MATLAB commands in numerical Python (NumPy)

The idea of this document (and the corresponding XML instance) is to provide a quick reference[1] for switching from MATLAB to an open-source environment, such as Python, Scilab, Octave and Gnuplot, or R for numeric processing and data visualisation.

Where Octave and Scilab commands are omitted, expect Matlab compatibility, and similarly where non given use the generic command.

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1 Help

Desc.	MATLAB/Octave	Python	R
Browse help interactively	`doc` Octave: `help -i % browse with Info`	`help()`	`help.start()`
Help on using help	`help help` or `doc doc`	`help`	`help()`
Help for a function	`help plot`	`help(plot)` or `?plot`	`help(plot)` or `?plot`
Help for a toolbox/library package	`help splines` or `doc splines`	`help(pylab)`	`help(package=’splines’)`
Demonstration examples	`demo`		`demo()`
Example using a function			`example(plot)`

1.1 Searching available documentation

Desc.	MATLAB/Octave	Python	R
Search help files	`lookfor plot`		`help.search(’plot’)`
Find objects by partial name			`apropos(’plot’)`
List available packages	`help`	`help(); modules [Numeric]`	`library()`
Locate functions	`which plot`	`help(plot)`	`find(plot)`
List available methods for a function			`methods(plot)`

1.2 Using interactively

Desc.	MATLAB/Octave	Python	R
Start session	Octave: `octave -q`	`ipython -pylab`	`Rgui`
Auto completion	Octave: `TAB` or `M-?`	`TAB`	
Run code from file	`foo(.m)`	`execfile(’foo.py’)` or `run foo.py`	`source(’foo.R’)`
Command history	Octave: `history`	`hist -n`	`history()`
Save command history	`diary on [..] diary off`		`savehistory(file=".Rhistory")`

End session	`exit` or `quit`	`CTRL-D`
		`CTRL-Z # windows`
		`sys.exit()`
			`q(save=’no’)`

2 Operators

Desc.	MATLAB/Octave	Python	R
Help on operator syntax	`help -`		`help(Syntax)`

[1] References: Hankin, Robin. *R for Octave users* (2001), available from http://cran.r-project.org/doc/contrib/R-and-octave-2.txt (accessed 2005.07.24); Martelli, Alex. *Python in a Nutshell* (O’Reilly, 2003); Oliphant, Travis. *Guide to NumPy* (Trelgol, 2006); Hunter, John. *The Matplotlib User’s Guide* (2005), available from http://matplotlib.sf.net/ (accessed 2005.07.31); Langtangen, Hans Petter. *Python Scripting for Computational Science* (Springer, 2004); Ascher et al.: *Numeric Python manual* (2001), available from http://numeric.scipy.org/numpy.pdf (accessed 2005.06.25); Moler, Cleve. *Numerical Computing with MATLAB* (MathWorks, 2004), available from http://www.mathworks.com/moler/ (accessed 2005.03.10); Eaton, John W. *Octave Quick Reference* (1996); Merrit, Ethan. *Demo scripts for gnuplot version 4.0* (2004), available from http://gnuplot.sourceforge.net/demo/ (accessed 2005.07.24); Woo, Alex. *Gnuplot Quick Reference* (2004), available from http://www.gnuplot.info/docs/gpcard.pdf (accessed 2005.07.14); Venables & Smith: *An Introduction to R* (2005), available from http://cran.r-project.org/doc/manuals/R-intro.pdf (accessed 2005.07.25); Short, Tom. *R reference card* (2005), available from http://www.rpad.org/Rpad/R-refcard.pdf (accessed 2005.07.24).

2.1 Arithmetic operators

Desc.	MATLAB/Octave	Python	R
Assignment; defining a number	a=1; b=2;	a=1; b=1	a<-1; b<-2
Addition	a + b	a + b or add(a,b)	a + b
Subtraction	a - b	a - b or subtract(a,b)	a - b
Multiplication	a * b	a * b or multiply(a,b)	a * b
Division	a / b	a / b or divide(a,b)	a / b

Power, a^b	a .^ b	a ** b
		power(a,b)
		pow(a,b)
			a ^ b

Remainder	rem(a,b)	a % b
		remainder(a,b)
		fmod(a,b)
			a %% b

Integer division			a %/% b
In place operation to save array creation overhead	Octave: a+=1	a+=b or add(a,b,a)	
Factorial, $n!$	factorial(a)		factorial(a)

2.2 Relational operators

Desc.	MATLAB/Octave	Python	R
Equal	a == b	a == b or equal(a,b)	a == b
Less than	a < b	a < b or less(a,b)	a < b
Greater than	a > b	a > b or greater(a,b)	a > b
Less than or equal	a <= b	a <= b or less_equal(a,b)	a <= b
Greater than or equal	a >= b	a >= b or greater_equal(a,b)	a >= b
Not Equal	a ~= b	a != b or not_equal(a,b)	a != b

2.3 Logical operators

Desc.	MATLAB/Octave	Python	R
Short-circuit logical AND	a && b	a and b	a && b
Short-circuit logical OR	a || b	a or b	a || b
Element-wise logical AND	a & b or and(a,b)	logical_and(a,b) or a and b	a & b
Element-wise logical OR	a | b or or(a,b)	logical_or(a,b) or a or b	a | b
Logical EXCLUSIVE OR	xor(a, b)	logical_xor(a,b)	xor(a, b)
Logical NOT	~a or not(a) Octave: ~a or !a	logical_not(a) or not a	!a
True if any element is nonzero	any(a)		
True if all elements are nonzero	all(a)		

