
Table of Contents

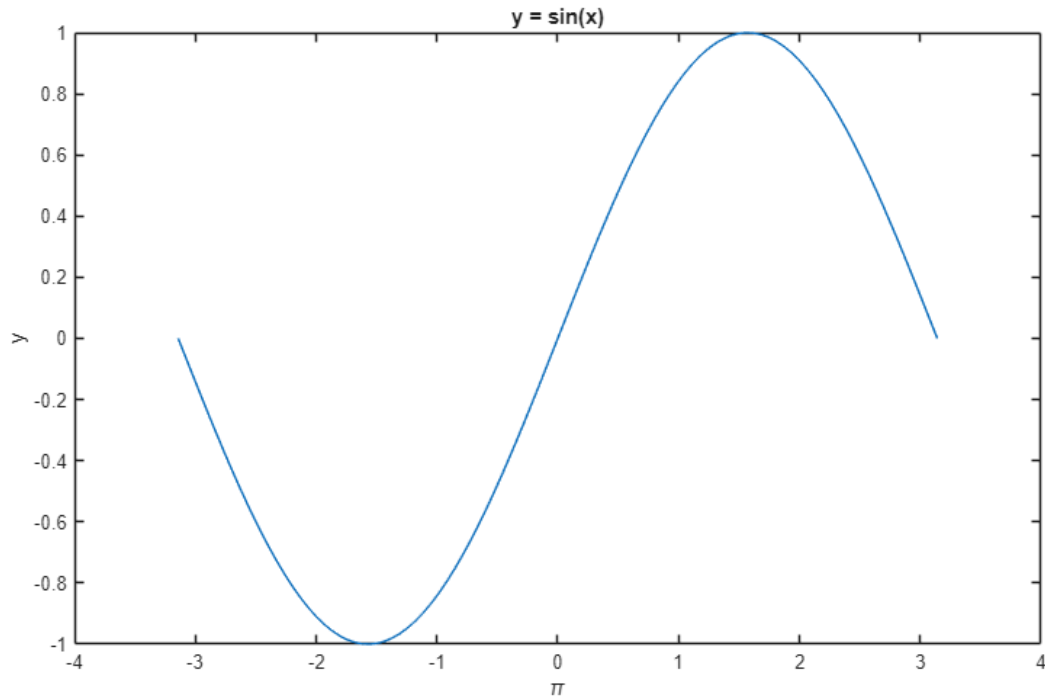
using a script file (I)	1
defining a function (II)	2
Numerical differentiation	3
Numerical Integration 1. Trapezoidal Method	4
Numerical Integration 2. Composite Trapezium Rule	4
Numerical Integration 3. Simpson's Rule	14

using a script file (I)

```
clear, format short g

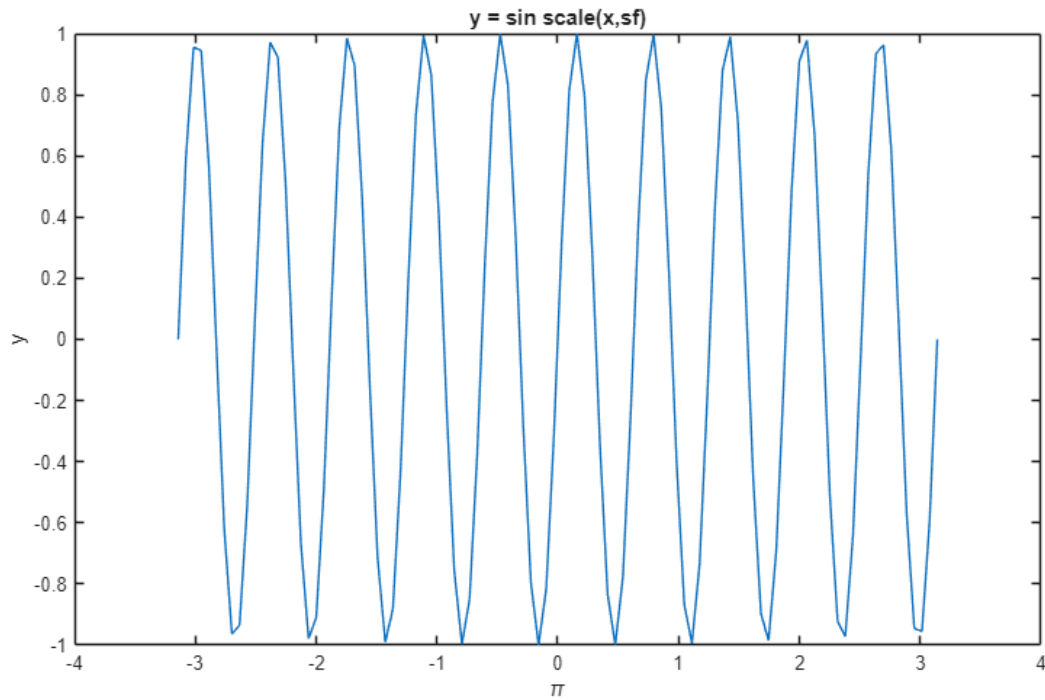
N = 100;
x = linspace(-pi,pi,N)';

y = sin (x);
figure (1),
plot (x,y)
xlabel('\pi')
ylabel('y')
title('y = sin(x)')
```



