CM 3110 – Computational Mathematics

Assignment 1
Introduction to numerical Methods

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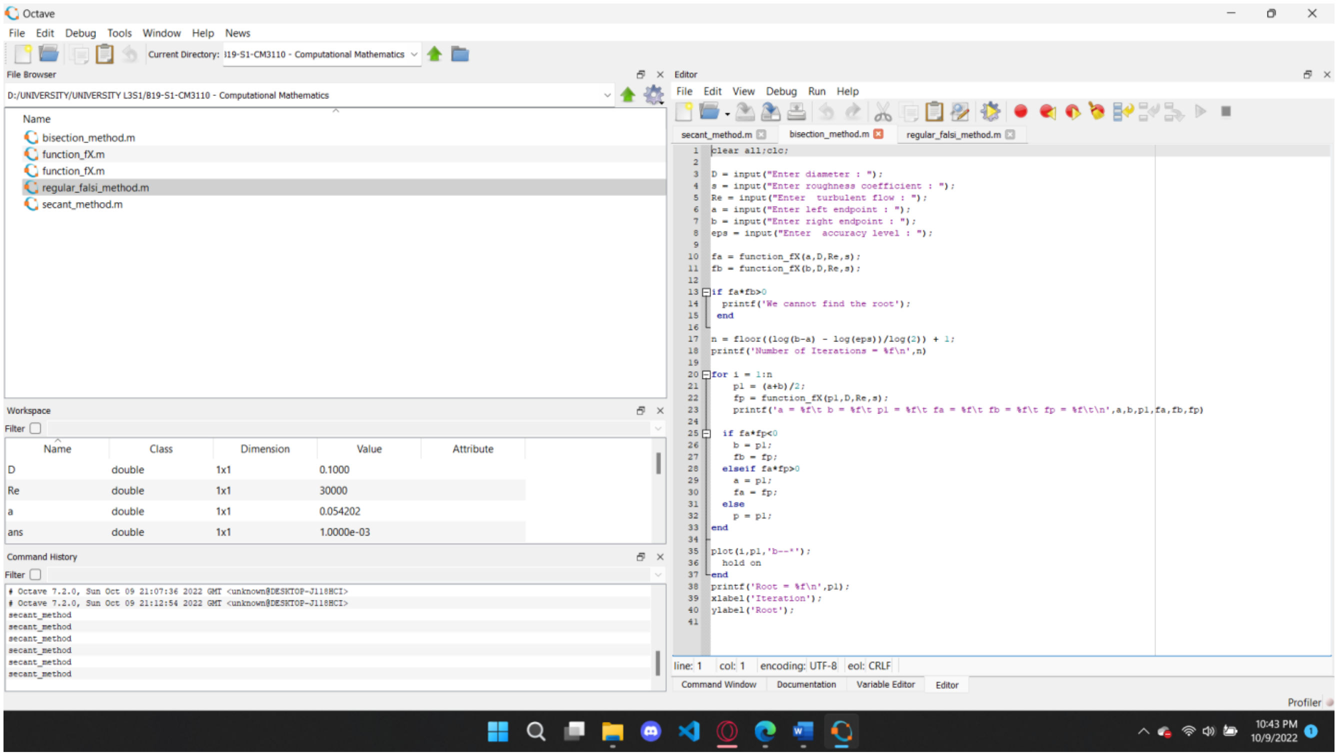
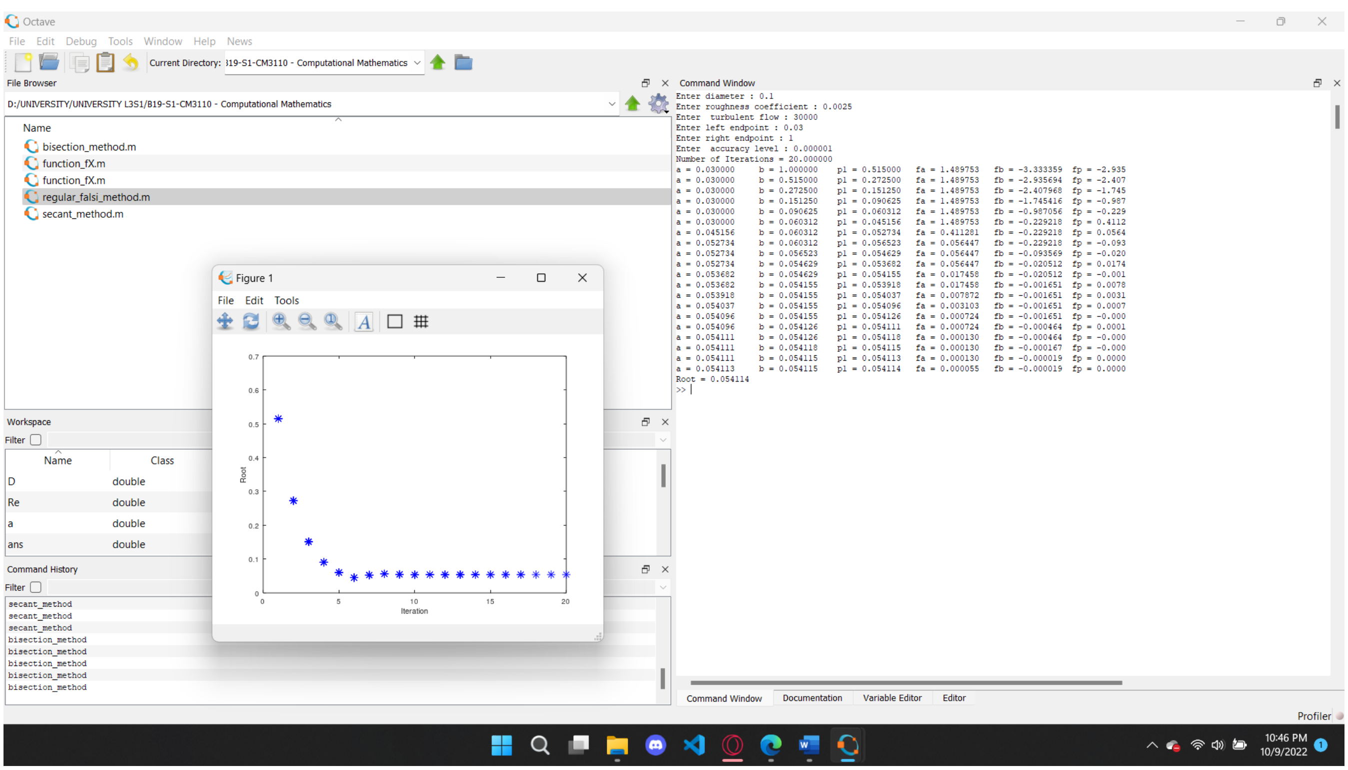
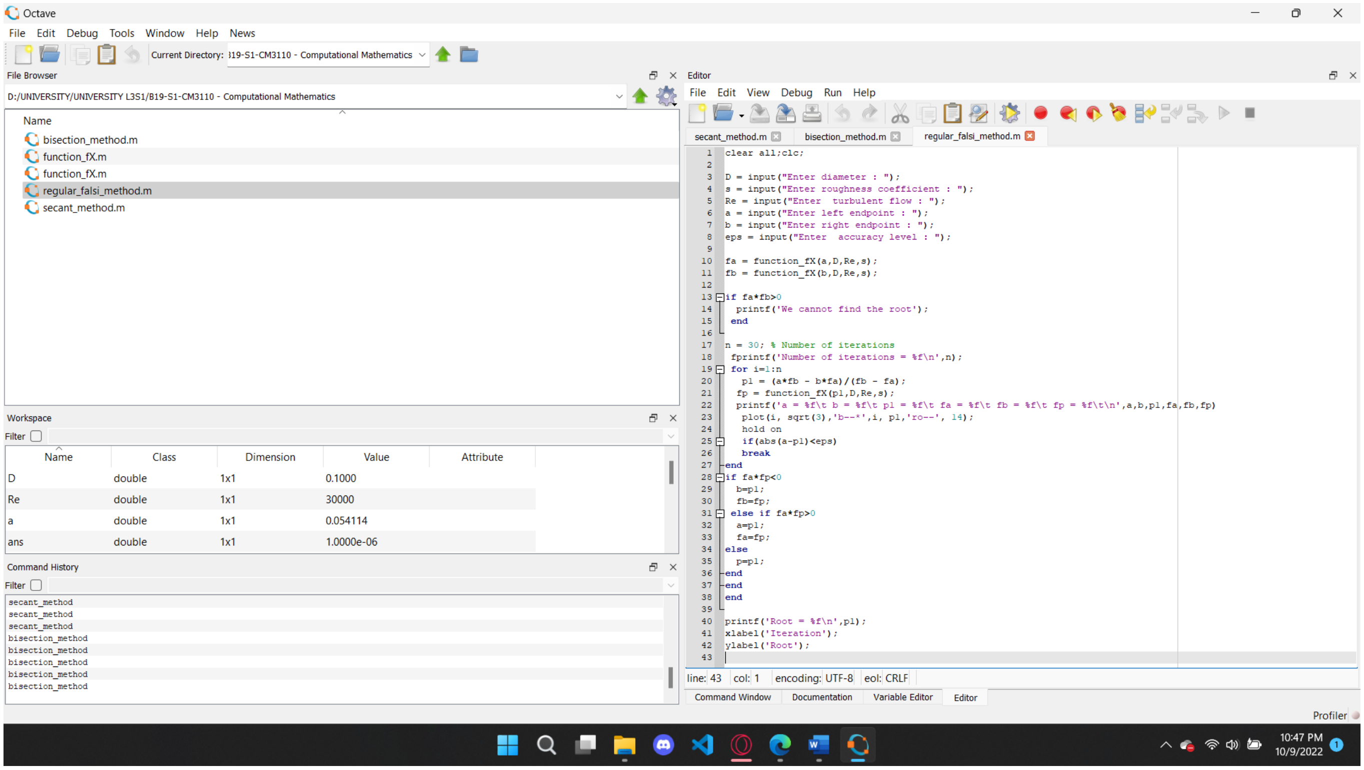