2.4 root and logarithm

Desc.	MATLAB/Octave	Python	R	
Square root	sqrt(a)	math.sqrt(a)	sqrt(a)	$\sqrt{a}$
Logarithm, base e (natural)	log(a)	math.log(a)	log(a)	$\ln a = \log_e a$
Logarithm, base 10	log10(a)	math.log10(a)	log10(a)	$\log_{10} a$
Logarithm, base 2 (binary)	log2(a)	math.log(a, 2)	log2(a)	$\log_2 a$
Exponential function	exp(a)	math.exp(a)	exp(a)	e^a

2.5 Round off

Desc.	MATLAB/Octave	Python	R
Round	`round(a)`	`around(a)` or `math.round(a)`	`round(a)`
Round up	`ceil(a)`	`ceil(a)`	`ceil(a)`
Round down	`floor(a)`	`floor(a)`	`floor(a)`
Round towards zero	`fix(a)`	`fix(a)`	

2.6 Mathematical constants

Desc.	MATLAB/Octave	Python	R
$\pi = 3.141592$	`pi`	`math.pi`	`pi`
$e = 2.718281$	`exp(1)`	`math.e` or `math.exp(1)`	`exp(1)`

2.6.1 Missing values; IEEE-754 floating point status flags

Desc.	MATLAB/Octave	Python	R
Not a Number	`NaN`	`nan`	
Infinity, ∞	`Inf`	`inf`	
Infinity, $+\infty$		`plus_inf`	
Infinity, $-\infty$		`minus_inf`	
Plus zero, $+0$		`plus_zero`	
Minus zero, -0		`minus_zero`	

2.7 Complex numbers

Desc.	MATLAB/Octave	Python	R	
Imaginary unit	`i`	`z = 1j`	`1i`	$i = \sqrt{-1}$
A complex number, $3 + 4i$	`z = 3+4i`	`z = 3+4j` or `z = complex(3,4)`	`z <- 3+4i`	
Absolute value (modulus)	`abs(z)`	`abs(3+4j)`	`abs(3+4i)` or `Mod(3+4i)`	
Real part	`real(z)`	`z.real`	`Re(3+4i)`	
Imaginary part	`imag(z)`	`z.imag`	`Im(3+4i)`	
Argument	`arg(z)`		`Arg(3+4i)`	
Complex conjugate	`conj(z)`	`z.conj(); z.conjugate()`	`Conj(3+4i)`	

2.8 Trigonometry

Desc.	MATLAB/Octave	Python	R	
Arctangent, $\arctan(b/a)$	`atan(a,b)`	`atan2(b,a)`	`atan2(b,a)`	
Hypotenus; Euclidean distance		`hypot(x,y)`		$\sqrt{x^2 + y^2}$

2.9 Generate random numbers

Desc.	MATLAB/Octave	Python	R

Uniform distribution	`rand(1,10)`	`random.random((10,))`
		`random.uniform((10,))`
			`runif(10)`

Uniform: Numbers between 2 and 7	`2+5*rand(1,10)`	`random.uniform(2,7,(10,))`	`runif(10, min=2, max=7)`
Uniform: 6,6 array	`rand(6)`	`random.uniform(0,1,(6,6))`	`matrix(runif(36),6)`
Normal distribution	`randn(1,10)`	`random.standard_normal((10,))`	`rnorm(10)`

3 Vectors

Desc.	MATLAB/Octave	Python	R
Row vector, $1 \times n$-matrix	`a=[2 3 4 5];`	`a=array([2,3,4,5])`	`a <- c(2,3,4,5)`

Column vector, $m \times 1$-matrix	`adash=[2 3 4 5]';`	`array([2,3,4,5])[:,NewAxis]`
		`array([2,3,4,5]).reshape(-1,1)`
		`r_[1:10,'c']`
			`adash <- t(c(2,3,4,5))`

3.1 Sequences

Desc.	MATLAB/Octave	Python	R

1,2,3, ... ,10	`1:10`	`arange(1,11, dtype=Float)`
		`range(1,11)`
			`seq(10)` or `1:10`

0.0,1.0,2.0, ... ,9.0	`0:9`	`arange(10.)`	`seq(0,length=10)`
1,4,7,10	`1:3:10`	`arange(1,11,3)`	`seq(1,10,by=3)`
10,9,8, ... ,1	`10:-1:1`	`arange(10,0,-1)`	`seq(10,1)` or `10:1`
10,7,4,1	`10:-3:1`	`arange(10,0,-3)`	`seq(from=10,to=1,by=-3)`
Linearly spaced vector of n=7 points	`linspace(1,10,7)`	`linspace(1,10,7)`	`seq(1,10,length=7)`
Reverse	`reverse(a)`	`a[::-1]` or	`rev(a)`
Set all values to same scalar value	`a(:) = 3`	`a.fill(3), a[:] = 3`	

3.2 Concatenation (vectors)

Desc.	MATLAB/Octave	Python	R
Concatenate two vectors	`[a a]`	`concatenate((a,a))`	`c(a,a)`
	`[1:4 a]`	`concatenate((range(1,5),a), axis=1)`	`c(1:4,a)`

3.3 Repeating

Desc.	MATLAB/Octave	Python	R
1 2 3, 1 2 3	`[a a]`	`concatenate((a,a))`	`rep(a,times=2)`
1 1 1, 2 2 2, 3 3 3		`a.repeat(3)` or	`rep(a,each=3)`
1, 2 2, 3 3 3		`a.repeat(a)` or	`rep(a,a)`

3.4 Miss those elements out

Desc.	MATLAB/Octave	Python	R
miss the first element	`a(2:end)`	`a[1:]`	`a[-1]`
miss the tenth element	`a([1:9])`		`a[-10]`
miss 1,4,7, ...			`a[-seq(1,50,3)]`
last element	`a(end)`	`a[-1]`	
last two elements	`a(end-1:end)`	`a[-2:]`	

