MatLab Basics: Data type, Matrices, Graphics

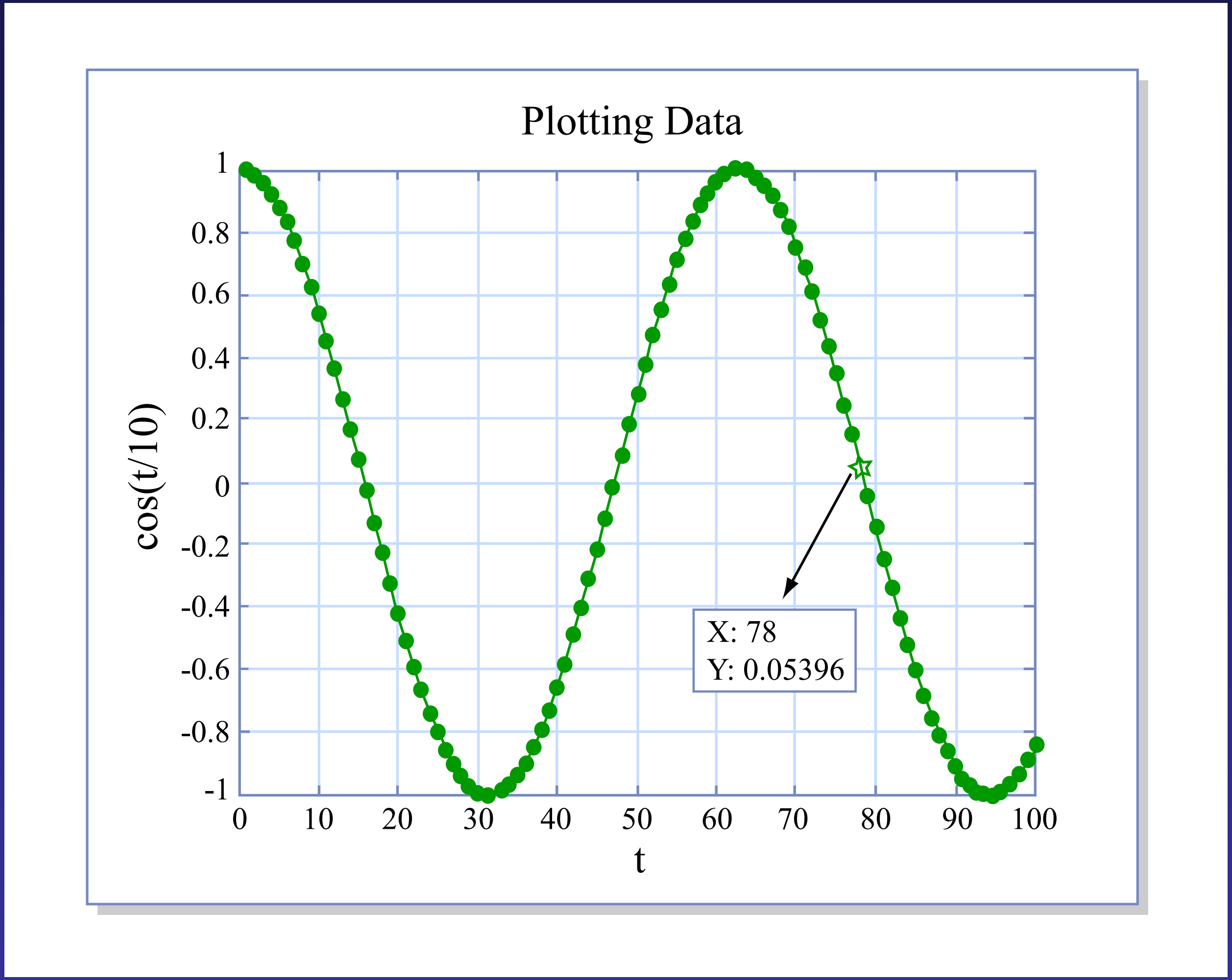
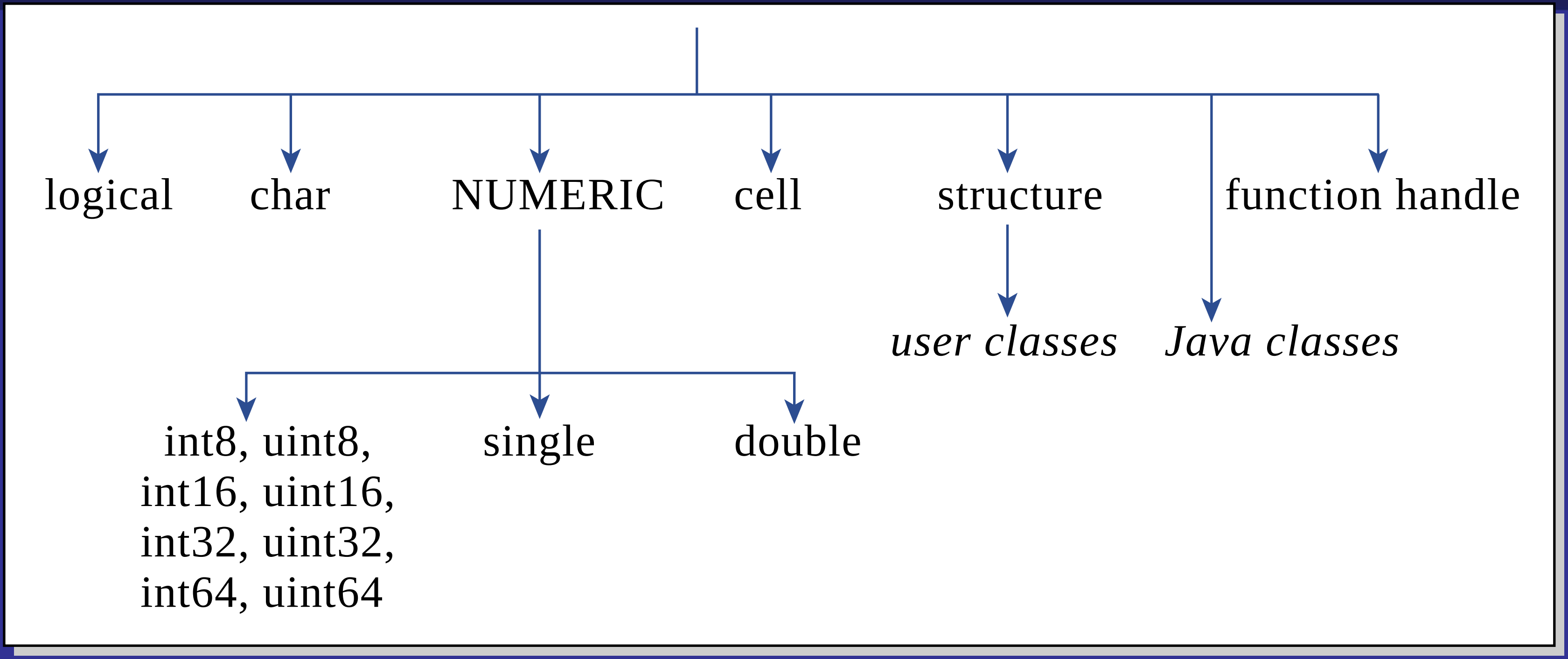


