Excel 365: Advanced Data Analysis

Seminar for

February 2022

THE MARQUEE GROUP

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Setup Considerations

Access to New Features

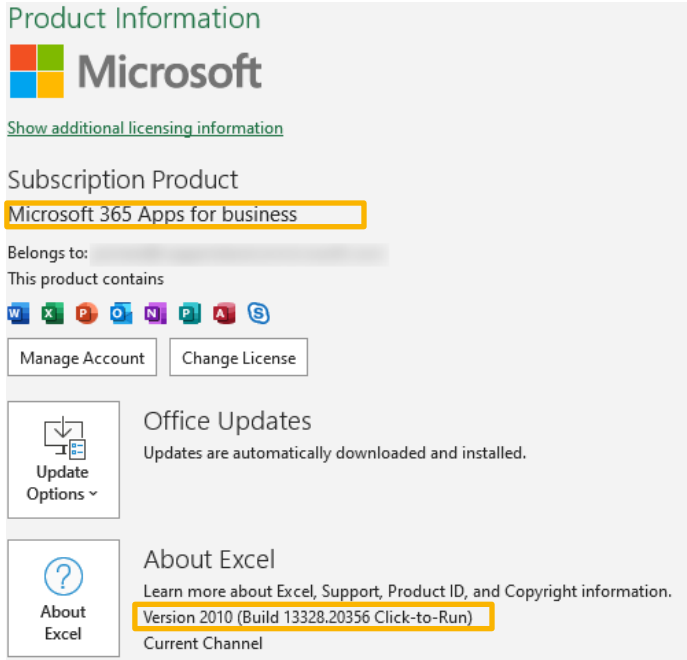
- Many of the features discussed in this course are available only in the version of Excel included with a Microsoft 365 subscription
  - There are various versions of Microsoft 365 in circulation; depending on your subscription details you may have a different version

Determining Your Version of Excel

Excel 365

➢ File [F] ➢ Account [D]

- Under Subscription Product, you must be using a version of Microsoft 365 or Office 365 to access many of these features
- To use Dynamic Arrays & associated functions (UNIQUE, SORT, SORTBY, FILTER, SEQUENCE, RANDARRAY) – version must be higher than 1911
- To use XLOOKUP & XMATCH: version must be higher than 2001



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Setting Up Your System

- The Options menu in Excel contains many important settings that control the operation of the spreadsheets

Excel 365

➢ File [F] ➢ Options [T] ➢ Advanced

- One important setting is as follows:

Editing Options

  - Turn off "Allow Editing Directly in Cells"
  - When this selection is "off" and you edit a cell (F2 key), you will be prompted to edit the formula in the formula bar at the top of the screen. This is optimal.
  - Alternatively, when this selection is "on" and you edit a cell, you will be prompted to edit the formula directly in the cell. This can be problematic because the formula may cover up numerous other cells on the screen that you want to see while editing the formula.
  - The other benefit from keeping this selection "off" is that if you double click on a cell that contains a formula, the cursor will jump to the precedent cells (it will only jump to the first cell reference in the formula if the first cell in the formula is on a different worksheet).

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Setting Up Your System (Cont'd)

- Some other important settings are as follows:

Excel 365

➢ File [F] ➢ Options [T] ➢ Formulas

Calculation Options

- Check the "Automatic" box in the Calculation Options section
- This setting ensures that all formulas calculate automatically
- If this option is set to "Manual", nothing will happen when you enter a formula until you press the F9 key to manually recalculate the spreadsheet
- You may want to set this option to "Manual" if you are working on an extremely large file because it could take Excel a few seconds to recalculate the spreadsheet every time you make a change
- Turn off the "Enable Iterative Calculation" check box (the "Iterative" check box should only be turned on when you are working on a spreadsheet that contains an intentional circular reference)

- The settings on the "Excel Options" menu affect all spreadsheets that are currently open. Therefore, if a setting is changed, the change will take place on all the Excel files that are open.

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Spilled Ranges: The Basics

What are Spilled Ranges?

- Historically, Excel's system of cell referencing required entering a reference to a single cell or entering formula that refers to a range of cells
  - In the example table, entering the reference **=B2** would return 63% while entering the formula **=AVERAGE(B2:B6)** would return 69%
- Regardless of whether you entered a reference or a formula, the result would be a single answer in a single cell

Example Table

	A	B
1	Name	Grade
2	Kelsey	63.0%
3	Connor	72.0%
4	Max	42.0%
5	Cora	87.0%
6	Arman	81.0%

- With spilled ranges (newly introduced in Excel 365), users can enter formulas (or references) that will result in multiple answers that "spill" out of the cell you entered the formula in
  - With our example table, entering the reference **=A1:B6** in cell **D1** would return the results to the right
  - Note that the formula is *only* entered into cell **D1**, the formula refers to the entire table, which results in an answer that "spills" out of **D1** to fill the range
- This behavior mirrors some of the previous "Array" functionality in Excel (sometimes known as "CTRL + SHIFT + ENTER" or "CSE" functions); however, this classic array behavior was not user friendly or flexible