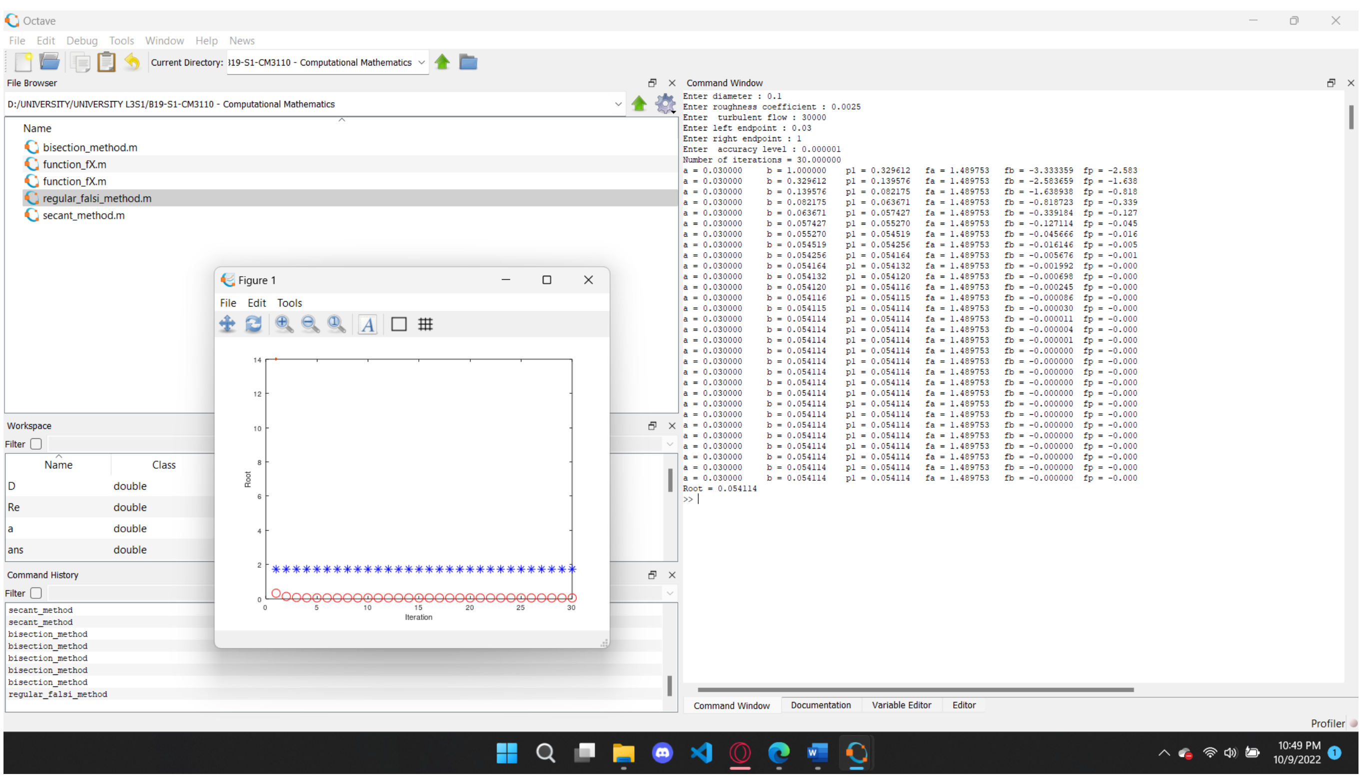
- **Screenshots of program running**
    a) Bisection Method



