



# MATLAB Basics 3b matrices

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<http://controleducation.group.shef.ac.uk/indexwebbook.html>

# Introduction

1. The previous video introduced the vector/array notation.
2. More generally, MATLAB treats every variable as a matrix, thus with two dimensions rather than one.
3. This resources gives a quick introduction into how MATLAB handles matrices and what matrix operations it supports.

**Higher dimensional matrices are possible but not a topic appropriate for an introductory resource.**

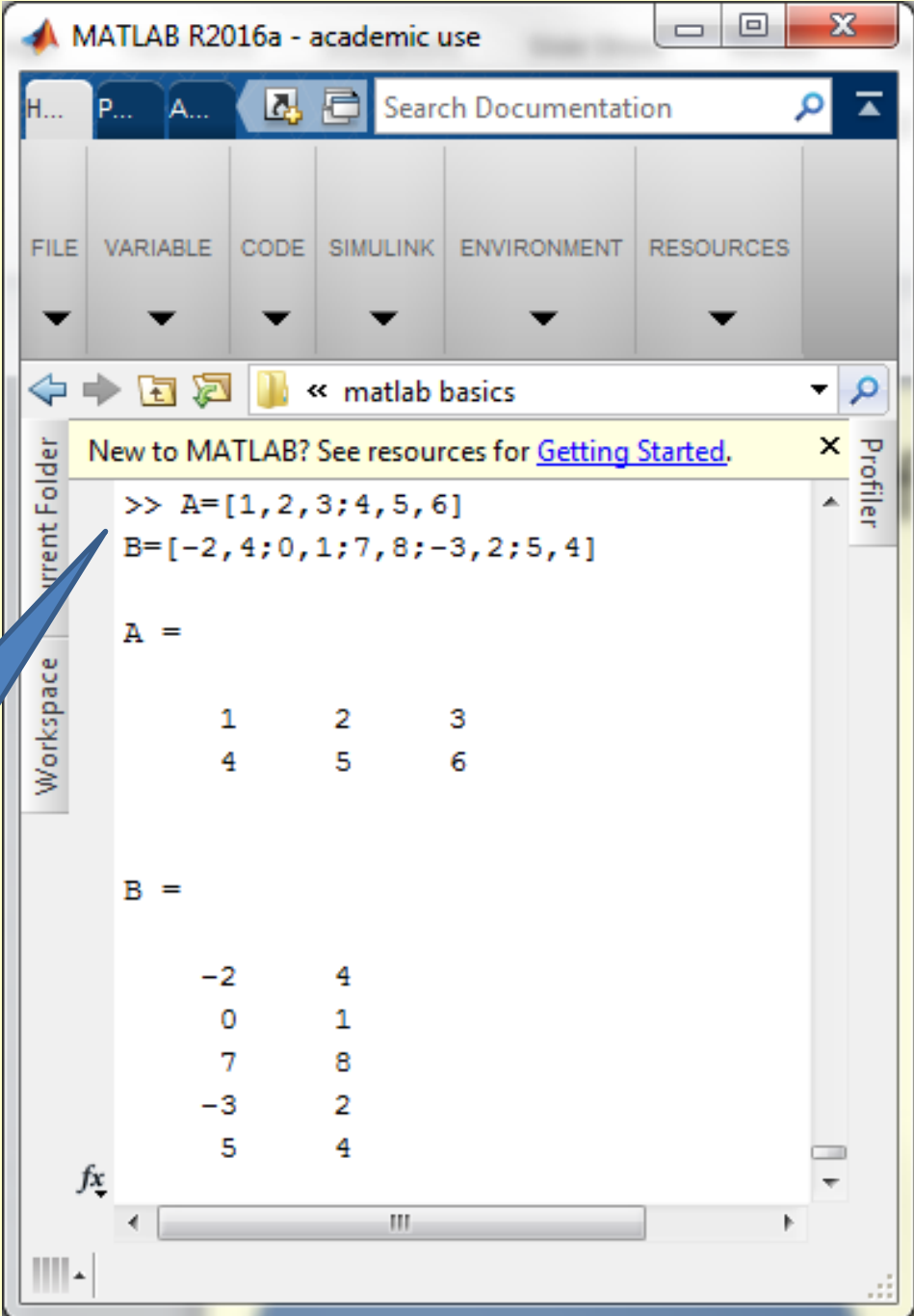
# Defining a matrix

Matrices are entered using the same notation as vectors.

