自动控制原理

朱英华

Email: yhzhu@swjtu. edu.cn

西南交通大学电气工程学院

MATLAB软件

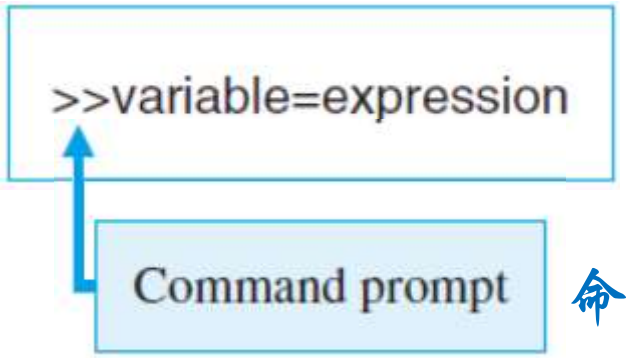
用于自动控制系统的仿真研究

建模、仿真分析、仿真设计

MATLAB软件（1）

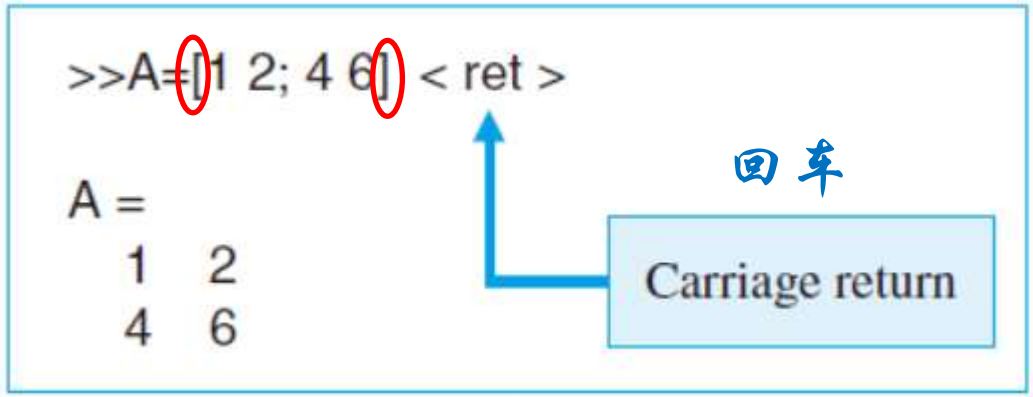
——MATLAB基础

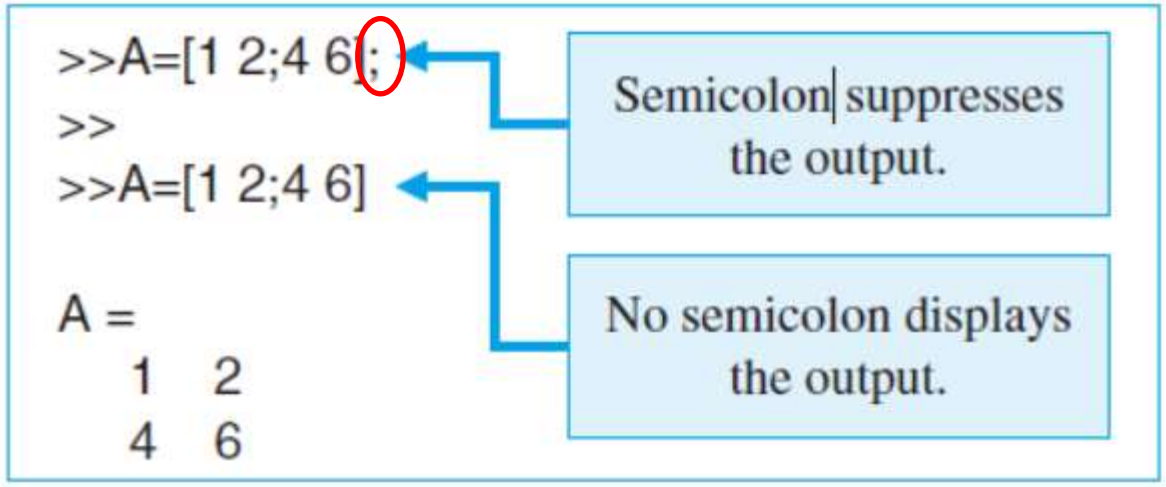
1. MATLAB 语句结构



方括号

$$A=\begin{bmatrix}1 & 2\\ 4 & 6\end{bmatrix}$$





分号的存在，
隐藏了输出

没有分号，
输出正常显示

2. 数学运算符和常用的数学函数

Table A.1 Mathematical Operators 数学运算符	
+	Addition
−	Subtraction
*	Multiplication
/	Division
^	Power

