Chittagong University of Engineering Technology

EEE-496

Digital Signal Processing Sessional

Familiarization with basic commands and tools

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1 Wallis product

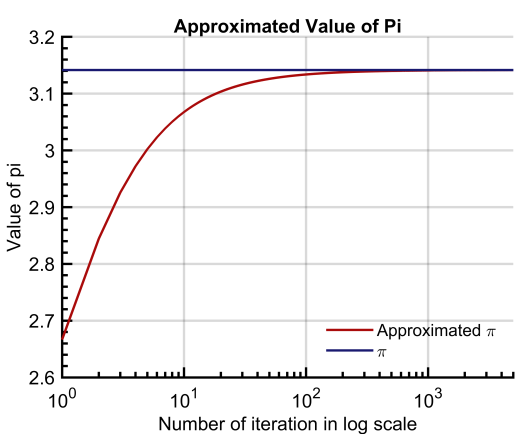
$$\pi = 2 \times \frac{2 \cdot 2 \cdot 4 \cdot 4 \cdot 6 \cdot 6 \cdots}{1 \cdot 3 \cdot 3 \cdot 5 \cdot 5 \cdot 7 \cdots}$$

1.1 Code

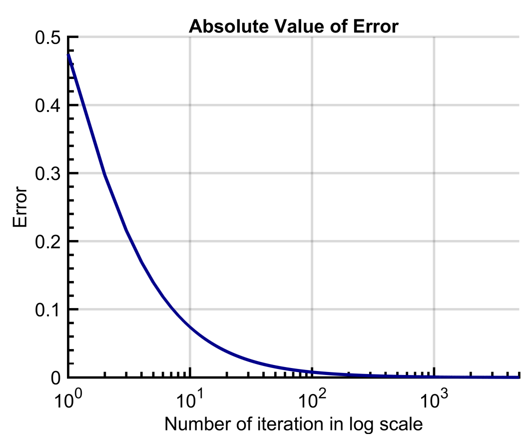
```
clc;
clear;
close all;
multiply=1;
iteration=1:5000;
len=length(iteration);
pi_array=zeros(1, len);
error=zeros(1, len);
%% Approximate the value of pi and determine error
for i=iteration;
    series=4*i^2/(4*i^2-1);
    multiply=multiply*series;
    appro_pi=2*multiply
    er=abs(pi-appro_pi);
    pi_array(1,i)=appro_pi;
    error(1, i)=er;
end
%% Wallis product series convergence to pi
plt=Plot(iteration, pi_array, [1,len],[pi pi])
plt.XLabel='Number of iteration in log scale'
plt.YLabel="Value of pi";
plt.Title="Approximated Value of Pi";
plt.XGrid="on";
plt.YGrid="on";
plt.XScale="log";
plt.XLim=[1 len];
plt.Legend = {'Approximated \pi', '\pi'};
plt.LegendLoc="southeast"
plt.Colors={[170/256 10/256 10/256],[25/256 ...
  25/256 112/256]};
```

```
plt.BoxDim = [4, 3];
plt.ShowBox="off";
plt.export('problemOnePi.png');
%% Plot the absolute value of error
plt=Plot(iteration, error)
plt.XLabel='Number of iteration in log scale'
plt.YLabel="Error";
plt.Title="Absolute Value of Error";
plt.XGrid="on";
plt.YGrid="on";
plt.XScale="log";
plt.LineWidth=2;
plt.Colors={[0 0 139/256]};
plt.XLim=[1 len];
plt.BoxDim = [4, 3];
plt.ShowBox="off";
plt.export('problemOneError.png');
```

1.2 Figure



(a)



(b)

Figure 1: (a) Change in approximated Value of π with number of terms. (b) Error in approximation

2 Continued fraction

$$\frac{\pi}{4} = 1 + \cfrac{1^2}{2 + \cfrac{3^2}{2 + \cfrac{5^2}{2 + \cdots}}}$$