Commas to separate columns and semicolons to separate rows.

A is a 2 by 3 matrix.

B is a 5 by 2 matrix.



The image shows a screenshot of the MATLAB R2016a - academic use interface. The Command Window displays the following code and output:

```
>> A=[1,2,3;4,5,6]
B=[-2,4;0,1;7,8;-3,2;5,4]
```

The Workspace window shows the resulting matrices:

A =			
	1	2	3
	4	5	6

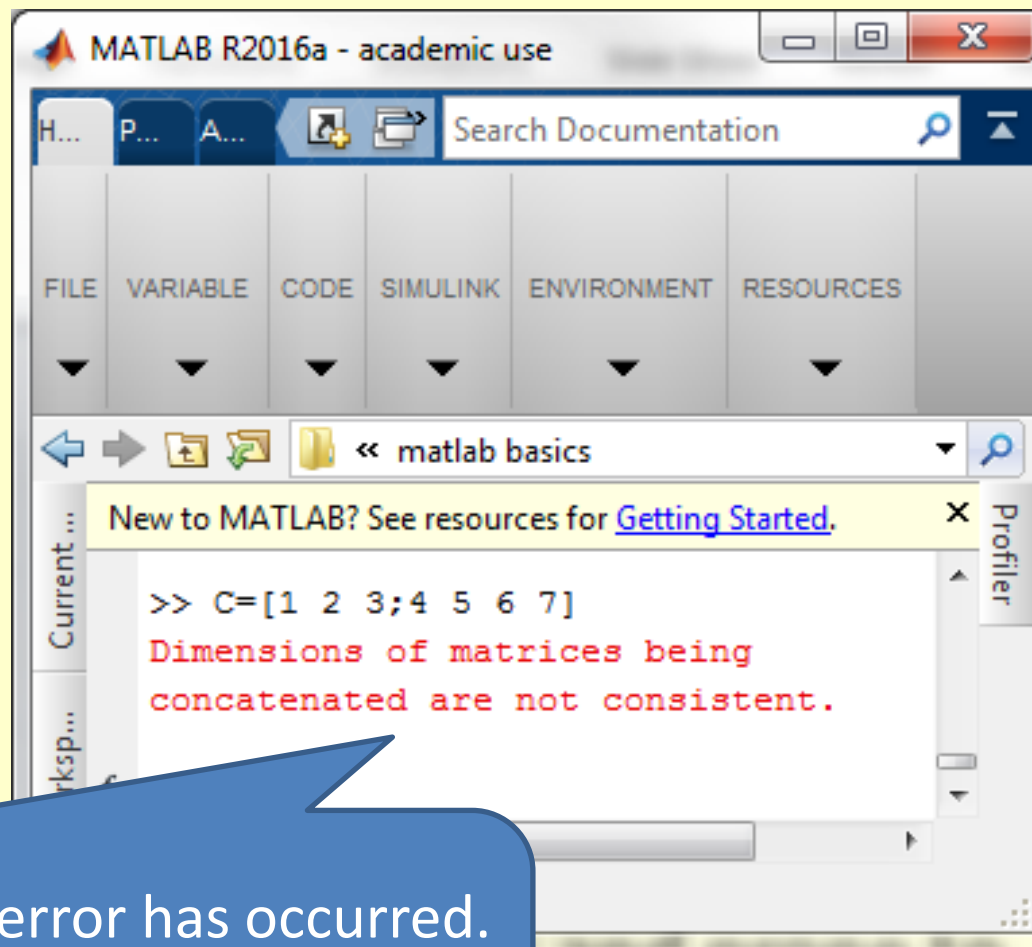
  

B =		
	-2	4
	0	1
	7	8
	-3	2
	5	4

# Errors in matrix entry

For anything other than small matrices, entry by hand is tedious and prone to error.

Each row/column must have the correct number of terms or errors will result.

A screenshot of the MATLAB R2016a - academic use interface. The Command Window shows the command `>> C=[1 2 3;4 5 6 7]` and a red error message: `Dimensions of matrices being concatenated are not consistent.` The error message is highlighted in a blue speech bubble. The interface includes a menu bar with options like FILE, VARIABLE, CODE, SIMULINK, ENVIRONMENT, and RESOURCES. A search bar for documentation is visible at the top right. The current workspace shows the variable C.

```
MATLAB R2016a - academic use
H... P... A... Search Documentation
FILE VARIABLE CODE SIMULINK ENVIRONMENT RESOURCES
« matlab basics
New to MATLAB? See resources for Getting Started.
>> C=[1 2 3;4 5 6 7]
Dimensions of matrices being concatenated are not consistent.
```

Inconsistent data entry, so an error has occurred.