defining a function (II)

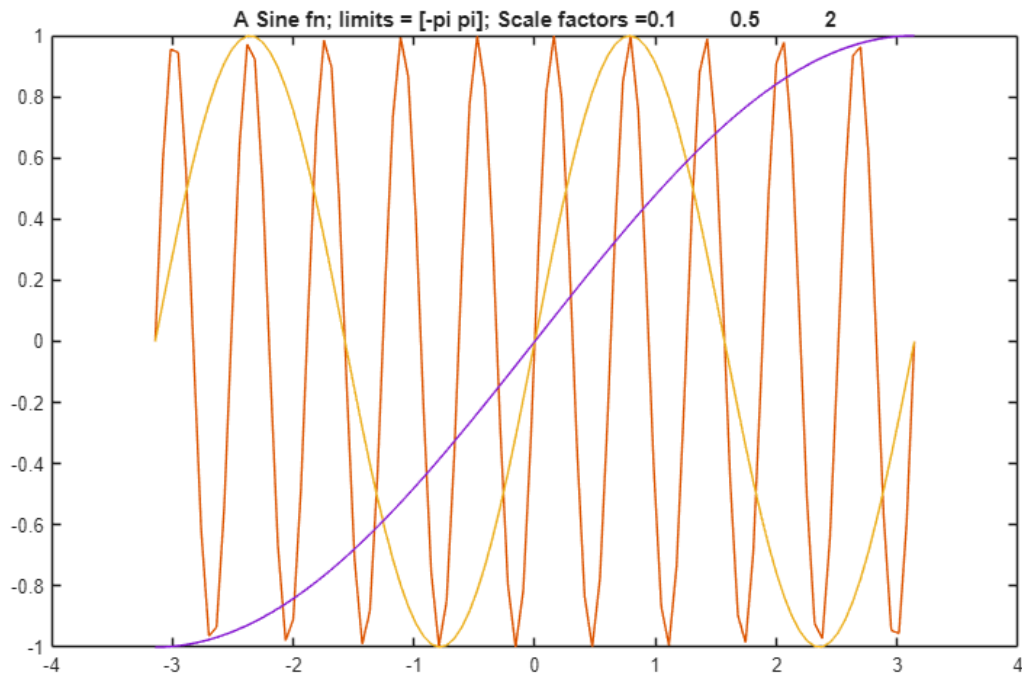
```
sf = 0.1;
y = sin_scale(x, sf);
figure (2),
plot (x,y)
xlabel('\pi')
ylabel('y')
title('y = sin scale(x,sf)')
```



```
sf=[0.1 0.5 2];
N_sf=numel(sf);
sin_array=zeros(N,N_sf);

for ndx=1:N_sf
    sin_array(:,ndx) = sin_scale(x,sf(ndx));
end

figure(3), plot(x,sin_array)
title(['A Sine fn; limits = [-pi pi]; Scale factors =', num2str(sf)])
```



