ÖZYEĞİN UNIVERSITY

CS 100

Introduction to Engineering Computation

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Slides courtesy of
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Arrays in MATLAB/ OCTAVE

- An ordered collection of numbers a1, a2, ...,an are defined in MATLAB as an array

>> A=[a1 a2 ... an]

- For example, let us create an array of the first six prime numbers and define this array using the name “prime.”

```
>> prime=[2 3 5 7 11 13]
prime=
2 3 5 7 11 13
```

Arrays in MATLAB/ OCTAVE

- Instead of separating the elements of the array by blanks, commas may also be used:

```
>> prime=[2,3,5,7,11,13]
prime=
2 3 5 7 11 13
```

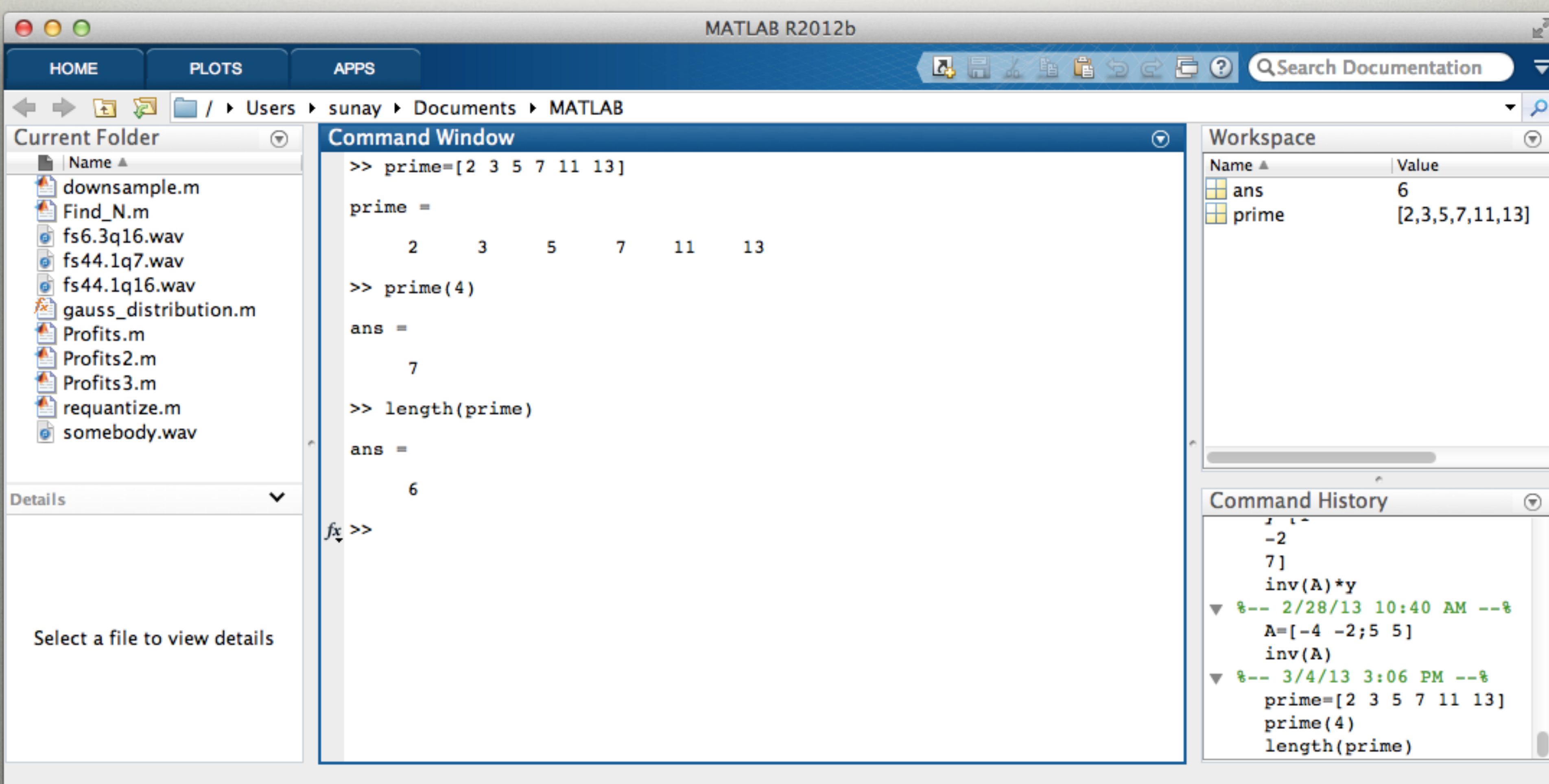
Arrays in MATLAB/ OCTAVE

- The elements of an array are identified by their index.

```
>> prime(4)
ans=
    7
```

- The indices need always be positive
- The number of elements in an array could be retrieved with the length function