Figure by MIT OCW.

MatLab Data Types



Adapted from MATLAB Help Sections. Figure by MIT OCW.

Numeric Types

Number representation

Binary: 0, 1 1011101

Decimal: 0-9 93

Hexadecimal 0-9, A,B,C,D,E,F 5D

Bit: a single binary digit
Byte: 8 binary digits
Word: 16 binary digits
Double Word: 32 binary digits

Numeric Types In MatLab

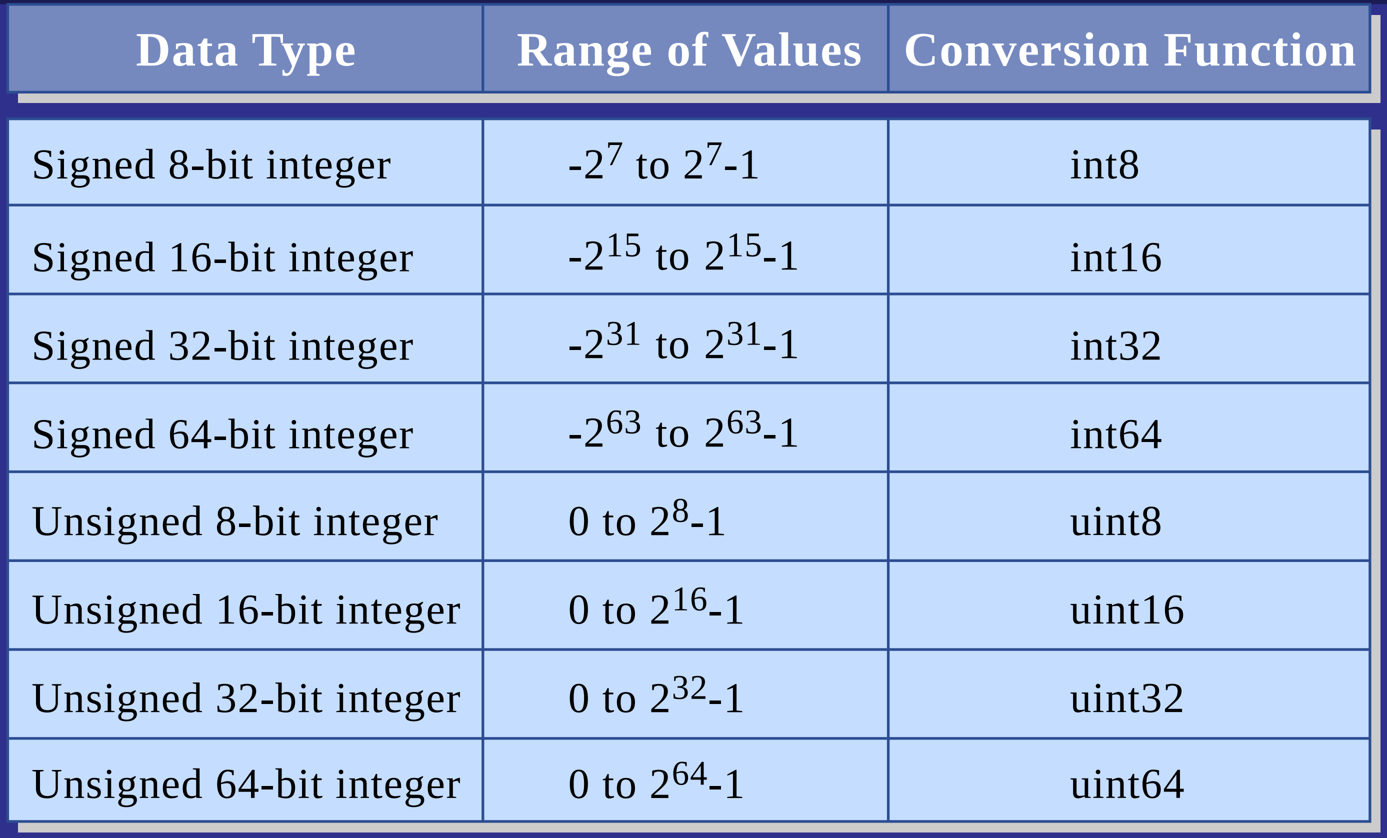
Integers: 12523

Floating points: 1.234e-72

Complex number: 2.3+5.2i

Infinity and NAN: Inf (1/0), NAN (not a number)

MatLab Integer Type



Data Type	Range of Values	Conversion Function
Signed 8-bit integer	-2^{7} to $2^{7}-1$	int8
Signed 16-bit integer	-2^{15} to $2^{15}-1$	int16
Signed 32-bit integer	-2^{31} to $2^{31}-1$	int32
Signed 64-bit integer	-2^{63} to $2^{63}-1$	int64
Unsigned 8-bit integer	0 to $2^{8}-1$	uint8
Unsigned 16-bit integer	0 to $2^{16}-1$	uint16
Unsigned 32-bit integer	0 to $2^{32}-1$	uint32
Unsigned 64-bit integer	0 to $2^{64}-1$	uint64

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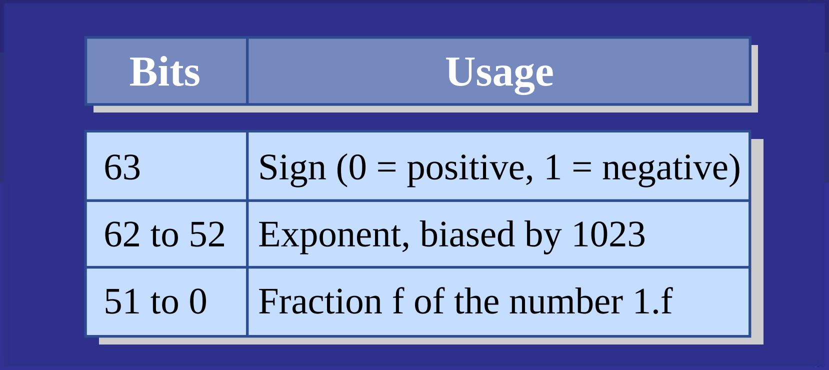
MatLab Floating Point Type

Uses IEEE Standard 754: Double type, Single type

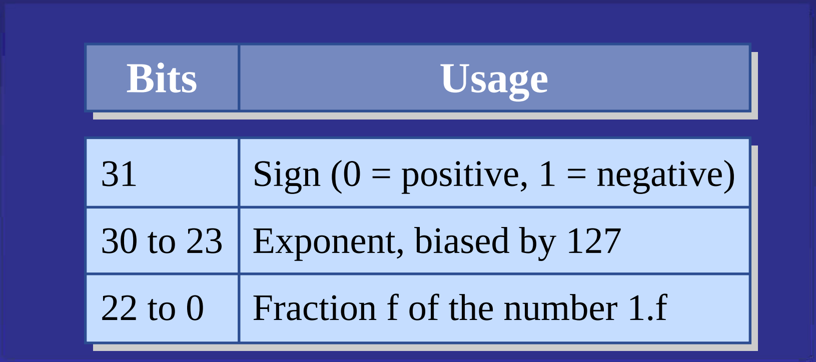
+2.2345e-34

Double



Bits	Usage
63	Sign (0 = positive, 1 = negative)
62 to 52	Exponent, biased by 1023
51 to 0	Fraction f of the number 1.f

Single



Bits	Usage
31	Sign (0 = positive, 1 = negative)
30 to 23	Exponent, biased by 127
22 to 0	Fraction f of the number 1.f

