Logical Values and their Applications

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Today

• Logical Values

• Related Operators and Functions

• Applications

• Using temporary work areas.

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Types of Values in Excel

• So far:
  – Text : Boston College
  – Numbers:
    • integer : e.g., 0, 343
    • floating point : e.g., 3.14159, $24.50

• Related operators : +, -, *, /, ^

• Related built-in functions : MIN, FV, IRR, …

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A Note on Text and Strings

- Related type string:

  – Type: Hello into cell A1
  – Type: = "Hello" into cell A1

- The latter is a string. These are equal.

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Types of Values in Excel

- Now logical (or *Boolean*) values:

  TRUE, FALSE

- NB:
  – TRUE is not the same as the string "TRUE"

  – FALSE is not the same as the string "FALSE"

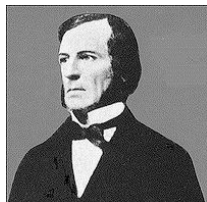CS 021 Computers in Management   5

George Boole (1815-1864)

An Investigation of the **Laws of Thought** *on Which are Founded the Mathematical Theories of Logic and Probabilities, 1854*

" … provided the theoretical grounding for the Digital Age."

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Relational Operators

- The symbols $<$, $>$, $<=$, $>=$, $=$ and $<>$ denote relational operators.

- An expression of the form:

    Expression$_1$ RelationalOperator Expression$_2$

denotes a logical value, i.e., either TRUE or FALSE.

- NB: The same operator (e.g., $>$) can be used with different types of operands.

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Nomenclature

- From here on, when the value of a given formula is a logical value (i.e., either TRUE or FALSE) we may refer to the formula as a *logical* or *relational formula* or a *test*.

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Numerical Examples

- The value of the formula $2 = 3$ is FALSE.

- The value of the formula $2 <> 3$ is TRUE.

- The value of the formula $2 <= 3$ is TRUE.

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Numerical Examples

- The value of the formula 3 = 3.0 is TRUE.

- The value of the formula 2 < 3 < 4 is FALSE!

  – As you will see, we use AND(2 < 3, 3 < 4) instead.

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String Examples

- The value of the formula "this" = "that" is FALSE.

- The value of the formula "this" = "tHiS" is TRUE.
  – String comparison disregards case.

  space

- The value of the formula "this" = " this" is FALSE. (spaces matter)

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Example

Problem: Cells B2:B8 contain test scores. Cell E1 contains a number specifying a passing grade. Cells C2:C8 should indicate whether or not the corresponding score is a passing grade.

Answer:

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Example

◇	A	B	C	D	E
1	**Name**	**Score**	**Pass**	**Min**	**70**
2	Joe	75	TRUE		
3	Mary	99	TRUE		
4	Carlos	81	TRUE		
5	Rham	62	FALSE		
6	Barbara	100	TRUE		
7	Tom	58	FALSE		
8	Annette	97	TRUE		
9					
10					

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Example

Problem: Cells B2:B8 contain test scores. Cell E1 contains a number specifying a passing grade. Cells C2:C8 should indicate whether or not the corresponding score is a passing grade.

Answer:
1. C2 gets = B2 >= E$1
2. Copy C2 to C2:C8

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Functions Related to Logical Values

IF, AND, OR, NOT

VLOOKUP, HLOOKUP

SUMIF, COUNTIF, IFERROR

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IF(testFormula, thenFormula, elseFormula)

- The testFormula must be a logical formula

- If value of testFormula is TRUE then value of entire IF-formula is the value of thenFormula

- If value of testFormula is FALSE then value of entire IF-formula is the value of elseFormula

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Example Revisited

◆	A	B	C	D	E
1	**Name**	**Score**	**Pass**	**Min**	**70**
2	Joe	75	Yes		
3	Mary	99	Yes		
4	Carlos	81	Yes		
5	Rham	62	No		
6	Barbara	100	Yes		
7	Tom	58	No		
8	Annette	97	Yes		
9					
10					
11					

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Example

Problem: Cells B2:B8 contain test scores. Cell E1 contains a number specifying a passing grade. Cells C2:C8 should indicate whether or not the corresponding score is a passing grade.

Answer:
1. C2 gets = IF(B2 >= E$1, "Yes", "No")
2. Copy C2 to C2:C8

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Loan Amortization Example Revisited

Problem: Referring to the Loan Amortization spreadsheet from before, cell E7 has a year number. Cell E8 should show the interest paid that year.