常用的数学函数

Table A.2 Common Mathematical Functions

sin(x)	Sine	acoth(x)	Inverse hyperbolic cotangent
sinh(x)	Hyperbolic sine	exp(x)	Exponential
asin(x)	Inverse sine	log(x)	Natural logarithm
asinh(x)	Inverse hyperbolic sine	log10(x)	Common (base 10) logarithm
cos(x)	Cosine	log2(x)	Base 2 logarithm and dissect floating point number
cosh(x)	Hyperbolic cosine	pow2(x)	Base 2 power and scale floating point number
acos(x)	Inverse cosine	sqrt(x)	Square root
acosh(x)	Inverse hyperbolic cosine	nextpow2(x)	Next higher power of 2
tan(x)	Tangent	abs(x)	Absolute value
tanh(x)	Hyperbolic tangent	angle(x)	Phase angle
atan(x)	Inverse tangent	complex(x,y)	Construct complex data from real and imaginary parts
atan2(y,x)	Four quadrant inverse tangent	conj(x)	Complex conjugate
atanh(x)	Inverse hyperbolic tangent	imag(x)	Complex imaginary part
sec(x)	Secant	real(x)	Complex real part
sech(x)	Hyperbolic secant	unwrap(x)	Unwrap phase angle
asec(x)	Inverse secant	isreal(x)	True for real array
asech(x)	Inverse hyperbolic secant	cplxpair(x)	Sort numbers into complex conjugate pairs
csc(x)	Cosecant	fix(x)	Round towards zero
csch(x)	Hyperbolic cosecant	floor(x)	Round towards minus infinity
acsc(x)	Inverse cosecant	ceil(x)	Round towards plus infinity
acsch(x)	Inverse hyperbolic cosecant	round(x)	Round towards nearest integer
cot(x)	Cotangent	mod(x,y)	Modulus (signed remainder after division)
coth(x)	Hyperbolic cotangent	rem(x,y)	Remainder after division
acot(x)	Inverse cotangent		

3. 几个预定义变量

Inf 表示 $+\infty$

Pi 表示 π

NaN 表示 非数值项

（*Not-a-Number*）

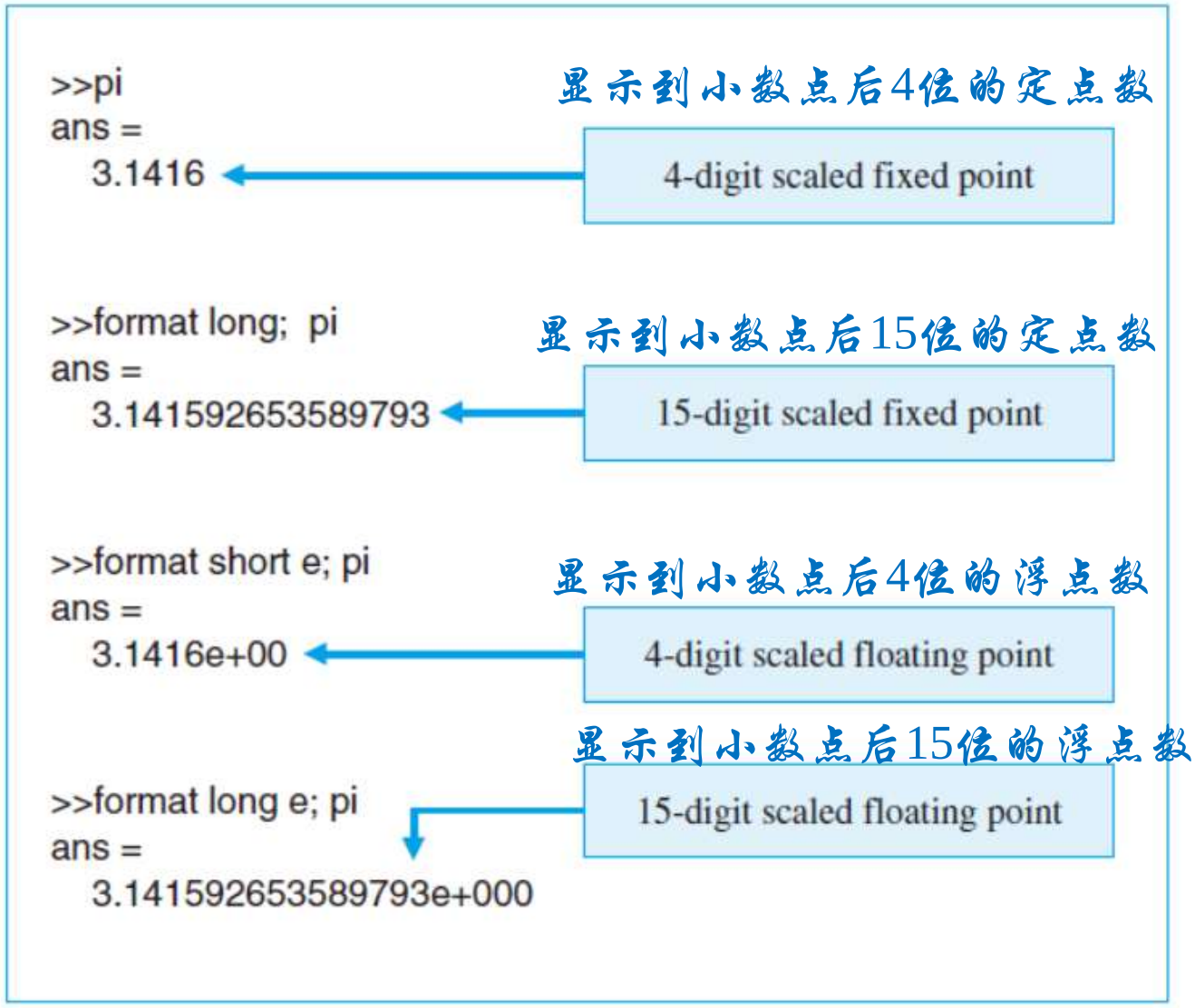
$i=\sqrt{-1}$ 或 $j=\sqrt{-1}$

```
>>0/0
Warning:  Divide by zero
ans =
   NaN

>>z=3+4*i
z =
   3.0000 + 4.0000i
```