Length


MATLAB R2012b
HOME
PLOTS
APPS
Search Documentation
/ Users sunay Documents MATLAB
Current Folder
Name
downsample.m
Find_N.m
fs6.3q16.wav
fs44.1q7.wav
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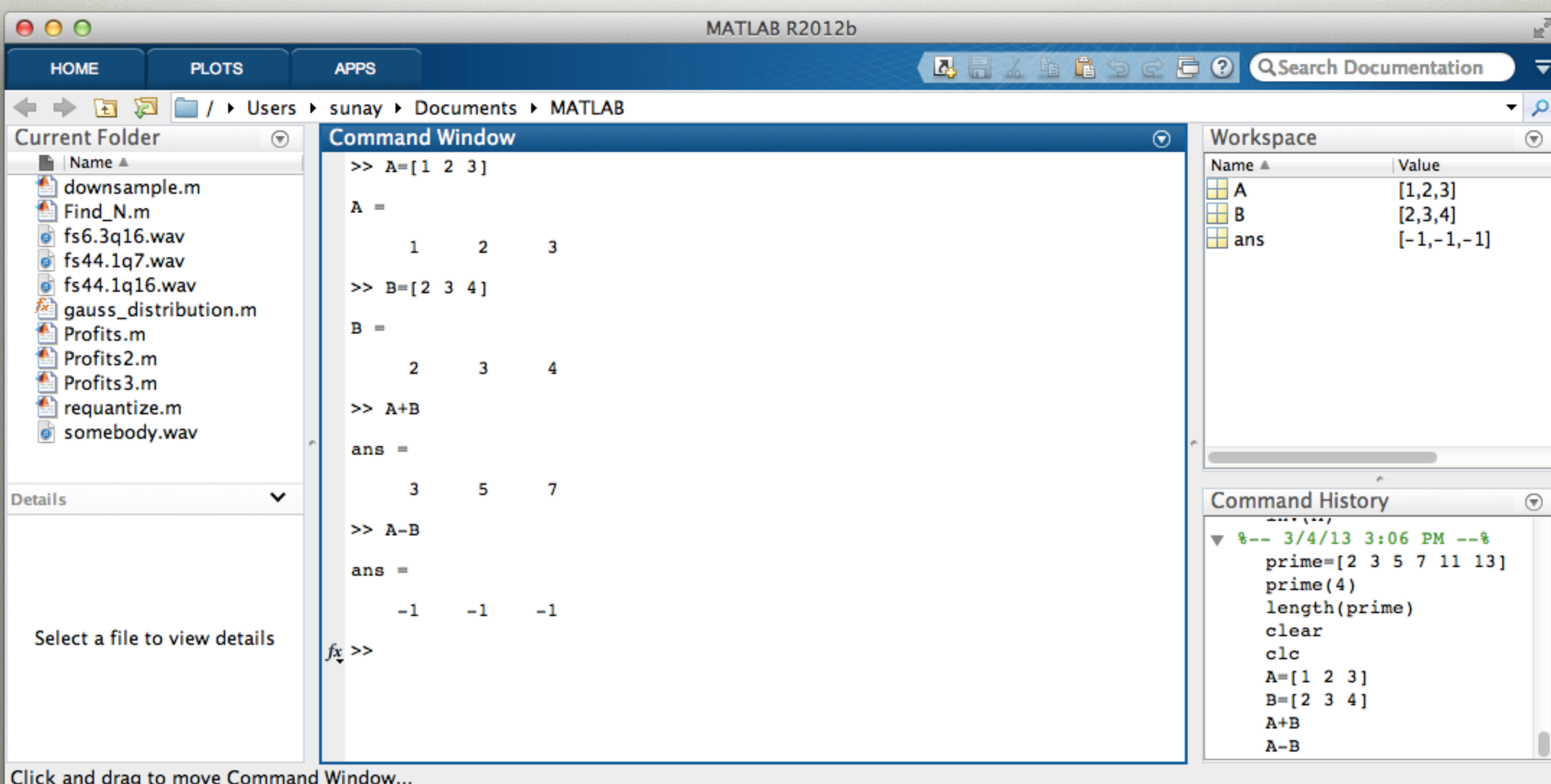
gauss_distribution.m
Profits.m
Profits2.m
Profits3.m
requantize.m
somebody.wav
Details
Select a file to view details
Command Window
>> prime=[2 3 5 7 11 13]
prime =
2 3 5 7 11 13
>> prime(4)
ans =
7
>> length(prime)
ans =
6
>>
Workspace
Name
Value
ans
6
prime
[2,3,5,7,11,13]
Command History
-2
7]
inv(A)*y
%-- 2/28/13 10:40 AM --%
A=[-4 -2;5 5]
inv(A)
%-- 3/4/13 3:06 PM --%
prime=[2 3 5 7 11 13]
prime(4)
length(prime)