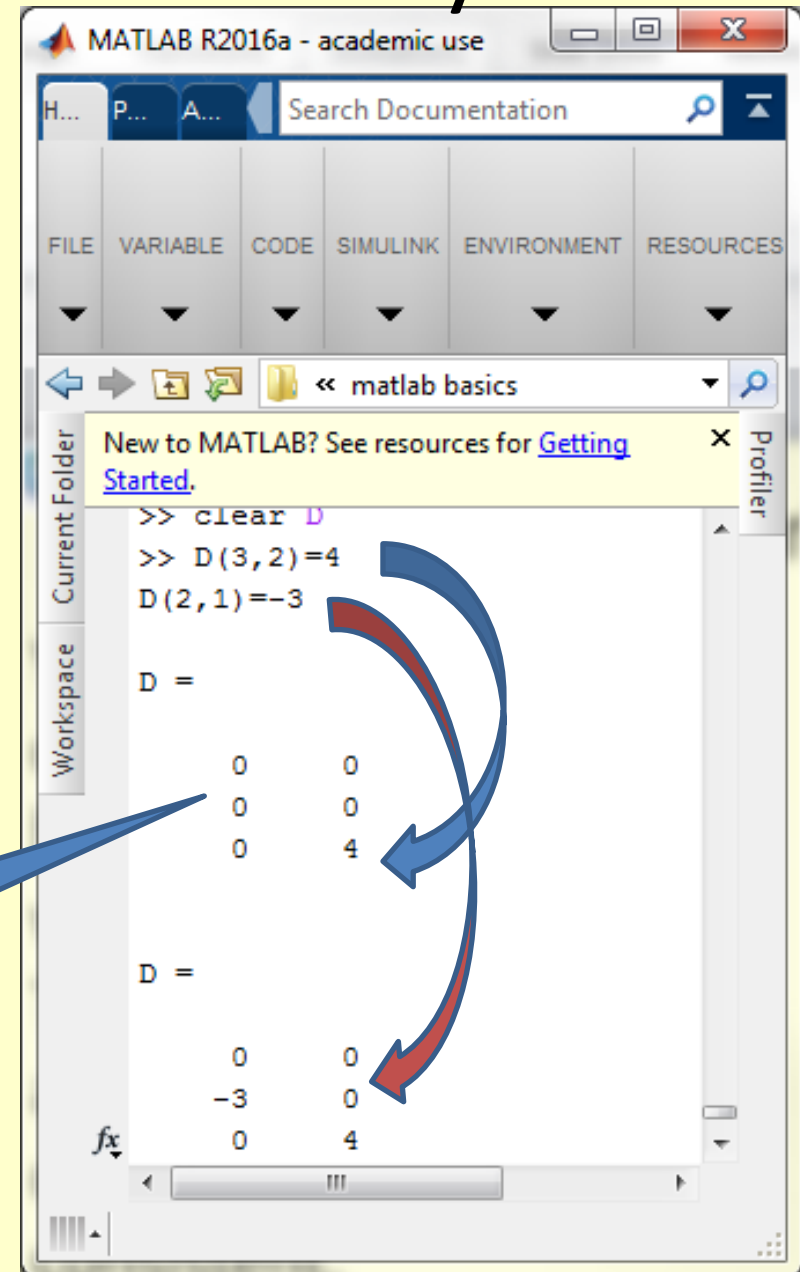
**(3 columns in row 1 and 4 columns in row 2)**

# Building matrices indirectly

You can build matrix coefficients slowly by gradually adding values or blocks.

Take care to ensure any command is dimensionally consistent.

MATLAB automatically fills unknown coefficients with zero.