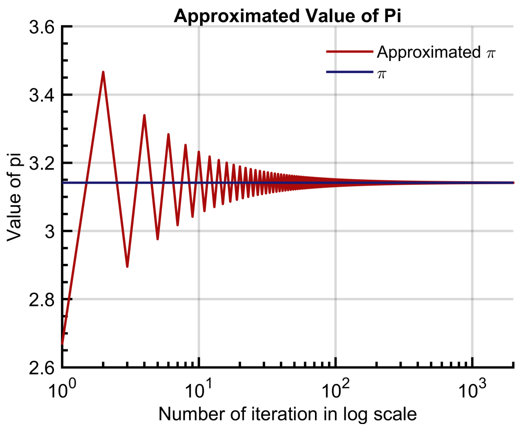
2.1 Code

```
clc;
clear;
close all;
iteration=1:2000;
len=length(iteration);
error=zeros(1, len);
pi_array=zeros(1,len);
%% Approximate the value of pi and determine error
for n=iteration
    appro_pi=4/FourByPi(n,1);
    disp(appro_pi);
    er=abs(pi-appro_pi);
    pi_array(1,n)=appro_pi;
    error(1,n)=er;
end
%% Continued fraction series convergence to pi
plt=Plot(iteration, pi_array, [1,len],[pi pi])
plt.XLabel='Number of iteration in log scale'
plt.YLabel="Value of pi";
plt.Title="Approximated Value of Pi";
plt.XGrid="on";
plt.YGrid="on";
plt.XScale="log";
plt.XLim=[1 len];
plt.Legend = {'Approximated \pi', '\pi'};
plt.Colors={[170/256 10/256 10/256],[25/256 ...
  25/256 112/256]};
plt.BoxDim = [4, 3];
```

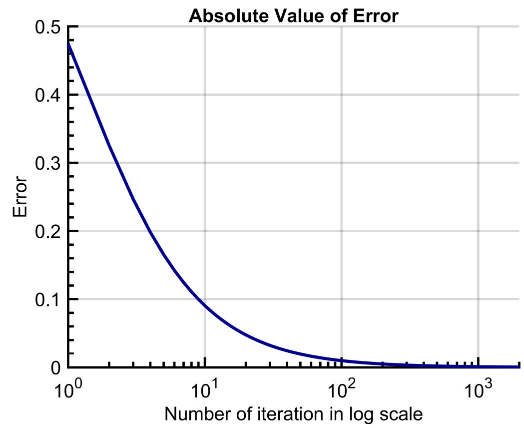
```
plt.ShowBox="off";
plt.export('problemTwoPi.png');
%% Plot the absolute value of error
plt=Plot(iteration, error)
plt.XLabel='Number of iteration in log scale'
plt.YLabel="Error";
plt.Title="Absolute Value of Error";
plt.XGrid="on";
plt.YGrid="on";
plt.XScale="log";
plt.LineWidth=2;
plt.Colors={[0 0 139/256]};
plt.XLim=[1 len];
plt.BoxDim = [4, 3];
plt.ShowBox="off";
plt.export('problemTwoError.png');
disp(appro_pi)
%% Define a recursive function
function y=FourByPi(i, ctr)
if (i==0)
    y=0;
    return;
end
x = ((2*ctr)-1)^2 / (2 + FourByPi(i - 1, ctr + 1));
if ctr == 1
    y=x+1;
    return
else
    y=x+0;
    return
end
end
```

2.2 Figure

Required figure for problem 2



(a)



(b)

Figure 2: (a) Change in approximated Value of π with number of terms. (b) Error in approximation

3 Gregory–Leibniz series for π

$$\pi = 4(1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} - \cdots)$$

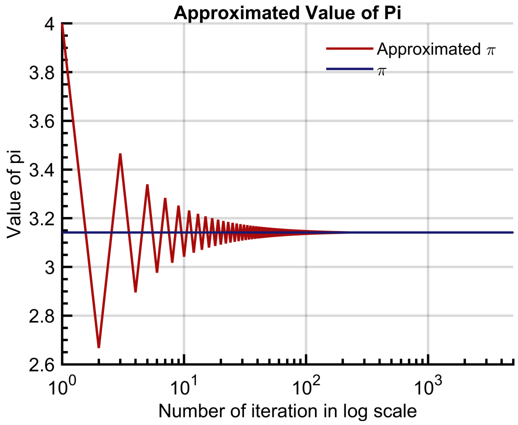
3.1 Code

```
clc;
clear;
close all;
s=0;
iteration=1:5000;
len=length(iteration);
pi_array=zeros(1, len);
error=zeros(1, len);
%% Approximate the value of pi and determine error
for i=iteration;
    series=(-1)^(i+1)/(2*i-1);
    s=s+4*series;
    er=abs(pi-s);
    pi_array(1,i)=s;
    error(1, i)=er;
end
```