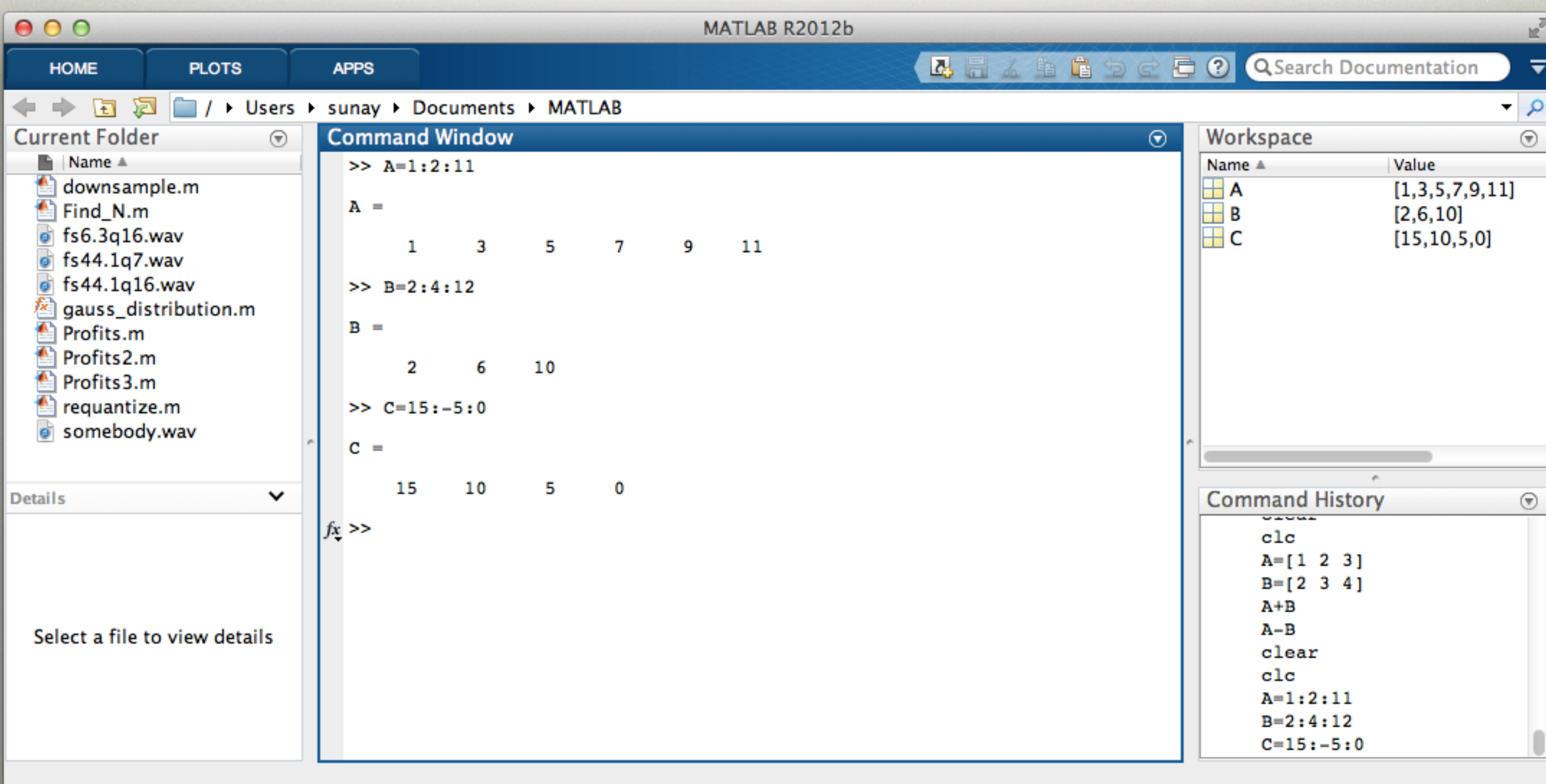
Addition & Subtraction



Arrays in MATLAB/OCTAVE

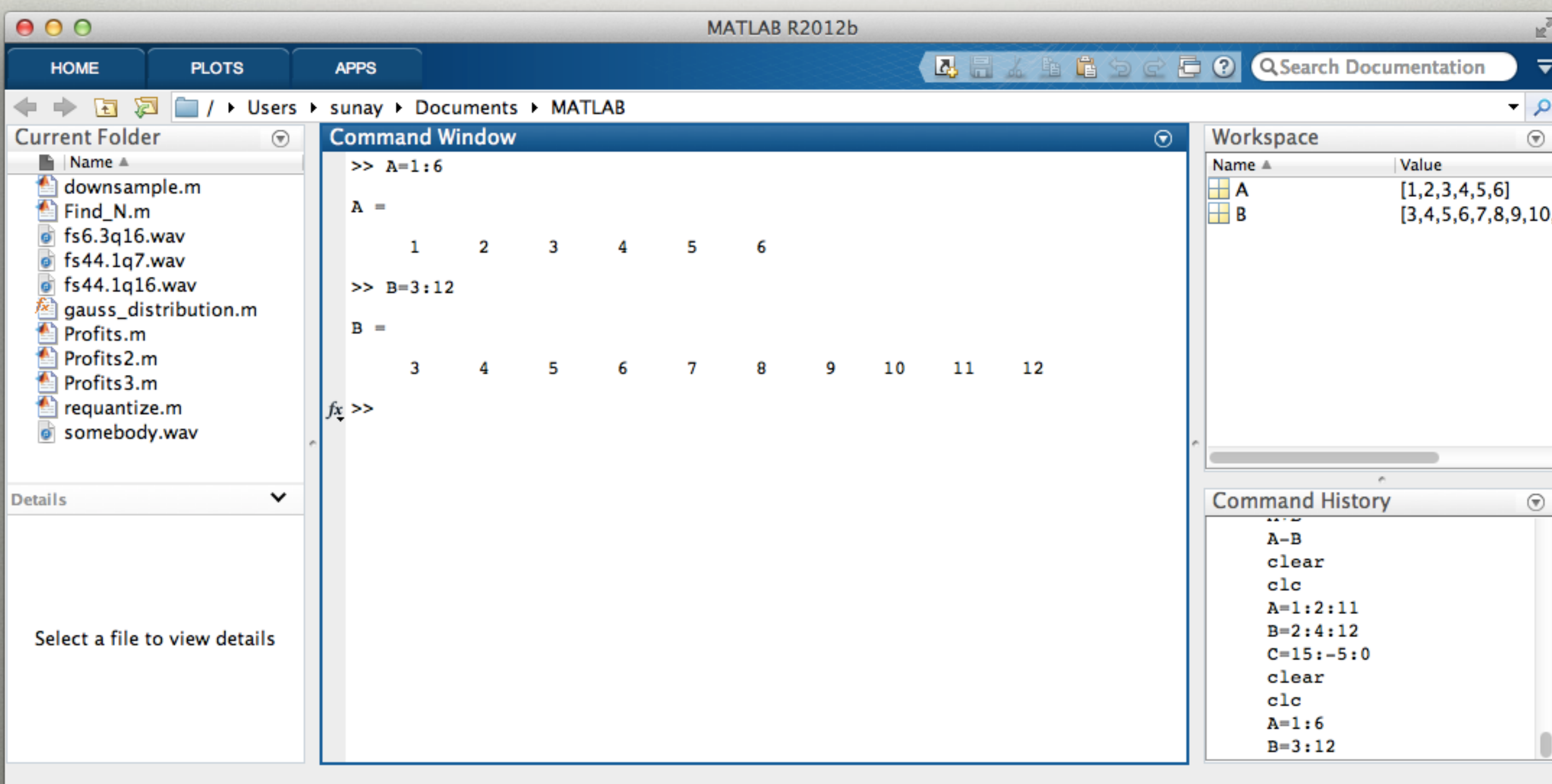
- Arrays of equally spaced elements can be entered by stating the first element, the increment and the last element. For example,

