Notes

Notes

123, -345, 0

Matlab variable types

integer

123, -345, 0

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- real or float

 - 12.2344
 5.445454
 engineering notation
 - 4.2323e-9 = 4.2323 × 10⁻⁹

Notes

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Matlab variable types

integer

- 123, -345, 0
- real or float
 - 12.2344
 - 5.445454
 - engineering notation
 - 4.2323e-9 = 4.2323 × 10⁻⁹
- complex
 - $i = \sqrt{-1} = 1i$
 - 34.23+21.21i
 - (1+1i) * (1-1i) = 2

. ∂• Eugeniy Mikhailov (W&M) Practical Computing Lecture 02 0/05 Matlab variable types Notes integer 123, -345, 0 real or float • 12.2344 • 5.445454 engineering notation • 4.2323e-9 = 4.2323 × 10⁻⁹ • complex • $i = \sqrt{-1} = 1i$ • 34.23+21.21i • (1+1i) * (1-1i) = 2 • strings (put your words inside apostrophes) • handy for file names and messages • 'programming is fun' • s='Williamsburg' Eugeniy Mikhailov (W&M) Practical Computing Lecture 02 2/25 Some built in constants and functions Notes • $\pi = 3.141592653589793238462643383279502 \cdots$ • use pi • trigonometry functions By default angle is in radians But can be done in degrees • sin, cos, tan, cot • sind, cosd, tand, cotd • asin, acos, atan, acot • asind, acosd, atand, acotd sin(pi/2)=1 sind(90)=1 • hyperbolic functions • sinh, cosh, tanh, coth \bullet asinh, acosh, atanh, acoth logarithms natural log • base of 10 log10 o power • x^y use x^y or alternatively power (x, y) • e^y use exp (y) Eugeniy Mikhailov (W&M) Practical Computing Lecture 02 Assignment operator Notes

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x = 1.2 + 3.4

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Assignment operator

x = 1.2 + 3.4

Despite the look = is not an equality operator. = is an assignment operator.

Notes

Notes

x = 1.2 + 3.4

Despite the look = is not an equality operator.

= is an assignment operator.

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Assignment operator

The expression above should be read as

• evaluate expression at the right hand side of equality symbol

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Lecture 02

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- assign the result of the RHS to the variable on the left hand sign
- now variable x holds the value 4.6

We are free to use the value of the variable \times in any further expressions

> x + 4.2 ans = 8.8

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Efficient editing - Tab-completition

Notes

Once you typed some expressions in "Command window"

- type couple of first symbols of variable or function name
- hit tab and you will get

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- either fully typed name (if it is uniq)
- or little chart with choices
 - use <up> or <down> arrows to choose
 - alternatively <Ctrl-p>, <Ctrl-n>
 - then hit <enter> to make your choise

Help related commands

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Notes

These are the most important commands

- \bullet docsearch word
 - will search for word in the help files and show up matched help files
 example: docsearch trigonometry

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- help name
 - output short help text into "Command window" about
 - function/method named name
 - example: help sin
- doc name
 - show a reference page about function/method named name in the help vrowser
 - usually has more information compare to help name
 - example: doc sin

Operator Precedence

Look at the following Matlab expression

-2^4*5 + tan(pi/8+pi/8)^2

Guess the answer.

| | | () < | → (E) E | ୬୯୯ |
|-------------------------|---------------------|-------|------------|--------|
| Eugeniy Mikhailov (W&M) | Practical Computing | | Lecture 02 | 7 / 25 |
| Operator Preceder | nce | | | |

Look at the following Matlab expression

-2^4*5 + tan(pi/8+pi/8)^2

Guess the answer.

- (2^4)*5 + (tan((pi/8+pi/8)))^2

Operator Precedence

Look at the following Matlab expression

-2^4*5 + tan(pi/8+pi/8)^2

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Guess the answer.