3.5 Maximum and minimum

Desc.	MATLAB/Octave	Python	R
pairwise max	`max(a,b)`	`maximum(a,b)`	`pmax(a,b)`
max of all values in two vectors	`max([a b])`	`concatenate((a,b)).max()`	`max(a,b)`
	`[v,i] = max(a)`	`v,i = a.max(0),a.argmax(0)`	`v <- max(a) ; i <- which.max(a)`

3.6 Vector multiplication

Desc.	MATLAB/Octave	Python	R
Multiply two vectors	`a.*a`	`a*a`	`a*a`
Vector dot product, $u \cdot v$	`dot(u,v)`	`dot(u,v)`	

4 Matrices

Desc.	MATLAB/Octave	Python	R	

Define a matrix	`a = [2 3;4 5]`	`a = array([[2,3],[4,5]])`	`rbind(c(2,3),c(4,5))`
			`array(c(2,3,4,5), dim=c(2,2))`
				$\begin{bmatrix}2 & 3\\4 & 5\end{bmatrix}$

4.1 Concatenation (matrices); rbind and cbind

Desc.	MATLAB/Octave	Python	R

Bind rows	`[a ; b]`	`concatenate((a,b), axis=0)`
		`vstack((a,b))`
			`rbind(a,b)`

Bind columns	`[a , b]`	`concatenate((a,b), axis=1)`
		`hstack((a,b))`
			`cbind(a,b)`

Bind slices (three-way arrays)		`concatenate((a,b), axis=2)`
		`dstack((a,b))`	

Concatenate matrices into one vector	`[a(:), b(:)]`	`concatenate((a,b), axis=None)`	

Bind rows (from vectors)	`[1:4 ; 1:4]`	`concatenate((r_[1:5],r_[1:5])).reshape(2,-1)`
		`vstack((r_[1:5],r_[1:5]))`
			`rbind(1:4,1:4)`

Bind columns (from vectors)	`[1:4 ; 1:4]'`		`cbind(1:4,1:4)`

4.2 Array creation

Desc.	MATLAB/Octave	Python	R	
0 filled array	`zeros(3,5)`	`zeros((3,5),Float)`	`matrix(0,3,5)` or `array(0,c(3,5))`	$\begin{bmatrix}0&0&0&0&0\\0&0&0&0&0\\0&0&0&0&0\end{bmatrix}$
0 filled array of integers		`zeros((3,5))`		
1 filled array	`ones(3,5)`	`ones((3,5),Float)`	`matrix(1,3,5)` or `array(1,c(3,5))`	$\begin{bmatrix}1&1&1&1&1\\1&1&1&1&1\\1&1&1&1&1\end{bmatrix}$
Any number filled array	`ones(3,5)*9`		`matrix(9,3,5)` or `array(9,c(3,5))`	$\begin{bmatrix}9&9&9&9&9\\9&9&9&9&9\\9&9&9&9&9\end{bmatrix}$
Identity matrix	`eye(3)`	`identity(3)`	`diag(1,3)`	$\begin{bmatrix}1&0&0\\0&1&0\\0&0&1\end{bmatrix}$
Diagonal	`diag([4 5 6])`	`diag((4,5,6))`	`diag(c(4,5,6))`	$\begin{bmatrix}4&0&0\\0&5&0\\0&0&6\end{bmatrix}$
Magic squares; Lo Shu	`magic(3)`			$\begin{bmatrix}8&1&6\\3&5&7\\4&9&2\end{bmatrix}$
Empty array		`a = empty((3,3))`		

4.3 Reshape and flatten matrices

Desc.	MATLAB/Octave	Python	R	

Reshaping (rows first)	`reshape(1:6,3,2)';`	`arange(1,7).reshape(2,-1)`
		`a.setshape(2,3)`
			`matrix(1:6,nrow=3,byrow=T)`	$\begin{bmatrix}1&2&3\\4&5&6\end{bmatrix}$

Reshaping (columns first)	`reshape(1:6,2,3);`	`arange(1,7).reshape(-1,2).transpose()`	`matrix(1:6,nrow=2)`
			`array(1:6,c(2,3))`
				$\begin{bmatrix}1&3&5\\2&4&6\end{bmatrix}$

Flatten to vector (by rows, like comics)	`a'(:)`	`a.flatten()` or	`as.vector(t(a))`	$\begin{bmatrix}1&2&3&4&5&6\end{bmatrix}$
Flatten to vector (by columns)	`a(:)`	`a.flatten(1)`	`as.vector(a)`	$\begin{bmatrix}1&4&2&5&3&6\end{bmatrix}$
Flatten upper triangle (by columns)	`vech(a)`		`a[row(a) <= col(a)]`	

4.4 Shared data (slicing)

Desc.	MATLAB/Octave	Python	R
Copy of a	`b = a`	`b = a.copy()`	`b = a`

4.5 Indexing and accessing elements (Python: slicing)

Desc.	MATLAB/Octave	Python	R	

Input is a 3,4 array	`a = [ 11 12 13 14 ...`
	`21 22 23 24 ...`
	`31 32 33 34 ]`
		`a = array([[ 11, 12, 13, 14 ],`
		`[ 21, 22, 23, 24 ],`
		`[ 31, 32, 33, 34 ]])`
			`a <- rbind(c(11, 12, 13, 14),`
			`c(21, 22, 23, 24),`
			`c(31, 32, 33, 34))`
				$\begin{bmatrix}a_{11}&a_{12}&a_{13}&a_{14}\\a_{21}&a_{22}&a_{23}&a_{24}\\a_{31}&a_{32}&a_{33}&a_{34}\end{bmatrix}$