$z=3+4*j$

MATLAB 是区分大小写的，变量 M 和 m 是不同变量。

4. 输出格式


>>pi
ans =
3.1416
显示到小数点后4位的定点数
4-digit scaled fixed point
>>format long; pi
ans =
3.141592653589793
显示到小数点后15位的定点数
15-digit scaled fixed point
>>format short e; pi
ans =
3.1416e+00
显示到小数点后4位的浮点数
4-digit scaled floating point
>>format long e; pi
ans =
3.141592653589793e+000
显示到小数点后15位的浮点数
15-digit scaled floating point

5. 三种基本的矩阵运算：相加、相乘和转置

$$A=\begin{bmatrix}1 & 3\\ 5 & 9\end{bmatrix}$$

$$B=\begin{bmatrix}4 & -7\\ 10 & 0\end{bmatrix}$$

$$b=\begin{bmatrix}1\\ 5\end{bmatrix}$$

```
>>A=[1 3; 5 9]; B=[4 -7; 10 0];
>>A+B
ans =
   5   -4
  15    9
```

Matrix addition

矩阵相加

```
>>b=[1;5];
>>A*b
ans =
  16
  50
```

Matrix multiplication

矩阵相乘

确定矩阵A的共轭转置矩阵

```
>>A'
ans =
   1   5
   3   9
```

Matrix transpose

矩阵转置

A.' 确定矩阵A的转置矩阵

数组运算符

*　和　.*

$$A=\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \qquad B=\begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

Table A.3 Mathematical Array Operators

+	Addition
−	Subtraction
.*	Multiplication
./	Division
.^	Power

$$A * B=\begin{bmatrix} a_{11}b_{11}+a_{12}b_{21} & a_{11}b_{12}+a_{12}b_{22} \\ a_{21}b_{11}+a_{22}b_{21} & a_{21}b_{12}+a_{22}b_{22} \end{bmatrix}$$

$$A .* B=\begin{bmatrix} a_{11}b_{11} & a_{12}b_{12} \\ a_{21}b_{21} & a_{22}b_{22} \end{bmatrix}$$

*A.*B* 是矩阵A和B中对应元素的乘积。

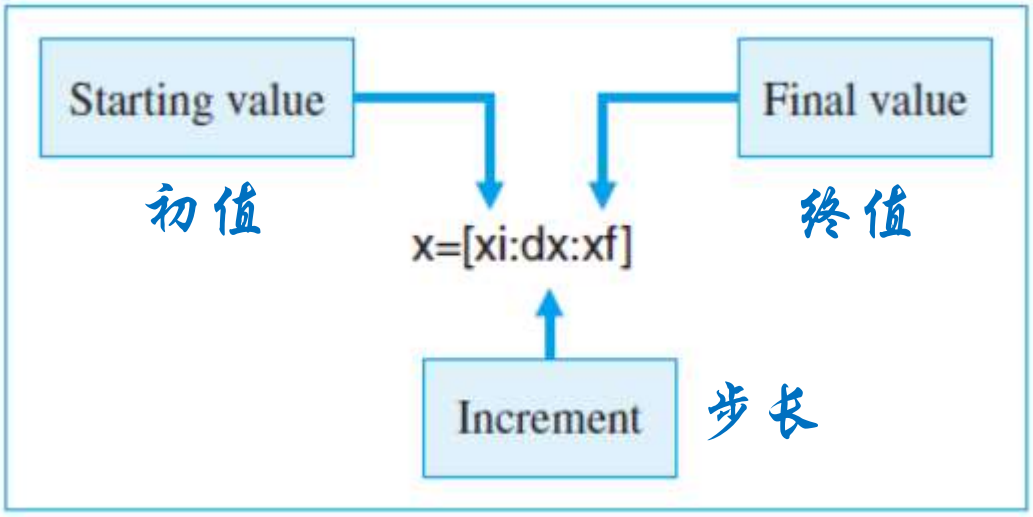
$$A=\begin{bmatrix}4 & 2\\ -3 & 8\end{bmatrix} \qquad B=\begin{bmatrix}7 & -2\\ 0 & 9\end{bmatrix}$$

$$A * B=\begin{bmatrix}4\times 7+2\times 0 & 4\times(-2)+2\times 9\\ (-3)\times 7+8\times 0 & (-3)\times(-2)+8\times 9\end{bmatrix}=\begin{bmatrix}28 & 10\\ -21 & 78\end{bmatrix}$$

$$A .* B=\begin{bmatrix}4\times 7 & 2\times(-2)\\ (-3)\times 0 & 8\times 9\end{bmatrix}=\begin{bmatrix}28 & -4\\ 0 & 72\end{bmatrix}$$

```
>> A=[4 2;-3 8];
>> B=[7 -2;0 9];
>> d=A*B

d =

    28    10
   -21    78

>> e=A.*B

e =

    28    -4
     0    72
```

6. 利用冒号来产生向量



使用冒号运算符，能够产生一个行向量，其值从给定的初值xi到终值xf，步长为 dx。

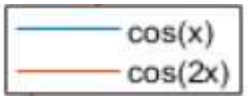
Table A.4 Plot Formats 绘图指令

plot(x,y)	Plots the vector **x** versus the vector **y**.
semilogx(x,y)	Plots the vector **x** versus the vector **y**. The x-axis is $\log_{10}$; the y-axis is linear.
semilogy(x,y)	Plots the vector **x** versus the vector **y**. The x-axis is linear; the y-axis is $\log_{10}$.
loglog(x,y)	Plots the vector **x** versus the vector **y**. Creates a plot with $\log_{10}$ scales on both axes.