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```
- (2^4)*5 + (tan( (pi/8+pi/8) ))^2
```

```
-(16)*5+(tan((pi/4)))^2
```

Eugeniy Mikhailov (W&M) Practical Computing Lecture 02 **Operator Precedence** Look at the following Matlab expression -2^4*5 + tan(pi/8+pi/8)^2 Guess the answer.

-
$$(2^4) \times 5$$
 + $(\tan((pi/8+pi/8)))^2$

Lecture 02

Notes



Notes

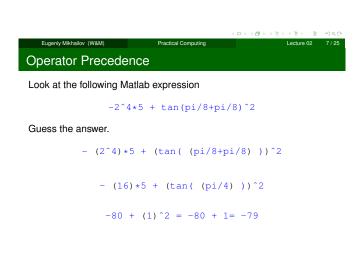
Operator Precedence

Look at the following Matlab expression

-2^4*5 + tan(pi/8+pi/8)^2

Guess the answer.

- $(2^4) * 5 + (tan((pi/8+pi/8)))^2$
 - $(16) * 5 + (tan((pi/4)))^2$
 - $-80 + (1)^2 = -80 + 1$



Operator Precedence

Look at the following Matlab expression

-2^4*5 + tan(pi/8+pi/8)^2

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Guess the answer.

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- (2^4)*5 + (tan((pi/8+pi/8)))^2

 $-(16)*5+(tan((pi/4)))^2$

 $-80 + (1)^2 = -80 + 1 = -79$

Rule of thumb: if not sure use extra parentheses ()

Operator Precedence

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Look at the following Matlab expression

 $-2^{4}+5 + \tan(pi/8+pi/8)^{2}$

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Guess the answer.

- $(2^4) * 5 + (tan((pi/8+pi/8)))^2$

$$-(16)*5+(tan((pi/4)))^2$$

 $-80 + (1)^2 = -80 + 1 = -79$

Rule of thumb: if not sure use extra parentheses ()

- Read more by executing doc precedence
- or searching for 'precedence' in the help browser.

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Matrices

Recall that Matlab stands for Matrix Laboratory

- So deep inside everything is a matrix (array)
- \bullet a number is the case of 1 \times 1 matrix

Notes

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Recall that Matlab stands for Matrix Laboratory

- So deep inside everything is a matrix (array)
- $\bullet\,$ a number is the case of 1 \times 1 matrix

Let's create a 3×5 matrix (3 rows and 5 columns)

| >> | Mz=zeros(3,5) | | | | | | | | |
|----|---------------|---|---|---|--|--|--|--|--|
| Mz | = | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | | | | | |
| 0 | 0 | 0 | 0 | 0 | | | | | |
| 0 | 0 | 0 | 0 | 0 | | | | | |
| | | | | | | | | | |

This is not the only way, but it is one which make sure that matrix is filled with zeros

Note: it is possible to have more than 2 dimensional arrays.

| Eugeniy Mikhailov (W8M) Practical Computing Lecture 0 | 2 8/25 |
|---|--------|
| | |
| Matrix elements assignment | |
| | |
| >> Mz(2,4)=1 % 2nd row, 4th column | |
| | |
| Mz = | |
| 0 0 0 0 | |
| | |
| 0 0 0 1 0 | |
| 0 0 0 0 0 | |

Notes

Notes

Matrix elements assignment

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| >> | Mz(2,4)=1 | olo | 2nd row, | 4th | column | | |
|-------------|------------------------|-------------|-------------|-------------|--------|------------|--------|
| Mz | = | | | | | | |
| 0 0 0 | 0 0 0 | 0 0 0 | 0 1 0 | 0 0 0 | | | |
| | Mz(3,5)=4 | olo | 3rd row, | 5th | column | | |
| Mz | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | | | |
| 0 | 0 | 0 | 1 | 0 | | | |
| 0 | 0 | 0 | 0 | 4 | | | |
| | | | | | 4 | | ୬୯୯ |
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Alternative way to assign a matrix

• comma separates column elements

• semicolon separates row elements

| >> | Mz= | = [| | | | | | | | |
|----|-----|-----|----|----|---|---|--|--|--|--|
| Ο, | Ο, | Ο, | Ο, | 0; | | | | | | |
| Ο, | Ο, | Ο, | 1, | 0; | | | | | | |
| Ο, | Ο, | Ο, | Ο, | 4] | | | | | | |
| | | | | | | | | | | |
| Mz | = | | | | | | | | | |
| | | | | | | | | | | |
| 0 | | 0 | | 0 | 0 | 0 | | | | |
| 0 | | 0 | | 0 | 1 | 0 | | | | |
| 0 | | 0 | | 0 | 0 | 4 | | | | |

Notice $\cdots\,$ mark, which means that input continues on the next line

| | | 10110 | 지수는 지수가 문제 문제 | *) Q (* |
|-------------------------|---------------------|-------|---------------|---------|
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| Strength of Matlab | | | | |
| | | | | |

Native matrix operations

| Mz = | | | | | |
|-----------|--------|----|---|---|---|
| | | | | | |
| 0 0 0 0 0 | >> Mz- | +5 | | | |
| 0 0 0 1 0 | ans = | | | | |
| 0 0 0 0 4 | 5 | 5 | 5 | 5 | 5 |
| | 5 | 5 | 5 | 6 | 5 |
| | 5 | 5 | 5 | 5 | 9 |

| | | + = > + (10) > + (2) > + (2) > | ₹ •9¢@ |
|-----------|---------------------|--------------------------------|---------|
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| of Matlab | | | |

Native matrix operations

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Eugeniy Mikhai

| 5 | 5 | 5 | 5 | 5 |
|--------|---|---|---|---|
| 5 | 5 | 5 | 6 | 5 |
| 5 | 5 | 5 | 5 | 9 |
| | | | | |
| >> Mz* | 2 | | | |
| ans = | | | | |
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 2 | 0 |
| 0 | 0 | 0 | 0 | 8 |
| | | | | |

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Lecture 02

More example on matrices operations

>> Mz+5 ans =

| Mz = | >> Mz+Mz | | | | | | |
|-----------|----------|---|---|---|---|--|--|
| 0 0 0 0 0 | ans = | | | | | | |
| 0 0 0 1 0 | 0 | 0 | 0 | 0 | 0 | | |
| 0 0 0 0 4 | 0 | 0 | 0 | 2 | 0 | | |
| | 0 | 0 | 0 | 0 | 8 | | |

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More example on matrices operations

| Mz = | >> Mz+Mz |
|-----------|---|
| 0 0 0 0 0 | ans = |
| 0 0 0 1 0 | 0 0 0 0 0 |
| 0 0 0 0 4 | 0 0 0 2 0 |
| | 0 0 0 8 |
| | algebra rules |
| | Matrix multiplication according to the linear algebra rules |
| | >> Mz*Mz' |
| | ans = |
| | 0 0 0 |
| | 0 1 0 |
| | 0 0 16 |
| | Here Mz' corresponds to transposed matrix Mz, i.e. $Mz'(i, j) = Mz(j, i)$ |
| | (日)(間)(日)(日)(日)(日)(日)(日)(日)(日)(日)(日)(日)(日)(日) |

Matrix as a function argument

A function can take a matrix as the function argument, it will evaluate the value of the function for each matrix element

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| Mz = | >> sin(| Mz) | | | |
|-----------|---------|-----|---|--------|---------|
| 0 0 0 0 0 | ans = | | | | |
| 0 0 0 1 0 | 0 | 0 | 0 | 0 | 0 |
| 0 0 0 0 4 | 0 | 0 | 0 | 0.8415 | 0 |
| | 0 | 0 | 0 | 0 | -0.7568 |