The screenshot shows the MATLAB R2016a - academic use interface. The Command Window displays the following commands and output:

```
>> clear D
>> D(3,2)=4
D(2,1)=-3
```

The Workspace window shows the matrix  $D$  as:

$$D = \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 4 \end{bmatrix}$$

Below this, the matrix is shown again with the updated values:

$$D = \begin{bmatrix} 0 & 0 \\ -3 & 0 \\ 0 & 4 \end{bmatrix}$$

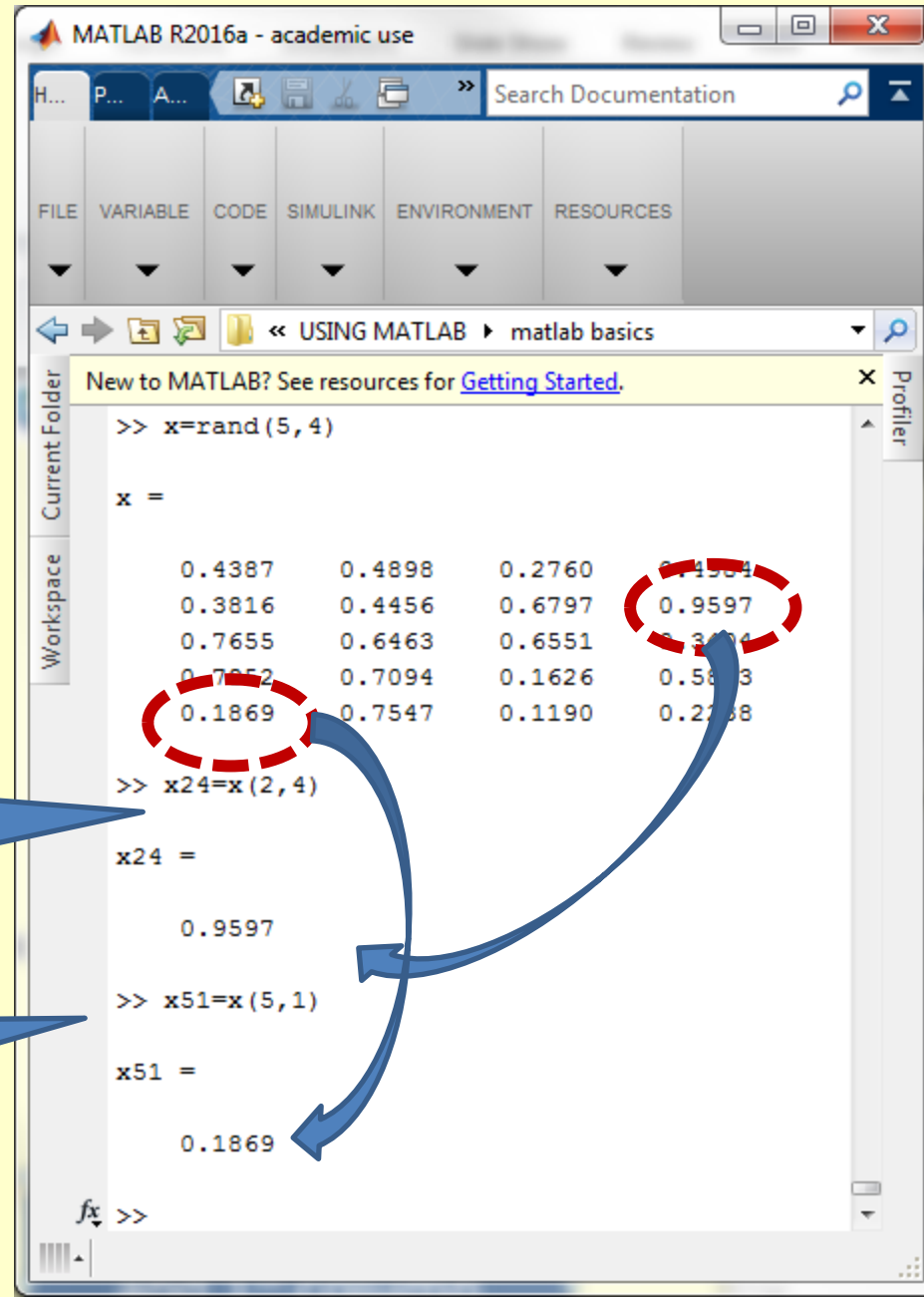
Blue and red arrows indicate the transition from the initial state to the final state, showing how the missing elements are filled with zero.

# Accessing matrix values

MATLAB uses a common sense notation to access values. The value in the  $i^{\text{th}}$  row and  $j^{\text{th}}$  column is accessed with the notation  $x(i,j)$ .

