


Review of Arrays


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Mechanical Engineering 209
**Computer Programming for
Mechanical Engineers**

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Outline

- Review arrays
 - Declaring Arrays
 - Using arrays in for loops and expressions
 - Arrays to and from worksheet
 - Transferring Excel data from rectangular ranges into type variant VBA variables
 - Sending arrays from VBA to worksheets
 - Comparing range.value and cells method for transferring arrays
- Programming assignment six



Semester Calendar


Date	Assignment	Date	Assignment
April 25	Assignment 5 Due	April 27	
May 2	Quiz 5 on Arrays	May 4	
May 9	Assignment 6 Due	May 11	Programming Exam
		May 18	Final Exam 12:45 to 2:45 pm



Declaring Arrays

- Examples (assume Option Explicit 0)



```
Dim x(12) as Double
Dim z(15, 17) as Integer
Dim s(1 to 12, 1 To 7) as String
Dim w()
N = InputBox("Enter N")
ReDim w(1 to N)
Function mean(x() as double)
```



Example Arrays and For Loops

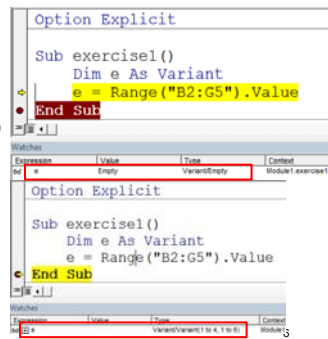

```
Const as Long max = 175
Dim x(1 to max) : Sum = x(1)
For k = 2 to max
    Sum = Sum + x(k)
Next k
```

```
Dim d(1 to 12, 1 To 7) as String
For k = 1 To 12
    For j = 1 to 7
        d(k, j) = M*P(k) / (R*T(j))
    Next j
Next k
```



Review The Mysterious Variant

- Type Variant Variables, declared as scalars, can be equated to an array
- They then become arrays
- Used for getting cell data to VBA

Range.Value gives 2D Array

```

Sub exerciseA()
    Dim I As Variant
    Dim V As Variant
    I = Range("B1: G1").Value
    V = Range("A2: A5").Value
End Sub
    
```

Setting a Variant to a single row or column gives a two-dimensional array

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Cells Gives 1D Array

```

Sub exerciseB()
    Dim I(1 to 6) As Double
    Dim V(1 to 4) As Double
    Dim k As Integer
    For k = 1 To 6
        I(k) = Cells(1, k+1).Value
    Next k
    For k = 1 To 4
        V(k) = Cells(k+1, 1).Value
    Next k
End Sub
    
```

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Function Arrays from Worksheets

- To pass a worksheet range into a function as an array use the following steps
 - Declare the worksheet array passed to the function as an input of type range
 - Dim an equivalent array as type Variant
 - Set the variant array equal to the input array

```

Function mean(xIn As Range) As Double
    Dim x as Variant
    x = xIn
    
```

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Example

```

Option Explicit
Function sumArray(xIn As Range) As Double
    Dim x As Variant
    Dim nRows As Long, nCols As Long
    Dim i As Long, j As Long
    x = xIn
    nRows = UBound(x,1)
    nCols = UBound(x,2)
    sumArray = 0
    For i = 1 To nRows
        For j = 1 To nCols
            sumArray = sumArray + x(i, j)
        Next j
    Next i
    
```

All code below red line on next slide

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Example Concluded

```

x = xIn
nRows = UBound(x,1)
nCols = UBound(x,2)
sumArray = 0
For i = 1 To nRows
    For j = 1 To nCols
        sumArray = sumArray + x(i, j)
    Next j
Next i
End Function
    
```

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Use of sumArray

Equation View

Normal View

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sumArray in Debug Mode

```
Function sumArray(xIn As Range)
    Dim x As Variant
    Dim nRows As Long, nCols As Long
    Dim i As Long, j As Long
    x = xIn
    nRows = UBound(x)
    nCols = UBound(x)
```

Before x = xIn is executed

Expression	Value	Type
x	Empty	Variant/Empty
xIn		Range/Range
AddIdent	False	Variant/Boolean
AllowEdit	True	Boolean
Application		Application/Applica

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sumArray in Debug Mode 2

```
Dim i As Long, j As Long
x = xIn
nRows = UBound(x)
```

After x = xIn is executed

Expression	Value	Type
x		Variant/Variant(1 to 5, 1 to 6)
x(1)		Variant(1 to 6)
x(1,1)	0.936	Variant/Double
x(1,2)	0.804	Variant/Double
x(1,3)	0.432	Variant/Double
x(1,4)	0.84	Variant/Double
x(1,5)	0.377	Variant/Double
x(1,6)	0.306	Variant/Double
x(2)		Variant(1 to 6)
x(3)		Variant(1 to 6)
x(4)		Variant(1 to 6)
x(5)		Variant(1 to 6)

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VBA Arrays from Excel

- Will always be two-dimensional VBA arrays
- First array index will run from 1 to number of rows
- Second array index will run from 1 to number of columns
- Range with only one row or only one column will still be two-dimensional array

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1D Excel Worksheet Arrays

	A	B	C	D	E	F	G
1		x					
2		1					
3		2					
4		3					
5		4					
6		5					
7		6					
8		7					
9							
10	y	1	2	3	4	5	
11							

What happens when we use the column array x or the row array y as an input to a VBA function?