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Vectors and column vector

A special case of the matrix is it has only one dimension. Such matrices generally called vectors

• $m \times 1$ column vector

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• $1 \times m$ just a vector

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Vectors and column vector

A special case of the matrix is it has only one dimension. Such matrices generally called vectors

- $m \times 1$ column vector
- $1 \times m$ just a vector

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To create a vector

>> % use comma to separate column elements >> v=[1, 2, 3, 4, 5, 6, 7, 8] v = 1 2 3 4 5 6 7 8 >> % alternatively you can use spaces >> v=[1 2 3 4 5 6 7 8]; >> % or mix of these two notations (NOT RECOMMENDED) >> v=[1 2 3, 4, 5, 6 7 8] v 3 4 5 6 7 1 2 8 $\partial \rightarrow$ Eugeniy Mikhailov (W&M) Lecture 02 14 / 25

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Notes

Construction of column vector

| >> vc=[1; 2; 3] | | |
|-----------------|-------------|--------------|
| % use semicolon | to separate | row elements |
| | | |
| VC = | | |
| ve | | |
| | | |
| T | | |
| 2 | | |
| 3 | | |
| | | |

| | | $(\Box \rightarrow (\Box \rightarrow (\Box \rightarrow (\Xi \rightarrow (\Xi \rightarrow (\Box \rightarrow (\Box \rightarrow (\Box \rightarrow $ | 8) - 8 | Д |
|---|-------------------------|--|--------|-----|
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| Yet one more way | to create matrix | | | |
| If you have prearrange | d vectors or column vec | tors you can us | e thei | n |
| >> vc=[1; 2; 3]; >> % note that ; >> Mc=[vc, vc, vc | after a statement | suppresses | outr | put |

| ~ ~ | 110 | 1,001 | 00, | v C] |
|-----|-----|-------|-----|-------|
| Мс | = | | | |
| 1 | | 1 | 1 | |
| 2 | | 2 | 2 | |
| 3 | | 3 | 3 | |

Practical Computing Lecture 02 Yet one more way to create matrix

If you have prearranged vectors or column vectors you can use them

| >> | vc=[1; | 2; 3 | ; | | | | | | |
|-----|-------------------|---------|---------|---------------|--------|-----------|-----------|-------|---------|
| >> | % note | that | ; after | a sta | tement | suppr | esses | outp | ut |
| >> | Mc=[vc, | , vc, | vc] | | | | | | |
| Мc | = | | | | | | | | |
| 1 | 1 | 1 | | | | | | | |
| 2 | 2 | 2 | | | | | | | |
| 3 | 3 | 3 | | | | | | | |
| | | | | | | | | | |
| v = | = | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | |
| >> | Mv = [v; | 2*v; | 3*v] | | | | | | |
| Mv | = | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | |
| 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | | |
| 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | | |
| | | | | | | < 🗆 > < 🗗 | + ≥ > + 3 | | ୬୯୯ |
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Colon (:) operator

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The : operator is extremely useful to create vectors or matrix indexes It usually take form start:increment:stop and creates a vector with following values

