ChEn 263 Homework 22

Be sure to include "`Option Explicit`" at the beginning of every module. Remember that there are online resources that can help you learn about VBA programming. See the links from Learning Suite -> Content -> Course Documents.

1. **(2 points)** This problem does not require coding; nevertheless, place your answers in an Excel worksheet. If the following code is implemented, fill in the values that would be assigned to the indicated array elements. In other words, see if you can predict what the code would do.

```
Option Explicit
Sub Test ()
Dim I As Integer, j As Integer, n As Integer
Dim a(10,10) As Double
n = 4
For i = 1 To n
   For j = 1 To n
        a(i,j) = 2*(i*j)
   Next j
Next i
End Sub

a(1,1) = ______________________
a(2,3) = ______________________
a(5,5) = ______________________
```

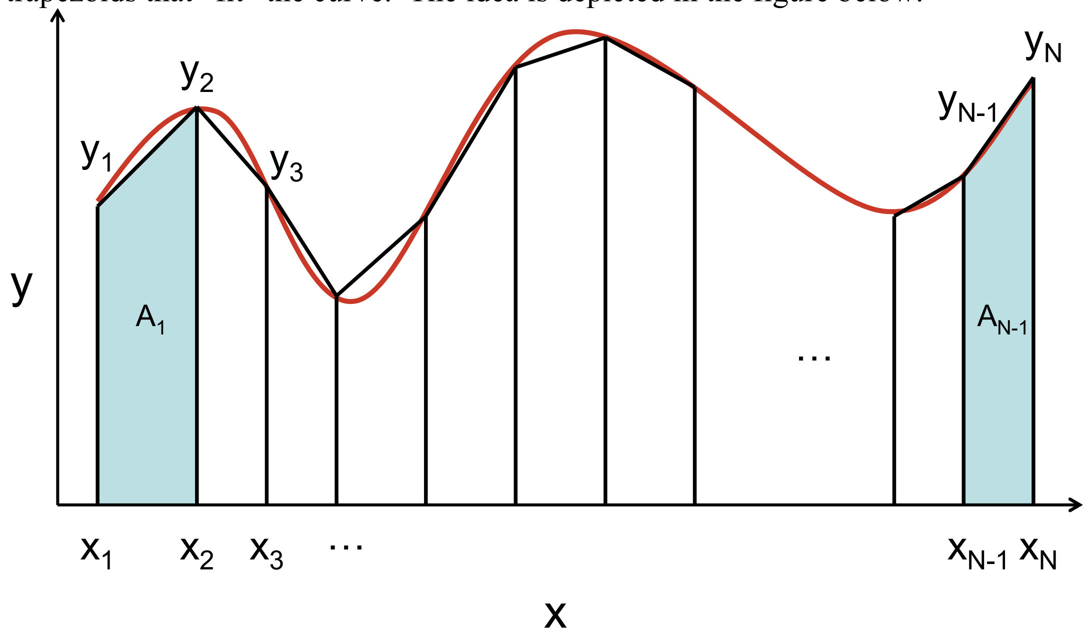
2. **(3 points)** Gottfried Wilhelm Leibniz (b. 1646) was a great German diplomat, philosopher, and mathematician. As a philosopher he is best remembered for his conclusion that our universe is the best possible one God could have made. In math he invented calculus independently of Newton, and it is his notation that we use today. He also proved that:

$$\sum_{n=0}^{\infty} \frac{(-1)^n}{2n+1} = \frac{\pi}{4}$$

Write a program, based upon Leibniz' formula, that calculates π to *d* digits of precision. The program should consist of the following steps

- Use an InputBox to get the number of decimal digits *d* required.
- Initialize the sum accumulator and the index *n* to zero.
- Use Do…Loop statements to calculate each term and add it to the sum. Loop until the absolute value of the current term in the sum is less than 10^{-d}.
- Display the calculated approximation to π and the number of required terms (*n*) in a MsgBox.

3. **(3 points)** In Math 113, you learned that the integral of an expression is equal to the area under the curve and can often be calculated analytically. Frequently in chemical engineering, we need to integrate a set of measured data and no expression for the "curve" is known (i.e. we only have pairs of data points and not an expression). One method to integrate a set of data numerically is known as the trapezoidal rule. This method approximates the area under the "curve" by calculating the area of several trapezoids that "fit" the curve. The idea is depicted in the figure below.



The area of one trapezoid segment is given by

$$A_i = \left(x_{i+1} - x_i\right)\left(\frac{y_i + y_{i+1}}{2}\right).$$

For example,

$$A_1 = (x_2 - x_1)\left(\frac{y_1 + y_2}{2}\right).$$

Since the integral is the area under the curve, the summation of the areas of each of the trapezoids gives an approximation to the integral, I, of the data. Mathematically, this can be written as

$$I = \int_{x_1}^{x_N} y(x) = \sum_{i=1}^{N-1} A_i$$

Frequently the data are uniformly distributed in x, so that $\delta x = x_{i+1} - x_i$ is a constant.

Below is the VBA code for a new Excel function called trap that takes two arguments. The first argument is δx and the second argument is a range (column) of y_i values.

```
Option Explicit
Public Function trap(deltax As Double, y As Range) As Double
Dim n As Long, i As Long
trap = 0
n = y.Rows.Count
For i = 1 To n - 1
   trap = trap + deltax*(y.Cells(i,1).Value+y.Cells(i+1,1).Value)/2
Next
End Function
```

Whoever wrote this code forgot to include comments, so you will have to figure out what each line does.

a. *Rewrite the above VBA function called **trap** so that it generates the integral of possibly unequally spaced data.* The new function should accept two ranges of data as arguments (each of the same length) and return the integral of that data using the trapezoidal rule. The first argument should be the range of cells containing possibly unequally spaced *x* data and the second argument the range of cells containing the corresponding *y* data. Note that the original trap function only accepted a Δx argument as a single value.

b. *Demonstrate the use of your function inside an Excel sheet by calculating the heat required to raise 1 mole of liquid water from 0 °C to 100 °C. Report you answer in units of J.* The heat per mole, *H*, required to change the temperature of an incompressible liquid, such as water, from T_{begin} to T_{end} can be calculated from

$$H = \int_{T_{begin}}^{T_{end}} C_p(T)dT.$$

where $C_p(T)$ is the heat capacity and *n* is the number of moles of the substance. The heat capacity of water as a function of temperature is given in the table below.

Temperature	Heat Capacity
(K)	(J/mol/K)
273.15	76.2
303.15	75.3
333.15	75.4
353.15	75.6
373.15	76.0