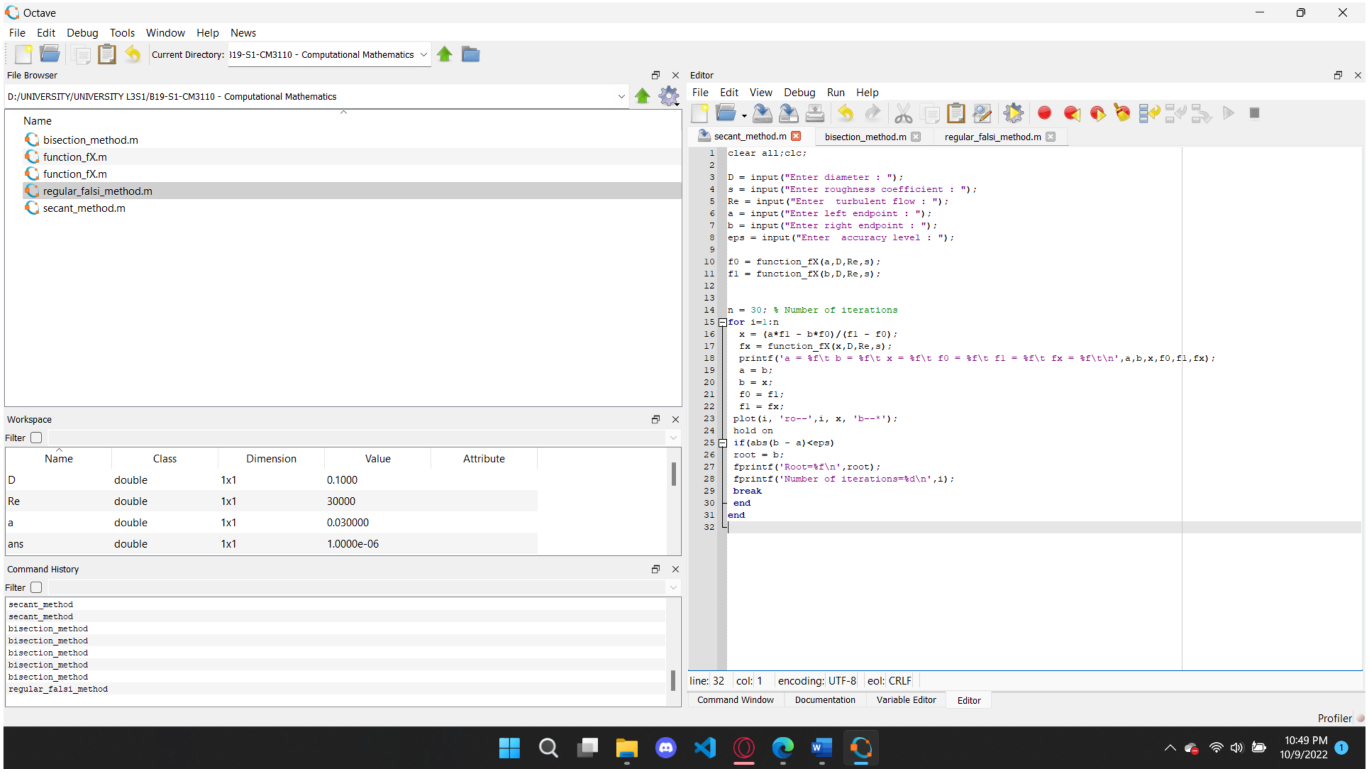


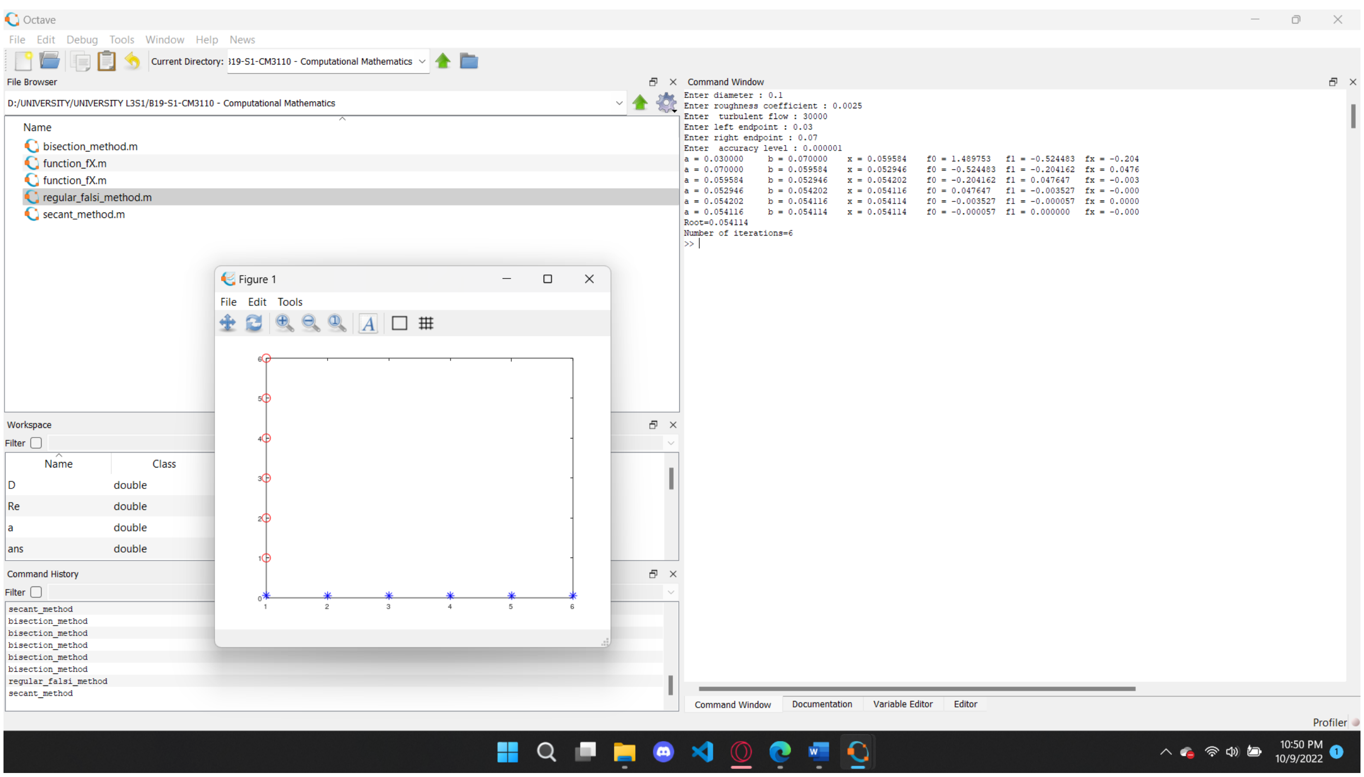
b) Regular Falsi method





c) Secant method





- **Program file**

a) Bisection Method

```
clear all;clc;

D = input("Enter diameter : ");

s = input("Enter roughness coefficient : ");

Re = input("Enter  turbulent flow : ");

a = input("Enter left endpoint : ");

b = input("Enter right endpoint : ");

eps = input("Enter  accuracy level : ");


fa = function_fX(a,D,Re,s);

fb = function_fX(b,D,Re,s);


if fa*fb>0

  printf('We cannot find the root');

 end


n = floor((log(b-a) - log(eps))/log(2)) + 1;

printf('Number of Iterations = %f\n',n)


for i = 1:n

    p1 = (a+b)/2;

    fp = function_fX(p1,D,Re,s);

    printf('a = %f\t b = %f\t p1 = %f\t fa = %f\t fb = %f\t fp = %f\t\n',a,b,p1,fa,fb,fp)


  if fa*fp<0

    b = p1;

    fb = fp;

  elseif fa*fp>0
```

```
    a = p1;

    fa = fp;

  else

    p = p1;

end


plot(i,p1,'b--*');

  hold on

end

printf('Root = %f\n',p1);

xlabel('Iteration');

ylabel('Root');
```

b) Regular Falsi method

```
clear all;clc;


D = input("Enter diameter : ");

s = input("Enter roughness coefficient : ");

Re = input("Enter  turbulent flow : ");

a = input("Enter left endpoint : ");

b = input("Enter right endpoint : ");

eps = input("Enter  accuracy level : ");


fa = function_fX(a,D,Re,s);

