Colon operators perform element-by-element operations.

### Syntax

- $a :+ b$  
  addition
- $a :- b$  
  subtraction
- $a :* b$  
  multiplication
- $a :/ b$  
  division
- $a :^ b$  
  power
- $a :== b$  
  equality
- $a :!= b$  
  inequality
- $a :> b$  
  greater than
- $a :>= b$  
  greater than or equal to
- $a :< b$  
  less than
- $a :<= b$  
  less than or equal to
- $a :& b$  
  and
- $a :| b$  
  or

### Remarks and examples

Remarks are presented under the following headings:

- C-conformability: element by element
- Usefulness of colon logical operators
- Use parentheses

#### C-conformability: element by element

The colon operators perform the indicated operation on each pair of elements of $a$ and $b$. For instance,

$$
\begin{bmatrix}
c & d \\
f & g \\
h & i \\
\end{bmatrix}
:*
\begin{bmatrix}
j & k \\
l & m \\
n & o \\
\end{bmatrix}
=
\begin{bmatrix}
c * j & d * k \\
f * l & g * m \\
h * n & i * o \\
\end{bmatrix}
$$
Also colon operators have a relaxed definition of conformability:

\[
\begin{align*}
\begin{bmatrix} c \\ f \\ g \end{bmatrix} :* \begin{bmatrix} j & k \\ l & m \\ n & o \end{bmatrix} &= \begin{bmatrix} c* j & c* k \\ f* l & f* m \\ g* n & g* o \end{bmatrix} \\
\begin{bmatrix} c & d \\ f & g \\ h & i \end{bmatrix} :* \begin{bmatrix} j \\ l \\ n \end{bmatrix} &= \begin{bmatrix} c* j & d* j \\ f* l & g* l \\ h* n & i* n \end{bmatrix} \\
\begin{bmatrix} c & d \\ f & g \\ h & i \end{bmatrix} :* \begin{bmatrix} j & k \\ l & m \\ n & o \end{bmatrix} &= \begin{bmatrix} c* j & d* k \\ c* l & d* m \\ c* n & d* o \end{bmatrix} \\
\begin{bmatrix} c & d \\ f & g \\ h & i \end{bmatrix} :* \begin{bmatrix} j & k \\ l & m \\ n & o \end{bmatrix} &= \begin{bmatrix} c* j & c* k \\ c* l & c* m \\ c* n & c* o \end{bmatrix} \\
\begin{bmatrix} c & d \\ f & g \\ h & i \end{bmatrix} :* \begin{bmatrix} j \end{bmatrix} &= \begin{bmatrix} c* j & d* j \\ f* j & g* j \\ h* j & i* j \end{bmatrix}
\end{align*}
\]

The matrices above are said to be c-conformable; the c stands for colon. The matrices have the same number of rows and columns, or one or the other is a vector with the same number of rows or columns as the matrix, or one or the other is a scalar.

C-conformability is relaxed, but not everything is allowed. The following is an error:

\[
(c \ d \ e) :* \begin{bmatrix} f \\ g \\ h \end{bmatrix}
\]

Usefulness of colon logical operators

It is worth paying particular attention to the colon logical operators because they can produce pattern vectors and matrices. Consider the matrix

\[
\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} = (5, \ 0 \ \ 0, \ 2 \ \ 3, \ 8)
\]

\[
\begin{bmatrix}
1 & 5 & 0 \\
2 & 0 & 2 \\
3 & 3 & 8
\end{bmatrix}
\]
Which elements of \( x \) contain 0?

\[
\begin{array}{ccc}
1 & 2 \\
1 & 0 & 1 \\
2 & 1 & 0 \\
3 & 0 & 0 \\
\end{array}
\]

How many zeros are there in \( x \)?

\[
\text{sum}(x==0)
\]

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Use parentheses

Because of their relaxed conformability requirements, colon operators are not associative even when the underlying operator is. For instance, you expect \((a+b)+c == a+(b+c)\), at least ignoring numerical roundoff error. Nevertheless, \((a:+b):+c == a:+(b:+c)\) does not necessarily hold. Consider what happens when

\[
a: 1 \times 4 \\
b: 5 \times 1 \\
c: 5 \times 4
\]

Then \((a:+b):+c\) is an error because \(a:+b\) is not c-conformable.

Nevertheless, \(a:+(b:+c)\) is not an error and in fact produces a \(5 \times 4\) matrix because \(b:+c\) is \(5 \times 4\), which is c-conformable with \(a\).

Conformability

\[
a : op b:
\]

a: \( r_1 \times c_1 \)

b: \( r_2 \times c_2 \), \( a \) and \( b \) c-conformable

result: \( \max(r_1, r_2) \times \max(c_1, c_2) \)

Diagnostics

The colon operators return missing and abort with error under the same conditions that the underlying operator returns missing and aborts with error.

Also see

[M-2] exp — Expressions

[M-2] Intro — Language definition