=A1:B6

	D	E
1	Name	Grade
2	Kelsey	63.0%
3	Connor	72.0%
4	Max	42.0%
5	Cora	87.0%
6	Arman	81.0%

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Spilled Range Basics

Example Table

	A	B	C	D	E
1	Name	Grade		Name	Grade
2	Kelsey	63.0%		Kelsey	63.0%
3	Connor	72.0%		Connor	72.0%
4	Max	42.0%		Max	42.0%
5	Cora	87.0%		Cora	87.0%
6	Arman	81.0%		Arman	81.0%

- The formula **=A1:B6** is entered in cell **D1**
- When your cursor is in D1, the formula bar will display the formula in black font

=A1:B6

- The other cells are spilled results from the formula in cell **D1**
- When your cursor is in any of these cells, the formula bar will display the formula cell D1, but it will be in grey font

=A1:B6

- The formula can ONLY be edited in cell D1

- Excel outlines the extent of a spilled range with a blue line when your cursor is in a cell within the spilled range
- Spilled results will never overwrite existing information in a spreadsheet
  - If there is information in the way, the formula will return a #SPILL error

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Spilled Range Errors

- Using Spilled Ranges may result in **#SPILL** errors when a formula returns multiple results (an array) and Excel cannot return the results to the spreadsheet for one of the following reasons:
  - The spill range isn't blank
  - The size of array is volatile (i.e. a random number is generating the array)
  - The result extends beyond the worksheet's boundaries
  - The formula is in a Table; currently, spilled ranges cannot be used in a Table, but spilled ranges can *refer to* a Table
  - The result is too large and Excel has run out of memory
  - The result is spilling into merged cells
  - Any other error preventing the display of spilled formula results

Example Table

	A	B	C	D	E	F	G
1	Name	Grade			SPILL RANGE IS NOT BLANK		
2	Kelsey	63.0%					
3	Connor	72.0%			#SPILL!	-> =A1:B6	
4	Max	42.0%					
5	Cora	87.0%			SPILLING OFF THE SHEET		
6	Arman	81.0%					
7					#SPILL!	-> =A:A	
8	SPILLED RANGE IS IN A TABLE						
9					SPILLING INTO A MERGED CELL		
10	Values	Formulas					
11	1	#SPILL!	-> =A1:B6		#SPILL!	-> =A1:B6	
12	2	#SPILL!	-> =A1:B6				
13	3	#SPILL!	-> =A1:B6		*THIS IS A MERGED CELL*		

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Spilled Range Operator (#)

- Spilled ranges are a dramatic change to Excel's functionality that created a need for new ways to refer to these spilled ranges
  - Microsoft has introduced two modifiers to help users harness spilled ranges in spreadsheets
- The Spilled Range Operator (#) allows you to write formulas that apply to *an entire spilled range* regardless of whether the extent of that range grows or shrinks
- Adding a "#" after a cell reference will refer to the value in that cell *along with all the values that are spilling out of that cell* with a single reference

Example Table

	A	B	C	D
1	Name	Grade		
2	Kelsey	63.0%		63.0%
3	Connor	72.0%		72.0%
4	Max	42.0%		42.0%
5	Cora	87.0%		87.0%
6	Arman	81.0%		81.0%

D2 = B2:B6

- Cell D2 contains a spilled range

=AVERAGE(D2#)

- This function will return 69%; the spilled range operator tells excel to refer to the entire spilled range which will include all of the values that spill out of cell D2
- If the spilled range changes in the future to include additional or less data, this function will automatically update to reflect the changes to the spilled range

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Implicit Intersection Operator (@)

- Along with the Spilled Range Operator, Microsoft introduced the Implicit Intersection Operator (@) to return a single value when it would otherwise return a spilled result
- If you add an "@" sign before a reference that would have returned a Spilled Range and Excel will return a result using the following logic:
  - If the value is a single item, then return the item;
  - If the value is a range, then return the value from the cell on the same row or column as the formula;
  - If the value is an array, then pick the top-left value.
- The Implicit Intersection Operator is a way to force Excel to behave as it did prior to the introduction of Spilled Ranges

Example Table

	A	B	C	D
1	Name	Grade		
2	Kelsey	63.0%		63.0%
3	Connor	72.0%		72.0%
4	Max	42.0%		42.0%
5	Cora	87.0%		87.0%
6	Arman	81.0%		81.0%

D2 = B2:B6

- Cell D2 contains a spilled range

=@D2#

- This function will return a single value that will depend on the row in which it is entered:
  - If entered anywhere on row 2 it will return 63%, if entered on row 5 it will return 87%, etc.
  - If entered in any row outside of row 2-6 the function will return a #VALUE error (there is no value on the same row)