fb = function_fX(b,D,Re,s);


if fa*fb>0

  printf('We cannot find the root');

 end
```

```
n = 30; % Number of iterations
 fprintf('Number of iterations = %f\n',n);
 for i=1:n
   p1 = (a*fb - b*fa)/(fb - fa);
  fp = function_fX(p1,D,Re,s);
  printf('a = %f\t b = %f\t p1 = %f\t fa = %f\t fb = %f\t fp = %f\t\n',a,b,p1,fa,fb,fp)
   plot(i, sqrt(3),'b--*',i, p1,'ro--', 14);
   hold on
   if(abs(a-p1)<eps)
   break
end
if fa*fp<0
  b=p1;
  fb=fp;
 else if fa*fp>0
  a=p1;
  fa=fp;
else
  p=p1;
end
end
end


printf('Root = %f\n',p1);
xlabel('Iteration');
ylabel('Root');
```

c) Secant method

```
clear all;clc;
```

```
D = input("Enter diameter : ");

s = input("Enter roughness coefficient : ");

Re = input("Enter  turbulent flow : ");

a = input("Enter left endpoint : ");

b = input("Enter right endpoint : ");

eps = input("Enter  accuracy level : ");


f0 = function_fX(a,D,Re,s);

f1 = function_fX(b,D,Re,s);



n = 30; % Number of iterations

for i=1:n

  x = (a*f1 - b*f0)/(f1 - f0);

  fx = function_fX(x,D,Re,s);

  printf('a = %f\t b = %f\t x = %f\t f0 = %f\t f1 = %f\t fx = %f\t\n',a,b,x,f0,f1,fx);

  a = b;

  b = x;

  f0 = f1;

  f1 = fx;

 plot(i, 'ro--',i, x, 'b--*');

 hold on

 if(abs(b - a)<eps)

 root = b;

 fprintf('Root=%f\n',root);

 fprintf('Number of iterations=%d\n',i);

 break

 end

end
```