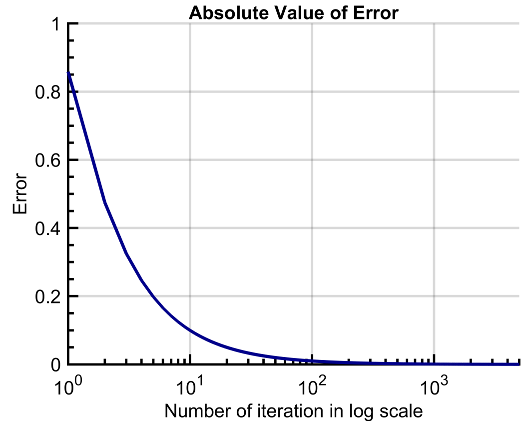
```matlab
%% Gregory-Leibniz series convergence to pi
plt=Plot(iteration, pi_array, [1,len],[pi pi])
plt.XLabel='Number of iteration in log scale'
plt.YLabel="Value of pi";
plt.Title="Approximated Value of Pi";
plt.XGrid="on";
plt.YGrid="on";
plt.XScale="log";
plt.XLim=[1 len];
plt.Legend = {'Approximated \pi', '\pi'};
plt.Colors={[170/256 10/256 10/256],[25/256 ...
  25/256 112/256]};
plt.BoxDim = [4, 3];
plt.ShowBox="off";
plt.export('problemThreePi.png');
%% Plot the absolute value of error
plt=Plot(iteration, error)
plt.XLabel='Number of iteration in log scale'
plt.YLabel="Error";
plt.Title="Absolute Value of Error";
plt.XGrid="on";
plt.YGrid="on";
plt.XScale="log";
plt.LineWidth=2;
plt.Colors={[0 0 139/256]};
plt.XLim=[1 len];
plt.BoxDim = [4, 3];
plt.ShowBox="off";
plt.export('problemThreeError.png');
```

3.2 Figure

Required figure for problem 3



(a)



(b)

Figure 3: (a) Change in approximated Value of π with number of terms. (b) Error in approximation

4 Arcsine series for π

$$\pi = 6(\frac{1}{2} + \frac{1}{2 \cdot 3 \cdot 2^3} + \frac{1 \cdot 3}{2 \cdot 4 \cdot 5 \cdot 2^5} + \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6 \cdot 7 \cdot 2^7} + \cdots)$$

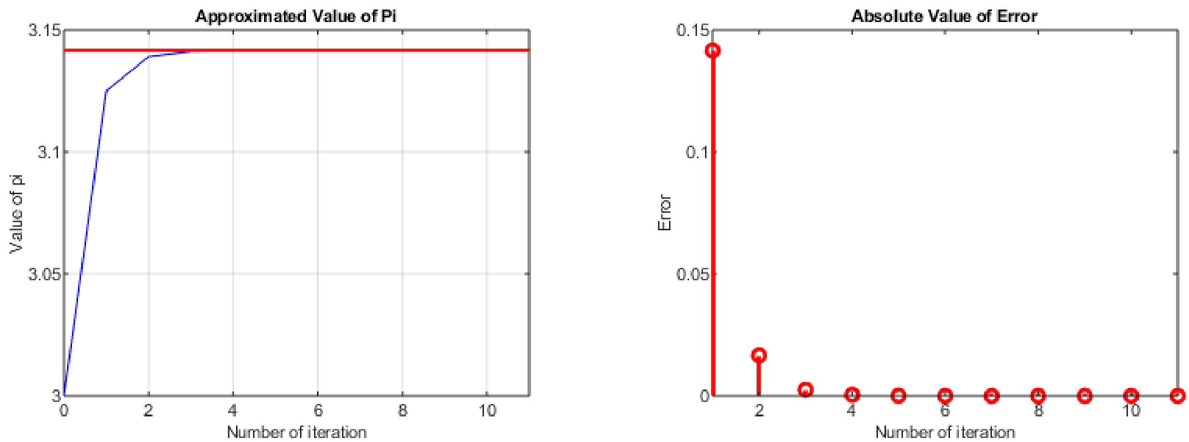
4.1 Code

```
clc;
clear;
close all;
s=0;
iteration=0:10;
len=length(iteration);
pi_array=zeros(1, len);
error=zeros(1, len);
%% Approximate the value of pi and determine error
for n=iteration;
    a=factorial(2*n)/(factorial(n)*factorial(n));
    b=(16^n)*(2*n+1);
```

```
    series=3*a/b;
    s=s+series;
    er=abs(pi-s);
    pi_array(1,n+1)=s;
    error(:,n+1)=er;
end
%% ArcSin series convergence to pi
figure
plot(iteration, pi_array, 'color', 'b')
hold on;
line([0 len], [pi pi],'color', 'r', "linewidth", ...
  1.5);
xlabel('Number of iteration')
ylabel("Value of pi");
title("Approximated Value of Pi")
grid on
xlim([0 len])
%% Plot the absolute value of error
figure
stem(1:length(error), error, "color","r", ...
  "linewidth",2);
xlabel("Number of iteration");
ylabel("Error");
title("Absolute Value of Error");
display(s)
```