自定义绘图函数

Table A.5 Functions for Customized Plots

title('text')	Puts 'text' at the top of the plot
legend (string1, string2, . . .) 图例	Puts a legend on current plot using specified strings as labels
xlabel('text')	Labels the *x*-axis with 'text'
ylabel('text')	Labels the *y*-axis with 'text'
text(p1,p2, 'text')	Adds 'text' to location (p1,p2), where (p1,p2) is in units from the current plot
subplot	Subdivides the graphics window
grid on	Adds grid lines to the current figure
grid off	Removes grid lines from the current figure
grid	Toggles the grid state



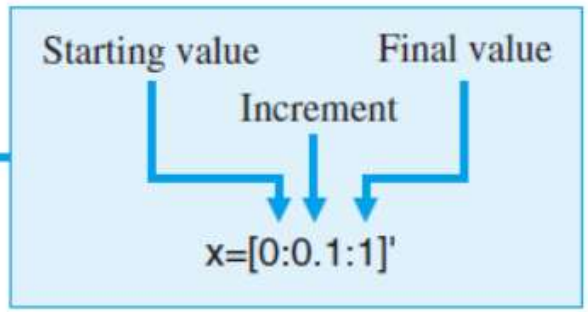
自定义绘图线型指令

Table A.6 Commands for Line Types for Customized Plots

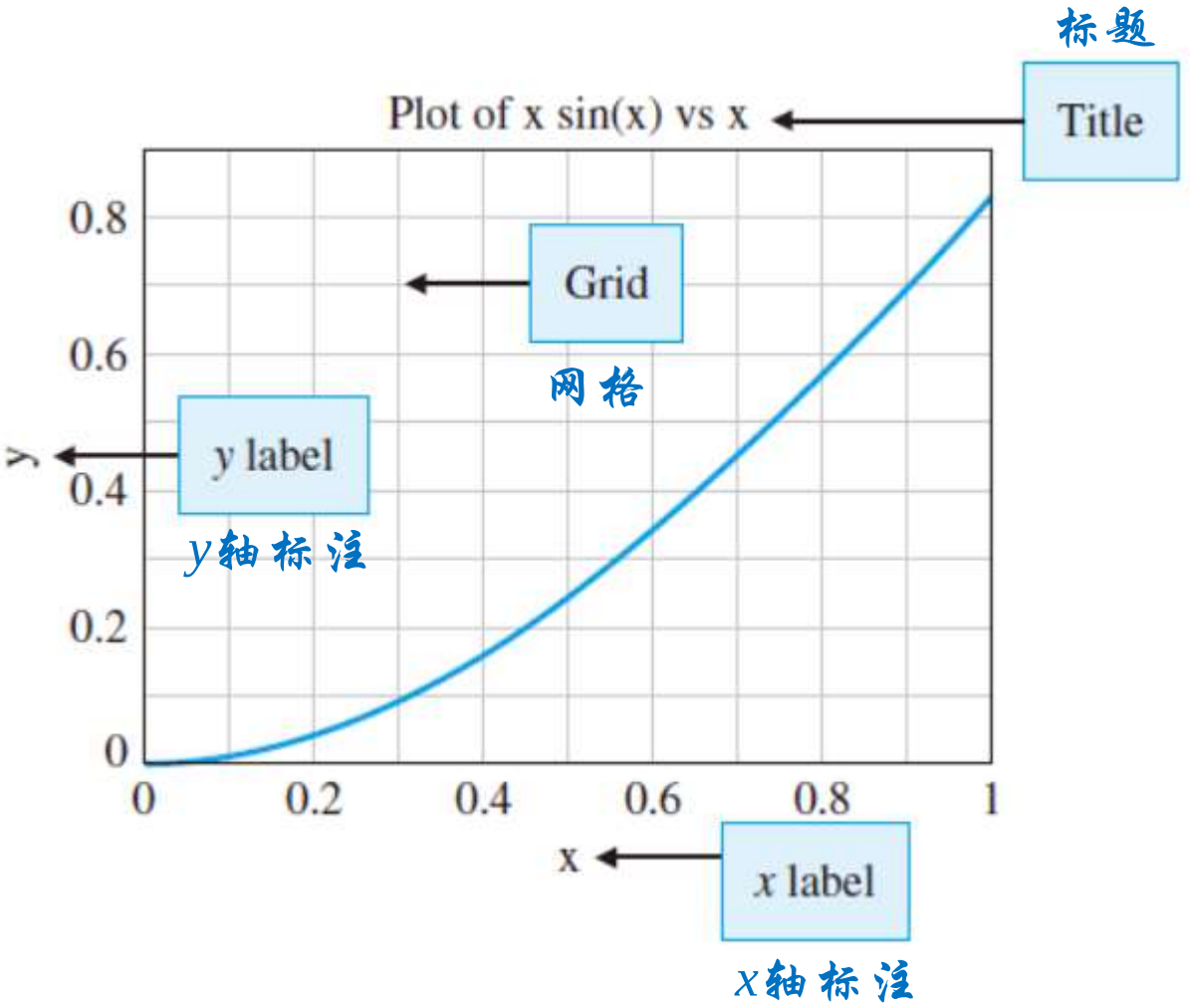
-	实线	Solid line
- -	虚线	Dashed line
:	点线	Dotted line
-.	点划线	Dashdot line