- **Output file**

a) Bisection Method

```
Enter diameter : 0.1
Enter roughness coefficient : 0.0025
Enter  turbulent flow : 30000
Enter left endpoint : 0.03
Enter right endpoint : 1
Enter  accuracy level : 0.000001
Number of Iterations = 20.000000
a = 0.030000   b = 1.000000   p1 = 0.515000   fa = 1.489753   fb = -3.333359  fp = -2.935694
a = 0.030000   b = 0.515000   p1 = 0.272500   fa = 1.489753   fb = -2.935694  fp = -2.407968
a = 0.030000   b = 0.272500   p1 = 0.151250   fa = 1.489753   fb = -2.407968  fp = -1.745416
a = 0.030000   b = 0.151250   p1 = 0.090625   fa = 1.489753   fb = -1.745416  fp = -0.987056
a = 0.030000   b = 0.090625   p1 = 0.060312   fa = 1.489753   fb = -0.987056  fp = -0.229218
a = 0.030000   b = 0.060312   p1 = 0.045156   fa = 1.489753   fb = -0.229218  fp = 0.411281
a = 0.045156   b = 0.060312   p1 = 0.052734   fa = 0.411281   fb = -0.229218  fp = 0.056447
a = 0.052734   b = 0.060312   p1 = 0.056523   fa = 0.056447   fb = -0.229218  fp = -0.093569
a = 0.052734   b = 0.056523   p1 = 0.054629   fa = 0.056447   fb = -0.093569  fp = -0.020512
a = 0.052734   b = 0.054629   p1 = 0.053682   fa = 0.056447   fb = -0.020512  fp = 0.017458
a = 0.053682   b = 0.054629   p1 = 0.054155   fa = 0.017458   fb = -0.020512  fp = -0.001651
a = 0.053682   b = 0.054155   p1 = 0.053918   fa = 0.017458   fb = -0.001651  fp = 0.007872
a = 0.053918   b = 0.054155   p1 = 0.054037   fa = 0.007872   fb = -0.001651  fp = 0.003103
a = 0.054037   b = 0.054155   p1 = 0.054096   fa = 0.003103   fb = -0.001651  fp = 0.000724
a = 0.054096   b = 0.054155   p1 = 0.054126   fa = 0.000724   fb = -0.001651  fp = -0.000464
a = 0.054096   b = 0.054126   p1 = 0.054111   fa = 0.000724   fb = -0.000464  fp = 0.000130
a = 0.054111   b = 0.054126   p1 = 0.054118   fa = 0.000130   fb = -0.000464  fp = -0.000167
a = 0.054111   b = 0.054118   p1 = 0.054115   fa = 0.000130   fb = -0.000167  fp = -0.000019
a = 0.054111   b = 0.054115   p1 = 0.054113   fa = 0.000130   fb = -0.000019  fp = 0.000055
a = 0.054113   b = 0.054115   p1 = 0.054114   fa = 0.000055   fb = -0.000019  fp = 0.000018
Root = 0.054114
>>
```

b) Regular Falsi method

```
Enter diameter : 0.1
Enter roughness coefficient : 0.0025
Enter  turbulent flow : 30000
Enter left endpoint : 0.03
Enter right endpoint : 1
Enter  accuracy level : 0.000001
Number of iterations = 30.000000
a = 0.030000   b = 1.000000   p1 = 0.329612   fa = 1.489753   fb = -3.333359  fp = -2.583659
a = 0.030000   b = 0.329612   p1 = 0.139576   fa = 1.489753   fb = -2.583659  fp = -1.638938
a = 0.030000   b = 0.139576   p1 = 0.082175   fa = 1.489753   fb = -1.638938  fp = -0.818723
a = 0.030000   b = 0.082175   p1 = 0.063671   fa = 1.489753   fb = -0.818723  fp = -0.339184
a = 0.030000   b = 0.063671   p1 = 0.057427   fa = 1.489753   fb = -0.339184  fp = -0.127114
a = 0.030000   b = 0.057427   p1 = 0.055270   fa = 1.489753   fb = -0.127114  fp = -0.045666
a = 0.030000   b = 0.055270   p1 = 0.054519   fa = 1.489753   fb = -0.045666  fp = -0.016146
a = 0.030000   b = 0.054519   p1 = 0.054256   fa = 1.489753   fb = -0.016146  fp = -0.005676
a = 0.030000   b = 0.054256   p1 = 0.054164   fa = 1.489753   fb = -0.005676  fp = -0.001992
a = 0.030000   b = 0.054164   p1 = 0.054132   fa = 1.489753   fb = -0.001992  fp = -0.000698
a = 0.030000   b = 0.054132   p1 = 0.054120   fa = 1.489753   fb = -0.000698  fp = -0.000245
a = 0.030000   b = 0.054120   p1 = 0.054116   fa = 1.489753   fb = -0.000245  fp = -0.000086
a = 0.030000   b = 0.054116   p1 = 0.054115   fa = 1.489753   fb = -0.000086  fp = -0.000030
a = 0.030000   b = 0.054115   p1 = 0.054114   fa = 1.489753   fb = -0.000030  fp = -0.000011
a = 0.030000   b = 0.054114   p1 = 0.054114   fa = 1.489753   fb = -0.000011  fp = -0.000004
a = 0.030000   b = 0.054114   p1 = 0.054114   fa = 1.489753   fb = -0.000004  fp = -0.000001
```