Numerical differentiation

```
N = 100;
x = linspace(-pi,pi,N)';

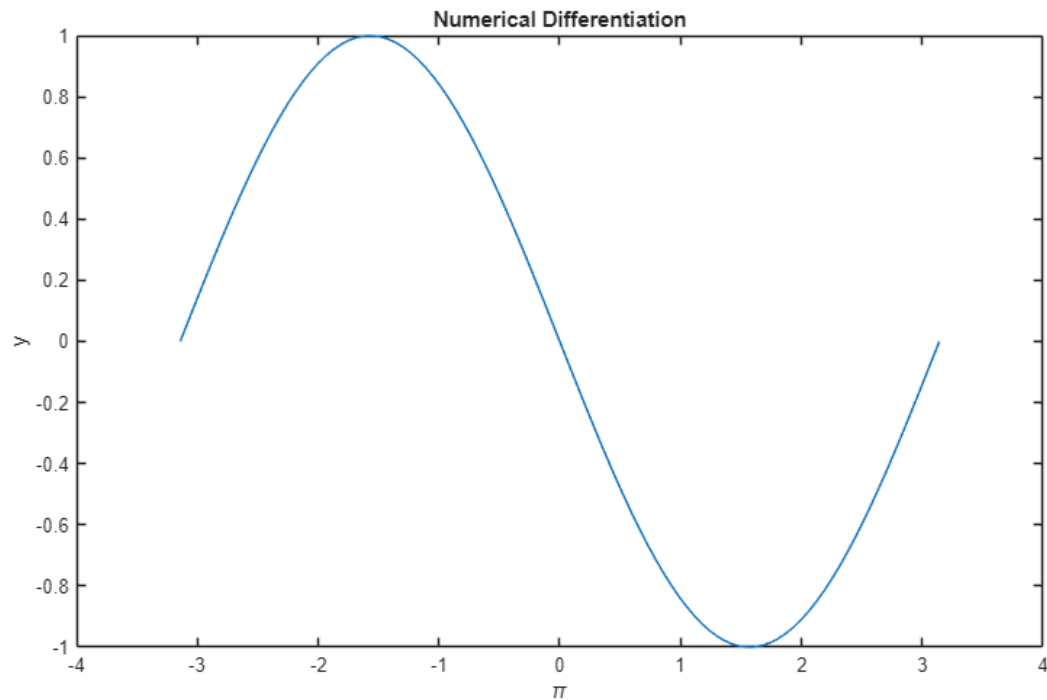
y=cos(x);
% h=(2*pi)./N;

df_dt = fdt(x,y);

df_dt_true=-sin(x);

hold on
figure(4),
plot (x,df_dt)
plot (x,df_dt_true)
xlabel('\pi')
ylabel('y')
title('Numerical Differentiation')

hold off
```



Numerical Integration 1. Trapezoidal Method

```
a = 0;
b = (pi)/2;
N = 100;
x = linspace(a, b, N)';
y = my_func(x);
fun = 'my_func';
int = trapz (fun ,a, b );
int_true = trapz(x, y);
p_error = (abs(int - int_true)/(int_true))*100;

fprintf ('Trapezium rule estimated area = %f \r', int)
fprintf ('real integral area = %f \r', int_true)
fprintf ('Percentage error =%f \r',p_error)
```

```
Trapezium rule estimated area = 1.233701 real integral area = 1.000021
Percentage error =23.367467
```