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New Excel 365 Functions

New Functions in Excel 365

- Microsoft has introduced several new functions to Excel 365, however, users *must* subscribe to Excel 365 (otherwise these functions are not available)
  - Detail on each function is available on subsequent pages

Functions That Return Dynamic Arrays

Function	Description
=SEQUENCE	Returns a list of sequential numbers in an array with the ability to specify the characteristics of that sequence
=RANDARRAY	Returns an array of random numbers with the ability to specify the characteristics of those numbers
=UNIQUE	Returns a list of unique values in a range
=FILTER	Returns all records from a selected array filtered for a specific item
=SORT	Sorts the contents of a range or array with the ability to specify which column to sort on and what order to sort in
=SORTBY	Sorts the contents of a range or array by the values in one or more corresponding ranges or arrays with the ability to define primary, secondary, etc. sort criteria to break ties

Other New Functions

Function	Description
=XLOOKUP	A modern, more flexible replacement for the HLOOKUP, VLOOKUP & LOOKUP functions; used to look for specific entries (whether they be the contents of a cell, or the contents of an entire row or column) within a large table
=XMATCH	A modern replacement for the MATCH function; returns the relative position of a specified item withing an array or range
=LET	Assigns a name to the results of a calculation allowing intermediate calculations and simplification of large complex formulas (the name will only exist withing that specific formula)

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SEQUENCE Function

- Microsoft has introduced new functions that allow you to generate large ranges of random or sequential data taking advantage of spilling behavior
- *SEQUENCE* is used to generate an array of sequential data with a defined height & width, starting number and step value

=SEQUENCE(rows, [columns], [start], [step])

The SEQUENCE function has 4 arguments:

rows:	The number of rows that the spilled range will contain; this is a required argument
columns:	The width of the spilled range of data; if this argument is omitted, Excel will return results one column wide by default
start:	The first number in the sequence
step:	This is the "step value" or the amount that Excel will increment by when generating the series of sequential data

Example Table

	A	B	C	D
1	1		2	4
2	2		6	8
3	3		10	12
4	4		14	16
5	5		18	20
6	6		22	24

A1 = SEQUENCE(6)

- In the simplest form, SEQUENCE will return a series of numbers starting at 1 and counting by 1 for a defined number of columns

C1 = SEQUENCE(6,2,2,2)

- This version counts by 2 (starting at 2) and generates a sequence 6 rows x 2 columns; note that when you are returning multiple columns, Excel will move from left to right then from top to bottom when generating the sequence

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RANDARRAY Function

- *RANDARRAY* is used to generate arrays of pseudo-random numbers
  - *Note that the RANDARRAY function is volatile and will calculate new random numbers every time a spreadsheet recalculates*

=RANDARRAY([rows], [columns], [min], [max], [integer])

The RANDARRAY function has 5 arguments; *all of them are optional*:

rows:	The number of rows that the spilled range will contain; if this argument is omitted, Excel defaults to one row
columns:	The width of the spilled range of data; if this argument is omitted, Excel defaults to one column
min:	The lowest possible random number; if this argument is omitted, Excel defaults to a min of 0
max:	The highest possible random number; if this argument is omitted, Excel defaults to a max of 1
integer:	To return integer values, type TRUE. To return decimal values, type FALSE (or omit)

Example Table

	A	B	C	D
1	0.5447		2	1
2			4	3
3			6	1
4			4	6
5			6	3
6			3	4

A1 = RANDARRAY()

- In the simplest form, RANDARRAY will return a random decimal number between 0 and 1; this duplicates the older =RAND() function

C1 = RANDARRAY(6,2,1,6,TRUE)

- This RANDARRAY will return a series of dice rolls (integers between 1 and 6) that is six rows by 2 columns

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UNIQUE Function

- *UNIQUE* is used to generate a list of unique values in a range (or to eliminate duplicates)

=UNIQUE(array, [by_col], [exactly_once])

The UNIQUE function has 3 arguments:

array:	The range or array from which to return unique rows or columns
by_col:	To compare rows against each other and return unique rows, type FALSE (or omit). To compare columns against each other and return unique columns, type TRUE.
exactly_once:	To return all distinct rows or columns from the array (i.e. eliminate duplicates), type FALSE (or omit). To return rows or columns that occur *exactly once* from the array, type TRUE.

Example Table

	A	B	C	D
1	Kelsey		Kelsey	Kelsey
2	Connor		Connor	Cora
3	Max		Max	
4	Max		Cora	
5	Cora			
6	Connor			

C1 = UNIQUE(A1:A6)

- In the simplest form, UNIQUE will list each name that appears in the list once; the returned list will be sorted in the same order they appear in the original list

D1 = UNIQUE(A1:A6,,TRUE)

- This returned list only includes only the names appear *exactly once* in the original list (i.e. Max & Connor both appear twice in the original list and are excluded)

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SORT Function

- *SORT* can be used to re-order a list in ascending order based on the contents of a particular column (or row)

=SORT(array, [sort_index], [sort_order], [by_col])

The SORT function has 4 arguments:

array:	The range or array to sort
sort_index:	An integer indicating the row or column number to sort the array based on (i.e. to sort based on the first row you would enter a 1)
sort_order:	To sort based on ascending order (or A->Z for text information) in the sort index column, enter a 1 (or omit). To sort based on descending order (or Z->A for text information) in the sort index column, enter a -1.
by_col:	To sort by row, enter FALSE (or omit). To sort by column, enter TRUE.