7. 绘制 $y = x\sin(x)$ 的图形，其中 $0 \le x \le 1$ 。

```
>>x=[0:0.1:1]';y=x.*sin(x);
>>[x y]

ans =
         0         0
    0.1000    0.0100
    0.2000    0.0397
    0.3000    0.0887
    0.4000    0.1558
    0.5000    0.2397
    0.6000    0.3388
    0.7000    0.4510
    0.8000    0.5739
    0.9000    0.7050
    1.0000    0.8415
```



```
>>x=[0:0.1:1]';
>>y=x.*sin(x);
>>plot(x,y)
>>title('Plot of x sin(x) vs x ')
>>xlabel('x')
>>ylabel('y')
>>grid on
```

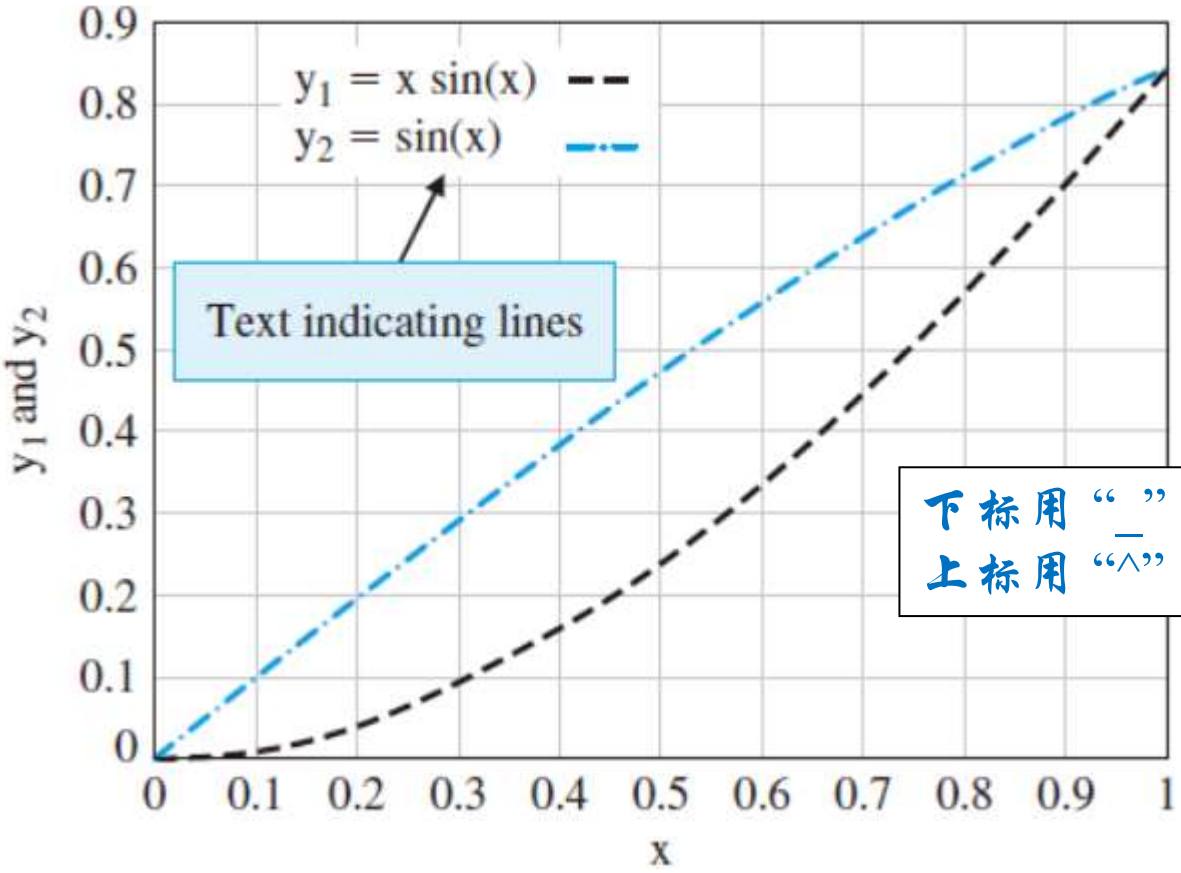


```
>>  x=[0:0.1:1]';
>>  y1=x.*sin(x); y2=sin(x);
>> plot(x,y1,'--',x,y2,'-.')
>> text(0.1,0.85,'y_1 = x sin(x) ---')
>> text(0.1,0.80,'y_2 = sin(x) .\_.\_')
>> xlabel('x'), ylabel('y_1 and y_2'), grid on
```