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VBA Function to Read x and y

```
Function readArrays(xIn As Range, yIn As Range) As Double
    Dim x As Variant, y As Variant
    Dim nRows As Long, nCols As Long
    x = xIn
    nRows = UBound(x, 1)
    nCols = UBound(x, 2)
    y = yIn
    nRows = UBound(y, 1)
    nCols = UBound(y, 2)
```

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Reading Column Array (Debug)

```
Function readArrays(xIn As Range, yIn As Range) As Double
    Dim x As Variant, y As Variant
    Dim nRows As Long, nCols As Long
    x = xIn
    nRows = UBound(x, 1)
    nCols = UBound(x, 2)
    y = yIn
```

The second argument to the uBound function is 1 for the first dimension of a 2D array and 2 for the second dimension

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Reading Column Array (Debug)

Expression	Value	Type
nCols	1	Long
nRows	7	Long
x		Variant/Variant(1 to 7, 1 to 1)
x(1)		Variant(1 to 1)
x(1,1)	1	Variant/Double
x(2)		Variant(1 to 1)
x(2,1)	2	Variant/Double
x(3)		Variant(1 to 1)
x(4)		Variant(1 to 1)
x(5)		Variant(1 to 1)
x(6)		Variant(1 to 1)
x(7)		Variant(1 to 1)
xIn		Range/Range

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Reading Row Array (Debug)

```

Function readArrays(xIn As Rang
  Dim x As Variant, y As Vari
  Dim nRows As Long, nCols As
  x = xIn
  nRows = UBound(x, 1)
  nCols = UBound(x, 2)
  y = yIn
  nRows = UBound(y, 1)
  nCols = UBound(y, 2)
  If nRows = 1 Or nCols = 1 T
End Function
    
```

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Reading Row Array (Debug)

Expression	Value	Type
nRows	1	Long
nCols	5	Long
y		Variant/Variant(1 to 1, 1 to 5)
y(1)		Variant(1 to 5)
y(1,1)	1	Variant/Double
y(1,2)	2	Variant/Double
y(1,3)	3	Variant/Double
y(1,4)	4	Variant/Double
y(1,5)	5	Variant/Double
yIn		Range/Range

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Programming Assignment Six

- See online assignment for details
- Fit straight line to experimental data
- Workbook pa6Start.xlsm has data and shell for function
- Equation of fitted line: $\hat{y} = ax + b$
- Equations to use for assignment:

$$\bar{y} = \frac{1}{N} \sum_{i=1}^N y_i \quad \bar{x} = \frac{1}{N} \sum_{i=1}^N x_i$$

$$b = \frac{\sum_{i=1}^N x_i y_i - N(\bar{x})(\bar{y})}{\sum_{i=1}^N x_i^2 - N(\bar{x})^2} \quad a = \bar{y} - b\bar{x}$$

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Programming Assignment Six II

- Download workbook pa6Start.xlsm with VBA shell for array function
- Create function that reads worksheet data into type Variant arrays x and y – Copy approach used in lectures
- Do calculations for a, b, and R² using this array data
- Use worksheet shell statements to create your own array function

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Assignment Six Code Shell

```

Function <yourFunctionName> _
  ( <arguments> ) As Variant
  Dim output(1 To 3, 1 To 2) As Variant
  <put code for computations here>
  output(1, 1) = " Slope = "
  output(2, 1) = " Intercept = "
  output(3, 1) = " R-squared = "
  output(1, 2) = <Result for b>
  output(2, 2) = <Result for a>
  output(3, 2) = <Result for R^2>
  <yourFunctionName> = output
End Function
    
```

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Program Design

- All equations shown below have sums of data (or calculations from data) over same set of (x_i, y_i) , $i = 1, N$
- All calculations can be done in a single For loop except for R^2 numerator $\sum_{i=1}^N (\hat{y}_i - \bar{y})^2$

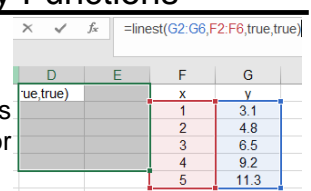
$$\bar{y} = \frac{1}{N} \sum_{i=1}^N y_i \quad \bar{x} = \frac{1}{N} \sum_{i=1}^N x_i \quad b = \frac{\sum_{i=1}^N x_i y_i - N(\bar{x})(\bar{y})}{\sum_{i=1}^N x_i^2 - N(\bar{x})^2} \quad a = \bar{y} - b\bar{x}$$

$$R^2 = 1 - \frac{\sum_{i=1}^N (\hat{y}_i - \bar{y})^2}{\sum_{i=1}^N y_i^2 - N(\bar{y})^2} \quad \hat{y}_i = a + bx_i$$

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Array Functions

- An Excel array function is one which produces values in two or more cells
- Example is Linest regression function
- Select multiple cells (here D1:E5) for output, enter formula, and press Ctrl+Shift+Enter



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Result of Linest Array Function

Output results from array formula

	D	E	F	G
	2.08	0.74	x	y
	0.110151	0.365331	1	3.1
	0.991657	0.348329	2	4.8
	356.5714	3	3	6.5
	43.264	0.364	4	9.2
			5	11.3

Input range from previous slide

Fitted line for data is

$$\hat{y}_i = 0.74 + 2.08x_i$$

With $R^2 = 0.991557$

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