Example Table

	A	B	C	D	E	F	G
1	Student	Course	Grade				
2	Kelsey	Math	75%		Kelsey	Gym	93%
3	Connor	Physics	85%		Connor	Physics	85%
4	Arman	Gym	80%		Arman	Gym	80%
5	Connor	Math	68%		Arman	Physics	78%
6	Kelsey	Gym	93%		Kelsey	Math	75%
7	Arman	Physics	78%		Connor	Math	68%

E2 = SORT(A2:C7,3,-1,FALSE)

- Results are sorted based on the 3rd column in the array (column C) in descending order

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FILTER Function

- *FILTER* is a powerful function that returns all records from a selected array filtered for a specific item

=FILTER(array, include, [if_empty])

The FILTER function has 3 arguments:

array:	The range or array to filter
include:	The criteria to be used to filter the array; technically, an array of boolean (TRUE or FALSE) values representing rows or columns to retain
if_empty:	What the function should return if no results are found

Example Table

	A	B	C	D	E	F	G
1	Student	Course	Grade				
2	Kelsey	Math	75%		Kelsey	Math	75%
3	Connor	Physics	85%		Connor	Math	68%
4	Arman	Gym	80%				
5	Connor	Math	68%		no results found		
6	Kelsey	Gym	93%				
7	Arman	Physics	78%				

E2 = FILTER(A2:C7,B2:B7=“Math”,“no results found”)

- FILTER can quickly extract simple subsets; in this case it is extracting all records where the course is equal to Math

E5 = FILTER(A2:C7,B2:B7=“English”,“no results found”)

- The “if_empty” argument can be helpful to avoid error messages when no valid results can be found with FILTER

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FILTER Function with AND / OR Logic

- The FILTER function can be used to generate more complicated filtered lists by relying on mathematical manipulation of the TRUE/FALSE values within the "include" argument
- To understand how this works, we must understand what is happening within the "include" argument on the previous page
  - On the prior page, the "include" argument B2:B7="Math" will return the array {TRUE, FALSE, FALSE, TRUE, FALSE, FALSE}
  - The FILTER function returns a list containing rows where the value = TRUE based on this array
- To create more complex FILTER functions, we can take advantage of how addition & multiplication of boolean values is handled in Excel

Multiplication of Boolean (AND Logic)	Addition of Boolean (OR Logic)
TRUE x TRUE = TRUE	TRUE + TRUE = TRUE
TRUE x FALSE or FALSE x TRUE = FALSE	TRUE + FALSE or FALSE + TRUE = TRUE
FALSE x FALSE = FALSE	FALSE + FALSE = FALSE

Example Table

	A	B	C
1	Student	Course	Grade
2	Kelsey	Math	75%
3	Connor	Physics	85%
4	Arman	Gym	80%
5	Connor	Math	68%
6	Kelsey	Gym	93%
7	Arman	Physics	78%

FILTER(A2:C7,((B2:B7="Math")+(B2:B7="Physics")),"no results found")

- Relying on *boolean addition* to return items where Course = Math **OR** Course = Physics; this function would return a list including Kelsey & Connor's Math results + Connor & Arman's Physics results

FILTER(A2:C7,((B2:B7="Math")*(A2:A7="Connor"),"no results found")

- Relying on *boolean multiplication* to return items where Course = Math **AND** Name = Connor; this function would return a list including only Connor's Math results

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SORTBY Function

- *SORTBY* has similar functionality to SORT (i.e. to re-order a list in ascending or descending order based on the contents of a particular column (or row))
  - SORTBY permits secondary sort criteria to create the desired ordering when there are ties (i.e. if there are multiple grades for each student)

=SORTBY(array, by_array1, [sort_order1], …)

The SORTBY function has 3 mandatory arguments:

array:	The range or array to sort
by_array1:	The range or array to sort based on
sort_order1:	To sort based on ascending order (or A->Z for text information) in the by_array1 array, enter a 1 (or omit). To sort based on descending order (or Z->A for text information) in the by_array1 array, enter a -1.
by_array2, sort_order2, etc.	Additional secondary, tertiary, etc. arrays to sort based upon

Example Table

	A	B	C	D	E	F	G
1	Student	Course	Grade				
2	Kelsey	Math	75%		Kelsey	Gym	93%
3	Connor	Physics	85%		Arman	Gym	80%
4	Arman	Gym	80%		Kelsey	Math	75%
5	Connor	Math	68%		Connor	Math	68%
6	Kelsey	Gym	93%		Connor	Physics	85%
7	Arman	Physics	78%		Arman	Physics	78%