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MatLab Complex Number Type

“i” or “j” are specially reserved symbols in MatLab

Complex numbers are represented as:

A+Bi

C=complex(1,2)	C=1+2i
D=real(C)	D=1
E=imag(C)	E=2

Logical (boolean) Types In MatLab

Logical state (e.g. 5>2) is represented by:

1 or 0

True or False

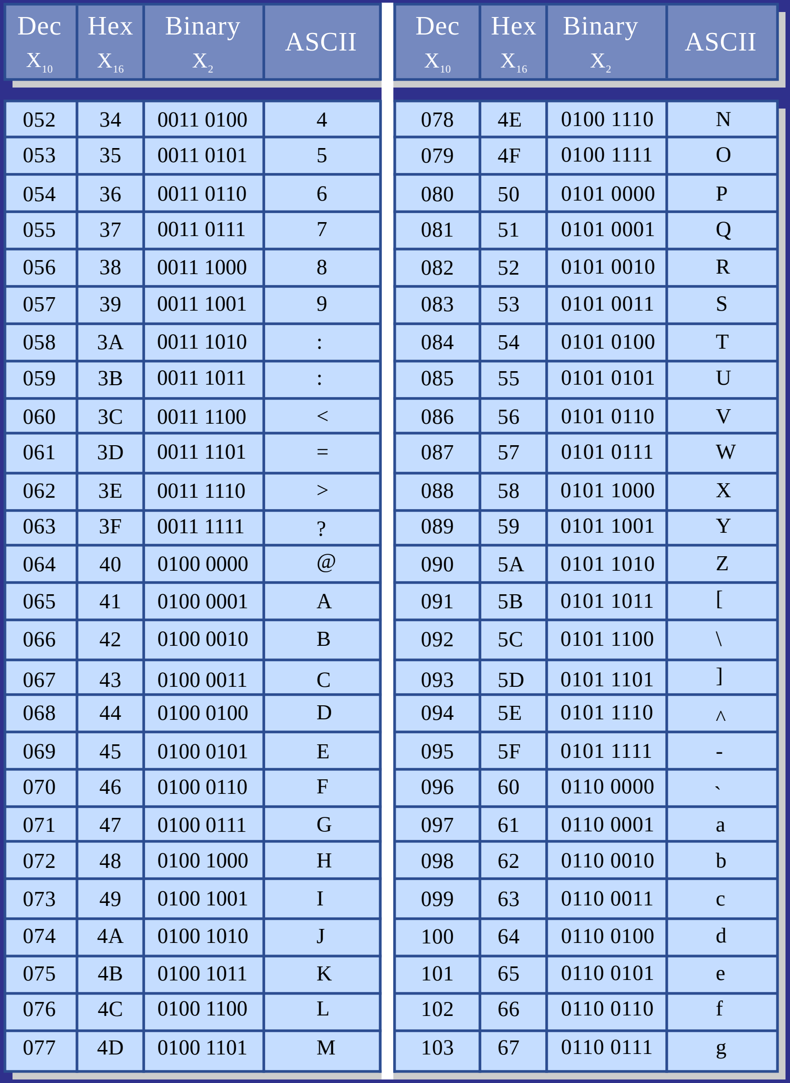
Logical types are important in programming when decision must be made depending on the validity (true or false) of some conditions

Character Types In MatLab

‘a’, ‘z’, ‘8’, ‘&’ are characters

MatLab treat any symbol placed inside SINGLE quotes as an array of characters!

Internally, each character is represented by an 8-bit number using Unicode (ASCII) decoding system



Dec	Hex	Binary	ASCII	Dec	Hex	Binary	ASCII
X_{10}	X_{16}	X_2		X_{10}	X_{16}	X_2	
052	34	0011 0100	4	078	4E	0100 1110	N
053	35	0011 0101	5	079	4F	0100 1111	O
054	36	0011 0110	6	080	50	0101 0000	P
055	37	0011 0111	7	081	51	0101 0001	Q
056	38	0011 1000	8	082	52	0101 0010	R
057	39	0011 1001	9	083	53	0101 0011	S
058	3A	0011 1010	:	084	54	0101 0100	T
059	3B	0011 1011	:	085	55	0101 0101	U
060	3C	0011 1100	<	086	56	0101 0110	V
061	3D	0011 1101	=	087	57	0101 0111	W
062	3E	0011 1110	>	088	58	0101 1000	X
063	3F	0011 1111	?	089	59	0101 1001	Y
064	40	0100 0000	@	090	5A	0101 1010	Z
065	41	0100 0001	A	091	5B	0101 1011	[
066	42	0100 0010	B	092	5C	0101 1100	\
067	43	0100 0011	C	093	5D	0101 1101	]
068	44	0100 0100	D	094	5E	0101 1110	^
069	45	0100 0101	E	095	5F	0101 1111	-
070	46	0100 0110	F	096	60	0110 0000	`
071	47	0100 0111	G	097	61	0110 0001	a
072	48	0100 1000	H	098	62	0110 0010	b
073	49	0100 1001	I	099	63	0110 0011	c
074	4A	0100 1010	J	100	64	0110 0100	d
075	4B	0100 1011	K	101	65	0110 0101	e
076	4C	0100 1100	L	102	66	0110 0110	f
077	4D	0100 1101	M	103	67	0110 0111	g

Figure by MIT OCW.