Arrays in MATLAB/ OCTAVE



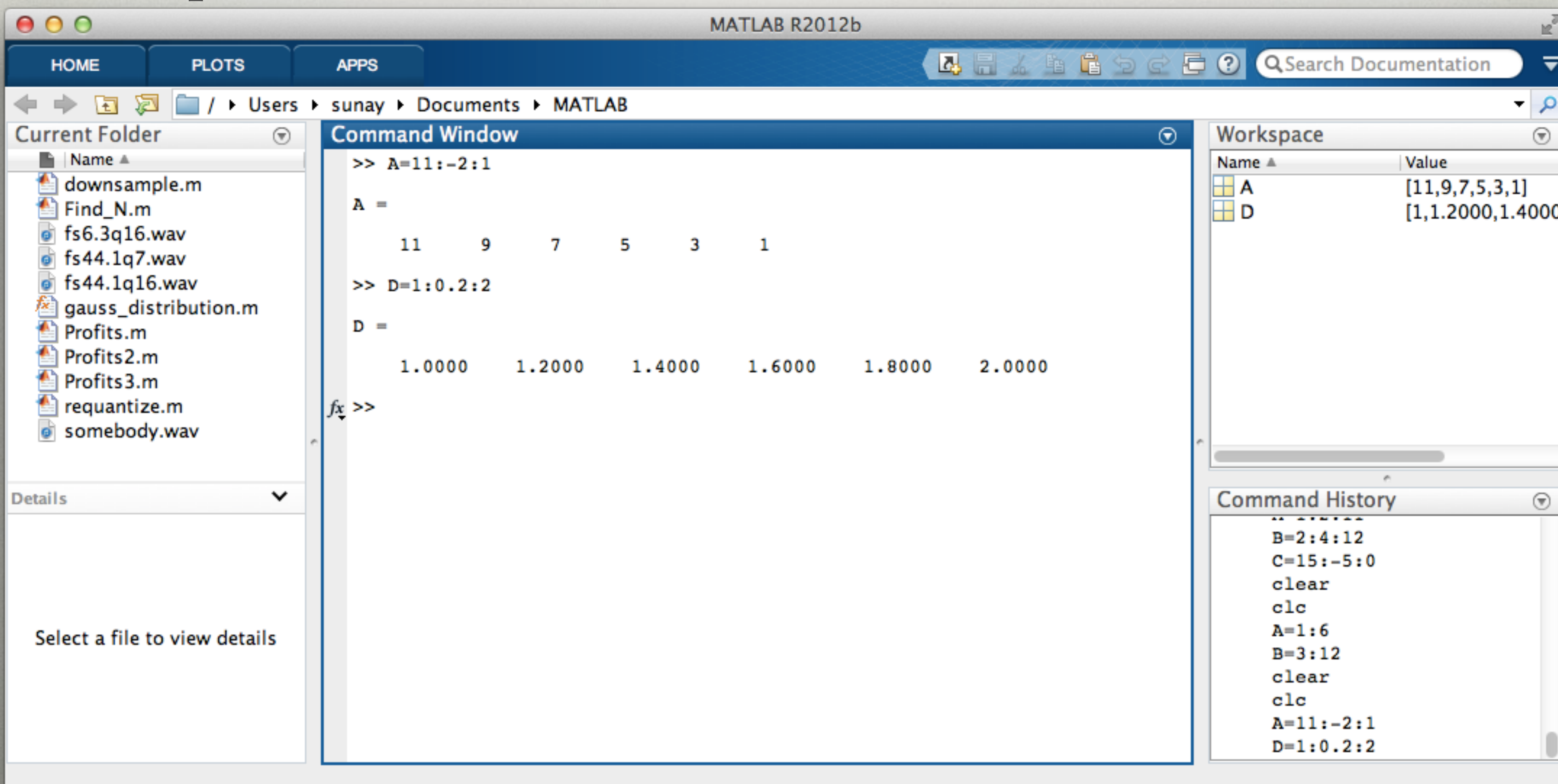
ARRAYS IN MATLAB/ OCTAVE

- When the increment is 1, it can be omitted.



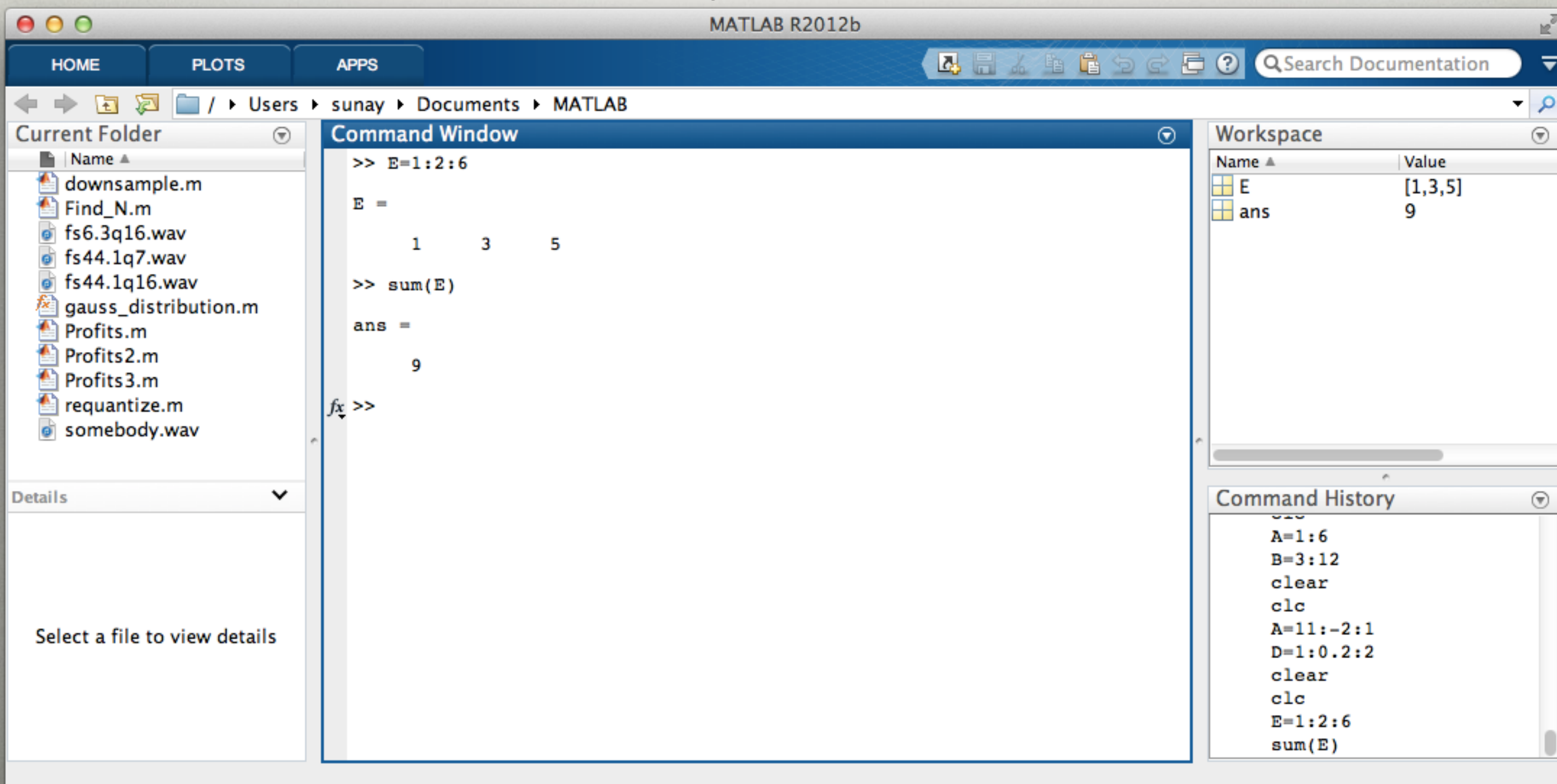
Arrays in MATLAB/ OCTAVE

- Negative and fractional increments are also permitted.