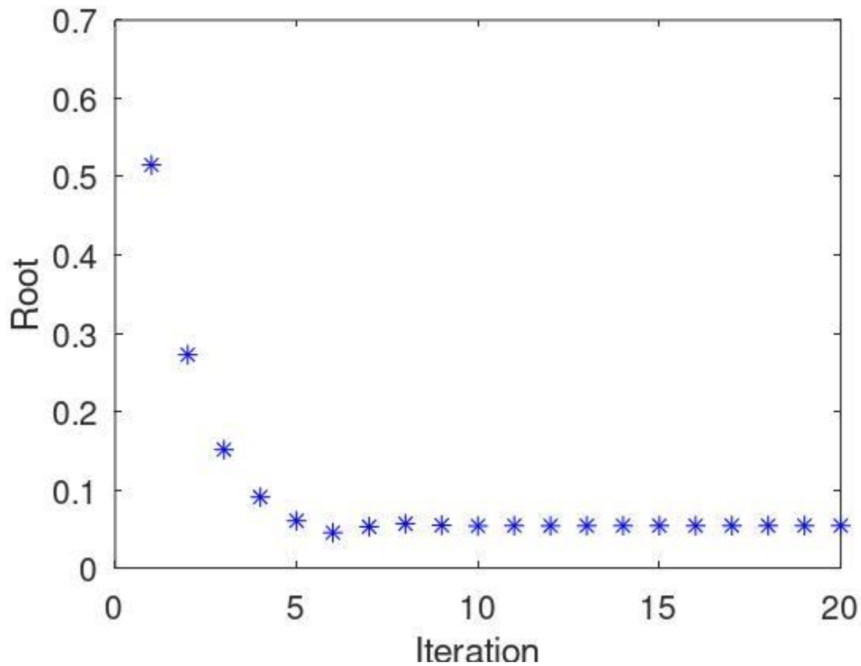
```
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000001  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
a = 0.030000    b = 0.054114    p1 = 0.054114   fa = 1.489753   fb = -0.000000  fp = -0.000000
Root = 0.054114
>>
```