Element 2,3 (row,col)	`a(2,3)`	`a[1,2]`	`a[2,3]`	a_{23}
First row	`a(1,:)`	`a[0,]`	`a[1,]`	$\begin{bmatrix}a_{11}&a_{12}&a_{13}&a_{14}\end{bmatrix}$
First column	`a(:,1)`	`a[:,0]`	`a[,1]`	$\begin{bmatrix}a_{11}\\a_{21}\\a_{31}\end{bmatrix}$
Array as indices	`a([1 3],[1 4]);`	`a.take([0,2]).take([0,3], axis=1)`		$\begin{bmatrix}a_{11}&a_{14}\\a_{31}&a_{34}\end{bmatrix}$
All, except first row	`a(2:end,:)`	`a[1:,]`	`a[-1,]`	$\begin{bmatrix}a_{21}&a_{22}&a_{23}&a_{24}\\a_{31}&a_{32}&a_{33}&a_{34}\end{bmatrix}$
Last two rows	`a(end-1:end,:)`	`a[-2:,]`		$\begin{bmatrix}a_{21}&a_{22}&a_{23}&a_{24}\\a_{31}&a_{32}&a_{33}&a_{34}\end{bmatrix}$
Strides: Every other row	`a(1:2:end,:)`	`a[::2,:]`		$\begin{bmatrix}a_{11}&a_{12}&a_{13}&a_{14}\\a_{31}&a_{32}&a_{33}&a_{34}\end{bmatrix}$
Third in last dimension (axis)		`a[...,2]`		
All, except row,column (2,3)			`a[-2,-3]`	$\begin{bmatrix}a_{11}&a_{13}&a_{14}\\a_{31}&a_{33}&a_{34}\end{bmatrix}$
Remove one column	`a(:,[1 3 4])`	`a.take([0,2,3],axis=1)`	`a[,-2]`	$\begin{bmatrix}a_{11}&a_{13}&a_{14}\\a_{21}&a_{23}&a_{24}\\a_{31}&a_{33}&a_{34}\end{bmatrix}$
Diagonal		`a.diagonal(offset=0)`		$\begin{bmatrix}a_{11}&a_{22}&a_{33}&a_{44}\end{bmatrix}$

4.6 Assignment

Desc.	MATLAB/Octave	Python	R
	`a(:,1) = 99`	`a[:,0] = 99`	`a[,1] <- 99`
	`a(:,1) = [99 98 97]'`	`a[:,0] = array([99,98,97])`	`a[,1] <- c(99,98,97)`

Clipping: Replace all elements over 90	`a(a>90) = 90;`	`(a>90).choose(a,90)`
		`a.clip(min=None, max=90)`
			`a[a>90] <- 90`

Clip upper and lower values		`a.clip(min=2, max=5)`	

4.7 Transpose and inverse

Desc.	MATLAB/Octave	Python	R
Transpose	`a'`	`a.conj().transpose()`	`t(a)`
Non-conjugate transpose	`a.'` or `transpose(a)`	`a.transpose()`	
Determinant	`det(a)`	`linalg.det(a)` or	`det(a)`
Inverse	`inv(a)`	`linalg.inv(a)` or	`solve(a)`
Pseudo-inverse	`pinv(a)`	`linalg.pinv(a)`	`ginv(a)`
Norms	`norm(a)`	`norm(a)`	
Eigenvalues	`eig(a)`	`linalg.eig(a)[0]`	`eigen(a)$values`
Singular values	`svd(a)`	`linalg.svd(a)`	`svd(a)$d`
Cholesky factorization	`chol(a)`	`linalg.cholesky(a)`	
Eigenvectors	`[v,l] = eig(a)`	`linalg.eig(a)[1]`	`eigen(a)$vectors`
Rank	`rank(a)`	`rank(a)`	`rank(a)`

4.8 Sum

Desc.	MATLAB/Octave	Python	R
Sum of each column	`sum(a)`	`a.sum(axis=0)`	`apply(a,2,sum)`
Sum of each row	`sum(a')`	`a.sum(axis=1)`	`apply(a,1,sum)`
Sum of all elements	`sum(sum(a))`	`a.sum()`	`sum(a)`
Sum along diagonal		`a.trace(offset=0)`	
Cumulative sum (columns)	`cumsum(a)`	`a.cumsum(axis=0)`	`apply(a,2,cumsum)`

4.9 Sorting

Desc.	MATLAB/Octave	Python	R	
Example data	`a = [ 4 3 2 ; 2 8 6 ; 1 4 7 ]`	`a = array([[4,3,2],[2,8,6],[1,4,7]])`		$\begin{bmatrix} 4 & 3 & 2 \\ 2 & 8 & 6 \\ 1 & 4 & 7 \end{bmatrix}$
Flat and sorted	`sort(a(:))`	`a.ravel().sort()` or	`t(sort(a))`	$\begin{bmatrix} 1 & 2 & 2 \\ 3 & 4 & 4 \\ 6 & 7 & 8 \end{bmatrix}$
Sort each column	`sort(a)`	`a.sort(axis=0)` or `msort(a)`	`apply(a,2,sort)`	$\begin{bmatrix} 1 & 3 & 2 \\ 2 & 4 & 6 \\ 4 & 8 & 7 \end{bmatrix}$
Sort each row	`sort(a')'`	`a.sort(axis=1)`	`t(apply(a,1,sort))`	$\begin{bmatrix} 2 & 3 & 4 \\ 2 & 6 & 8 \\ 1 & 4 & 7 \end{bmatrix}$
Sort rows (by first row)	`sortrows(a,1)`	`a[a[:,0].argsort(),]`		$\begin{bmatrix} 1 & 4 & 7 \\ 2 & 8 & 6 \\ 4 & 3 & 2 \end{bmatrix}$
Sort, return indices		`a.ravel().argsort()`	`order(a)`	
Sort each column, return indices		`a.argsort(axis=0)`		
Sort each row, return indices		`a.argsort(axis=1)`		