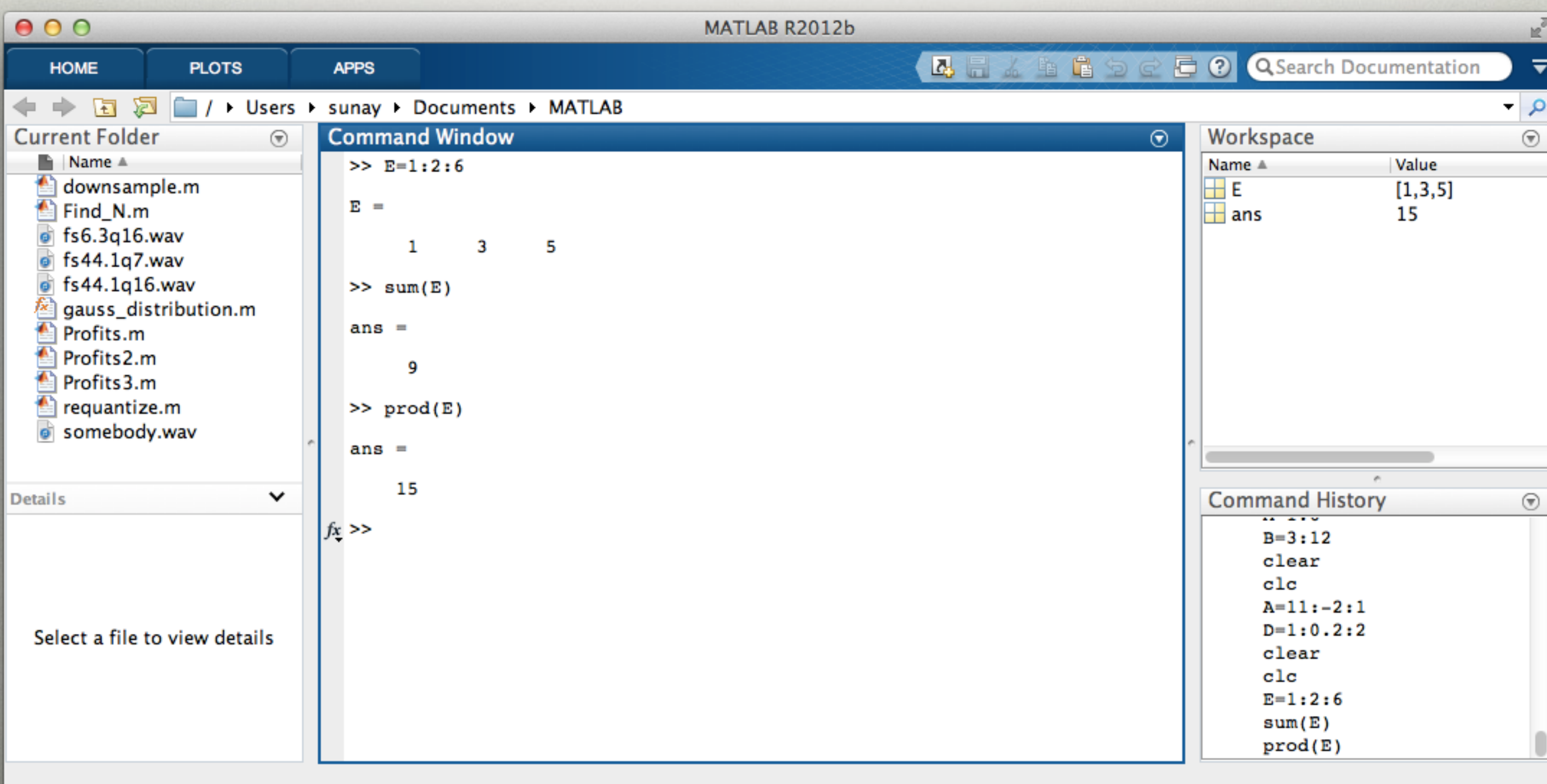
Array Operations

- If we want to calculate the sum of all the elements of the array:



Array Operations

- Similarly, for the product:

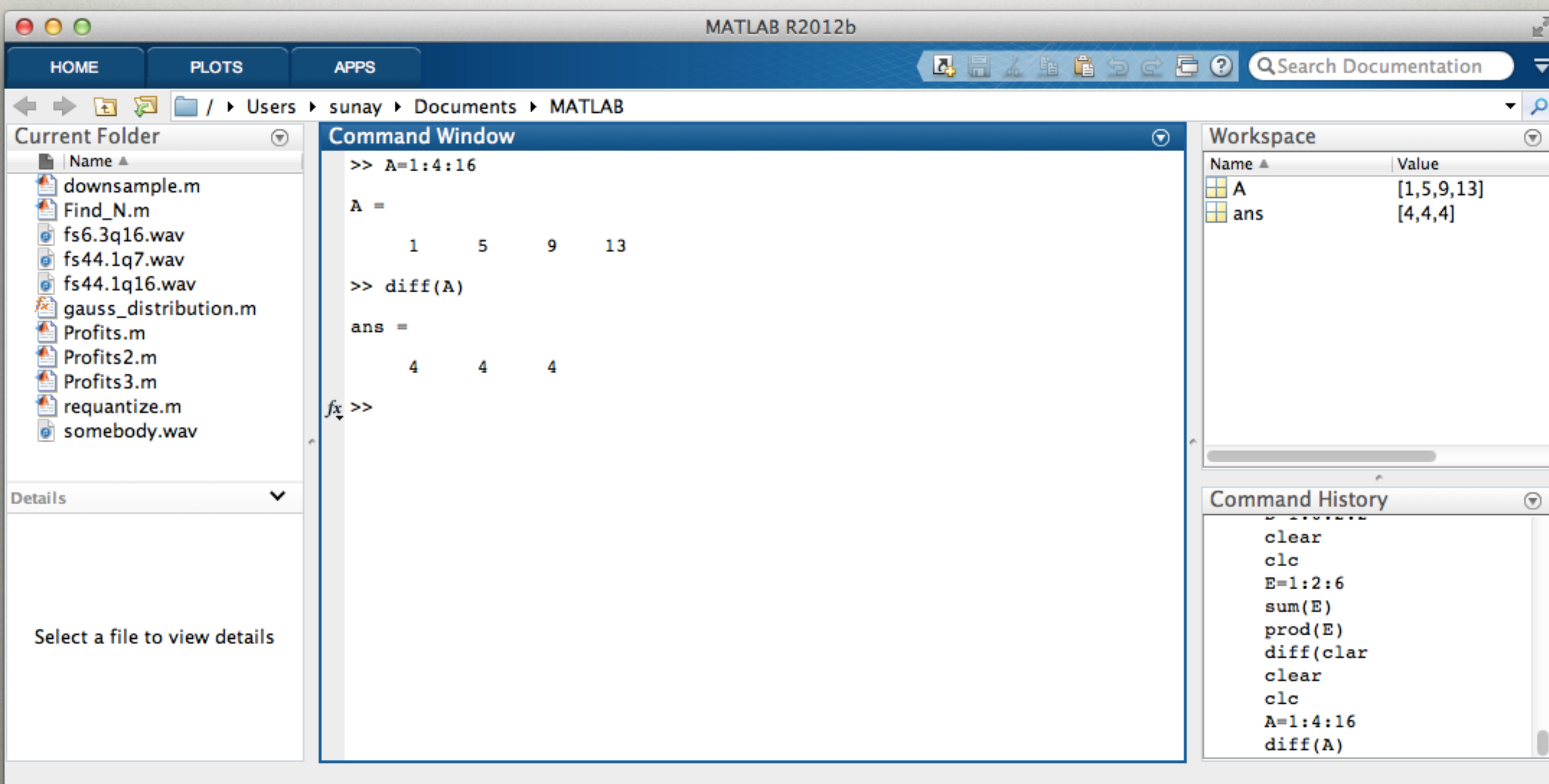


Array Operations

- The "diff" command in MATLAB is used to calculate the difference between the subsequent elements of an array. For example, let $A=[a_1\ a_2\ \ldots\ a_n]$, then

$$\text{diff(A)}=[a_2\text{-}a_1\ a_3\text{-}a_2\ \ldots\ a_n\text{-}a_{n\text{-}1}]$$