Answer:

Loan Amortization Example Revisited

◇	A	B	C	D	E
1	CS 021 Computers in Management				
2	Robert Muller				
3					
4	Loan Amortization				
5					
6	Principal	$400,000		Total Interest	
7	Annual Rate	7%		Year	2
8	Years	15		Amount	$26,374
9					
10		Payment	Balance	Principal	Interest
11	1	$3,595	$398,738	$1,262	$2,333
12	2	$3,595	$397,469	$1,269	$2,326
13	3	$3,595	$396,192	$1,277	$2,319
14	4	$3,595	$394,908	$1,284	$2,311
15	5	$3,595	$393,616	$1,292	$2,304

Loan Amortization Example Revisited

Problem: Referring to the Loan Amortization spreadsheet from before, cell E7 has a year number. Cell E8 should show the interest paid that year.

Answer:
1. F11 = IF(QUOTIENT(A11 - 1, 12) + 1 = E$7, E11, "")
2. Copy F11 to F11:F190
3. E8 = SUM(F11:F190)

Example

	A	B	C	D	E	F
1	Score	Grade				
2	85	B		Grades		
3	90	A		0	F	
4	73	C		70	C	
5	99	A		80	B	
6	66	F		90	A	
7						
8						
9						

Answer: B2 =

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Example

	A	B	C	D	E	F
1	Score	Grade				
2	85	B		Grades		
3	90	A		0	F	
4	73	C		70	C	
5	99	A		80	B	
6	66	F		90	A	
7						
8						
9						

Answer: B2 = IF(A2 < D$4, E$3,
　　　　　IF(A2 < D$5, E$4,
　　　　　　　IF(A2 < D$6, E$5, E$6)))

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Example

Problem: Cells A1:A100 contain 100 unique test scores. Give a formula for cell B1 that will evaluate to the second highest score.

Answer:

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Using a Work Area

Problem: Cells A1:A100 contain 100 unique test scores. Give a formula for cell B1 that will evaluate to the second highest score.

Answer:
1. C1 = IF(A1 = MAX(A$1:A$100), MIN(A$1:A$100),A1)
2. Copy C1 to C1:C100
3. B1 = MAX(C1:C100)

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Using a Work Area

• Sometimes appropriate to leave a work area visible;

• Sometimes appropriate to hide the rows or columns making up the work area;

• Sometimes appropriate to have work area on a separate sheet.

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Functions Related to Logical Values

• AND(formula$_1$, ..., formula$_n$) n >= 1

• OR(formula$_1$, ..., formula$_n$)   n >= 1

• NOT(formula)

• NB: all formulas above should be logical

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Truth Tables
AND

P	Q	AND(P, Q)
FALSE	FALSE	FALSE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	TRUE

OR

P	Q	OR(P, Q)
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

NOT

P	NOT(P)
FALSE	TRUE
TRUE	FALSE

Example

Problem: Scores 80 through 89 earned a B. Give an expression for B1 that indicates whether or not the score in A1 gets a B.

Answer:

Example

Problem: Scores 80 through 89 earned a B. Give an expression for B1 that indicates whether or not the score in A1 gets a B.
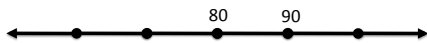
Answer:

B1 = AND(A1 < 90, A1 >= 80)

Example

AND(A1 < 90, A1 >= 80)

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Example

80   90

AND(A1 < 90, A1 >= 80)

Example

80   90

AND(A1 < 90, A1 >= 80)

Example

80   90

AND(A1 < 90, A1 >= 80)

Example

AND(A1 < 90, A1 >= 80)

Example

Problem: Applicants to Baldwin College are accepted if they are in the top 15% of their high school class and they either have 85th percentile SSAT scores or their GPA is 3.4 or better.

Answer:

Example

	A	B	C	D	E
1	Name	Class Rank	SSAT	GPA	Status
2	Joe	10%	85%	3.5	Accept
3	Mary	5%	95%	3.8	Accept
4	Carlos	20%	85%	3.6	Reject
5	Rham	30%	60%	3	Reject
6	Barbara	2%	93%	3.8	Accept
7	Tom	50%	99%	2.9	Reject
8	Annette	8%	81%	3.4	Accept
9					

NB: conditional formatting

Example

Problem: Applicants to Baldwin College are accepted if they are in the top 15% of their high school class and they either have 85th percentile SSAT scores or their GPA is 3.4 or better.

Answer:

= IF(AND(B2<=0.15, OR(C2>=0.85, D2>=3.4)),"Accept", "Reject")

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Example

Problem: Give a formula for cell C2 that computes the following truth table.

A2	B2	C2
FALSE	FALSE	TRUE
FALSE	TRUE	FALSE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

Answer:

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Example

Problem: Give a formula for cell C2 that computes the following truth table.

A2	B2	C2
FALSE	FALSE	TRUE
FALSE	TRUE	FALSE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

Answer:

=OR(AND(NOT(A2), NOT(B2)), AND(A2, NOT(B2)), AND(A2, B2))

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Example

Problem: Give a formula for cell C2 that computes the following truth table.

A2	B2	C2
FALSE	FALSE	TRUE
FALSE	TRUE	FALSE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

Answer:

=OR(AND(NOT(A2), NOT(B2)), A2)

Example

Problem: Give a formula for cell C2 that computes the following truth table.