Logical (boolean) Types In MatLab

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Constructing Matrix in MatLab

ones: matrix of all ones
zeros: matrix of all zero
eyes: Identity matrix
randn: Random matrix

ones(4, 6, ‘uint32’) creates a 4x6 matrix containing ones represented as unsigned 32 bit integer

randn(2) creates a 2x2 matrix containing random numbers of standard normal distribution

rand(2) creates a 2x2 matrix containing random numbers uniformly distributed between 0 and 1

Basic Linear Algebra

$$m \cdot \begin{bmatrix} a & c \\ b & d \end{bmatrix} = \begin{bmatrix} ma & mc \\ mb & md \end{bmatrix}$$

Scalar multi

$$\begin{bmatrix} a & c \\ b & d \end{bmatrix} \pm \begin{bmatrix} e & g \\ f & h \end{bmatrix} = \begin{bmatrix} a \pm b & c \pm g \\ b \pm f & d \pm h \end{bmatrix}$$

Add/sub

$$\begin{bmatrix} a & c \\ b & d \end{bmatrix} \cdot \begin{bmatrix} e & g \\ f & h \end{bmatrix} = \begin{bmatrix} ae + cf & ag + ch \\ be + df & bg + dh \end{bmatrix}$$

Matrix multi

$$A = \begin{bmatrix} a & c \\ b & d \end{bmatrix}$$

$$A \cdot A^{-1} = I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \quad A^{-1} = \frac{1}{ad - bc} \begin{bmatrix} d & -c \\ -b & a \end{bmatrix}$$

Inverse

$$[a \quad b \quad c]' = \begin{bmatrix} a \\ b \\ c \end{bmatrix}$$

Transpose

MatLab Operators – numeric

Operator	Description
+	Addition
-	Subtraction
.*	Multiplication
./	Right division
.\	Left division
+	Unary plus
-	Unary minus
:	Colon operator
.^	Power
.'	Transpose
'	Complex conjugate transpose
*	Matrix multiplication
/	Matrix right division
\	Matrix left division
^	Matrix power

$$A = \begin{bmatrix} 1 & 2 \end{bmatrix}, B = \begin{bmatrix} 3 \\ 4 \end{bmatrix}, C = \begin{bmatrix} 5 & 6 \end{bmatrix}$$

$$A + C = \begin{bmatrix} 6 & 8 \end{bmatrix}$$

$$A * C \quad bad!$$

$$A * B = 11$$

$$A .* C = \begin{bmatrix} 5 & 12 \end{bmatrix}$$

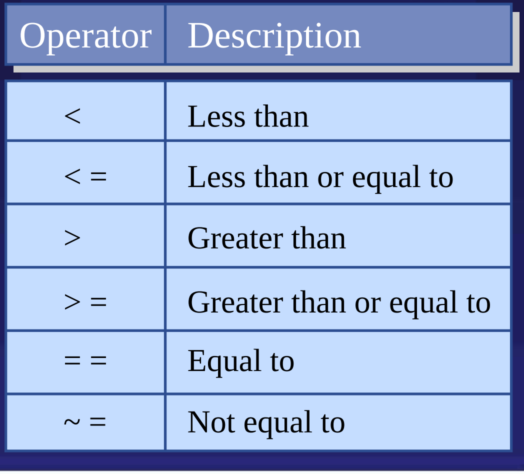
$$A ./ C = \begin{bmatrix} 0.200 & 0.333 \end{bmatrix}$$

$$A .\backslash C = \begin{bmatrix} 5 & 3 \end{bmatrix}$$

Adapted from MATLAB Help Sections. Figure by MIT OCW.