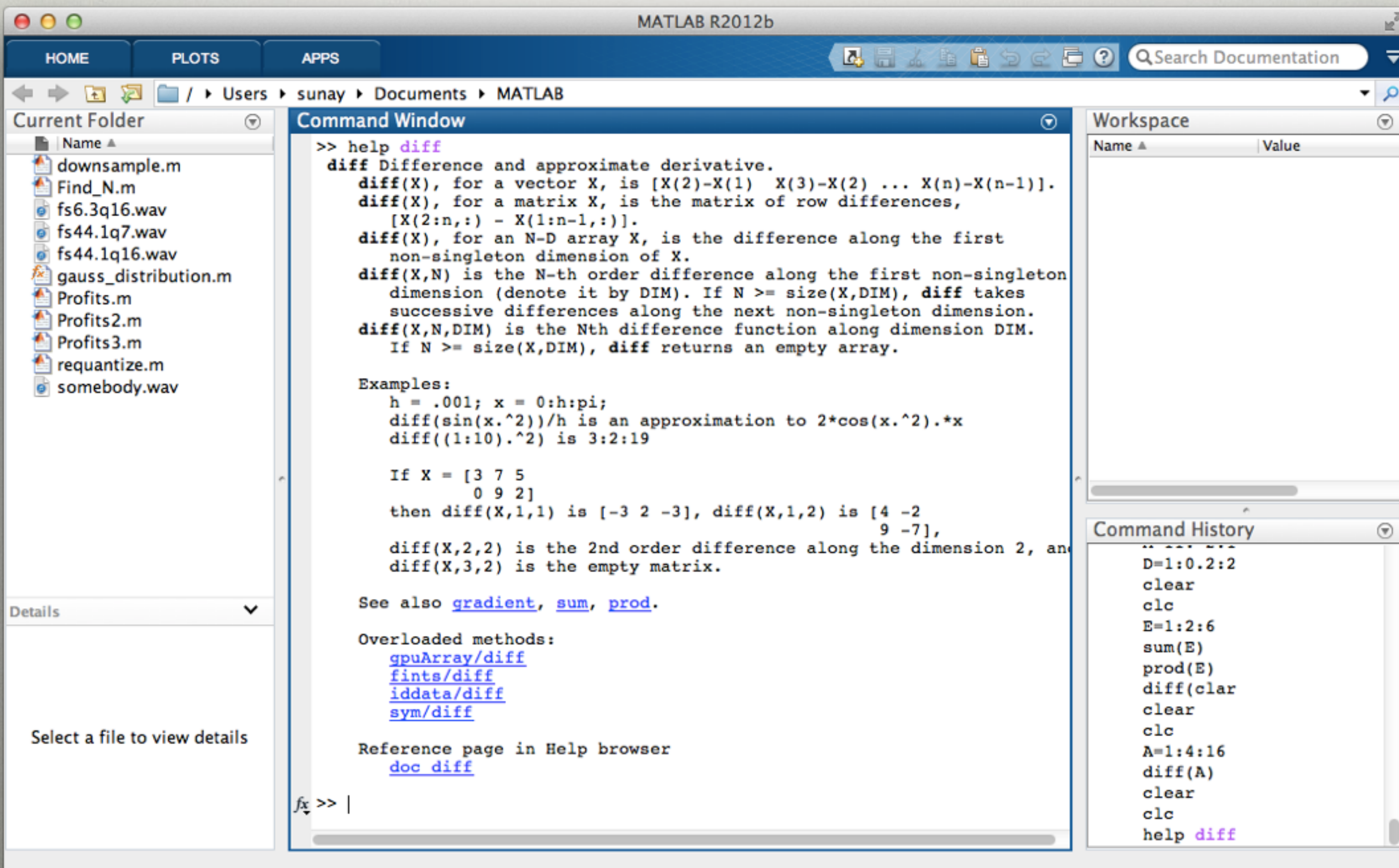
Diff Operator



Help

- The “help” command serves as a reminder about the purpose and syntax of all MATLAB built-in functions

Help


MATLAB R2012b
HOME
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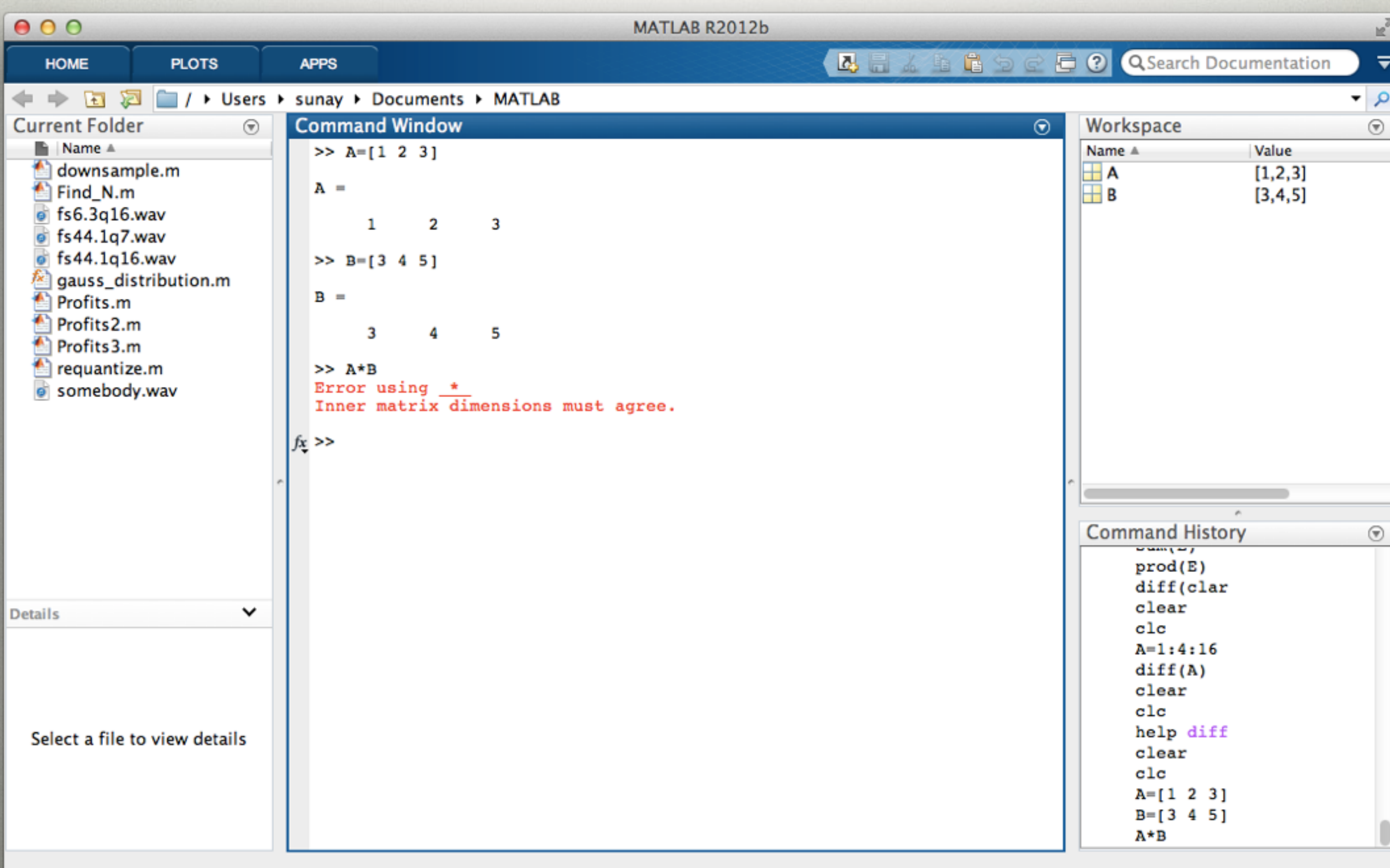
Search Documentation
/ Users sunay Documents MATLAB
Current Folder
Name
downsample.m
Find_N.m
fs6.3q16.wav
fs44.1q7.wav
fs44.1q16.wav
gauss_distribution.m
Profits.m
Profits2.m
Profits3.m
requantize.m
somebody.wav
Details
Select a file to view details
Command Window
>> help diff
diff Difference and approximate derivative.
diff(X), for a vector X, is [X(2)-X(1) X(3)-X(2) ... X(n)-X(n-1)].
diff(X), for a matrix X, is the matrix of row differences,
[X(2:n,:) - X(1:n-1,:)].
diff(X), for an N-D array X, is the difference along the first
non-singleton dimension of X.
diff(X,N) is the N-th order difference along the first non-singleton
dimension (denote it by DIM). If N >= size(X,DIM), diff takes
successive differences along the next non-singleton dimension.
diff(X,N,DIM) is the Nth difference function along dimension DIM.
If N >= size(X,DIM), diff returns an empty array.
Examples:
h = .001; x = 0:h:pi;
diff(sin(x.^2))/h is an approximation to 2*cos(x.^2).*x
diff((1:10).^2) is 3:2:19
If X = [3 7 5
0 9 2]
then diff(X,1,1) is [-3 2 -3], diff(X,1,2) is [4 -2
9 -7],
diff(X,2,2) is the 2nd order difference along the dimension 2, an
diff(X,3,2) is the empty matrix.
See also gradient, sum, prod.
Overloaded methods:
gpuArray/diff
fints/diff
iddata/diff
sym/diff
Reference page in Help browser
doc diff
fx >>
Workspace
Name
Value
Command History
D=1:0.2:2
clear
clc
E=1:2:6
sum(E)
prod(E)
diff(clar
clear
clc
A=1:4:16
diff(A)
clear
clc
help diff

