


## Programming Assignment Six


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

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## Outline

- Practice quiz for actual quiz on Thursday
- Review approach discussed last class for passing worksheet arrays as input arguments in a VBA function
- Review programming assignment six
- Work on programming assignment six



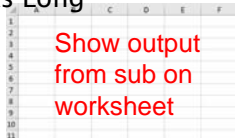
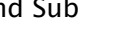
## Semester Calendar

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




```

Sub sampleArrayQuiz()
    Dim x(1 To 100) As Double
    Dim k As Long, row As Long
    Dim col As Long
    For k = 1 To 100
        x(k) = k ^ 2 + 2 * k
    Next k
    For row = 1 To 10 Step 3
        For col = 1 To 5 Step 2
            Cells(row, col).Value = x(row * col)
        Next col
    Next row
End Sub
    
```

## Review VBA Arrays from Excel


- Will be two-dimensional VBA arrays unless cells method used to set values for one-dimensional array
- For range.value or range input argument
  - 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 one column will still be two-dimensional array



## 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?



### 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)
End Function
```

### 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
End Function
```

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

### 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

### Reading Row Array (Debug)

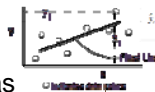
```
Function readArrays(xIn As Range, yIn As Range) As Double
    Dim x As Variant, y As Variant
    Dim nRows As Long, nCols As Long
    x = xIn
    nRows = UBound(x, 1)
    nCols = UBound(x, 2)
    y = yIn
    nRows = UBound(y, 1)
    nCols = UBound(y, 2)
    If nRows = 1 Or nCols = 1 Then
        ' ...
    End If
End Function
```

### 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

### 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:



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

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

### 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 R<sup>2</sup> 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<sub>i</sub>, y<sub>i</sub>), i = 1, N
- All calculations can be done in a single For loop except for R<sup>2</sup> numerator  $\sum_{i=1}^N (y_i - \bar{y})^2$

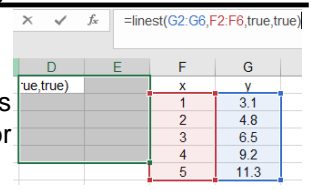
$$\bar{y} = \frac{1}{N} \sum_{i=1}^N y_i \quad \bar{x} = \frac{1}{N} \sum_{i=1}^N x_i \quad b = \frac{\sum_{i=1}^N x_i y_i - N(\bar{x})(\bar{y})}{\sum_{i=1}^N x_i^2 - N(\bar{x})^2} \quad a = \bar{y} - b\bar{x}$$

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

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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 **Practice: Copy data from F2:G6 and enter array formula in D1:E5**   
 Ctrl+Shift+Enter



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### Result of Linest Array Function

	D	E	F	G
Output results from array formula	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

- See Help for Linest function to get meaning of all results for statistical line fit of this function

**Input range from previous slide**  
 Fitted line for data is  $\hat{y}_i = 0.74 + 2.08x_i$   
 With R<sup>2</sup> = 0.991557

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```

Sub sampleArrayQuiz()
    Dim x(1 To 100) As Double
    Dim k As Long, row As Long
    Dim col As Long
    For k = 1 To 100
        x(k) = k ^ 2 + 2 * k
    Next k
    For row = 1 To 10 Step 3
        For col = 1 To 5 Step 2
            Cells(row, col).Value = x(row * col)
        Next col
    Next row
End Sub
    
```

**What is output from this sub?**  
**x array is defined here**  
**Cells(row, col).Value = x(row \* col)**  
**Values of x array sent to worksheet here**

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```

Sub sampleArrayQuiz()
  Dim x(1 To 100) As Double
  Dim k As Long, row As Long
  Dim col As Long
  For k = 1 To 100
    x(k) = k ^ 2 + 2 * k
  Next k
  For row = 1 To 10 Step 3
    For col = 1 To 5 Step 2
      Cells(row, col).Value = x(row * col)
    Next col
  Next row
End Sub
    
```

Row loop will produce output in rows 1, 4, 7 and 10  
 Col loop will produce output in columns 1, 3 and 5 (columns A, C, and E)

```

Sub sampleArrayQuiz()
  Dim x(1 To 100) As Double
  Dim k As Long, row As Long
  Dim col As Long
  For k = 1 To 100
    x(k) = k ^ 2 + 2 * k
  Next k
  For row = 1 To 10 Step 3
    For col = 1 To 5 Step 2
      Cells(row, col).Value = x(row * col)
    Next col
  Next row
End Sub
    
```

For row 1 in columns 1, 3, and 5, row\*col = 1, 3, and 5  
 So x(k) for k = 1, 3, 5 is 1<sup>2</sup> + 2(1) = 3, 3<sup>2</sup> + 2(3) = 15, and 5<sup>2</sup> + 2(5) = 35

### First Row of Output

	A	B	C	D	E	F
1	3		15		35	
2						
3						

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```

Sub sampleArrayQuiz()
  Dim x(1 To 100) As Double
  Dim k As Long, row As Long
  Dim col As Long
  For k = 1 To 100
    x(k) = k ^ 2 + 2 * k
  Next k
  For row = 1 To 10 Step 3
    For col = 1 To 5 Step 2
      Cells(row, col).Value = x(row * col)
    Next col
  Next row
End Sub
    
```

For row 4 in columns 1, 3, and 5, row\*col = 4, 12, and 20  
 So x(k) for k = 4, 12, 20 is 4<sup>2</sup> + 2(4) = 24, 12<sup>2</sup> + 2(12) = 168, and 20<sup>2</sup> + 2(20) = 440

### First Two Rows of Output

	A	B	C	D	E	F
1	3		15		35	
2						
3						
4	24		168		440	
5						

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```

Sub sampleArrayQuiz()
  Dim x(1 To 100) As Double
  Dim k As Long, row As Long
  Dim col As Long
  For k = 1 To 100
    x(k) = k ^ 2 + 2 * k
  Next k
  For row = 1 To 10 Step 3
    For col = 1 To 5 Step 2
      Cells(row, col).Value = x(row * col)
    Next col
  Next row
End Sub
    
```

For row 7 in columns 1, 3, and 5, row\*col = 7, 21, and 35  
 So x(k) for k = 7, 21, 35 is 7<sup>2</sup> + 2(7) = 63, 21<sup>2</sup> + 2(21) = 483, and 35<sup>2</sup> + 2(35) = 1295

### First Three Rows of Output

	A	B	C	D	E	F
1	3		15		35	
2						
3						
4	24		168		440	
5						
6						
7	63		483		1295	

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```

Sub sampleArrayQuiz()
  Dim x(1 To 100) As Double
  Dim k As Long, row As Long
  Dim col As Long
  For k = 1 To 100
    x(k) = k ^ 2 + 2 * k
  Next k
  For row = 1 To 10 Step 3
    For col = 1 To 5 Step 2
      Cells(row, col).Value = x(row * col)
    Next col
  Next row
End Sub
    
```

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### Complete Output from Sub

	A	B	C	D	E	F
1	3		15		35	
2						
3						
4	24		168		440	
5						
6						
7	63		483		1295	
8						
9						
10	120		960		2600	
11						

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