MatLab Operators – Relational, Logical

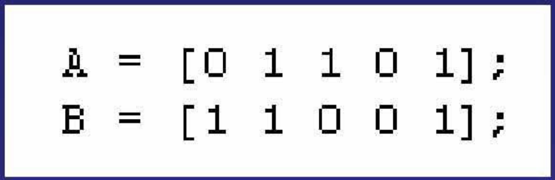
Relational



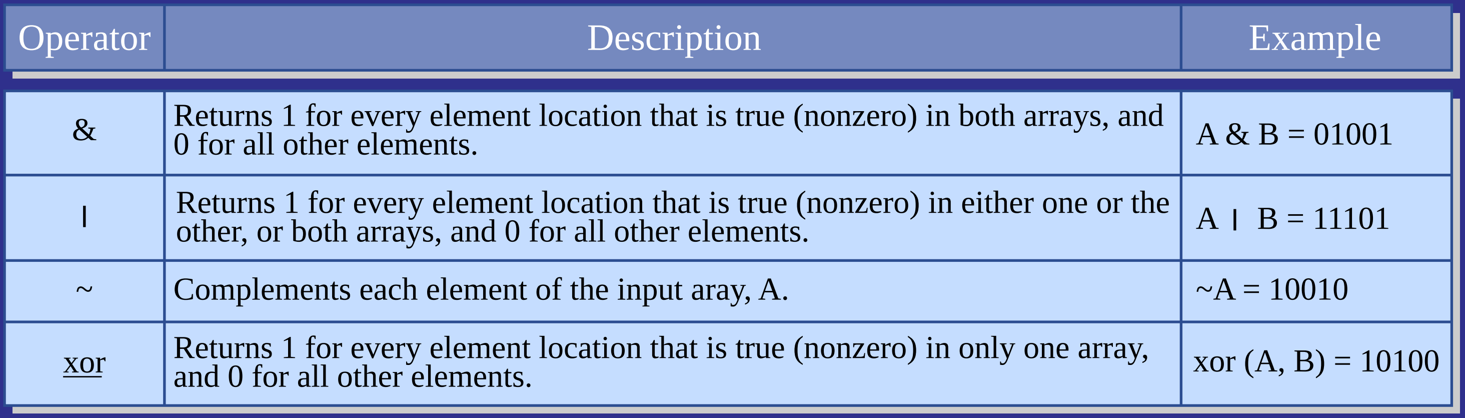
Operator	Description
<	Less than
< =	Less than or equal to
>	Greater than
> =	Greater than or equal to
= =	Equal to
~ =	Not equal to

Adapted from MATLAB Help Sections.
Figure by MIT OCW.

Logical



```
A = [0 1 1 0 1];
B = [1 1 0 0 1];
```



Operator	Description	Example
&	Returns 1 for every element location that is true (nonzero) in both arrays, and 0 for all other elements.	A & B = 01001
|	Returns 1 for every element location that is true (nonzero) in either one or the other, or both arrays, and 0 for all other elements.	A | B = 11101
~	Complements each element of the input aray, A.	~A = 10010
xor	Returns 1 for every element location that is true (nonzero) in only one array, and 0 for all other elements.	xor (A, B) = 10100

Adapted from MATLAB Help Sections. Figure by MIT OCW.

One more MatLab Operator – Sequence

“:” is the sequence operator that denote a range

$$A = 2:5 \quad A = \begin{bmatrix} 2 & 3 & 4 & 5 \end{bmatrix}$$

$$A = 2:3:11 \quad A = \begin{bmatrix} 2 & 5 & 8 & 11 \end{bmatrix}$$

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

$$B = A(2,:) \quad B = \begin{bmatrix} 4 & 5 & 6 \end{bmatrix}$$

$$C = A(:,2) \quad C = \begin{bmatrix} 2 \\ 5 \\ 8 \end{bmatrix}$$

$$D = A(2:3,:) \quad D = \left[\begin{array}{c|cc} 4 & 5 & 6 \\ 7 & 8 & 9 \end{array}\right]$$

$$A(:,2) = [\,] \quad A = \begin{bmatrix} 1 & 3 \\ 4 & 6 \\ 7 & 9 \end{bmatrix}$$