c) Secant method

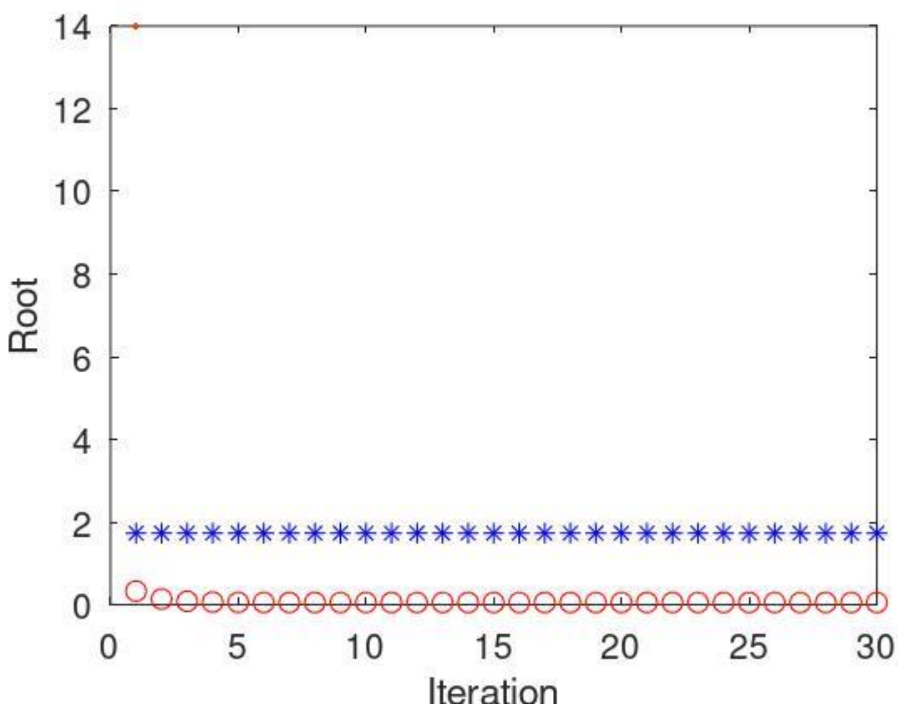
```
Enter diameter : 0.1
Enter roughness coefficient : 0.0025
Enter  turbulent flow : 30000
Enter left endpoint : 0.03
Enter right endpoint : 0.07
Enter  accuracy level : 0.000001
a = 0.030000    b = 0.070000    x = 0.059584    f0 = 1.489753   f1 = -0.524483  fx = -0.204162
a = 0.070000    b = 0.059584    x = 0.052946    f0 = -0.524483  f1 = -0.204162  fx = 0.047647
a = 0.059584    b = 0.052946    x = 0.054202    f0 = -0.204162  f1 = 0.047647   fx = -0.003527
a = 0.052946    b = 0.054202    x = 0.054116    f0 = 0.047647   f1 = -0.003527  fx = -0.000057
a = 0.054202    b = 0.054116    x = 0.054114    f0 = -0.003527  f1 = -0.000057  fx = 0.000000
a = 0.054116    b = 0.054114    x = 0.054114    f0 = -0.000057  f1 = 0.000000   fx = -0.000000
Root=0.054114
Number of iterations=6
>>
```

- **Plot of approximate solution vs. iteration in each techniques**

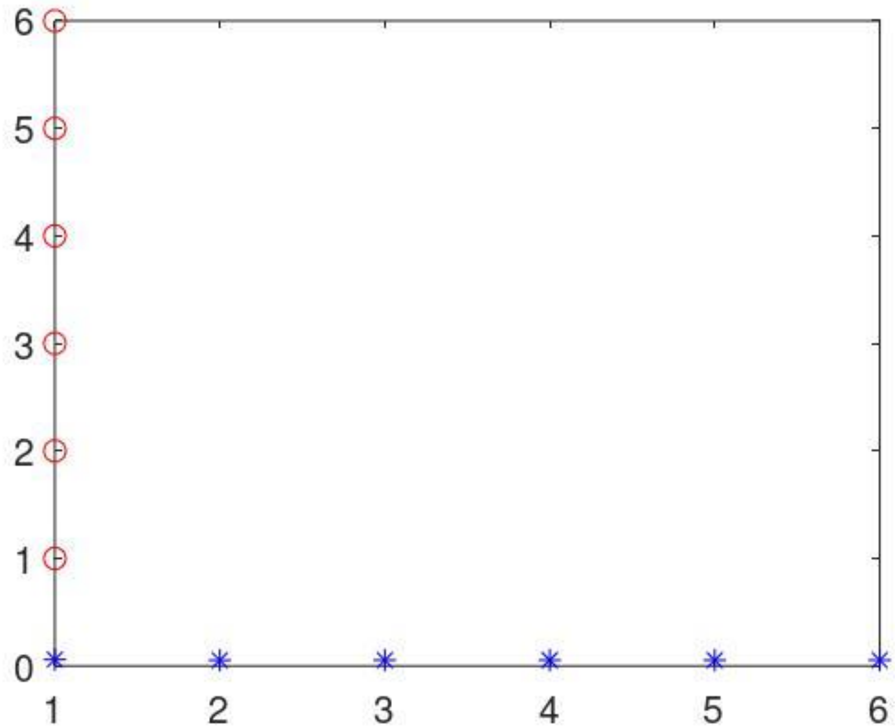
  1. **Bisection Method**



  2. **Regular Falsi method**



3. **Secant method**



- ## Comparison and analysis of different techniques
  - The estimated solution of the plot grows increasingly accurate as the number of iterations increases.
  - Comparison and analysis of different techniques
    1. The bisection Method is the simplest numerical scheme to find the roots. This method is very slow but the accuracy is high.
    2. The method of False position which is also known as the Regular Falsi Method is one of the bracketing methods for finding the roots of the equation. This was developed since the convergence of the Bisection method is very slow. Since this is a bracketing method, the root is located within an interval prescribed by a lower and an upper bound.
    3. The Secant method requires the selection of 2 initial approximates x0 and x1 which may or may not bracket the desired root, but which are chosen reasonably close to the exact root.
- When comparing the outputs of these 3 methods every method gives 0.054114.