Dashed line for y1
Dashed-dot line for y2

曲线y_1采用虚线

曲线y_2采用点划线



下标用“_”表示，
上标用“^”表示。

8. TeX数学字符

基于底层编程语言的电子排版系统

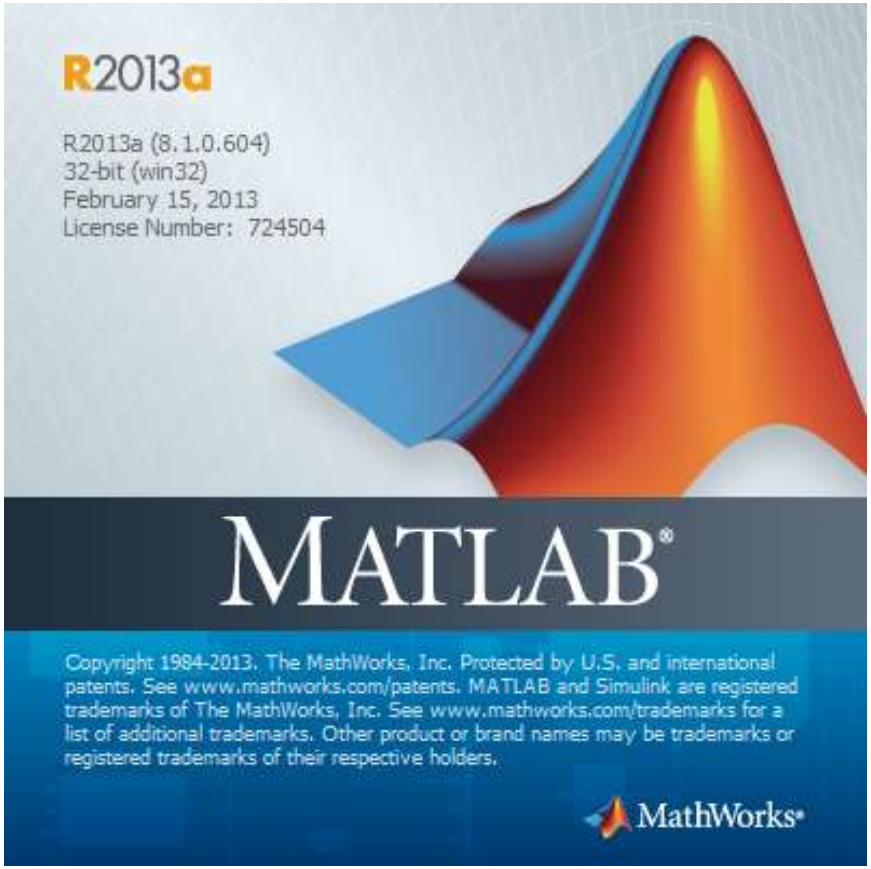
- \bf—bold font 黑体
- \it—italics font 斜体
- \rm—normal font 普通字体
- \fontname—specify the name of the font family to use 指定所用的字体名称
- \fontsize—specify the font size 指定字体大小

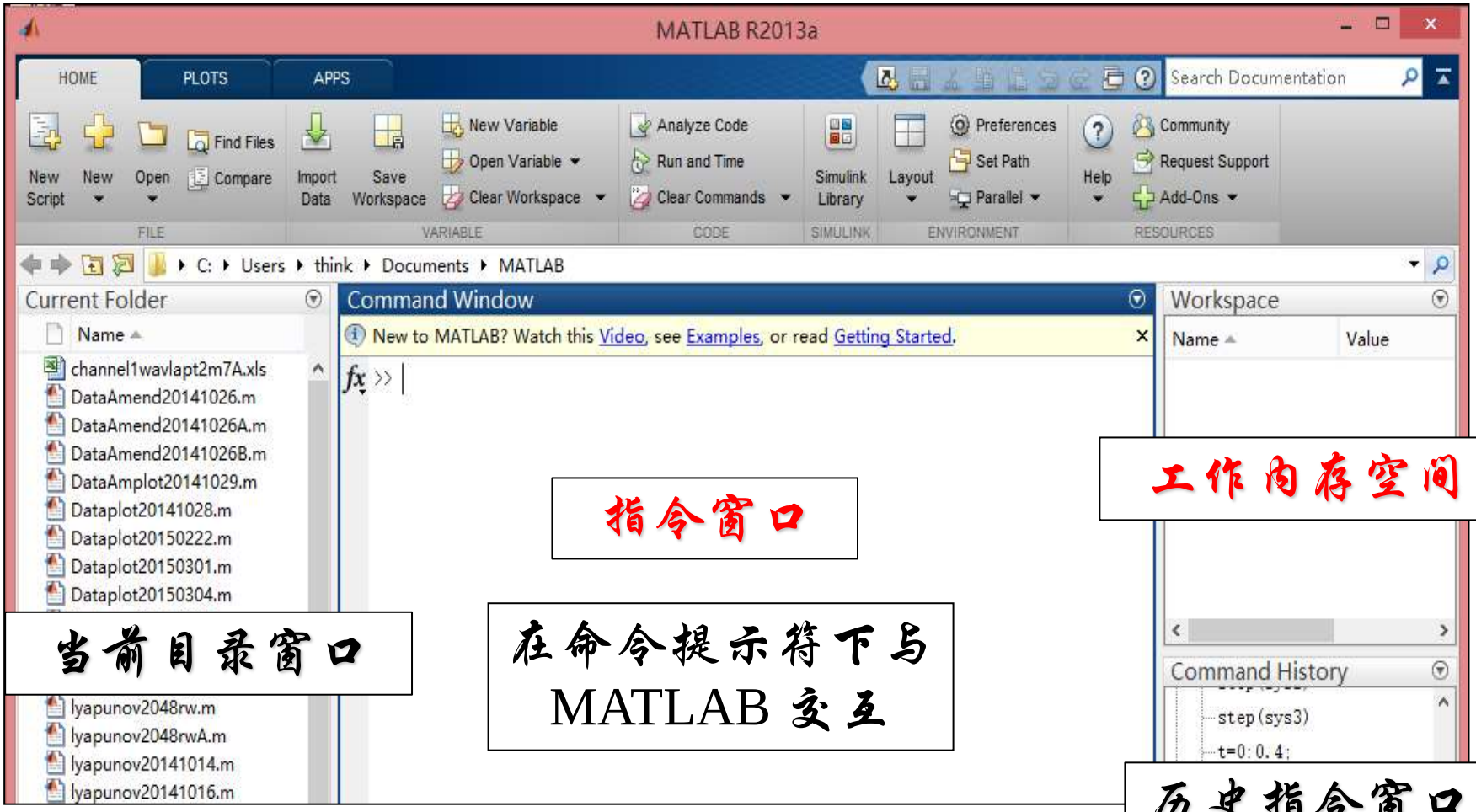
Table A.7 TeX Symbols and Mathematics Characters

