1 Solving Nonlinear Equations

- We have given the following function;

$$f(x) = 3x + sin(x) - e^x$$

Look at to the plot of the function to learn where the function crosses the x-axis. MATLAB can do it for us:

```
>> fx = inline ( ' 3 *x + sin ( x) - exp ( x) ')
>> fplot ( fx, [ 0 2 ]) ; grid on
```

An algorithm for Halving the Interval (Bisection):

To determine a root of $f(x) = 0$ that is accurate within a specified tolerance value, given values x_1 and x_2, such that $f(x_1) * f(x_2) < 0$,
Repeat
Set $x3 = (x_1 + x_2)/2$
If $f(x_3) * f(x_1) < 0$ Then
Set $x_2 = x_3$
Else Set $x_l = x_3$ End If
Until $(|x_1 - x_2|) < 2 * tolerance\ value$

The MATLAB program for this algorithm is given.

```
function rtn=bisec(fx,xa,xb,n)
%bisec does n bisections to approximate
% a root of fx
x=xa; fa=eval(fx);
x=xb; fb=eval(fx);
for i=1:n;
  xc=(xa+xb)/2; x=xc; fc=eval(fx);
  X=[i,xa,xb,xc,fc];
  disp(X);
  if fc*fa<0
    xb=xc;
    else xa=xc;
  end
end
```

save with the name *bisec.m*. Then;

```
>> fx=' 3 *x + sin ( x) - exp ( x) '
>> bisec(fx,0,1,13)
```

Modify this MATLAB program for the bisection method for using a tolerance value of 1E-4.

- Use the function used in the previous item, and write a MATLAB program for the method of false position (regula falsi):
  An algorithm for the method of false position (regula falsi):

To determine a root of $f(x) = 0$, given two values of x_0 and x_1 that bracket a root: that is, $f(x_0)$ and $f(x_1)$ are of opposite sign,
Repeat
Set $x_2 = x_1 - f(x_1) * \frac{(x_0 - x_1)}{f(x_0) - f(x_1)}$
If $f(x_2)$ is of opposite sign to $f(x_0)$ Then
Set $x_1 = x_2$,
Else
Set $x_0 = x_2$
End If
Until $\lvert f(x_2) \rvert < tolerance\ value.$

- To obtain the true value for the root r, which is needed to compute the actual error. MATLAB surely used a more advanced method than bisection.

```
>> solve('3*x + sin(x) - exp(x)')
ans=
.36042170296032440136932951583028
```

Tabulate the actual error values as the following;

n	Bisection $(x_n - r)$	Regula Falsi $(x_n - r)$	Bisection $f(x_n)$	Regula Falsi $f(x_n)$
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
12				
13				
14				
15				

Table 1: The Error Sequences