E2 = SORTBY(A2:C7,B2:B7,1,C2:C7,-1)

- Results are sorted first based upon Course (from A->Z) then within each Course based upon Grade (from highest to lowest)
- The SORT function could sort based on Course, but the entries within each Course would appear in the order in which they occur in the original list

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SORTBY Function (Cont'd)

- One of the limitations of the SORT function is that it will always return the full array (sorted by the sort_index, which *must* be part of the array)
  - In the example table, perhaps we didn't want to sort the full table, we just wanted to return the names, sorted by Course and then Grade
- With SORTBY, the by_arrays do not need to be a part of the array
  - The result is that we do not need to return the data which our source is based upon

Example Table

	A	B	C	D	E
1	Student	Course	Grade		
2	Kelsey	Math	75%		Kelsey
3	Connor	Physics	85%		Arman
4	Arman	Gym	80%		Kelsey
5	Connor	Math	68%		Connor
6	Kelsey	Gym	93%		Connor
7	Arman	Physics	78%		Arman

E2 = SORTBY(A2:A7,B2:B7,1,C2:C7,-1)

- Results are sorted first based upon Course (from A->Z) then within each Course based upon Grade (from highest to lowest)
- A key advantage of SORTBY vs. SORT is that SORTBY allow you to separate the return range (array) from the arrays which the function is sorting based on (the by_arrays)

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XLOOKUP Function

- XLOOKUP can be used to look for specific entries (whether they be the contents of a cell, or the contents of an entire row or column) within a large table

  =XLOOKUP(lookup_value, lookup_array, return_array, [if_not_found], [match_mode], [search mode])

  - XLOOKUP searches for a specified value in a specified array, and then returns a value in the same row or column from an array that you specify

The XLOOKUP function has 4 main arguments:

lookup_value:	The item you are searching for within the lookup array
lookup_array:	The range or array to search for the lookup_value within
return_array:	The range or array from which to return results
if_not_found:	The value returned if no match is found; if no value is entered for this argument and the lookup_value is not found in the lookup_array, the function will return a #N/A error

Example Table

	A	B	C	D
1	Employee	Division	Wage/hr	Status
2	John	Finance	$42.00	FT
3	Peter	Production	$33.00	FT
4	Miranda	Marketing	$75.00	Contract
5	David	HR	$40.00	PT
6	Katie	Production	$30.00	FT
7	Sarah	Purchasing	$26.00	PT

=XLOOKUP("Katie",A1:A7,C1:C7)

- This function will return $30.00. It will search for the word "Katie" in A1:A7 and then return the corresponding Wage/hr in C1:C7

=XLOOKUP("Tim",A1:A7,C1:C7,"invalid entry")

- This function will return "invalid entry" because it cannot find "Tim" in A1:A7

=XLOOKUP("Status",A1:D1,A4:D4)

- This function will return Contract; lookup_arrays for XLOOKUP can be rows OR columns making XLOOKUP a potential replacement for the VLOOKUP or HLOOKUP functions

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XLOOKUP Function (Cont'd)

- In addition, XLOOKUP has 2 additional modifiers to change how it searches for lookup_value within lookup_array:

match_mode:

If match_mode = 1, XLOOKUP finds the smallest value that is greater than or equal to lookup_value; lookup_value must be sorted in descending order: ...2, 1, 0, -1, -2,..., Z-A
If match_mode = 0 (or the argument is omitted), XLOOKUP finds the first value that is exactly equal to lookup_value; lookup_array can be in any order
If match_mode = -1, XLOOKUP finds an exact match or the largest value that is less than or equal to lookup_value; lookup_array must be placed in ascending order: ...-2, -1, 0, 1, 2, ..., A-Z
If match_mode = 2, XLOOKUP will look for matches using Excel's wildcard characters (?, * and ~)
CAUTION: the match mode arguments for XLOOKUP are the opposite of those in the previous MATCH function, so be careful when specifying approximate matches

search_mode:

If search_mode = 1 (or the argument is omitted), XLOOKUP performs a search starting at the first item
If search_mode = -1, XLOOKUP performs a search starting at the last item
If search_mode = 2, XLOOKUP performs a search using a faster binary search that relies on lookup_array being sorted in ascending order
If search_mode = -2, XLOOKUP performs a search using a faster binary search that relies on lookup_array being sorted in descending order

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XLOOKUP Function (Cont'd)

- XLOOKUP isn't limited to returning a single result from a single cell in a table, it can also take advantage of the new spilled range behavior to return an entire row or column of the return_array
  - If the return_array covers multiple rows or columns (rather than a single row or column), the XLOOKUP function will return a full row or column as a spilled range
- In addition, XLOOKUP combines the functionality of VLOOKUP and HLOOKUP; it can look vertically or horizontally depending on the orientation of the lookup_array and the return_array

