Class meeting #14
Monday, October 12th

GEEN 1300
Introduction to Engineering Computing

Excel & Visual Basic for Applications (VBA)

- Algorithm development: bisection
- Spreadsheet prototyping: bisection
- VBA programming: bisection
- Debugging and documentation

Homework #6 due Wednesday

Algorithm Design
- Statement of the objective
- Written step-wise description of the method
- Flowchart the method

Prototyping
- Develop an Excel spreadsheet to test the method and demonstrate its effectiveness & limitations

Program Development
- Write, code and test VBA program

Documentation
- Commenting of code
- Nomenclature tables
- Users’ guide
Case Study Problem

Develop a user-defined function in VBA that solves for a root of a nonlinear equation, given the evaluation of the equation on the spreadsheet based on input cells, and using the bisection method.

The Bisection Method

1) obtain two starting estimates for the root, $x_1$ and $x_2$
2) evaluate $f(x_1)$ and $f(x_2)$
3) check that $f(x_1)$ and $f(x_2)$ are of opposite sign. If not, the starting estimates are not appropriate, stop; otherwise, go on
4) compute the midpoint between $x_1$ and $x_2$: $x_{\text{mid}}$, and $f(x_{\text{mid}})$
5) if $f(x_{\text{mid}})$ and $f(x_1)$ have the same sign, let $x_1$ become $x_{\text{mid}}$, otherwise let $x_2$ become $x_{\text{mid}}$
6) repeat steps 4-6 nineteen more times
$x_1$ and $x_2$

f(x)

**Flowchart the method**

\[
\begin{align*}
&h^3 - 3Rh^2 + \frac{3V}{\pi} = 0 \\
\text{or} \\
&f(h) = 0
\end{align*}
\]

We will try a radius of 10 feet (3.05m) and a liquid volume of 500 gal (1.9m$^3$).

Initial estimates: $h_1 = 0 \quad h_2 = 2*R$
Excel spreadsheet prototype
[ done before, see Class 9 ]

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Radius</td>
<td>10 ft</td>
<td>Tank capacity</td>
<td>110.6 m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3.088 m³</td>
<td>11861 gal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3.79 m³</td>
<td>31332 gal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Depth</td>
<td>0.682 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2.14 ft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| | Iteration | | h₀ | | f(h₀) | | h₁ | | f(h₁) | | h_best | | f(h_best) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 1 | 0 | 3.615 | 6.098 | -100.550 | 3.048 | -53.019 |
| 12 | 2 | 0 | 3.615 | 3.048 | -53.019 | 1.524 | -14.083 |
| 13 | 3 | 0 | 3.615 | 1.524 | -14.083 | 0.762 | -1.252 |
| 14 | 4 | 0 | 3.615 | 0.762 | -1.252 | 0.391 | 2.343 |
| 15 | 5 | 0.391 | 2.343 | 0.762 | -1.252 | 0.572 | 0.816 |
| 16 | 6 | 0.572 | 0.615 | 0.762 | -1.252 | 0.607 | 0.154 |
| 17 | 7 | 0.572 | 0.815 | 0.887 | 0.164 | 0.819 | 0.347 |
| 18 | 8 | 0.572 | 0.347 | 0.667 | 0.164 | 0.643 | 0.101 |
| 19 | 9 | 0.643 | 0.101 | 0.887 | 0.164 | 0.655 | 0.026 |
| 20 | 10 | 0.643 | 0.101 | 0.667 | 0.164 | 0.646 | 0.058 |
| 21 | 11 | 0.649 | 0.038 | 0.666 | 0.105 | 0.652 | 0.006 |
| 22 | 12 | 0.652 | 0.006 | 0.666 | 0.036 | 0.653 | 0.010 |
| 23 | 13 | 0.652 | 0.006 | 0.666 | 0.010 | 0.663 | 0.002 |
| 24 | 14 | 0.652 | 0.006 | 0.663 | 0.002 | 0.662 | 0.002 |
| 25 | 15 | 0.652 | 0.002 | 0.663 | 0.002 | 0.652 | 0.000 |
| 26 | 16 | 0.652 | 0.000 | 0.663 | 0.002 | 0.663 | 0.001 |
| 27 | 17 | 0.652 | 0.000 | 0.663 | 0.001 | 0.652 | 0.000 |
| 28 | 18 | 0.652 | 0.000 | 0.662 | 0.000 | 0.652 | 0.000 |
| 29 | 19 | 0.652 | 0.000 | 0.662 | 0.000 | 0.652 | 0.000 |
| 30 | 20 | 0.65245 | 0.000 | 0.65246 | 0.000 | 0.65245 | 0.000 |

VBA Code Development

Function Bisect(x1, x2)
- End Function

Function f(x)
- End Function

Spreadsheet

= Bisect(h₀, h₁)
Option Explicit
Function Bisect(x1, x2)
Dim n As Integer, i As Integer, xmid As Double
n = 20
If f(x1) * f(x2) < 0 Then
  For i = 1 To n
    xmid = (x1 + x2) / 2
    If f(x1) * f(xmid) > 0 Then
      x1 = xmid
    Else
      x2 = xmid
    End If
  Next i
  Bisect = xmid
Else
  Bisect = "bad initial guesses"
End If
End Function

VBA Code for Bisect Function

Function f(h)
Dim r As Double, V As Double, Pi As Double
r = Range("Radius")
V = Range("Volume")
Pi = 4 * Atn(1)
f = h ^ 3 - 3 * r ^ h ^ 2 + 3 * V / Pi
End Function

VBA Code for Equation Evaluation

Spreadsheet used to test Bisect function

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Example Spherical Tank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Radius</td>
<td>10 ft</td>
<td>Tank capacity</td>
<td>115 R m²</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3.048 m</td>
<td>118613 L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Liquid volume</td>
<td>1000 gal</td>
<td>4189 ft³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3.79 m²</td>
<td>31332 gal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Depth</td>
<td>0.852 m</td>
<td>Bisect VBA function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>2.14 ft</td>
<td>=Bisect(10.27&quot;Radius)</td>
<td>Bisect VBA function</td>
<td>0.852454</td>
<td></td>
</tr>
</tbody>
</table>
Checking and debugging the Bisect function

Since Bisect is a function, you can’t step into it from the VBE, nor from Developer/Macros/Run

Put a breakpoint in the Function Bisect statement by clicking in the margin next to it or by pressing F9

```
Option Explicit
Function Bisect(x1, x2)
Dim n As Integer, i As Integer, xmid
n = 20
If f(x1) * f(x2) < 0 Then
```

Cause the Bisect function to calculate by editing the cell where the function is used or by changing one of the input cells to the function

```
Option Explicit
Function Bisect(x1, x2)
Dim n As Integer, i As Integer, xmid
n = 20
If f(x1) * f(x2) < 0 Then
```

Single-step the code, checking values along the way

```
Option Explicit
Function Bisect(x1, x2)
Dim n As Integer, i As Integer, xmid As Double
n = 20
If f(x1) * f(x2) < 0 Then
For i = 1 To n
    xmid = (x1 + x2) / 2
    If f(x1) * f(xmid) > 0 Then
        x1 = xmid
    Else
        x2 = xmid
    End If
```

Skip over stepping through Function f(x), once you know it works ok, with Shift-F8 (“step over”) instead of F8

Skip past the repetitive loop execution by executing to cursor position with Ctrl-F8

Run continuously to end with F5 or Run button
Documentation

add comments to your VBA code:

name and date

description of function

what it accomplishes

input requirements

warnings & limitations

nomenclature for variables

comments between and tagged onto statements