Numerical Integration 2. Composite Trapezium Rule

```
int_comp = comp_trapz(fun, a, b, N);

% Calculate the percentage error for the composite trapezium rule
p_error_comp = (abs(int_comp - int_true) / int_true) * 100;
```

```

fprintf('Percentage error for Composite Trapezium rule = %f\n \r',
p_error_comp);
fprintf('Composite Trapezium rule estimated area = %f\n \r', int_comp);

% this is totally useless, I find it funny because 'fra' means 'bro' in
Italian
fra = 'fract';
true_integral = integral(@fract, 1, 2);

tolerance = 1e-6;
counter = 1;
max_counter = 300;
int_comp_i = comp_trapz (fra, 1, 2, counter);

% Number of sub-intervals needed to achieve an accuracy to 6 decimal places
while (abs(true_integral-int_comp_i)>tolerance && counter<max_counter)
    int_comp_i = comp_trapz(fra, 1, 2, counter);
    p_error_i = (abs(int_comp_i - true_integral) / true_integral) * 100;

    %output to screen
    fprintf('ITERATIONS %i \r',counter)
    fprintf('Composite trapezium rule with %i intervals =%10.6f \r',
counter, int_comp_i );
    fprintf('Percentage error for Composite Trapezium at 1e-6 tol = %f \r
\r', p_error_i);

    counter = counter + 1;

end

```

```

Percentage error for Composite Trapezium rule = 0.000042
Composite Trapezium rule estimated area = 1.000021
ITERATIONS 1 Composite trapezium rule with 1 intervals = 0.750000
Percentage error for Composite Trapezium at 1e-6 tol = 8.202128 ITERATIONS
2 Composite trapezium rule with 2 intervals = 0.708333 Percentage error for
Composite Trapezium at 1e-6 tol = 2.190899 ITERATIONS 3 Composite trapezium
rule with 3 intervals = 0.700000 Percentage error for Composite Trapezium
at 1e-6 tol = 0.988653 ITERATIONS 4 Composite trapezium rule with 4
intervals = 0.697024 Percentage error for Composite Trapezium at 1e-6 tol =
0.559279 ITERATIONS 5 Composite trapezium rule with 5 intervals = 0.695635
Percentage error for Composite Trapezium at 1e-6 tol = 0.358905 ITERATIONS
6 Composite trapezium rule with 6 intervals = 0.694877 Percentage error
for Composite Trapezium at 1e-6 tol = 0.249610 ITERATIONS 7 Composite
trapezium rule with 7 intervals = 0.694419 Percentage error for Composite
Trapezium at 1e-6 tol = 0.183552 ITERATIONS 8 Composite trapezium rule with
8 intervals = 0.694122 Percentage error for Composite Trapezium at 1e-6
tol = 0.140615 ITERATIONS 9 Composite trapezium rule with 9 intervals =
0.693918 Percentage error for Composite Trapezium at 1e-6 tol = 0.111148
ITERATIONS 10 Composite trapezium rule with 10 intervals = 0.693771
Percentage error for Composite Trapezium at 1e-6 tol = 0.090056 ITERATIONS
11 Composite trapezium rule with 11 intervals = 0.693663 Percentage error
for Composite Trapezium at 1e-6 tol = 0.074443 ITERATIONS 12 Composite
trapezium rule with 12 intervals = 0.693581 Percentage error for Composite
Trapezium at 1e-6 tol = 0.062563 ITERATIONS 13 Composite trapezium rule

