

Topics

Use relational operators to test two values
Compare relationships using logical operators
Use logical expressions to find specific elements in an array

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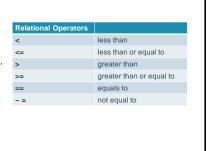
MATLAB has a logical data type, with the possible values: 1, representing true, 0, representing false. Logicals are produced by relational and logical operators/functions and by the functions true and false, or the logical class cast a = true b = false c = logical (variable)

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Relational Operators

- Used to compare two numeric values
- Returns a value of true or false.
- In MATLAB,
 - 1 = true (any non-zero <u>number</u>);
 - 0 = false;
 - Logical data type



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Relational Operators

- The MATLAB relational operators compare corresponding elements of arrays with equal dimensions.
- Relational operators always operate element-by-element.
- example

```
A = [2 7 6;9 0 5;3 0.5 6];

B = [8 7 0;3 2 5;4 -1 7];

A == B

ans =

0 1 0

0 0 1

0 0 0
```

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Relational Operators

- Comparisons between scalars produce logical 1 if the relation is true and logical 0 if it is false.
- Comparisons are also defined between arrays of the same dimension and between an array and a scalar.
- For array-array comparisons corresponding pairs of elements are compared, while for array-scalar comparisons the scalar is compared with each array element.

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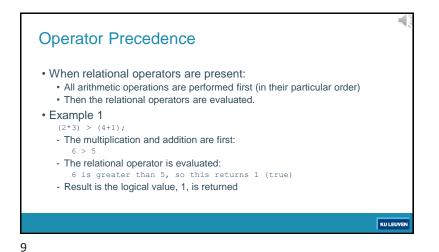
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Operator Precedence

- 1. Parentheses ()
- 2. Transpose (.'), power (.^), complex conjugate transpose ('), matrix power (^)
- 3. Unary plus (+), unary minus (-), logical negation (~)
- 4. Multiplication (.*), right division (./), left division (.\), matrix multiplication (*), matrix right division (/), matrix left division (\)
- 5. Addition (+), subtraction (-)
- 6. Colon operator (:)
- Less than (<), less than or equal to (<=), greater than (>), greater than or equal to (>=), equal to (==), not equal to (<=)
- B. Element-wise AND (&)
- 9. Element-wise OR (|)
- 10. Short-circuit AND (&&)
- 11. Short-circuit OR (||)

Good Practice: use parentheses to make the intention completely clear

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Logical Operators Logical Operators: Logical Operators AND Provide a way to combine results from Relational Expressions or OR between logical values NOT · Returns a value of true or false. XOR · Evaluated after all other operators have been performed (lowest precedence priority) KU LEUVEN

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Truth table b TAND 0 0 0 0 0 0 1 1 1 0 **1** 0 0 1 NOT Operation XOR Operation Operation Operation KU LEUVEN • AND: &
• Returns true if two expressions being compared are true.
• Returns false if any of the two is false.

• OR: |
• Returns true if any of the two expressions is true.
• Returns false only if the two are both false.

• NOT: ~
• Returns true if the single expression is false.
• Returns false if the single expression is true.

Examples: • Assume: a=7; b=4; c=3; • $\sim (a==3*b)$ • Evaluates: 3*b = 12 Evaluates: (a==12) and result is false • Evaluates ~ (false) and result is true • Returns ans = 1 (true) • a > 5 & b > 5 Evaluates (a>5) and (b>5) separately. . One returns true, the other returns false. . Since both are not true, the expression returns false. • a == 7 | b ==1 • Evaluates (a==7) and (b==1) separately One returns true and the other returns false . Since at least one is true, the expression returns true KU LEUVEN

Logical Operators: more

Short-Circuit Operators

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- The following operators perform AND and OR operations on logical expressions containing scalar values.
- They are short-circuit operators in that they evaluate their second operand only when the result is not fully determined by the first operand.

Operator	Description
88	Returns logical 1 (true) if both inputs evaluate to true, and logical 0 (false) if they do not.
П	Returns logical 1 (true) if either input, or both, evaluate to true, and logical 0 (false) if they do not.

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A Common Mistake

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- You will not get into trouble if you make sure that Logical Operators are always used with logical values.
- A > B & C (where A=10, B=5, C=0)
 - This looks like a relational expression asking if ${\tt A}$ is greater than \underline{both} ${\tt B}$ and ${\tt C}$ which should be true for these values.
 - · Here is what really happens:
 - . A>B is evaluated as true
 - result (true) is logically ANDed with C
 - Since MATLAB treats any zero numeric as false, it will mistakenly treat C as a logical and the result will be false
 - The $\underline{\text{CORRECT}}$ form is: (A > B) & (A > C) and this returns a true result.

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Logical Values in Assignments

- True/False values can be assigned to variables and then treated numerically in MATLAB.
- The variables will be assigned the value that is returned from relational and/or logical operators.
- The variables will thus have a value of 1 or 0.

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Some Other Warnings...

- Using numeric values to represent logicals can have some strange repercussions...
- Never try to use NaN in a relational or logical expression because NaN has no value (can be considered to have all values)

>> nan==nan
ans = 0
>> inf==inf
ans = 1

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Logical Operators: more

```
ages = [10 62 18 27]
anyKids = any(ages <= 12)
anySeniors = any(ages >= 65)
anyKids =

1
anySeniors =
0
```

```
allAdults = all(ages >= 18)
noSeniors = all(ages <= 65)
allAdults =
    0

noSeniors =
    1</pre>
```

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Logical Operators: more

- · Reduce Logical Arrays to Single Value: aggregating logical values
 - · any (
 - all()
- all:
 - returns 1 if all the elements of the vector are nonzero and 0 otherwise
 - matrix:
 - operates on columns of A, returning a row vector of 1s and 0s
 - returns 1 if all elements of the column are logical true
- anv:
 - returns 1 is at least 1 element in the vector is nonzero
 - matrix
 - · operates on columns of A, returning a row vector of 1s and 0s
 - · Returning logical true if any element of that column is true.

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Logical Conditions and arrays

- Find Array Elements That Meet a Condition
- filter the elements of an array by applying one or more conditions to the array

```
A = randi(15,3)

A = 13 14 5 14 10 9 2 2 15

>> A > 5

ans = 1 1 0 0 1

>> A > 5

ans = 1

14 10 0 1

>> A (A>5)

ans = 1

14 10 0 1

19 9 9 13
```

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Logical Conditions and arrays • find() · find returns the indices corresponding to the nonzero elements of a vector. 14 10 • find applied to a matrix A, the index vector corresponds to A regarded as a vector of the >> find(A>5) columns stacked one on top of the other (that is, A(:)), and this vector can be used to index ans = into A · information about the locations of the array elements that meet a condition rather than their actual values. KU LEUVEN

Searching • The find command "finds" members of an array that meet a criteria. The -5 5 15 25 35 45 55 65 75 85 95 105 result of the command is a list of element numbers. >> set1 = find(grades>100 | grades <0) http://blogs.mathworks.com/loren/2009/ 01/20/more-ways-to-find-matching-data/ >> set2 = find(grades>=0 & grades <=100) set2 = 2 3 4 5 6 7 8 >> grades(set1) ans = -5 105 >> grades(set2) ans = 5 15 25 35 45 55 65 75 85 95 KU LEUVEN

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