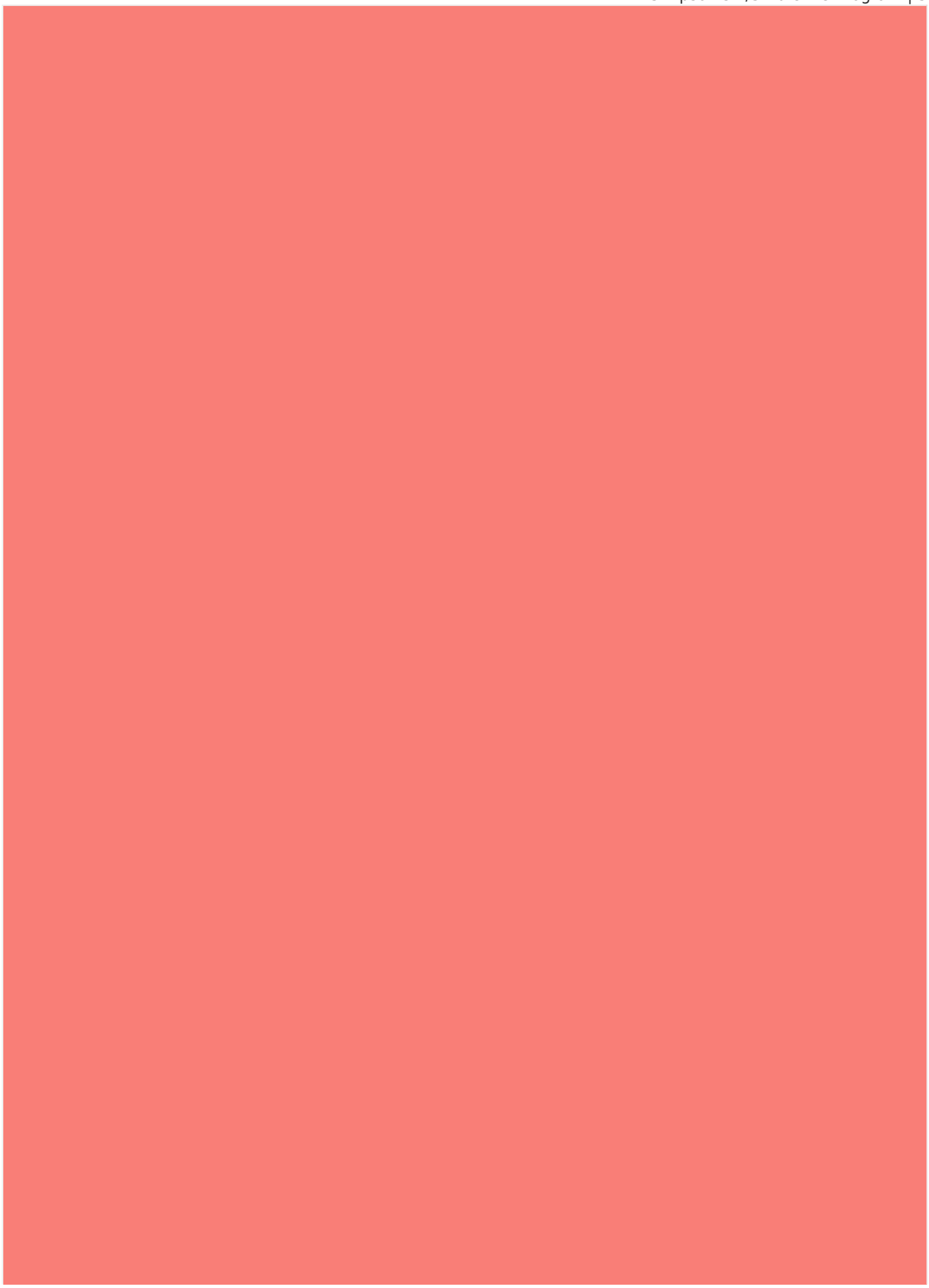