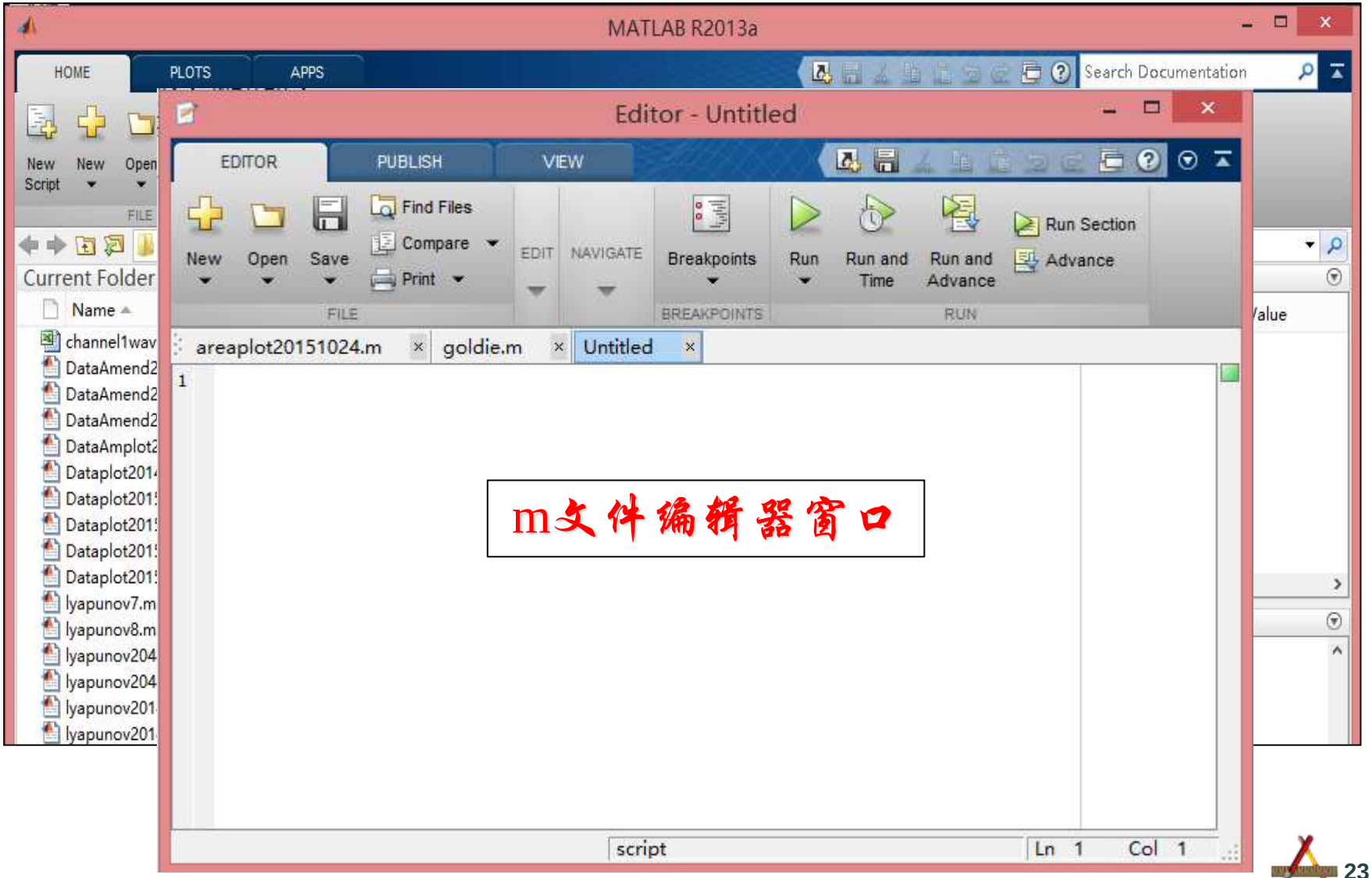
Character Sequence	Symbol	Character Sequence	Symbol	Character Sequence	Symbol
\alpha	α	\upsilon	υ	\sim	$\sim$
\beta	β	\phi	φ	\leq	$\leqslant$
\gamma	γ	\chi	χ	\infty	∞
\delta	δ	\psi	ψ	\clubsuit	$\clubsuit$
\epsilon	ϵ	\omega	ω	\diamondsuit	$\diamondsuit$
\zeta	ζ	\Gamma	Γ	\heartsuit	$\heartsuit$
\eta	η	\Delta	Δ	\spadesuit	$\spadesuit$
\theta	θ	\Theta	Θ	\leftrightarrow	$\leftrightarrow$
\vartheta	ϑ	\Lambda	Λ	\leftarrow	$\leftarrow$
\iota	ι	\Xi	Θ	\uparrow	$\uparrow$
\kappa	κ	\Pi	Π	\rightarrow	$\rightarrow$