```

with 13 intervals = 0.693517 Percentage error for Composite Trapezium
at 1e-6 tol = 0.053315 ITERATIONS 14 Composite trapezium rule with 14
intervals = 0.693466 Percentage error for Composite Trapezium at 1e-6 tol
= 0.045975 ITERATIONS 15 Composite trapezium rule with 15 intervals =
0.693425 Percentage error for Composite Trapezium at 1e-6 tol = 0.040053
ITERATIONS 16 Composite trapezium rule with 16 intervals = 0.693391
Percentage error for Composite Trapezium at 1e-6 tol = 0.035205 ITERATIONS
17 Composite trapezium rule with 17 intervals = 0.693363 Percentage error
for Composite Trapezium at 1e-6 tol = 0.031187 ITERATIONS 18 Composite
trapezium rule with 18 intervals = 0.693340 Percentage error for Composite
Trapezium at 1e-6 tol = 0.027819 ITERATIONS 19 Composite trapezium rule
with 19 intervals = 0.693320 Percentage error for Composite Trapezium
at 1e-6 tol = 0.024969 ITERATIONS 20 Composite trapezium rule with 20
intervals = 0.693303 Percentage error for Composite Trapezium at 1e-6 tol
= 0.022535 ITERATIONS 21 Composite trapezium rule with 21 intervals =
0.693289 Percentage error for Composite Trapezium at 1e-6 tol = 0.020441
ITERATIONS 22 Composite trapezium rule with 22 intervals = 0.693276
Percentage error for Composite Trapezium at 1e-6 tol = 0.018625 ITERATIONS
23 Composite trapezium rule with 23 intervals = 0.693265 Percentage error
for Composite Trapezium at 1e-6 tol = 0.017041 ITERATIONS 24 Composite
trapezium rule with 24 intervals = 0.693256 Percentage error for Composite
Trapezium at 1e-6 tol = 0.015651 ITERATIONS 25 Composite trapezium rule
with 25 intervals = 0.693247 Percentage error for Composite Trapezium
at 1e-6 tol = 0.014424 ITERATIONS 26 Composite trapezium rule with 26
intervals = 0.693240 Percentage error for Composite Trapezium at 1e-6 tol
= 0.013336 ITERATIONS 27 Composite trapezium rule with 27 intervals =
0.693233 Percentage error for Composite Trapezium at 1e-6 tol = 0.012367
ITERATIONS 28 Composite trapezium rule with 28 intervals = 0.693227
Percentage error for Composite Trapezium at 1e-6 tol = 0.011499 ITERATIONS
29 Composite trapezium rule with 29 intervals = 0.693221 Percentage error
for Composite Trapezium at 1e-6 tol = 0.010720 ITERATIONS 30 Composite
trapezium rule with 30 intervals = 0.693217 Percentage error for Composite
Trapezium at 1e-6 tol = 0.010017 ITERATIONS 31 Composite trapezium rule
with 31 intervals = 0.693212 Percentage error for Composite Trapezium
at 1e-6 tol = 0.009382 ITERATIONS 32 Composite trapezium rule with 32
intervals = 0.693208 Percentage error for Composite Trapezium at 1e-6 tol
= 0.008804 ITERATIONS 33 Composite trapezium rule with 33 intervals =
0.693205 Percentage error for Composite Trapezium at 1e-6 tol = 0.008279
ITERATIONS 34 Composite trapezium rule with 34 intervals = 0.693201
Percentage error for Composite Trapezium at 1e-6 tol = 0.007799 ITERATIONS
35 Composite trapezium rule with 35 intervals = 0.693198 Percentage error
for Composite Trapezium at 1e-6 tol = 0.007360 ITERATIONS 36 Composite
trapezium rule with 36 intervals = 0.693195 Percentage error for Composite
Trapezium at 1e-6 tol = 0.006957 ITERATIONS 37 Composite trapezium rule
with 37 intervals = 0.693193 Percentage error for Composite Trapezium
at 1e-6 tol = 0.006586 ITERATIONS 38 Composite trapezium rule with 38
intervals = 0.693190 Percentage error for Composite Trapezium at 1e-6 tol
= 0.006244 ITERATIONS 39 Composite trapezium rule with 39 intervals =
0.693188 Percentage error for Composite Trapezium at 1e-6 tol = 0.005928
ITERATIONS 40 Composite trapezium rule with 40 intervals = 0.693186
Percentage error for Composite Trapezium at 1e-6 tol = 0.005635 ITERATIONS
41 Composite trapezium rule with 41 intervals = 0.693184 Percentage error
for Composite Trapezium at 1e-6 tol = 0.005364 ITERATIONS 42 Composite
trapezium rule with 42 intervals = 0.693183 Percentage error for Composite

