# Visual Basic – Exercises

The exercise involving vector operations basically required direct conversion of mathematical expressions into a computer code. The example below – to calculate a mathematical series – may at first sight seem to involve the same process. However as the functions created are to be used by others much of the code is there to perform checks that the function is being used correctly. As an example we look at the binomial expansion

$$(1+x)^n = 1 + nx + \frac{n(n-1)}{1.2}x^2 + \frac{n(n-1)(n-2)}{1.2.3}x^3 \ldots + \frac{n(n-1)(n-2)\ldots(n-r+2)}{1.2.3\ldots(r-1)}x^{r-1} + \ldots$$

The r-th term is $+\dfrac{n(n-1)(n-2)\ldots(n-r+2)}{1.2.3\ldots(r-1)}x^{r-1}$. The **Function** procedure below calculates this term, given $x, r \ (= \text{nbTerm})$ and $n \ (= \text{nPower})$.

```
Function BinomialTerm(x, nbTerm, nPower) As Double
' calculates term nbterm of the binomial expansion of
' (1 + x) ^nPower
Dim binTerm As Double, k As Integer, termOK As Boolean
' check thet nbTerm is an integer
    termOK = True
    binTerm = 0
    If Abs(nbTerm - Int(nbTerm)) <> 0 Then
        MsgBox "Error * Non-integer term requested " & nbTerm
        termOK = False
    End If
' check that nbTerm is at least 1
    If nbTerm < 1 Then
        MsgBox "Error * Term number less than 1: " & nbTerm
        termOK = False
    End If
' calculate term value
    If termOK Then
        If nbTerm = 1 Then
            binTerm = 1
        Else
            k = 1
            binTerm = 1
            Do While k < nbTerm
                binTerm = binTerm * x * (nPower - k + 1) / k
                k = k + 1
            Loop
        End If
    End If
    BinomialTerm = binTerm
End Function
```

The first thing to notice is that a large part of the code in the procedure is NOT devoted to evaluating the mathematical term, but rather to checking that it is being used properly. Hence the checks on the values of the data supplied to the function by the user. When a user writes a **Function** procedure there is a strong temptation to believe that it will used as the writer intended! This, alas, is more often not the case.

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Secondly you will note that the r-th term could be evaluated by calculating the numerator $n(n-1)\ldots(n-r+2)$ and the denominator $(r-1)!$ of the above expression separately and dividing one by the other. This is not done in this direct manner because if $n$ and/or $x$ and $r$, are large then the factorials or powers will evaluate to very large numbers, or if $x$ is small $x^{r-1}$ may be very small and precision will be lost due to the small number of significant figures stored by the computer. The loop in the procedure is based on a mathematical re-write of the r-th term as

$$\frac{n(n-1)(n-2)\ldots(n-r+2)}{1.2.3\ldots(r-1)}x^{r-1} = \frac{n}{1}\cdot x\cdot\frac{(n-1)}{2}\cdot x\cdot\frac{(n-2)}{3}\cdot x\ldots\cdot\frac{(n-r+2)}{r-1}\cdot x,$$

and avoids some of these problems.

## Exercises

The exponential function has the power series expansion,

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots + \frac{x^{r-1}}{(r-1)!} + \ldots = \sum_{r=1}^{\infty}\frac{x^{r-1}}{(r-1)!},$$

with the r-th term being $+\dfrac{x^{r-1}}{(r-1)!} = 1\cdot\dfrac{x}{1}\cdot\dfrac{x}{2}\cdot\dfrac{x}{3}\ldots\cdot\dfrac{x}{r-1}\ldots$

The sinc($x$) function has the expansion

$$\text{sinc}(x) = 1 - \frac{x^2}{3!} + \frac{x^4}{5!} + \ldots + (-1)^{r-1}\frac{x^{2r-2}}{(2r-1)!} + \ldots = \sum_{r=1}^{\infty}(-1)^{r-1}\frac{x^{2r-2}}{(2r-1)!}.$$

## Part 1

- Using the `BinomialTerm` function as an example, write a **Function** procedure, e.g. Function `ExpTerm(xexp,rexpTerm)`, to calculate the r-th term of the exponential series.
- Enter some values for $r$ in cells in a spreadsheet and check by using your function in spreadsheet cells that it returns the correct values.
- Write a **Function** procedure, `SincTerm`, to calculate the r-th term of the sinc($x$) series. Use spreadsheet cells to check your function.

## Part 2

- Write a **Function** procedure, `ExpSum`, to calculate the exponential series up to term $N$, i.e. $\displaystyle\sum_{r=1}^{N}\frac{x^{r-1}}{(r-1)!}$, making use of your ExpTerm function to calculate the individual terms.
- Use your function in a spreadsheet cell. See, using some cells in the spreadsheet, how the value your function returns compares with that obtained from Excel's `Exp(x)` function for different choices of $x$ and $N$.
- Write a **Function** procedure, `SincSum`, to calculate the sinc series up to term $N$. Again use your function procedure, `SincTerm`, for the individual terms.
- Plot your sinc($x$) function over the $x$ range from 0 to 20. Investigate how the result depends on $N$, the number of terms used. Try several values of $N$ between 1 and 50.

Save your spreadsheet and its associated macros as "*username-Series*".