Example Table

	A	B	C	D	E	F
1	Employee	Division	Wage/hr	Status		Wage/hr
2	John	Finance	$42.00	FT		$42.00
3	Peter	Production	$33.00	FT		$33.00
4	Miranda	Marketing	$75.00	Contract		$75.00
5	David	HR	$40.00	PT		$40.00
6	Katie	Production	$30.00	FT		$30.00
7	Sarah	Purchasing	$26.00	PT		$26.00
8						
9	David	HR	$40.00	PT		

A9=XLOOKUP("David",A1:A7,A1:D7)

- This function returns the entire "David" row from the table; it searches for "David" in A1:A7 and returns every value in that row in the range A1:D7

F1=XLOOKUP("Wage/hr",A1:D1,A1:D7)

- This function returns the entire "Wage/hr" column from the table: it searches for "Wage/hr" in A1:D1 and returns every value in that column in the range A1:D7

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XLOOKUP Overcomes Many Shortcomings of VLOOKUP

- There are several reasons why a VLOOKUP function may not return the correct result (there is a page with details on VLOOKUP later in this presentation)

Pitfall of VLOOKUP Function	How XLOOKUP Solve This Issue
• The lookup_value and the cell that contains the data you are looking to extract must both be within the table_array	• XLOOKUP separates the lookup_array and the return_array so that a full table_array no longer needs to be referenced
• The cell that contains the data you are looking to extract must be located to the right of the lookup_value	• XLOOKUP does not care about the relative position of the return_array vs. the lookup_array
• The VLOOKUP function is most helpful when there are no repetitive instances of the lookup_value in the leftmost column of the table_array	• This is still an issue with XLOOKUP, however, the added ability to search from the last item to first item with search_mode adds some flexibility
• table_array will not automatically expand when more data is added to the table in which you are searching	• This is still a limitation of XLOOKUP, however, the use of the Table Tool can overcome this (see later in this presentation)
• col_index_num should be automated in case any columns are inserted or deleted within the table_array	• A col_index_num is no longer necessary, XLOOKUP asks you to explicitly define the return_array (which will move when columns are inserted or deleted)
• range_lookup can either return a close match (TRUE) or an exact match (FALSE)	• This functionality still exists, but XLOOKUP has changed to select “exact match” as the default match_mode to limit unintentional approximate results
• Looking vertically (rather than horizontally) requires the use of a separate function (HLOOKUP)	• XLOOKUP can look vertically or horizontally depending on the orientation of lookup_array and return_array

- Microsoft has long recognized many of the limitations of VLOOKUP and has spent many years designing XLOOKUP to overcome these pitfalls

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XMATCH Function

- The XMATCH function returns the relative position of an item within a table of data that matches a specific value in a specified order

  =XMATCH(lookup_value, lookup_array, [match_mode], [search_mode])

  - XMATCH provides similar functionality to the legacy MATCH function, but adds wildcard search features and control over search mode

    The XMATCH function has 4 arguments:

    lookup_value: The item you are searching for within the lookup array

    lookup_array: The range or array to search for the lookup_value within

    match_mode: *Identical match modes to the XLOOKUP function.*
    NOTE: These are the opposite of the older MATCH function!

    search_mode: *Identical search modes to the XLOOKUP function.*

Example Table

	A	B	C	D
1	Employee	Division	Wage/hr	Status
2	John	Finance	$42.00	FT
3	Peter	Production	$33.00	FT
4	Miranda	Marketing	$75.00	Contract
5	David	HR	$40.00	PT
6	Katie	Production	$30.00	FT
7	Sarah	Purchasing	$26.00	PT

=XMATCH("Miranda",A1:A7)

- This function will return the number 4; it will search for the word "Miranda" in A1:A7, "Miranda" is the 4th item in this list

=XMATCH("Division",A1:D1)

- This function will return the number 2; it will search for the word "Division" in A1:D1, "Division" is the 2nd item in this list

  - A key benefit of XMATCH (vs. MATCH) is that there is a default match_mode (i.e. the match mode is set to *exact match* by default and one less argument must be entered)

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LET Function

- The LET function allows the user to set a variable and use such variable in another calculation
  - This may allow for more understandable formulas in certain circumstances

=LET(name1, name_value1, …, calculation)

The LET function has a minimum of 3 arguments:

name1:	The name you are applying to the first variable; names must start with a letter, cannot be the output of a formula, or conflict with a range
name_value1:	The value associated with a name, this can be an entered value, a range, a function or a calculation
calculation:	The formula to be evaluated using the applied names

  - Note that multiple names can be applied with the LET function; just enter additional names and values separated by commas after name_value1 and before calculation
  - Names assigned by a LET function *only apply within the LET function* and cannot be referenced in other cells or functions within Excel; if you want to refer to something in other cells or functions, you should use Static Naming (i.e. Formulas -> Define Name -> Define Name)

- **EXAMPLE: =LET(x, 3, y, 5+7, x * y) ->** this function returns 36; x = 3, y = 12, x * y = 36

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Old Tools with New Uses

OFFSET Function

- The OFFSET lookup function is also extremely useful at extracting information and can be used to create summary tables

= OFFSET(Reference, Rows, Cols, Height, Width)

  - OFFSET returns a reference to a cell that is a specified number of rows and columns from a reference cell.