Trapezium at $1e-6$ tol = 0.005111 ITERATIONS 43 Composite trapezium rule
 with 43 intervals = 0.693181 Percentage error for Composite Trapezium
 at $1e-6$ tol = 0.004876 ITERATIONS 44 Composite trapezium rule with 44
 intervals = 0.693179 Percentage error for Composite Trapezium at $1e-6$ tol
 = 0.004657 ITERATIONS 45 Composite trapezium rule with 45 intervals =
 0.693178 Percentage error for Composite Trapezium at $1e-6$ tol = 0.004452
 ITERATIONS 46 Composite trapezium rule with 46 intervals = 0.693177
 Percentage error for Composite Trapezium at $1e-6$ tol = 0.004261 ITERATIONS
 47 Composite trapezium rule with 47 intervals = 0.693175 Percentage error
 for Composite Trapezium at $1e-6$ tol = 0.004082 ITERATIONS 48 Composite
 trapezium rule with 48 intervals = 0.693174 Percentage error for Composite
 Trapezium at $1e-6$ tol = 0.003913 ITERATIONS 49 Composite trapezium rule
 with 49 intervals = 0.693173 Percentage error for Composite Trapezium
 at $1e-6$ tol = 0.003755 ITERATIONS 50 Composite trapezium rule with 50
 intervals = 0.693172 Percentage error for Composite Trapezium at $1e-6$ tol
 = 0.003607 ITERATIONS 51 Composite trapezium rule with 51 intervals =
 0.693171 Percentage error for Composite Trapezium at $1e-6$ tol = 0.003467
 ITERATIONS 52 Composite trapezium rule with 52 intervals = 0.693170
 Percentage error for Composite Trapezium at $1e-6$ tol = 0.003334 ITERATIONS
 53 Composite trapezium rule with 53 intervals = 0.693169 Percentage error
 for Composite Trapezium at $1e-6$ tol = 0.003210 ITERATIONS 54 Composite
 trapezium rule with 54 intervals = 0.693169 Percentage error for Composite
 Trapezium at $1e-6$ tol = 0.003092 ITERATIONS 55 Composite trapezium rule
 with 55 intervals = 0.693168 Percentage error for Composite Trapezium
 at $1e-6$ tol = 0.002981 ITERATIONS 56 Composite trapezium rule with 56
 intervals = 0.693167 Percentage error for Composite Trapezium at $1e-6$ tol
 = 0.002875 ITERATIONS 57 Composite trapezium rule with 57 intervals =
 0.693166 Percentage error for Composite Trapezium at $1e-6$ tol = 0.002775
 ITERATIONS 58 Composite trapezium rule with 58 intervals = 0.693166
 Percentage error for Composite Trapezium at $1e-6$ tol = 0.002680 ITERATIONS
 59 Composite trapezium rule with 59 intervals = 0.693165 Percentage error
 for Composite Trapezium at $1e-6$ tol = 0.002590 ITERATIONS 60 Composite
 trapezium rule with 60 intervals = 0.693165 Percentage error for Composite
 Trapezium at $1e-6$ tol = 0.002505 ITERATIONS 61 Composite trapezium rule
 with 61 intervals = 0.693164 Percentage error for Composite Trapezium
 at $1e-6$ tol = 0.002423 ITERATIONS 62 Composite trapezium rule with 62
 intervals = 0.693163 Percentage error for Composite Trapezium at $1e-6$ tol
 = 0.002346 ITERATIONS 63 Composite trapezium rule with 63 intervals =
 0.693163 Percentage error for Composite Trapezium at $1e-6$ tol = 0.002272
 ITERATIONS 64 Composite trapezium rule with 64 intervals = 0.693162
 Percentage error for Composite Trapezium at $1e-6$ tol = 0.002201 ITERATIONS
 65 Composite trapezium rule with 65 intervals = 0.693162 Percentage error
 for Composite Trapezium at $1e-6$ tol = 0.002134 ITERATIONS 66 Composite
 trapezium rule with 66 intervals = 0.693162 Percentage error for Composite
 Trapezium at $1e-6$ tol = 0.002070 ITERATIONS 67 Composite trapezium rule
 with 67 intervals = 0.693161 Percentage error for Composite Trapezium
 at $1e-6$ tol = 0.002009 ITERATIONS 68 Composite trapezium rule with 68
 intervals = 0.693161 Percentage error for Composite Trapezium at $1e-6$ tol
 = 0.001950 ITERATIONS 69 Composite trapezium rule with 69 intervals =
 0.693160 Percentage error for Composite Trapezium at $1e-6$ tol = 0.001894
 ITERATIONS 70 Composite trapezium rule with 70 intervals = 0.693160
 Percentage error for Composite Trapezium at $1e-6$ tol = 0.001840 ITERATIONS
 71 Composite trapezium rule with 71 intervals = 0.693160 Percentage error
 for Composite Trapezium at $1e-6$ tol = 0.001789 ITERATIONS 72 Composite