4.10 Maximum and minimum

Desc.	MATLAB/Octave	Python	R
max in each column	`max(a)`	`a.max(0)` or `amax(a [,axis=0])`	`apply(a,2,max)`
max in each row	`max(a')`	`a.max(1)` or `amax(a, axis=1)`	`apply(a,1,max)`
max in array	`max(max(a))`	`a.max()` or	`max(a)`
return indices, i	`[v i] = max(a)`		`i <- apply(a,1,which.max)`
pairwise max	`max(b,c)`	`maximum(b,c)`	`pmax(b,c)`
	`cummax(a)`		`apply(a,2,cummax)`
max-to-min range		`a.ptp(); a.ptp(0)`	

4.11 Matrix manipulation

Desc.	MATLAB/Octave	Python	R
Flip left-right	`fliplr(a)`	`fliplr(a)` or `a[:,::-1]`	`a[,4:1]`
Flip up-down	`flipud(a)`	`flipud(a)` or `a[::-1,]`	`a[3:1,]`
Rotate 90 degrees	`rot90(a)`	`rot90(a)`	
Repeat matrix: [a a a ; a a a]	`repmat(a,2,3)` Octave: `kron(ones(2,3),a)`	`kron(ones((2,3)),a)`	`kronecker(matrix(1,2,3),a)`
Triangular, upper	`triu(a)`	`triu(a)`	`a[lower.tri(a)] <- 0`
Triangular, lower	`tril(a)`	`tril(a)`	`a[upper.tri(a)] <- 0`

4.12 Equivalents to "size"

Desc.	MATLAB/Octave	Python	R
Matrix dimensions	`size(a)`	`a.shape` or `a.getshape()`	`dim(a)`
Number of columns	`size(a,2)` or `length(a)`	`a.shape[1]` or `size(a, axis=1)`	`ncol(a)`
Number of elements	`length(a(:))`	`a.size` or `size(a[, axis=None])`	`prod(dim(a))`
Number of dimensions	`ndims(a)`	`a.ndim`	
Number of bytes used in memory		`a.nbytes`	`object.size(a)`

4.13 Matrix- and elementwise- multiplication

Desc.	MATLAB/Octave	Python	R	
Elementwise operations	`a .* b`	`a * b` or `multiply(a,b)`	`a * b`	$\begin{bmatrix} 1 & 5 \\ 9 & 16 \end{bmatrix}$
Matrix product (dot product)	`a * b`	`matrixmultiply(a,b)`	`a %*% b`	$\begin{bmatrix} 7 & 10 \\ 15 & 22 \end{bmatrix}$
Inner matrix vector multiplication $a \cdot b'$		`inner(a,b)` or		$\begin{bmatrix} 5 & 11 \\ 11 & 25 \end{bmatrix}$
Outer product		`outer(a,b)` or	`outer(a,b)` or `a %o% b`	$\begin{bmatrix} 1 & 2 & 3 & 4 \\ 2 & 4 & 6 & 8 \\ 3 & 6 & 9 & 12 \\ 4 & 8 & 12 & 16 \end{bmatrix}$
Cross product			`crossprod(a,b)` or `t(a) %*% b`	$\begin{bmatrix} 10 & 14 \\ 14 & 20 \end{bmatrix}$
Kronecker product	`kron(a,b)`	`kron(a,b)`	`kronecker(a,b)`	$\begin{bmatrix} 1 & 2 & 2 & 4 \\ 3 & 4 & 6 & 8 \\ 3 & 6 & 4 & 8 \\ 9 & 12 & 12 & 16 \end{bmatrix}$
Matrix division, $b{\cdot}a^{-1}$	`a / b`			
Left matrix division, $b^{-1}{\cdot}a$ (solve linear equations)	`a \ b`	`linalg.solve(a,b)`	`solve(a,b)`	$Ax = b$
Vector dot product		`vdot(a,b)`		
Cross product		`cross(a,b)`		

4.14 Find; conditional indexing

Desc.	MATLAB/Octave	Python	R
Non-zero elements, indices	`find(a)`	`a.ravel().nonzero()`	`which(a != 0)`

Non-zero elements, array indices	`[i j] = find(a)`	`(i,j) = a.nonzero()`
		`(i,j) = where(a!=0)`
			`which(a != 0, arr.ind=T)`

Vector of non-zero values	`[i j v] = find(a)`	`v = a.compress((a!=0).flat)`
		`v = extract(a!=0,a)`
			`ij <- which(a != 0, arr.ind=T); v <- a[ij]`

Condition, indices	`find(a>5.5)`	`(a>5.5).nonzero()`	`which(a>5.5)`
Return values		`a.compress((a>5.5).flat)`	`ij <- which(a>5.5, arr.ind=T); v <- a[ij]`
Zero out elements above 5.5	`a .* (a>5.5)`	`where(a>5.5,0,a)` or `a * (a>5.5)`	
Replace values		`a.put(2,indices)`	

5 Multi-way arrays

Desc.	MATLAB/Octave	Python	R

Define a 3-way array	`a = cat(3, [1 2; 1 2],[3 4; 3 4]);`
	`a(1,:,:)`
		`a = array([[[1,2],[1,2]], [[3,4],[3,4]]])`
		`a[0,...]`	

6 File input and output

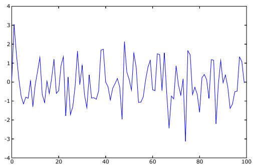
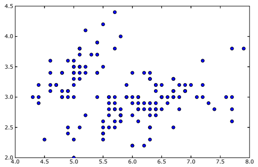
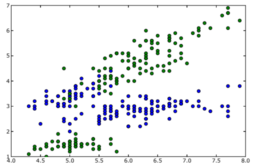
Desc.	MATLAB/Octave	Python	R

Reading from a file (2d)	`f = load('data.txt')`	`f = fromfile("data.txt")`
		`f = load("data.txt")`
			`f <- read.table("data.txt")`