It is very useful to create, decimate, and generate submatrix

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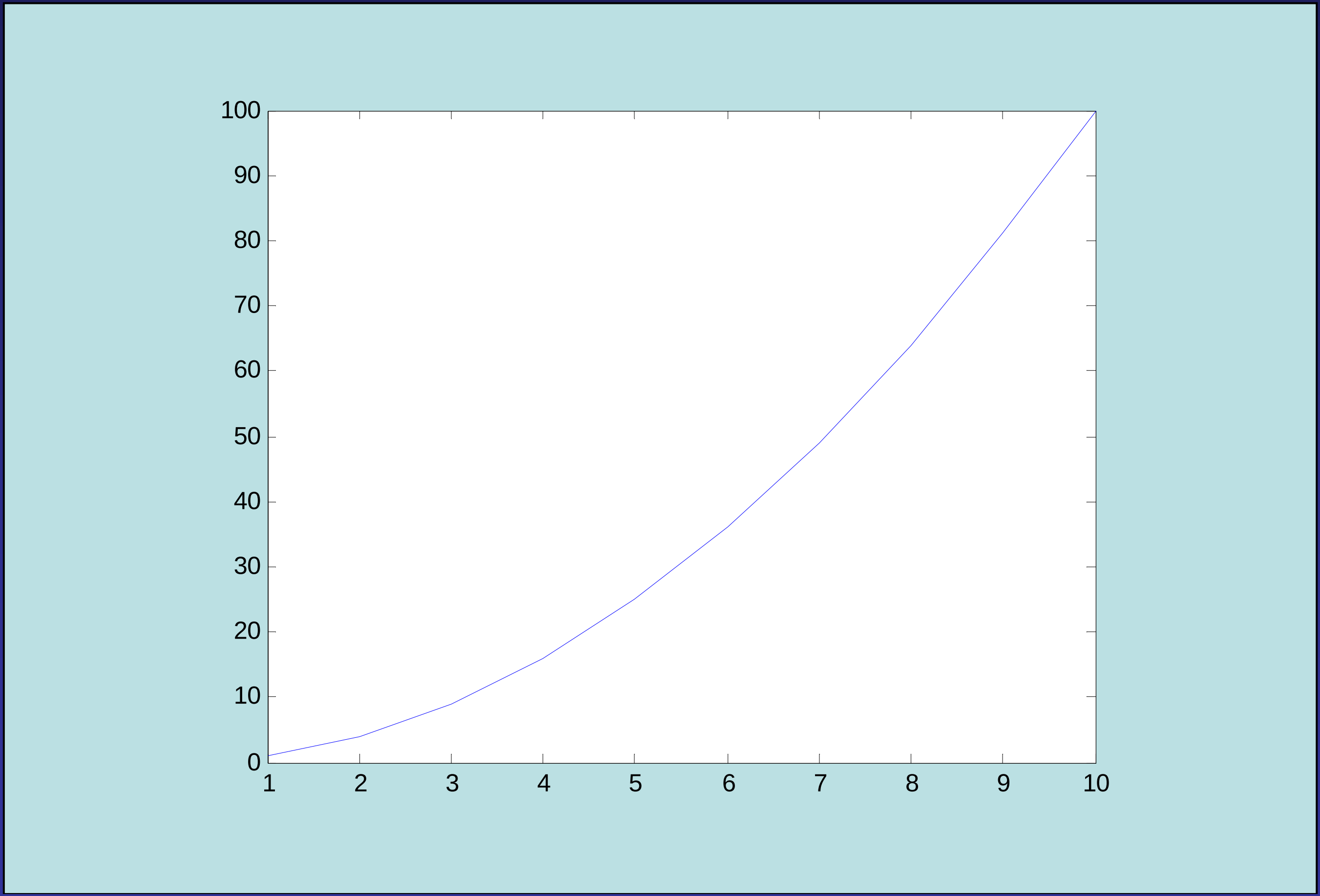