\lambda	λ	\Sigma	Σ	\downarrow	$\downarrow$
\mu	μ	\Upsilon	Υ	\circ	$\circ$
\nu	ν	\Phi	Φ	\pm	$\pm$
\xi	ξ	\Psi	Ψ	\geq	$\geqslant$
\pi	π	\Omega	Ω	\propto	$\propto$
\rho	ρ	\forall	$\forall$	\partial	∂
\sigma	σ	\exist	$\exists$	\bullet	$\bullet$
\varsigma	ς	\ni	$\ni$	\div	$\div$
\tau	τ	\cong	$\cong$	\neq	$\neq$
\equiv	$\equiv$	\approx	$\approx$	\aleph	$\aleph$
\Im	$\Im$	\Re	$\Re$	\wp	$\wp$
\otimes	$\otimes$	\oplus	$\oplus$	\oslash	$\oslash$
\cap	$\cap$	\cup	$\cup$	\supseteq	$\supseteq$
\supset	$\supset$	\subseteq	$\subseteq$	\subset	$\subset$
\int	$\int$	\in	$\in$	\o	o

9. MATLAB 软件界面




MATLAB R2013a
HOME
PLOTS
APPS
Search Documentation
New Script
New
Open
Find Files
Compare
Import Data
Save Workspace
New Variable
Open Variable
Clear Workspace
Analyze Code
Run and Time
Clear Commands
Simulink Library
Layout
Preferences
Set Path
Parallel
Help
Community
Request Support
Add-Ons
FILE
VARIABLE
CODE
SIMULINK
ENVIRONMENT
RESOURCES
C: ▸ Users ▸ think ▸ Documents ▸ MATLAB
Current Folder
Name
channel1wavlapt2m7A.xls
DataAmend20141026.m
DataAmend20141026A.m
DataAmend20141026B.m
DataAmplot20141029.m
Dataplot20141028.m
Dataplot20150222.m
Dataplot20150301.m
Dataplot20150304.m
lyapunov2048rw.m
lyapunov2048rwA.m
lyapunov20141014.m
lyapunov20141016.m
Command Window
New to MATLAB? Watch this Video, see Examples, or read Getting Started.
fx >>
Workspace
Name
Value
Command History
step(sys3)
t=0:0.4;
指令窗口
工作内存空间
当前目录窗口
在命令提示符下与MATLAB交互
历史指令窗口

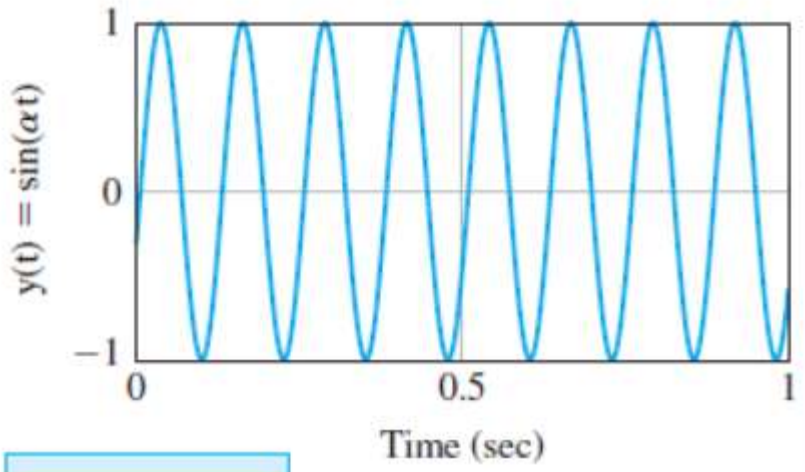

MATLAB R2013a
HOME
PLOTS
APPS
Search Documentation
New Script
New
Open
Current Folder
Name
channel1wav
DataAmend2
DataAmend2
DataAmend2
DataAmplot2
Dataplot201
Dataplot201
Dataplot201
Dataplot201
Dataplot201
lyapunov7.m
lyapunov8.m
lyapunov204
lyapunov204
lyapunov201
lyapunov201
Editor - Untitled
EDITOR
PUBLISH
VIEW
New
Open
Save
Find Files
Compare
Print
FILE
EDIT
NAVIGATE
Breakpoints
BREAKPOINTS
Run
Run and Time
Run and Advance
Run Section
Advance
RUN
areaplot20151024.m
goldie.m
Untitled
1
script
Ln 1
Col 1
Value
m文件编辑器窗口

```
>>alpha=50;
>>plotdata
```

plotdata.m

```
% This is a script to plot the function y=sin(alpha*t).
%
% The value of alpha must exist in the workspace prior
% to invoking the script.
%
t=[0:0.01:1];
y=sin(alpha*t);
plot(t,y)
xlabel('Time (sec)')
ylabel('y(t) = sin(\alpha  t )')
grid on
```

注释



Graph display