4.2 Figure

Required figure for problem 4



(a) (b)

Figure 4: (a) Change in approximated Value of π with number of terms. (b) Error in approximation

5 Euler series for π

$$\frac{\pi^2}{6} = (\frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \frac{1}{4^2} + \frac{1}{5^2} \cdots)$$

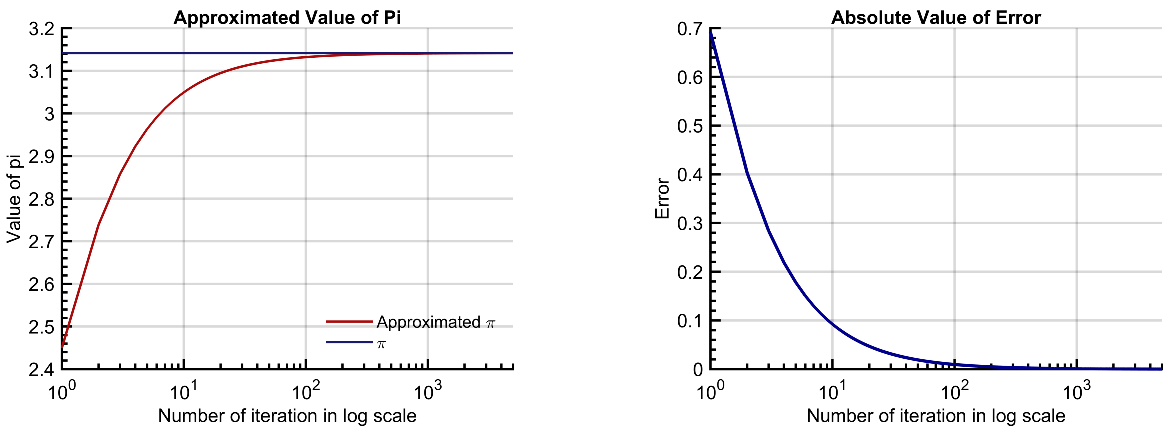
5.1 Code

```
clc;
clear;
close all;
s=0;
iteration=1:50000;
len=length(iteration);
pi_array=zeros(1,len);
error=zeros(1, len);
for k=iteration;
    series=1/k^2;
    s=s+series;
    appro_pi=sqrt(6*s);
```

```
    pi_array(1,k)=appro_pi;
    er=abs(pi-appro_pi);
    error(:,k)=er;
end
%% Leonar Euler series convergence to pi
figure
semilogx(iteration, pi_array, 'color', 'b')
hold on;
line([1 len], [pi pi],'color', 'r', "linewidth", ...
  1.5);
xlabel('Number of iteration in log scale')
ylabel("Value of pi");
title("Approximated Value of Pi")
grid on
xlim([1 len])
%% Plot the absolute value of error
figure
semilogx(iteration, error, "color", "b", ...
  "linewidth",2)
xlabel('Number of iteration in log scale')
ylabel("Error");
title("Absolute Value of Error")
xlim([1 len]);
grid on
disp(appro_pi)
```