[illegible]

```
= 0.000147  ITERATIONS 249 Composite trapezium rule with 249 intervals =  
0.693148 Percentage error for Composite Trapezium at 1e-6 tol = 0.000145  
ITERATIONS 250 Composite trapezium rule with 250 intervals = 0.693148  
Percentage error for Composite Trapezium at 1e-6 tol = 0.000144
```

Numerical Integration 3. Simpson's Rule

```
count = 1;  
errore = inf;  
max_count = 300; % Set a maximum count to prevent infinite loops  
  
int_simp_i = Simpson (fra, 1, 2, counter);  
  
% Number of sub-intervals needed to achieve an accuracy to 6 decimal places  
while (errore > tolerance && count < max_count)  
    int_simp_i = Simpson (fra, 1, 2, count);  
    errore = abs(true_integral - int_simp_i);  
  
    p_error_is = (abs(int_simp_i - true_integral) / true_integral) * 100;  
  
    %output to screen  
    fprintf('ITERATIONS %i \r', count)  
    fprintf('Simpsons rule with %i intervals =%10.6f \r', count,  
int_simp_i );  
    fprintf('Percentage error with %i intervals for Simpsons rule at 1e-6  
tol = %f \r \r', count, p_error_is);  
  
    count = count + 1;  
end
```

```
ITERATIONS 1 Simpsons rule with 1 intervals = 0.500000 Percentage error  
with 1 intervals for Simpsons rule at 1e-6 tol = 27.865248  ITERATIONS 2  
Simpsons rule with 2 intervals = 0.694444 Percentage error with 2 intervals  
for Simpsons rule at 1e-6 tol = 0.187156  ITERATIONS 3 Simpsons rule with  
3 intervals = 0.500000 Percentage error with 3 intervals for Simpsons  
rule at 1e-6 tol = 27.865248  ITERATIONS 4 Simpsons rule with 4 intervals  
= 0.693254 Percentage error with 4 intervals for Simpsons rule at 1e-6  
tol = 0.015406  ITERATIONS 5 Simpsons rule with 5 intervals = 0.584127  
Percentage error with 5 intervals for Simpsons rule at 1e-6 tol = 15.728290  
ITERATIONS 6 Simpsons rule with 6 intervals = 0.693170 Percentage error  
with 6 intervals for Simpsons rule at 1e-6 tol = 0.003262  ITERATIONS 7  
Simpsons rule with 7 intervals = 0.617220 Percentage error with 7 intervals  
for Simpsons rule at 1e-6 tol = 10.954003  ITERATIONS 8 Simpsons rule with 8  
intervals = 0.693155 Percentage error with 8 intervals for Simpsons rule at  
1e-6 tol = 0.001060  ITERATIONS 9 Simpsons rule with 9 intervals = 0.634904  
Percentage error with 9 intervals for Simpsons rule at 1e-6 tol = 8.402717  
ITERATIONS 10 Simpsons rule with 10 intervals = 0.693150 Percentage error  
with 10 intervals for Simpsons rule at 1e-6 tol = 0.000440  ITERATIONS  
11 Simpsons rule with 11 intervals = 0.645908 Percentage error with 11  
intervals for Simpsons rule at 1e-6 tol = 6.815213  ITERATIONS 12 Simpsons  
rule with 12 intervals = 0.693149 Percentage error with 12 intervals for  
Simpsons rule at 1e-6 tol = 0.000214  ITERATIONS 13 Simpsons rule with 13  
intervals = 0.653415 Percentage error with 13 intervals for Simpsons rule
```

at $1e-6$ tol = 5.732183 ITERATIONS 14 Simpsons rule with 14 intervals =
0.693148 Percentage error with 14 intervals for Simpsons rule at $1e-6$ tol =
0.000116

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