Value in 2<sup>nd</sup> row and 4<sup>th</sup> column is accessed by  $x(2,4)$

Value in 5<sup>th</sup> row and 1<sup>st</sup> column accessed by  $x(5,1)$



The screenshot shows the MATLAB R2016a interface. The Command Window displays the following code and output:

```

>> x=rand(5,4)

x =

    0.4387    0.4898    0.2760    0.1504
    0.3816    0.4456    0.6797    0.9597
    0.7655    0.6463    0.6551    0.3004
    0.7052    0.7094    0.1626    0.5803
    0.1869    0.7547    0.1190    0.2208

>> x24=x(2,4)

x24 =

    0.9597

>> x51=x(5,1)

x51 =

    0.1869
  
```

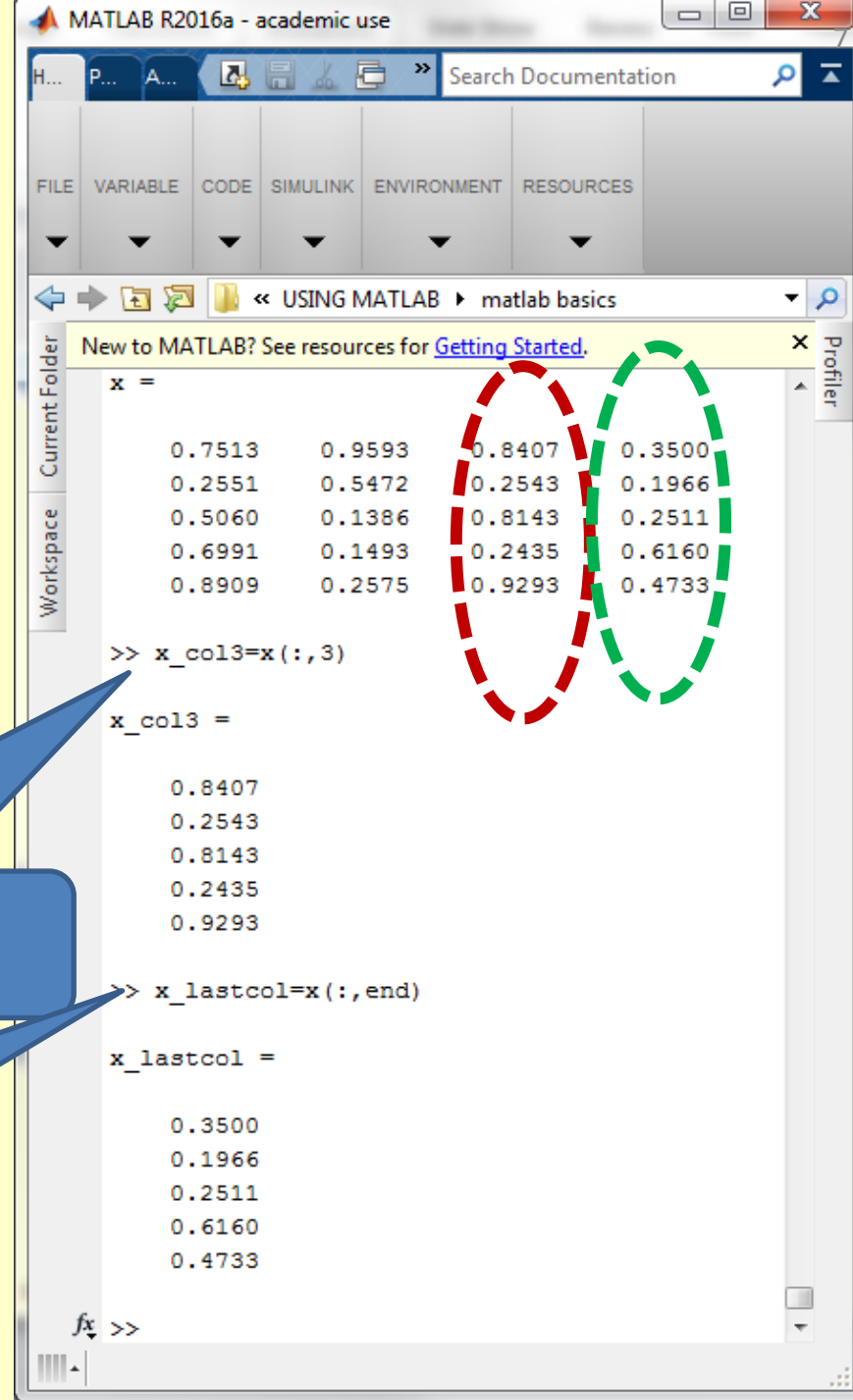
Red dashed circles highlight the values 0.1504, 0.9597, and 0.1869 in the matrix. Blue arrows point from the text boxes to these specific elements: one from the top box to 0.9597 and another from the bottom box to 0.1869.