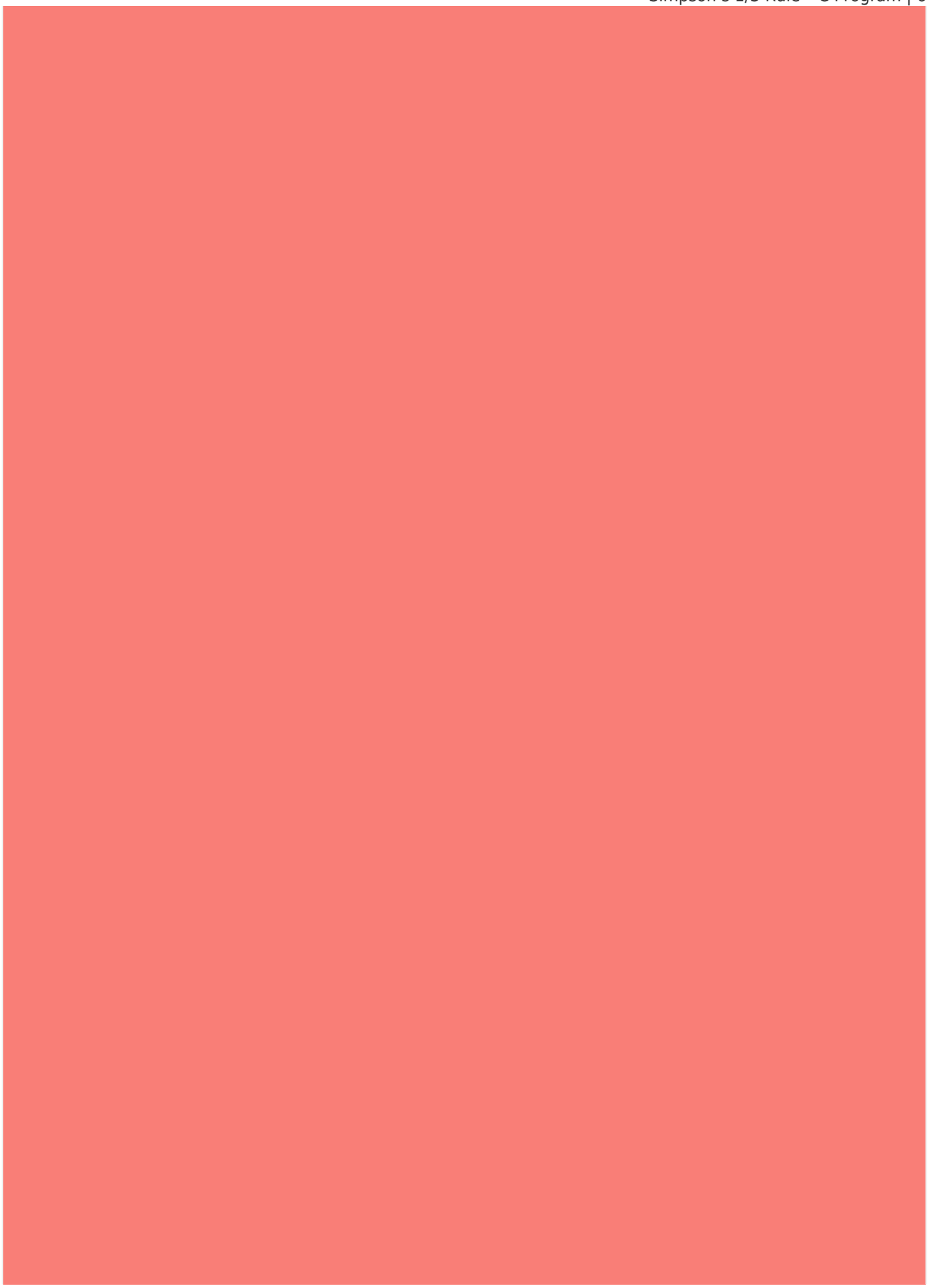

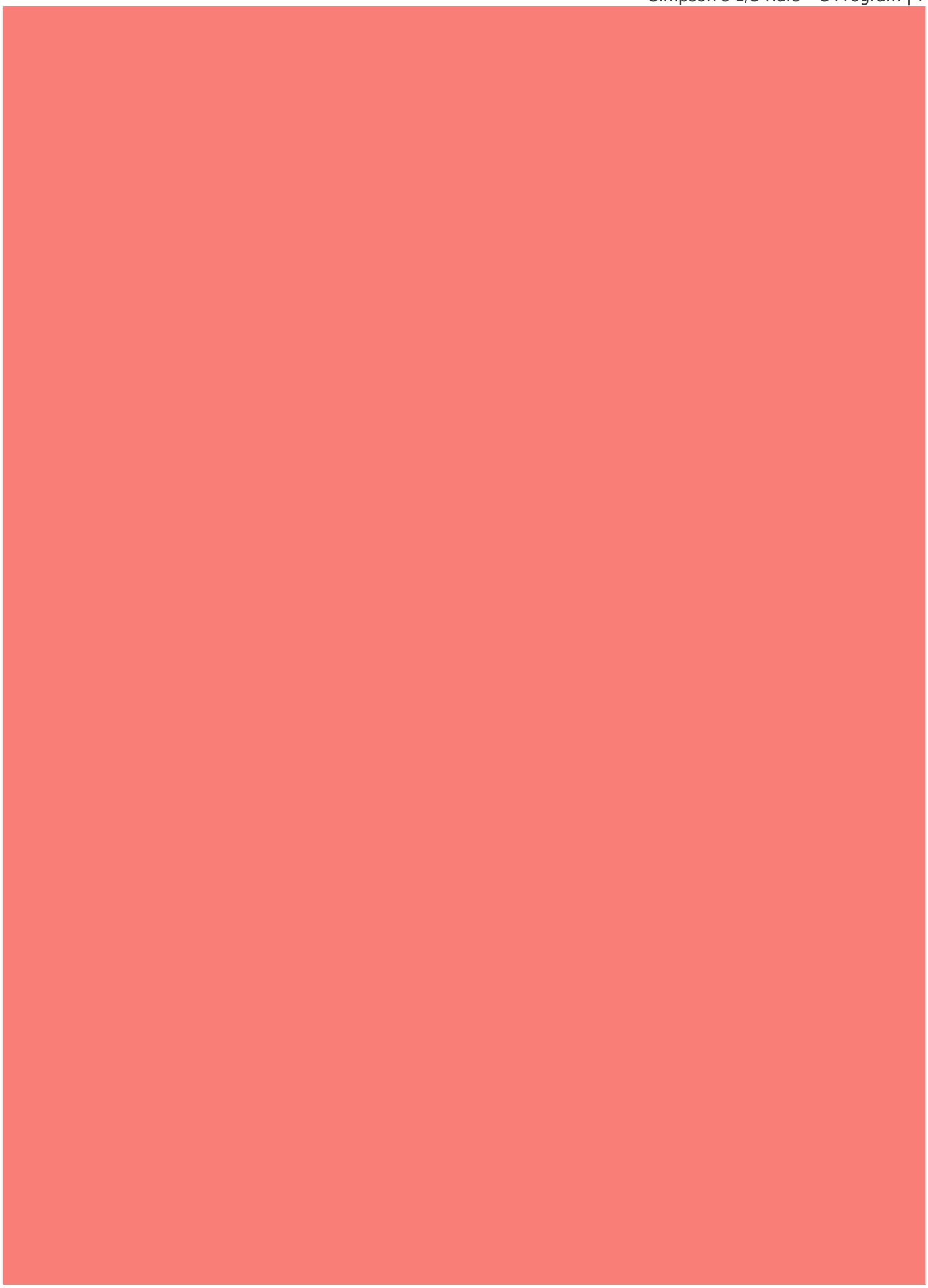

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