# opColon — Colon operators

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## 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`  
  Logical AND
- `a :| b`  
  Logical OR

## Description

Colon operators perform element-by-element operations.

## 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,

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

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

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

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

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

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:

\[(c \ d \ e) :*[f \ g \ h]\]

**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

\[
: \ x = (5, \ 0 \ \ 0 \ \ \ 2 \ \ 3, \ 8)
: \ x
\]

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

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

How many zeros are there in x?

\[
\text{sum}(x:==0) = 2
\]

**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

\[
\begin{align*}
a & : 1 \times 4 \\
b & : 5 \times 1 \\
c & : 5 \times 4
\end{align*}
\]

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**

\[
a : \text{op} b: \\
a: r_1 \times c_1 \\
b: r_2 \times c_2, \quad a \text{ and } b \text{ c-conformable} \\
\text{result: } \max(r_1, r_2) \times \max(c_1, c_2)
\]

**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