Array Multiplication



Array Multiplication

- For two arrays A and B of equal size, the array multiplication indicated by ".*" is defined by

  $A.*B=[a_1b_1\ a_2b_2\ \dots\ a_nb_n]$

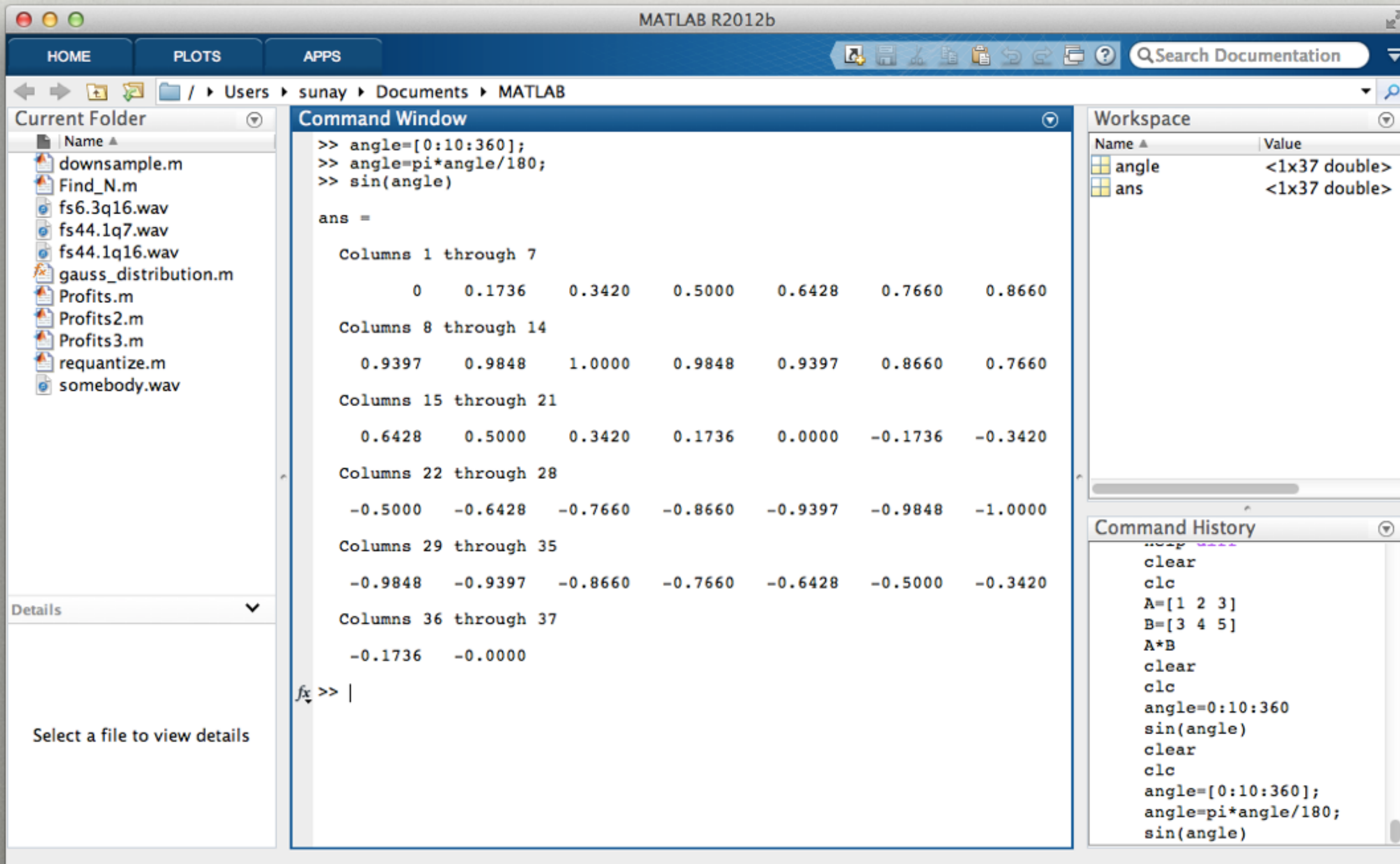
  Similarly

  $A./B=[a_1/b_1\ a_2/b_2\ \dots\ a_n/b_n]$

  $A.\hat{}m=[a_1^m\ a_2^m\ \dots\ a_n^m]$

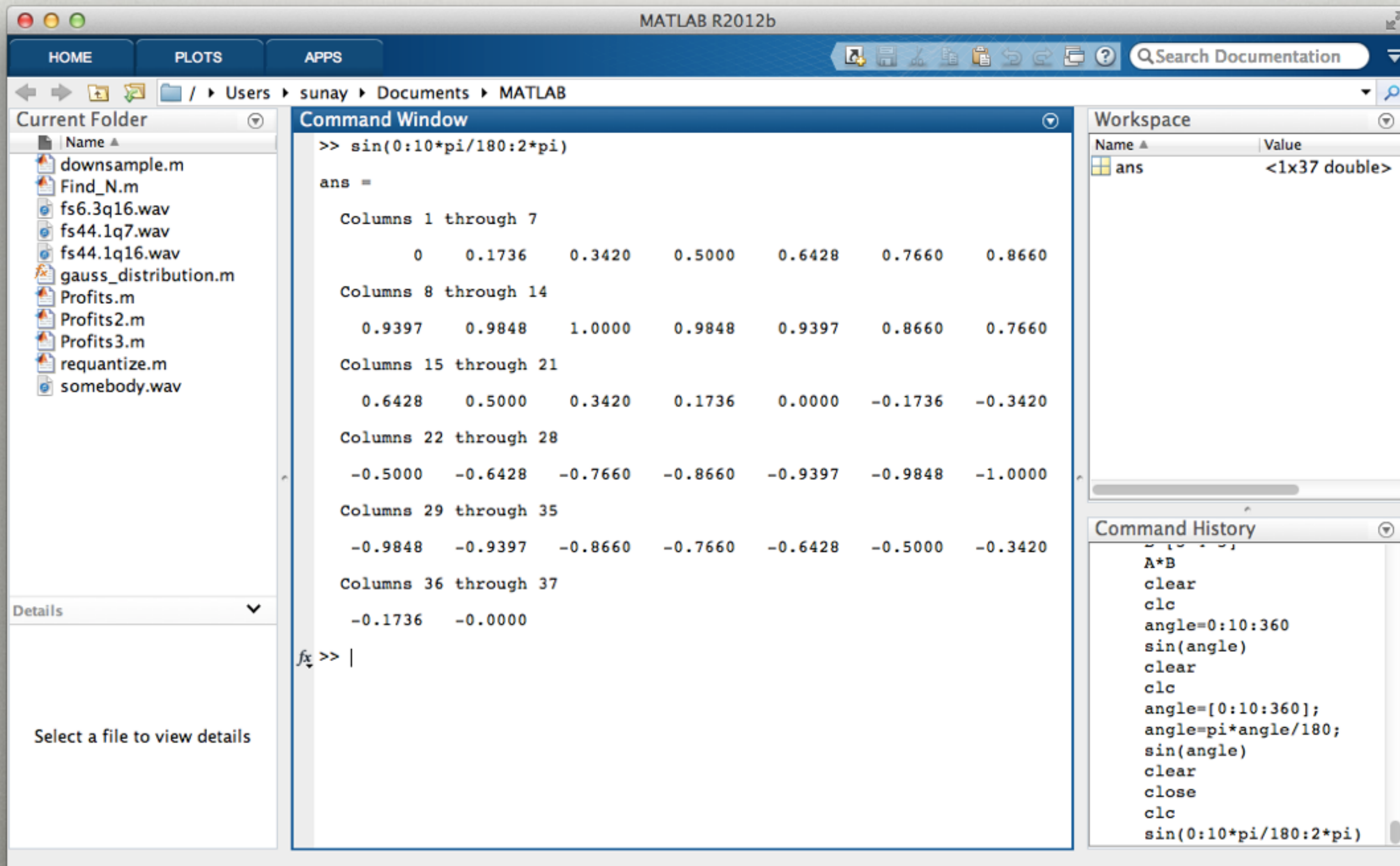
Example

- Let us calculate the sine of the angles 0, 10, 20, 30,...,360^{o}



Example

- We could have used a single line to get to the answer.



Matrices

- A matrix is a multi dimensional array
- It is simply a rectangular array of numbers where each number in the array is called an entry.
- A matrix of m rows and n columns is said to have a dimension of mxn.

Scalar Multiplication

$$c \cdot \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ & & \vdots & \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} = \begin{bmatrix} c \cdot a_{11} & c \cdot a_{12} & \cdots & c \cdot a_{1n} \\ c \cdot a_{21} & c \cdot a_{22} & \cdots & c \cdot a_{2n} \\ & & \vdots & \\ c \cdot a_{m1} & c \cdot a_{m2} & \cdots & c \cdot a_{mn} \end{bmatrix}$$

Matrix Addition

$$\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ & & \vdots & \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ & & \vdots & \\ b_{m1} & b_{m2} & \cdots & b_{mn} \end{bmatrix}$$

$$= \begin{bmatrix} a_{11}+b_{11} & a_{12}+b_{12} & \cdots & a_{1n}+b_{1n} \\ a_{21}+b_{21} & a_{22}+b_{22} & \cdots & a_{2n}+b_{2n} \\ & & \vdots & \\ a_{m1}+b_{m1} & a_{m2}+b_{m2} & \cdots & a_{mn}+b_{mn} \end{bmatrix}$$