Reading from a file (2d)	`f = load('data.txt')`	`f = load("data.txt")`	`f <- read.table("data.txt")`
Reading fram a CSV file (2d)	`x = dlmread('data.csv', ';')`	`f = load('data.csv', delimiter=';')`	`f <- read.table(file="data.csv", sep=";")`
Writing to a file (2d)	`save -ascii data.txt f`	`save('data.csv', f, fmt='%.6f', delimiter=';')`	`write(f,file="data.txt")`
Writing to a file (1d)		`f.tofile(file='data.csv', format='%.6f', sep=';')`	
Reading from a file (1d)		`f = fromfile(file='data.csv', sep=';')`	

7 Plotting

7.1 Basic x-y plots

Desc.	MATLAB/Octave	Python	R	
1d line plot	`plot(a)`	`plot(a)`	`plot(a, type="l")`	
2d scatter plot	`plot(x(:,1),x(:,2),'o')`	`plot(x[:,0],x[:,1],'o')`	`plot(x[,1],x[,2])`	
Two graphs in one plot	`plot(x1,y1, x2,y2)`	`plot(x1,y1,'bo', x2,y2,'go')`		

Overplotting: Add new plots to current	`plot(x1,y1)`
	`hold on`
	`plot(x2,y2)`
		`plot(x1,y1,'o')`
		`plot(x2,y2,'o')`
		`show() # as normal`
			`plot(x1,y1)`
			`matplot(x2,y2,add=T)`	

subplots	`subplot(211)`	`subplot(211)`		
Plotting symbols and color	`plot(x,y,'ro-')`	`plot(x,y,'ro-')`	`plot(x,y,type="b",col="red")`	

7.1.1 Axes and titles

Desc.	MATLAB/Octave	Python	R
Turn on grid lines	`grid on`	`grid()`	`grid()`

1:1 aspect ratio	`axis equal`
	Octave:
	`axis(’equal’)`
	`replot`
		`figure(figsize=(6,6))`	`plot(c(1:10,10:1), asp=1)`

Set axes manually	`axis([ 0 10 0 5 ])`	`axis([ 0, 10, 0, 5 ])`	`plot(x,y, xlim=c(0,10), ylim=c(0,5))`

Axis labels and titles	`title(’title’)`
	`xlabel(’x-axis’)`
	`ylabel(’y-axis’)`
			`plot(1:10, main="title",`
			`  xlab="x-axis", ylab="y-axis")`

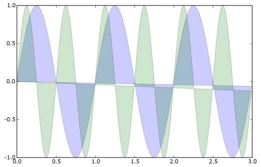
Insert text		`text(2,25,’hello’)`	

7.1.2 Log plots

Desc.	MATLAB/Octave	Python	R
logarithmic y-axis	`semilogy(a)`	`semilogy(a)`	`plot(x,y, log="y")`
logarithmic x-axis	`semilogx(a)`	`semilogx(a)`	`plot(x,y, log="x")`
logarithmic x and y axes	`loglog(a)`	`loglog(a)`	`plot(x,y, log="xy")`

7.1.3 Filled plots and bar plots

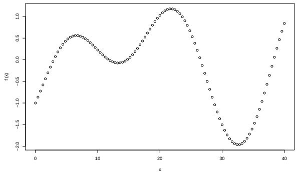
Desc.	MATLAB/Octave	Python	R	

Filled plot	`fill(t,s,’b’, t,c,’g’)`
	Octave: `% fill has a bug?`
		`fill(t,s,’b’, t,c,’g’, alpha=0.2)`	`plot(t,s, type="n", xlab="", ylab="")`
			`polygon(t,s, col="lightblue")`
			`polygon(t,c, col="lightgreen")`
				

Stem-and-Leaf plot			`stem(x[,3])`	`5 | 5`
				`6 | 71`
				`7 | 033`
				`8 | 00113345567889`
				`9 | 0133566677788`
				`10 | 32674`

7.1.4 Functions

Desc.	MATLAB/Octave	Python	R	
Defining functions	`f = inline(’sin(x/3) - cos(x/5)’)`		`f <- function(x) sin(x/3) - cos(x/5)`	$f(x) = \sin\left(\frac{x}{3}\right) - \cos\left(\frac{x}{5}\right)$

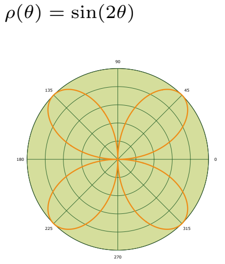
Plot a function for given range	`ezplot(f,[0,40])`
	`fplot(’sin(x/3) - cos(x/5)’,[0,40])`
	Octave: `% no ezplot`
		`x = arrayrange(0,40,.5)`
		`y = sin(x/3) - cos(x/5)`
		`plot(x,y, ’o’)`
			`plot(f, xlim=c(0,40), type=’p’)`	

7.2 Polar plots

Desc.	MATLAB/Octave	Python	R

	theta = 0:.001:2*pi;
	r = sin(2*theta);
		theta = arange(0,2*pi,0.001)
		r = sin(2*theta)	

	polar(theta, rho)	polar(theta, rho)	



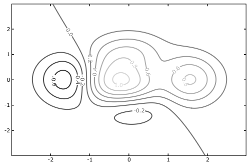
7.3 Histogram plots

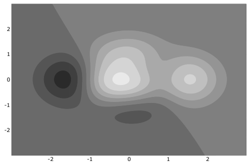
Desc.	MATLAB/Octave	Python	R
	hist(randn(1000,1))		hist(rnorm(1000))
	hist(randn(1000,1), -4:4)		hist(rnorm(1000), breaks= -4:4)
			hist(rnorm(1000), breaks=c(seq(-5,0,0.25), seq(0.5,5,0.5)), freq=F)
	plot(sort(a))		plot(apply(a,1,sort),type="l")