5.2 Figure

Required figure for problem 5



(a) (b)

Figure 5: (a) Change in approximated Value of π with number of terms. (b) Error in approximation

6 Series of pi for $\zeta(2)$

$$\frac{\pi^2}{6} = (\frac{2^2}{2^2-1} \cdot \frac{3^2}{3^2-1} \cdot \frac{5^2}{5^2-1} \cdot \frac{7^2}{7^2-1} \cdot \frac{11^2}{11^2-1} \cdots)$$

6.1 Code

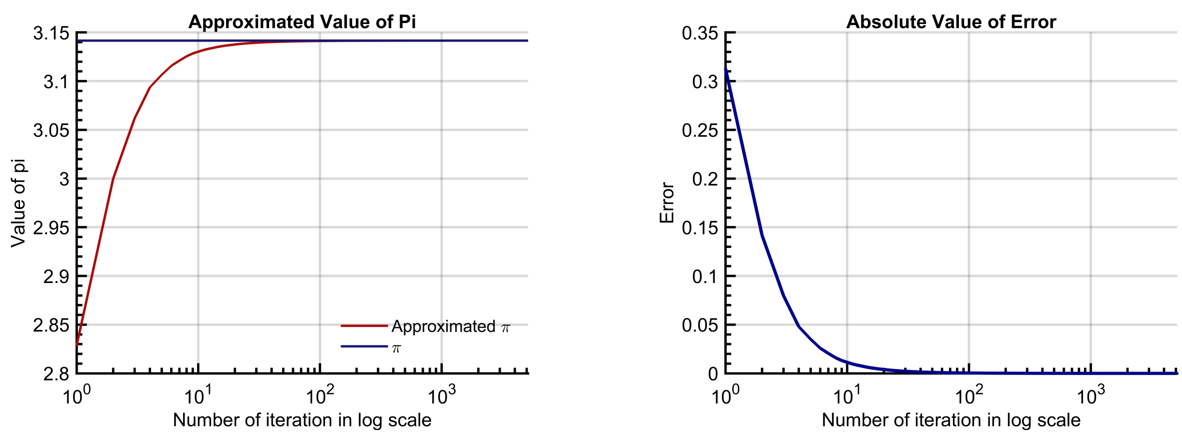
```
clc;
clear;
close all;
number=1:50000;
filter=isprime(number);
prime=number(filter);
multiply=1;
count=0
len=length(prime);
pi_array=zeros(1, len);
error=zeros(1, len);
for n=prime;
```

```
    series=n^2/(n^2-1);
    m=series;
    multiply=multiply*m;
    appro_pi=sqrt(6*multiply);
    er=abs(pi-appro_pi);
    count=count+1;
    pi_array(1,count)=appro_pi;
    error(1,count)=er;
end
%% Zeta function for z=2 series convergence to pi
plt=Plot(1:len, pi_array, [1,len],[pi pi])
plt.XLabel='Number of iteration in log scale'
plt.YLabel="Value of pi";
plt.Title="Approximated Value of Pi";
plt.XGrid="on";
plt.YGrid="on";
plt.XScale="log";
plt.XLim=[1 len];
plt.Legend = {'Approximated \pi', '\pi'};
plt.LegendLoc="southeast"
plt.Colors={[170/256 10/256 10/256],[25/256 ...
  25/256 112/256]};
plt.BoxDim = [4, 3];
plt.ShowBox="off";
plt.export('problemSixPi.png');
%% Plot the absolute value of error
plt=Plot(1:len, error)
plt.XLabel='Number of iteration in log scale'
plt.YLabel="Error";
plt.Title="Absolute Value of Error";
plt.XGrid="on";
plt.YGrid="on";
plt.XScale="log";
plt.LineWidth=2;
plt.Colors={[0 0 139/256]};
plt.XLim=[1 len];
```

```
plt.BoxDim = [4, 3];
plt.ShowBox="off";
plt.export('problemSixError.png');
disp(appro_pi)
```

6.2 Figure

Required figure for problem 6



(a) (b)

Figure 6: (a) Change in approximated Value of π with number of terms. (b) Error in approximation