A2	B2	C2
FALSE	FALSE	TRUE
FALSE	TRUE	FALSE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

Answer:

=OR(A2 = B2, A2)

Rules of the Road

- If you are thinking about writing:

  IF(test, TRUE, FALSE)

  write test instead.

- If you are thinking about writing:

  IF(test, FALSE, TRUE)

  write NOT(test) instead.

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Rules of the Road

- If you are thinking about writing:

    IF(NOT(test), Ans1, Ans2)

    consider writing this instead:

    IF(test, Ans2, Ans1)

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Rules of the Road

- FYI, the following are the same:

    IF(AND(test1, test2), Ans1, Ans2)

    IF(test1, IF(test2, Ans1, Ans2), Ans2)

- The following are the same:

    IF(OR(test1, test2), Ans1, Ans2)

    IF(test1, Ans1, IF(test2, Ans1, Ans2))

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Example

Problem: The number 371 is special because it is equal to the sum of the cubes of its digits. Find all 3-digit special numbers.

Answer:

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Example

Problem: The number 371 is special because it is equal to the sum of the cubes of its digits. Find all 3-digit special numbers.

Answer:
1. Put all 3-digit numbers, 000 through 999 in cells A1:A1000.
2. B1 gets = QUOTIENT(A1,100)
3. C1 gets = MOD(QUOTIENT(A1,10),10)
4. D1 gets = MOD(A1,10)
5. E1 gets = IF(A1 = B1^3+C1^3+D1^3, A1, 0)
6. Copy B1:E1 to B1:E1000.

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Example

Problem: The number 371 is special because it is equal to the sum of the cubes of its digits. Give a formula for H1 that tells how many 3-digit numbers are special.

Answer:

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Example

Problem: The number 371 is special because it is equal to the sum of the cubes of its digits. Give a formula for H1 that tells how many 3-digit numbers are special.

Answer:
1. Solve the previous problem.
2. H1 gets = COUNTIF(E1:E1000, "<> 0")

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LOOKUP Tables

- Cascaded IFs are idiomatic.

- Lookup Tables (vertical or horizontal) capture the idiom.

VLOOKUP(key, table, index, [flag])

	A	B	C	D	E	F
1	Score	Grade				
2	85	B		Grades		
3	90	A		0	F	
4	73	C		70	C	
5	99	A		80	B	
6	66	F		90	A	
7						
8						
9						

Answer: B2 = VLOOKUP(A2, $D$3:$E$6, 2)
IF(A2 < D$4, E$3,
        IF(A2 < D$5, E$4,
                IF(A2 < D$6, E$5, E$6)))

How VLOOKUP Works (inexact mode)

VLOOKUP(A2, $D$3:$E$6, 2)

- Starting from $D$3, scan down column D looking for a value that is larger than A2.
  - Values in column D must be in ascending order!

- If such a value is found in row k, then the answer is in column 2 of row k-1 of the table.

How VLOOKUP Works (inexact mode)

VLOOKUP(A2, $D$3:$E$6, 2)

- If no such value is found, then the value of the VLOOKUP formula is in column 2 of row 6.

- If $D$3 > A2 (i.e., first row) then ERROR.

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Lookup Tables with Exact Matching

VLOOKUP(key, table, index, FALSE)

- The key is expected to match a value in the left column exactly.

- Fourth argument of TRUE (meaning inexact match) is the default.

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◇	A	B	C	D	E	F
1	My Real Estate Co.			Referral Type		
2			Sales Associate	Self	Office	
3			Detz, Susan	4.50%	4.00%	
4				... hidden rows ...		
10			Anderson, Brady	4.30%	4.10%	
11						
12	Transaction	Sale Price	Sales Associate	Referral	Commission	Net
13	2145	$100,000	Anderson, Brady	Self	$4,300	$95,700
14	... hidden rows ...					
26	3832	$200,000	Anderson, Brady	Office	$8,200	$191,800
27	1024	$150,000	Detz, Susan	Self	$6,750	$143,250
28						

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◇	A	B	C	D	E	F
1	My Real Estate Co.			Referral Type		
2			Sales Associate	Self	Office	
3			Detz, Susan	4.50%	4.00%	
4			… hidden rows …			
10			Anderson, Brady	4.30%	4.10%	
11						
12	Transaction	Sale Price	Sales Associate	Referral	Commission	Net
13	2145	$100,000	Anderson, Brady	Self	$4,300	$95,700
14	… hidden rows …					
26	3832	$200,000	Anderson, Brady	Office	$8,200	$191,800
27	1024	$150,000	Detz, Susan	Self	$6,750	$143,250
28						

E13 gets
    VLOOKUP(C13, $C$3:$E$10, IF(D13="SELF",2,3),FALSE) * B13