7.4 3d data

7.4.1 Contour and image plots

Desc.	MATLAB/Octave	Python	R	

Contour plot	`contour(z)`	`levels, colls = contour(Z, V,`
		`    origin='lower', extent=(-3,3,-3,3))`
		`clabel(colls, levels, inline=1,`
		`    fmt='%1.1f', fontsize=10)`
			`contour(z)`	

Filled contour plot	`contourf(z); colormap(gray)`	`contourf(Z, V,`
		`    cmap=cm.gray,`
		`    origin='lower',`
		`    extent=(-3,3,-3,3))`
			`filled.contour(x,y,z,`
			`    nlevels=7, color=gray.colors)`
				

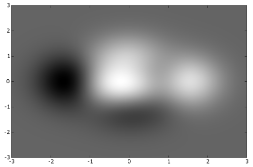
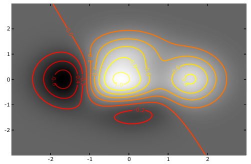
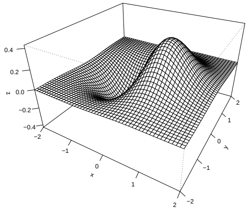
Plot image data	`image(z)`
	`colormap(gray)`
		`im = imshow(Z,`
		`    interpolation='bilinear',`
		`    origin='lower',`
		`    extent=(-3,3,-3,3))`
			`image(z, col=gray.colors(256))`	

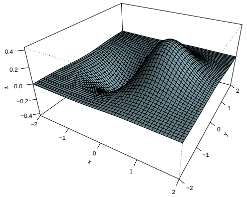
Image with contours		`# imshow() and contour() as above`		
Direction field vectors	`quiver()`	`quiver()`		

7.4.2 Perspective plots of surfaces over the x-y plane

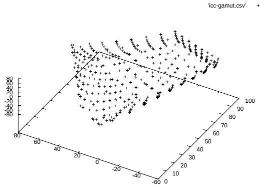
Desc.	MATLAB/Octave	Python	R

	`n=-2:.1:2;`
	`[x,y] = meshgrid(n,n);`
	`z=x.*exp(-x.^2-y.^2);`
		`n=arrayrange(-2,2,.1)`
		`[x,y] = meshgrid(n,n)`
		`z = x*power(math.e,-x**2-y**2)`
			`f <- function(x,y) x*exp(-x^2-y^2)`
			`n <- seq(-2,2, length=40)`
			`z <- outer(n,n,f)`
			$f(x,y) = xe^{-x^2-y^2}$

Mesh plot	`mesh(z)`		
			`persp(x,y,z,`
			`  theta=30, phi=30, expand=0.6,`
			`  ticktype='detailed')`

Surface plot	`surf(x,y,z) or surfl(x,y,z)`
	Octave: `% no surfl()`
			
			`persp(x,y,z,`
			`  theta=30, phi=30, expand=0.6,`
			`  col='lightblue', shade=0.75, ltheta=120,`
			`  ticktype='detailed')`

7.4.3 Scatter (cloud) plots

Desc.	MATLAB/Octave	Python	R
3d scatter plot	`plot3(x,y,z,'k+')`		 `cloud(z~x*y)`

7.5 Save plot to a graphics file

Desc.	MATLAB/Octave	Python	R

PostScript	`plot(1:10)`
	`print -depsc2 foo.eps`
	Octave:
	`gset output "foo.eps"`
	`gset terminal postscript eps`
	`plot(1:10)`
		`savefig('foo.eps')`	`postscript(file="foo.eps")`
			`plot(1:10)`
			`dev.off()`

PDF		`savefig('foo.pdf')`	`pdf(file='foo.pdf')`
SVG (vector graphics for www)		`savefig('foo.svg')`	`devSVG(file='foo.svg')`
PNG (raster graphics)	`print -dpng foo.png`	`savefig('foo.png')`	`png(filename = "Rplot%03d.png"`

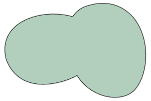
8 Data analysis

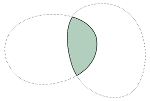
8.1 Set membership operators

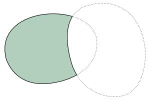
Desc.	MATLAB/Octave	Python	R	

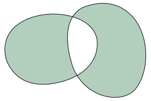
Create sets	`a = [ 1 2 2 5 2 ];`
	`b = [ 2 3 4 ];`
		`a = array([1,2,2,5,2])`
		`b = array([2,3,4])`
		`a = set([1,2,2,5,2])`
		`b = set([2,3,4])`
			`a <- c(1,2,2,5,2)`
			`b <- c(2,3,4)`	

Set unique	`unique(a)`	`unique1d(a)`
		`unique(a)`
		`set(a)`
			`unique(a)`	$\begin{bmatrix} 1 & 2 & 5 \end{bmatrix}$

Set union	`union(a,b)`	`union1d(a,b)`
		`a.union(b)`
			`union(a,b)`	

Set intersection	`intersect(a,b)`	`intersect1d(a)`
		`a.intersection(b)`
			`intersect(a,b)`	

Set difference	`setdiff(a,b)`	`setdiff1d(a,b)`
		`a.difference(b)`
			`setdiff(a,b)`	

Set exclusion	`setxor(a,b)`	`setxor1d(a,b)`
		`a.symmetric_difference(b)`
			`setdiff(union(a,b),intersect(a,b))`	

True for set member	`ismember(2,a)`	`2 in a`
		`setmember1d(2,a)`
		`contains(a,2)`
			`is.element(2,a)` or `2 %in% a`	