The OFFSET function has 3 mandatory arguments:

Reference: The reference cell (also known as the "anchor" cell) from which the offset function is based

Rows: The number of rows, up or down, that you want to move from the reference cell

Cols: The number of columns, to the left or right, that you want to move from the reference cell

Example Table

	A	B	C
1	Name	University	Age
2	Michelle	Western	24
3	Paul	McGill	32
4	Ken	Queens	21
5	Cindy	Western	26

=OFFSET(A1,2,1)

- This function will return McGill, because it will start at the reference cell (A1), drop down 2 rows, move to the right 1 column and retrieve the contents of the destination cell

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OFFSET Function – Height & Width Arguments

- OFFSET has some interesting applications that work well with Excel's new Spilled Range functionality
  - There are two optional arguments to the OFFSET function that allow you to create a spilled range:

Optional OFFSET Arguments

height:	The height (in number of rows) that you want the results to be; same as the reference if omitted
width:	The width (in number of columns) that you want the results to be; same as the reference if omitted

- The use of OFFSET in conjunction with MATCH or XMATCH will can allow you to extract a specific range of data from a larger data set
  - For example, you could use a combination of OFFSET and XMATCH to extract pricing data for the last x days beginning at any point in time (by using XMATCH to find the correct row in a larger pricing dataset and using a *negative* height argument to extract the previous x entries)

Example Table

	A	B	C	D	E	F
1	**Name**	**University**	**Age**			
2	Michelle	Western	24		McGill	32
3	Paul	McGill	32			
4	Ken	Queens	21			
5	Cindy	Western	26			

E2=OFFSET(A1,2,1,1,2)

- The addition of a height & width argument creates a spilled range; Excel will start at the reference cell (A1), drop down 2 rows, move to the right 1 column and retrieve an array 1 row high x 2 columns wide starting in that cell

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VLOOKUP Function

- While Microsoft expects that XLOOKUP will ultimately replace VLOOKUP, VLOOKUP remains the most popular lookup function widely in use today

= VLOOKUP(Lookup_value, Table_array, Col_index_num, Range_lookup)

  - VLOOKUP (vertical lookup) searches for a value in the leftmost column of a table, and then returns a value in the same row from a column you specify

The VLookup function has 4 arguments:

Lookup_value: This is the item you are searching for. This item must be found in the leftmost column of the Table_array.

Table_array: The entire table in which you are searching for the data.

Col_index_num: When Excel finds the item you are searching for (the Lookup-value) in the leftmost column of the table (the Table_array), it will move a certain number of columns to the right to extract the data that you are looking to retrieve.

Range_lookup: To find a close match, type TRUE (or omit).
To find an exact match, type FALSE.

Example Table

	A	B	C
1	Name	University	Age
2	Michelle	Western	24
3	Paul	McGill	32
4	Ken	Queens	21
5	Cindy	Western	26

=VLOOKUP("Ken",A1:C5,3,False)

- This function will return 21, because it will search for the word "Ken" in column A and then return the corresponding age in the third column

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VLOOKUP Function (Cont'd) – Returning Multiple Columns

- One of the benefits of the XLOOKUP function is that can return an array of data (rather than a single value); this can be helpful when we want to return an entire row of data with a single formula
  - One limitation is that XLOOKUP (without using more complicated functions) will only return data with columns in the order they appear in the source data
- With the use of an *array constant* in a VLOOKUP function, we can tell Excel to return multiple columns of data (a spilled range) in any order that we define
  - An array constant is an array of data contained within {..} symbols (i.e. {1,2} is an array constant)
  - Excel can handle an array constant in the col_index_num argument to return multiple columns in any order that you specify

Example Table

	A	B	C
1	**Name**	**University**	**Age**
2	Michelle	Western	24
3	Paul	McGill	32
4	Ken	Queens	21
5	Cindy	Western	26
6			
7	Cindy	26	
8			
9	21	Queens	Ken

A7=VLOOKUP("Cindy",A1:C5,{1,3},FALSE)

- This function searches for the word "Cindy" in column A and then return the corresponding name and age (the first and third column)

A9=VLOOKUP("Ken",A1:C5,{3,2,1},FALSE)

- This function searches for the word "Ken" in column A and then returns the corresponding age, university and name *in that order* (these are the third, second and first columns, respectively)

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Table Tool

- A Table (previously known as a List) can be created to manage and analyze data
  - The Table can perform powerful calculations on a dataset:
    - The Table will automatically expand datasets when new data is added allowing for dynamic calculations
    - Tables also automate the expansion of any included formulas that are used within the data set
    - Note – Tables do not provide as much flexibility in managing data as Dynamic Named Ranges (see previous slides)
- The steps to run the Table Tool are as follows:

Excel 365

➢ Insert [N] ➢ Table [T]

  - In the menu box that appears, fill in the following information:
    - **Where is the data for your table?:** On a worksheet, select the range of cells to be included in the table. The cells can be empty or can contain data.
    - **My Table has headers:** If the selected range contains data to be displayed as table headers, select the "My table has headers" check box.
    - Keyboard shortcut: **Ctrl+T** or **Ctrl+L**

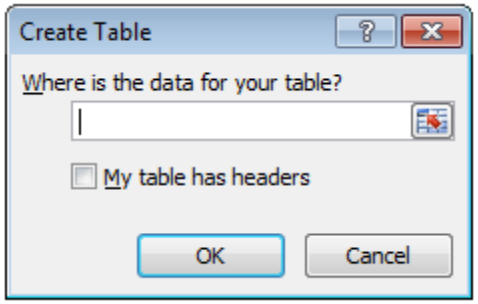

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Table Tool (Cont'd)

- Once a Table is created, the Table Tools become available in the ribbon, and a Design tab is displayed
  - Tools on the Design tab can be used to customize or edit the Table
  - Note that the Design tab is only visible when a cell in the Table is selected
- Formatting of a Table can be completed in the following way:
  - Place the cursor within the Table and access Table Styles:

    Excel 365

    ➢ Design [JT] ➢ Table Styles [S]

  - Table Style Options has additional formatting options:
    - Header Row: Turns the header row on or off
    - Total Row: Turns the total row on or off
    - Banded Rows: Displays even and odd rows differently
    - First Column: Displays special formatting for the first column
    - Last Column: Displays special formatting for the last column
    - Banded Columns: Displays even and odd columns differently

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Table Tool (Cont'd)

- Convert the Table to a regular range of data in the worksheet to stop working in a Table format
  - To convert without losing any Table style formatting that was applied:

    Excel 365

    ➢ Design [JT] ➢ Convert to Range [G]

    - Click anywhere in the Table – this displays the Table Tools, adding the Design tab
    - On the Design tab, click Convert to Range and then click Yes.
  - To convert with no Table style formatting it is necessary to first remove the Table style formatting:

    Excel 365

    ➢ Design [JT] ➢ Table Style [S] ➢ Clear [C]

    - Click anywhere in the Table – this displays the Table Tools, adding the Design tab
    - On the Design tab, open Table Styles and remove formatting by selecting Clear
    - Use the Convert to Range tool to convert the table back to a normal range of cells
  - If you no longer want to work with a Table or the data that it contains, you can delete it
    - Select a Table, highlight the entre Table (including the Table header), press DELETE

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Structured Reference Functions

- Structured references make it much easier and more intuitive to work with Table data when you are using formulas that reference a Table

  = CALCULATION(Table[Column_specifier])

  - Useful because Table data ranges often change and the cell references for structured references adjust automatically
  - Minimizes the need to rewrite formulas as rows and columns are added and deleted in a table, or when external data is refreshed.

The Structured Reference Functions have 3 arguments:

CALCULATION: The mathematical calculation you wish to preform (i.e., SUM, COUNT, etc.)

Table: A meaningful name that you provide to reference the actual Table data (excluding the headers row and totals row, if any)

Column_specifier: Derived from the column header, enclosed in brackets, and references the column data (excluding the column header and total, if any)

Table 1

	A	B	C
1	Name	University	Age
2	Michelle	Western	24
3	Paul	McGill	32
4	Ken	Queens	21
5	Cindy	Western	26

=COUNT(Table1[Age])

- This function returns 4, because there are four people listed in Table 1

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Structured Reference Functions (Cont'd)

- Special item specifiers can also be used to refer to various portions of a Table, such as the Totals row, to make it easier to refer to these portions in formulas.
  - The following are the special item specifiers that you can use in a structured reference:

#All	Returns the entire contents of the Table, including column headers, data, and totals (if any)
#Data	Returns the data cells of the Table
#Headers	Returns the column headers of the Table
#Total	Returns the total rows for the Table. If none exists, then it returns null
@-ThisRow	Just the portion of the columns in the current row. @-ThisRow cannot be combined with any other special item specifiers. Use it to force implicit intersection behavior for the reference or to override implicit intersection behavior and refer to single values from a column.

- Structured references & tables can be very useful when dealing with some of Excel's new functionality – for example, when using the XLOOKUP function

Table 1

	A	B	C
1	Name	University	Age
2	Michelle	Western	24
3	Paul	McGill	32
4	Ken	Queens	21
5	Cindy	Western	26

=XLOOKUP("Ken",Table1[Name],Table1[Age])

- This function returns 21; Excel searches the Name column for "Ken" and returns the corresponding entry from the "Age" column of the table

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