# Accessing a whole column

MATLAB has a short cut to extract the entire column of a matrix. Use ":" in lieu of the row position and this is interpreted as select all rows.

Extract 3<sup>rd</sup> column

Extract last column



The screenshot shows the MATLAB R2016a interface. The Command Window displays the following code and output:

```
>> x =  
    0.7513    0.9593    0.8407    0.3500  
    0.2551    0.5472    0.2543    0.1966  
    0.5060    0.1386    0.8143    0.2511  
    0.6991    0.1493    0.2435    0.6160  
    0.8909    0.2575    0.9293    0.4733  
  
>> x_col3=x(:,3)  
  
x_col3 =  
  
    0.8407  
    0.2543  
    0.8143  
    0.2435  
    0.9293  
  
>> x_lastcol=x(:,end)  
  
x_lastcol =  
  
    0.3500  
    0.1966  
    0.2511  
    0.6160  
    0.4733  
  
fx >>
```

The matrix `x` is a 5x4 matrix. The 3rd column is highlighted with a red dashed oval, and the 4th column is highlighted with a green dashed oval. The output shows the 3rd column extracted into `x_col3` and the 4th column extracted into `x_lastcol`.

# Accessing a whole row

MATLAB has a short cut to extract the entire row of a matrix.

**Use “:”** in lieu of the column position and this is interpreted as select all columns.

Extract 2<sup>nd</sup> row

Extract last two rows

```

MATLAB R2016a - academic use
H... P... A... Search Documentation
FILE VARIABLE CODE SIMULINK ENVIRONMENT RESOURCES
<< USING MATLAB matlab basics
New to MATLAB? See resources for Getting Started.
>> x=rand(5,4)
x =
    0.1622    0.6020    0.4505    0.8058
    0.7943    0.2630    0.0838    0.5383
    0.3172    0.6341    0.2250    0.9961
    0.5285    0.6892    0.9133    0.0782
    0.1656    0.7482    0.1524    0.4427

>> x_row2=x(2,:)
x_row2 =
    0.7943    0.2630    0.0838    0.5383

>> x_last2rows=x([end-1,end],:)
x_last2rows =
    0.5285    0.6892    0.9133    0.0782
    0.1656    0.7482    0.1524    0.4427

fx >>
  
```



# Extracting parts of matrices

Example of selecting given rows and columns.

Can rearrange the order if desired.

2<sup>nd</sup> and 4<sup>th</sup> rows with 4<sup>th</sup> and 1<sup>st</sup> columns

```

MATLAB 7.7.0 (R2008b)
File Edit Debug Parallel Desktop Window Help
C:\Documents and Settings\...
Shortcuts How to Add What's New
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
>> D=rand(4,4)
Dblock = D([2 4],[4,1])

D =
    0.8147    0.6324    0.9575    0.9572
    0.9058    0.0975    0.9649    0.4854
    0.1270    0.2785    0.1576    0.8003
    0.9134    0.5469    0.9706    0.1419

Dblock =
    0.4854    0.9058
    0.1419    0.9134
  
```

# Matrix operations

The main thing to note is that the default variable in MATLAB is a matrix (or vector if the row or column dimension is one).

Any BODMAS type operation that is valid with matrices can be carried out with the same syntax.

MATLAB also includes a large number of matrix analysis tools that you will find useful (*e.g. inv.m, eig.m, svd.m, cond.m, norm.m,...*)

# Addition and subtraction

Exactly as on a piece of paper.