[start, start+increment, ... , start+m*increment]

where

 $\min(\text{start}, \text{stop}) \leq \text{m*increment} \leq \max(\text{start}, \text{stop})$

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Colon (:) operator

The : operator is extremely useful to create vectors or matrix indexes It usually take form start:increment:stop and creates a vector with following values

. د الله

| [| start, | <pre>start+increment,</pre> | , | <pre>start+m*increment]</pre> |
|----|--------|-----------------------------|-------|-------------------------------|
| wh | ere | | | |

 $\min(\text{start}, \text{stop}) \leq \text{m} \star \text{increment} \leq \max(\text{start}, \text{stop})$ >> v=5:2:11

v = 5 7 9 11

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|---------------------------|--|------------------------------|----------------|
| Colon (:) operato | r | | |
| | emely useful to create art:increment:sto vith following values | | œs |
| [start, start+i | ncrement, , | start+m*incremer | ıt] |
| where | | | |
| min(start,stop) | \leq m*increment \leq 1 | max(start,stop) | |
| >> v=5:2:11 | | | |
| v = 5 7 | 9 11 | | |
| It is also possible to ha | ave negative increme | nt | |
| >> v2=12:-3:1 | | | |
| v2 = 12 9 | 6 3 | | C. |
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| Colon (:) operato | r continued | | |
| | stop in this case inc | rement = 1 | |
| >> v1=1:5 | | | |

| v1 | = | | | |
|----|---|--|--|--|

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Colon (:) operator continued

1 2 3 4 5

Another form start:stop in this case increment = 1

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| >> | v1=1:5 | | | | | |
|-----|----------|---|---|---|---|--|
| v1 | = | | | | | |
| | 1 | 2 | 3 | 4 | 5 | |
| Not | ice that | | | | | |
| >> | v3=5:1 | | | | | |
| v3 | = | | | | | |
| | | | | | | |

Empty matrix: 1-by-0

Produce somewhat unexpected result, since default increment is positive $\Box \mapsto \neg \Box \to \neg = \Xi$ E> イミ> ミ のへで Lecture 02 18 / 25

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Slicing matrices

It is handy to choose a subset (block) from the matrix We have a matrix Mv with size 3×8 and we want to choose all elements from columns 2,5,6

| >> 1 | Mv | | | | | | | |
|------|--------|--------|----|----|----|----|----|--|
| Mv : | = | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | |
| 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | |
| | | | | | | | | |
| >> 1 | Mv(:,[| 2,5,6] |) | | | | | |
| ans | = | | | | | | | |
| 2 | 5 | 6 | | | | | | |
| 4 | 10 | 12 | | | | | | |
| 6 | 15 | 18 | | | | | | |
| | | | | | | | | |

The meaning of the : now is choose all. Notice also that we use vector to specify desired columns

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|-------------------------|---------------------|--------------------|
| Plotting | | |

Fiotung

Suppose you have a vector with values of x coordinates and we want to plot sin(x).