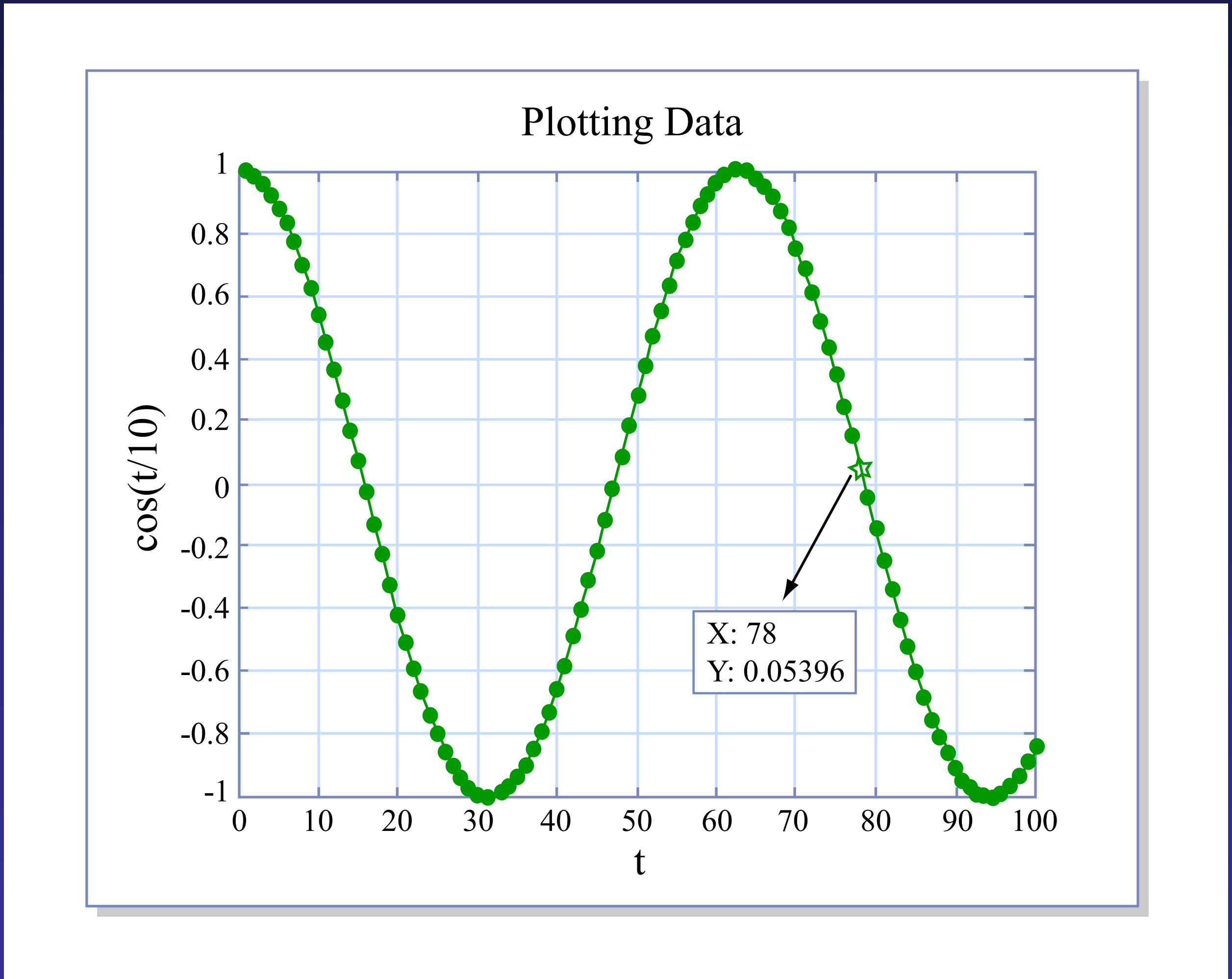
Basic Graphic Output in MatLab

```
X =[1 2 3 4 5 6 7 8 9 10]

Y =[1 4 9 16 25 36 49 64 81 100]

plot(X,Y)
```



