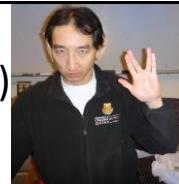


## Logic

You will learn three common logical operations that will be applied in much of the course (spreadsheets, databases, web searches and both programming sections)

### Logic: Not Just Theory (*Fascinating*)

- Example (an actual question from an computer science student):
  - “Why is when I type your full name [JT: “James Tam”] that I get fewer search results than just with your last name?”
  - This is an example of how you actually apply a logical operation in your day-to-day activities!



Logic: not just ‘geeks’ who use it

Image of James Tam courtesy of James Tam

## Expressions

- Mathematics
  - These types of expressions produce a numerical result (e.g., integer, real, complex)
- Logic
  - These types of expressions produce a Boolean result (can only be true or false)

## Logical Operators

- Similar to mathematical operators they take one or two inputs and product an output.
- Mathematical operators:
  - Take numbers as input, produce a number as output
    - Two input  
 $3 * 2$
    - One input (negation)  
 $-(2)$
- Logical operators (in this section AND, OR, NOT):
  - Can only take true or false Booleans as input
  - Can only produce a true or false Booleans as output

## Truth Tables

- Examples (input columns specifying all possible combinations of TRUE, FALSE)

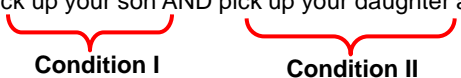
Column 1	Column 2			
FALSE	FALSE			
FALSE	TRUE			
TRUE	FALSE	Column 1	Column 2	Column 3
TRUE	TRUE	FALSE	FALSE	FALSE
		FALSE	FALSE	TRUE
		FALSE	TRUE	FALSE
		FALSE	TRUE	TRUE
		TRUE	FALSE	FALSE
		TRUE	FALSE	TRUE
		TRUE	TRUE	FALSE
		TRUE	TRUE	TRUE

## Truth Tables (2)

- Can be used for evaluating logical operations

Column 1	Column 2	Result of (Column 1) OPERATION (COLUMN 2)
FALSE	FALSE	TRUE OR FALSE
FALSE	TRUE	TRUE OR FALSE
TRUE	FALSE	TRUE OR FALSE
TRUE	TRUE	TRUE OR FALSE

## Logical AND

- The popular usage of the logical AND applies when *ALL* conditions must be met.
  - Example:
    - Pick up your son AND pick up your daughter after school today.
- 
- Logical AND can be specified more formally in the form of a truth table.

Truth table (AND)		
C1	C2	C1 AND C2
False	False	False
False	True	False
True	False	False
<i>True</i>	<i>True</i>	<i>True</i>

## Logical AND: Three Input Truth Table

Truth table			
C1	C2	C3	C1 AND C2 AND C3
False	False	False	False
False	False	True	False
False	True	False	False
False	True	True	False
True	False	False	False
True	False	True	False
True	True	False	False
<i>True</i>	<i>True</i>	<i>True</i>	<i>True</i>

### Logical AND: An Example

	T	T	F	F	T	F
AND	F	T	F	T	T	F
	F	T	F	F	T	F

### Evaluating Logical AND Expressions

- For 'AND', 'OR' the order of operation is left to right
- True **AND** True **AND** True
- False **AND** True **AND** True
- Extra practice
  1. True **AND** True **AND** True **AND** True
  2. True **AND** True **AND** True **AND** False
  3. False **AND** True **AND** False **AND** False **AND** False **AND** True  
**AND** False **AND** True **AND** False **AND** False **AND** False **AND**  
False **AND** False **AND** False

## Logical OR

- The correct everyday usage of the logical OR applies when *ATLEAST* one condition must be met.
- Example:
  - You are using additional recommended resources for this course: the online textbook OR the paper textbook available in the bookstore.

**Condition I**

**Condition II**

- Similar to AND, logical OR can be specified more formally in the form of a truth table.

Truth table		
C1	C2	C1 OR C2
<i>False</i>	<i>False</i>	<i>False</i>
False	True	True
True	False	True
True	True	True

## Logical OR: Three Input Truth Table

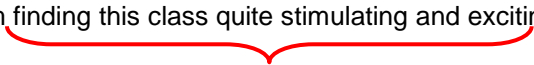
Truth table			
C1	C2	C3	C1 OR C2 OR C3
<i>False</i>	<i>False</i>	<i>False</i>	<i>False</i>
False	False	True	True
False	True	False	True
False	True	True	True
True	False	False	True
True	False	True	True
True	True	False	True
True	True	True	True

## Evaluating Logical OR Expressions

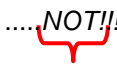
- In class examples
  - True **OR** True **OR** True
  - False **OR** True **OR** True
  - Extra practice
1. False **OR** False **AND** False **AND** False
  2. False **OR** False **AND** False **AND** True
  3. False **OR** True **OR** False **OR** False **OR** False **OR** True **OR** False  
**OR** True **OR** False **OR** False **OR** False **OR** False **OR** False **OR** False

## Logical NOT

- The everyday usage of logical NOT negates (or reverses) a statement.
- Example:  
 – I am finding this class quite stimulating and exciting .....*NOT!!!*  



Statement (logical condition)



Negation of the statement/condition
- The truth table for logical NOT is quite simple:

Truth table	
S	Not S
False	True
True	False

## Logical NOT: An Example

	T	F	F	T
NOT	F	T	T	F

## Evaluating More Complex Logical Expressions

•Order of operation (left to right evaluation if the 'level' is equal)

1. Brackets (inner first)
2. Negation
3. AND
4. OR

1. True **OR** False **AND** False
2. **NOT** (False **OR** True) **OR** True
3. (False **AND** False) **OR** (False **AND** True)
4. False **OR** (False **OR** True) **AND** False
5. **NOT NOT** True
6. **NOT NOT** False
7. **NOT NOT NOT** False



## Evaluating More Complex Logic: Truth Table

C1	C2	C1 AND C2	NOT (C1 AND C2)	(C1 OR C2)	NOT(C1 AND C2) AND (C1 OR C2)
FALSE	FALSE				
FALSE	TRUE				
TRUE	FALSE				
TRUE	TRUE				

## After This Section You Should Now Know

- Three logical operators: AND, OR, NOT
- How to evaluate logical expressions regardless the method of specification e.g., truth table