8.2 Statistics

Desc.	MATLAB/Octave	Python	R

Average	`mean(a)`	`a.mean(axis=0)`
		`mean(a [,axis=0])`
			`apply(a,2,mean)`

Median	`median(a)`	`median(a)` or `median(a [,axis=0])`	`apply(a,2,median)`
Standard deviation	`std(a)`	`a.std(axis=0)` or `std(a [,axis=0])`	`apply(a,2,sd)`
Variance	`var(a)`	`a.var(axis=0)` or `var(a)`	`apply(a,2,var)`
Correlation coefficient	`corr(x,y)`	`correlate(x,y)` or `corrcoef(x,y)`	`cor(x,y)`
Covariance	`cov(x,y)`	`cov(x,y)`	`cov(x,y)`

8.3 Interpolation and regression

Desc.	MATLAB/Octave	Python	R

Straight line fit	`z = polyval(polyfit(x,y,1),x)`
	`plot(x,y,’o’, x,z ,’-’)`
		`(a,b) = polyfit(x,y,1)`
		`plot(x,y,’o’, x,a*x+b,’-’)`
			`z <- lm(y˜x)`
			`plot(x,y)`
			`abline(z)`

Linear least squares $y = ax + b$	`a = x\y`	`linalg.lstsq(x,y)`	`solve(a,b)`
Polynomial fit	`polyfit(x,y,3)`	`polyfit(x,y,3)`	

8.4 Non-linear methods

8.4.1 Polynomials, root finding

Desc.	MATLAB/Octave	Python	R	
Polynomial		`poly()`		
Find zeros of polynomial	`roots([1 -1 -1])`	`roots()`	`polyroot(c(1,-1,-1))`	$x^2 - x - 1 = 0$

Find a zero near $x = 1$	`f = inline(’1/x - (x-1)’)`
	`fzero(f,1)`
				$f(x) = \frac{1}{x} - (x - 1)$

Solve symbolic equations	`solve(’1/x = x-1’)`			$\frac{1}{x} = x - 1$
Evaluate polynomial	`polyval([1 2 1 2],1:10)`	`polyval(array([1,2,1,2]),arange(1,11))`		

8.4.2 Differential equations

Desc.	MATLAB/Octave	Python	R
Discrete difference function and approximate derivative	`diff(a)`	`diff(x, n=1, axis=0)`	
Solve differential equations			

8.5 Fourier analysis

Desc.	MATLAB/Octave	Python	R
Fast fourier transform	`fft(a)`	`fft(a)` or	`fft(a)`
Inverse fourier transform	`ifft(a)`	`ifft(a)` or	`fft(a, inverse=TRUE)`
Linear convolution		`convolve(x,y)`	

9 Symbolic algebra; calculus

Desc.	MATLAB/Octave	Python	R
Factorization	`factor()`		

10 Programming

Desc.	MATLAB/Octave	Python	R
Script file extension	`.m`	`.py`	`.R`
Comment symbol (rest of line)	`%`	`#`	`#`
	Octave: `%` or `#`		
Import library functions	`% must be in MATLABPATH`	`from pylab import *`	`library(RSvgDevice)`
	Octave: `% must be in LOADPATH`		
Eval	`string='a=234';`	`string="a=234"`	`string <- "a <- 234"`
	`eval(string)`	`eval(string)`	`eval(parse(text=string))`

10.1 Loops

Desc.	MATLAB/Octave	Python	R
for-statement	`for i=1:5; disp(i); end`	`for i in range(1,6): print(i)`	`for(i in 1:5) print(i)`
Multiline for statements	`for i=1:5`	`for i in range(1,6):`	`for(i in 1:5) {`
	`   disp(i)`	`    print(i)`	`    print(i)`
	`   disp(i*2)`	`    print(i*2)`	`    print(i*2)`
	`end`		`}`

10.2 Conditionals

Desc.	MATLAB/Octave	Python	R	
if-statement	`if 1>0 a=100; end`	`if 1>0: a=100`	`if (1>0) a <- 100`	
if-else-statement	`if 1>0 a=100; else a=0; end`			
Ternary operator (if?true:false)			`ifelse(a>0,a,0)`	$a > 0?a : 0$

10.3 Debugging

Desc.	MATLAB/Octave	Python	R
Most recent evaluated expression	`ans`		`.Last.value`
List variables loaded into memory	`whos` or `who`		`objects()`
Clear variable x from memory	`clear x` or `clear [all]`		`rm(x)`
Print	`disp(a)`	`print a`	`print(a)`

10.4 Working directory and OS

Desc.	MATLAB/Octave	Python	R
List files in directory	`dir` or `ls`	`os.listdir(".")`	`list.files()` or `dir()`
List script files in directory	`what`	`grep.grep("*.py")`	`list.files(pattern="\.r$")`
Displays the current working directory	`pwd`	`os.getcwd()`	`getwd()`
Change working directory	`cd foo`	`os.chdir('foo')`	`setwd('foo')`
Invoke a System Command	`!notepad`	`os.system('notepad')`	`system("notepad")`
	Octave: `system("notepad")`	`os.popen('notepad')`	

[2] This document is still draft quality. Most shown 2d plots are made using Matplotlib, and 3d plots using R and Gnuplot, provided as examples only.

[3] Version numbers and download URL for software used: Python 2.4.2, http://www.python.org/; NumPy 0.9.5, http://numeric.scipy.org/; Matplotlib 0.87, http://matplotlib.sf.net/; IPython 0.7.1, http://ipython.scipy.org/; R 2.1.1, http://www.r-project.org/; Octave 2.1.50, http://www.octave.org/; Scilab 4.0, http://www.scilab.org/; Gnuplot 4.0, http://www.gnuplot.info/.

[4] For referencing: Gundersen, Vidar Bronken. *MATLAB commands in numerical Python* (Oslo/Norway, 2005), available from: http://mathesaurus.sf.net/

[5] Contributions are appreciated: The best way to do this is to edit the XML and submit patches to our tracker or forums.