More Graphic Output

```
t=1:1:100;
plot(t,cos(t/10));
```



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Graphic output can also be modified via script

```
t=1:1:100;
plot(t, cos(t/10), ‘bo-’ );
title(‘Plotting Data2’);
xlabel(‘t’);
ylabel(‘cos(t/10)’);
legend(‘sim data’);
```

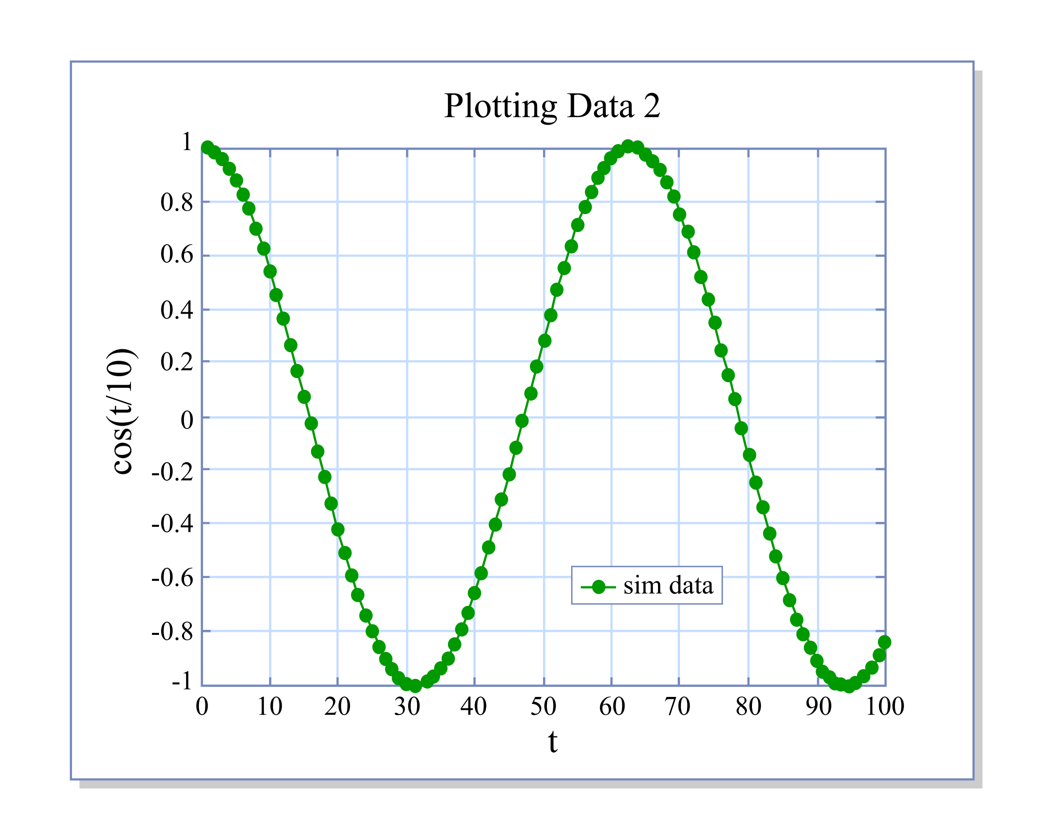

Figure by MIT OCW.

A couple more very useful graphic commands

(1) hold on/hold off – determines whether the next plot command overwrites or not

(2) figure – Creates new figure window

(3) From the figure window, under “edit menu”, the “copy figure” option allows you to copy the figure to the clipboard and then you can cut and paste it into other programs such as MSWord.