The screenshot shows the MATLAB R2016a - academic use interface. The Command Window displays the following code and output:

```

A =
    2    3
    0    4

>> B=[-2 1;1 5]

B =
   -2    1
    1    5

>> AplusB=A+B

AplusB =
    0    4
    1    9

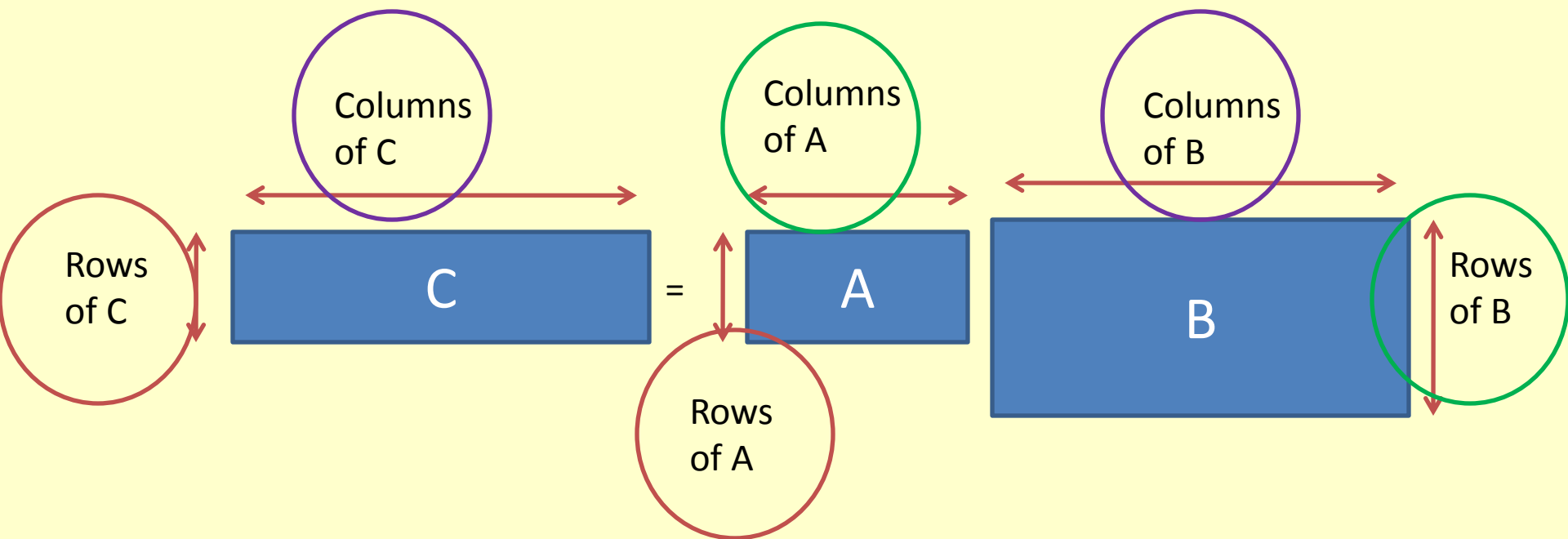
>> A_3B=A-3*B

A_3B =
    8    0
   -3   -11
  
```

# Rules for matrix algebra

Assume we wish to do  $C=A*B$ .

A must have same number of columns as B has rows



# Multiplication

Exactly as on a piece of paper.

Make sure dimensions are compatible or operation not defined!

Current Folder: matlab basics

```

>> G=F
Error using *
Inner matrix dimensions must agree.
fx >>

```

MATLAB R2016a - academic use

Current Folder: matlab basics

```

New to MATLAB? See resources for Getting Started.
>> G=rand(3,2);
>> F=rand(3,3)

F =

    0.4173    0.9448    0.3377
    0.0497    0.4909    0.9001
    0.9027    0.4893    0.3692

>> G=rand(3,2)

G =

    0.1112    0.2417
    0.7803    0.4039
    0.3897    0.0965

>> FG=F*G

FG =

    0.9152    0.5150
    0.7393    0.2971
    0.6260    0.4514

fx >>

```

# MATRIX handling

- Matrix addition/subtraction
- Matrix multiplication
- Matrix powers
- Matrix inversion

- $A+B$ ,  $A-B$
- $A*B$
- $A^3$  [What about  $A.^3$  ?]
- $\text{inv}(A)$  or  $A^{-1}$

# LIVE DEMONSTRATIONS WITH MATLAB

[Open the following and try the instructions](#)  
[matlab\\_basics3b.m](#)

# Conclusions

Demonstrated the matrix notation in MATLAB.

1. Syntax is same as for matrices in normal mathematics: row index and column index count from the top left corner.
2. Easy to extract specific values, rows, columns, blocks as required.
3. MATLAB supports normal mathematical operations for matrices with normal syntax.

**Users recommended to finish commands with a semi-colon to prevent flooding the command window with the data output.**



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