```
>> x=linspace(0,2*pi,10)
x =
                                     2.7925
0
     0.6981
               1.3963
                          2.0944
                                                3.4907
4.1888 4.8869
                5.5851
                           6.2832
>> y=sin(x)
У
0
    0.6428
              0.9848
                         0.8660
                                     0.3420
                                               -0.3420
-0.8660 -0.9848 -0.6428 -0.0000 >> plot(x,y,'o') % alternatively plot(x,sin(x),'o')
>> % every plot MUST have title, x and y labels
>> xlabel('x (radians)')
>> ylabel('sin(x)')
>> title('Plot of sin(x)')
```

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Saving plots

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Now we want to save the figure, use print

>> print('-dpdf', 'sin_of_x')

This will generate file *sin_of_x.pdf* notice automatic fileextension addition.

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Saving plots

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Now we want to save the figure, use print

>> print('-dpdf', 'sin_of_x')

This will generate file *sin_of_x.pdf* notice automatic fileextension addition.

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The '-d' switch stands for output format ('pdf', 'ps', 'eps', 'png". . .)

Saving plots

Now we want to save the figure, use print

>> print('-dpdf', 'sin_of_x')

This will generate file *sin_of_x.pdf* notice automatic fileextension addition.

The '-d' switch stands for output format ('pdf', 'ps', 'eps', 'png". . .) To generate 'png' file

>> print('-dpng', '-r100', 'sin_of_x')

By default figure size is 8×6 inches, the '-r' switch tells the figure resolution in dpi (dots per inch). In this case it is 100 dpi so resulting image will be 800×600 pixels.

| | | | Pet d | 100 | | | _ |
|-----|---|---|-------|-----|-----------------|---|---|
| | | | | | | | |
| - | ۰ | | | | | | - |
| 14 | | | | | | | - |
| 12 | | | | | | | |
| | | | | | | | - |
| 42 | | | | | | | - |
| 2.4 | | | - | | | | - |
| 4.6 | | | | | | | - |
| -12 | | | | | | | |
| | | 1 | 3 | - | a : 5 | 6 | |

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2

For 3D plots, please see help files for plot3, meshy, surfs, so concerning Learne 02 21/

Special array arithmetic operators

There are special arithmetic operators which applied to the elements of matrices (disregard linear algebra rules), they start with $\ .$

| • | •* | | |
|---|-----------|--------------------------------|--|
| | >> x=1:3 | | |
| | x = 1 | 2 3 | |
| | >> x*x % | will generate an error | |
| | >> x.*x % | equivalent to x.^2 (see below) | |
| | ans = 1 | 4 9 | |

Special array arithmetic operators

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There are special arithmetic operators which applied to the elements of matrices (disregard linear algebra rules), they start with .

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| ۹ | •* | | | | | | |
|---|-----------|----------|--------|-------|------|--------|--|
| | >> x=1:3 | | | | | | |
| | x = 1 | 2 3 | | | | | |
| | >> x*x % | will ger | nerate | an er | ror | | |
| | >> x.*x % | equivale | ent to | x.^2 | (see | below) | |
| | ans = 1 | 4 | 9 | | | | |
| • | · ^ | | | | | | |
| | >> x.^2 | | | | | | |
| | ans = 1 | 4 | 9 | | | | |
| | | | | | | | |

Special array arithmetic operators

There are special arithmetic operators which applied to the elements of matrices (disregard linear algebra rules), they start with .

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|--------------------------|----------------------|---------------------|-----------------------|-------------------------------------|---------|
| | | | $< \Box > < \Box > <$ | $B \rightarrow + B \rightarrow - B$ | ୬୯୦ |
| >> x./x ans = 1 | 1 | 1 | | | |
| • ./ | | | | | |
| | 4 | 9 | | | |
| •.^ >> x.^2 | | | | | |
| x = 1 :: >> x * x % i | will gen equivale | | error 2 (see belov | ī) | |
| • .* | | | | | |

Notes

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| >> | m=[1,2, | 3;4,5, | 6;7,8,9] |
|-----|---------|--------|----------|
| m = | = | | |
| 1 | 2 | 3 | |
| 4 | 5 | 6 | |

Spe

| 7 | 1 | 8 | 9 | | | | | | | | |
|---|--------|---------|-------|--|--|---------|-----------|----------|--|--|--|
| | Linear | algebra | rules | | | Elemer | nt wise c | peration | | | |
| | >> m*m | | | | | >> m.*m | | | | | |
| | ans = | : | | | | ans = | | | | | |
| | 30 | 36 | 42 | | | 1 | 4 | 9 | | | |
| | 66 | 81 | 96 | | | 16 | 25 | 36 | | | |
| | 102 | 126 | 150 | | | 49 | 64 | 81 | | | |

| | | - | |
|------------------------|---------------------|---|--|
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| cial array arith | metic operator | | |

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| > | > m=[| 1,2,3; | 4,5, | 6;7,8,9 |] | | | | | |
|---|----------------------|--------|------|---------|---|--------|------|-------------|----|------|
| n | n = | | | | | | | | | |
| 1 | . : | 2 | 3 | | | | | | | |
| 4 | L . | 5 | 6 | | | | | | | |
| 7 | 1 | 8 | 9 | | | | | | | |
| | Linear algebra rules | | | | | Elemer | nt w | ise operati | on | |
| | >> m/ | m % ur | nity | matrix | | >> m. | /m | %matrix | of | ones |
| | ans = | | | | | ans = | | | | |
| | 1 | 0 | 0 | | | 1 | 1 | 1 | | |
| | 0 | 1 | 0 | | | 1 | 1 | 1 | | |
| | 0 | 0 | 1 | | | 1 | 1 | 1 | | |
| | | | | | | | | | | |

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