Matrix Multiplication

$$\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ & & \vdots & \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \cdot \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1k} \\ b_{21} & b_{22} & \cdots & b_{2k} \\ & & \vdots & \\ b_{n1} & b_{n2} & \cdots & b_{nk} \end{bmatrix}$$

$$= \begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1k} \\ c_{21} & c_{22} & \cdots & c_{2k} \\ & & \vdots & \\ c_{m1} & c_{m2} & \cdots & c_{mk} \end{bmatrix}$$

In general AB $\neq$ BA

Alternative Approach

- Let us partition the first matrix, A into m row matrices such that

$$\left[\begin{array}{cccc} a_{11} & a_{12} & \cdots & a_{1n} \\ \hline a_{21} & a_{22} & \cdots & a_{2n} \\ \hline & & \vdots & \\ \hline a_{m1} & a_{m2} & \cdots & a_{mn} \end{array}\right] = \left[\begin{array}{c} r_1 \\ \hline r_2 \\ \hline \vdots \\ \hline r_m \end{array}\right]$$

Then $AB = \left[\begin{array}{c} r_1 B \\ \hline r_2 B \\ \hline \vdots \\ \hline r_m B \end{array}\right]$

Alternative Approach

- Alternatively, let us partition the second matrix B into k column matrices such that

$$\left[\begin{array}{c|c|c|c} b_{11} & b_{12} & \cdots & b_{1k} \\ b_{21} & b_{22} & \cdots & b_{2k} \\ & & \vdots & \\ b_{n1} & b_{n2} & \cdots & b_{nk} \end{array}\right] = \left[\begin{array}{c|c|c|c} c_1 & c_2 & \cdots & c_k \end{array}\right]$$

Then $AB = \left[\begin{array}{c|c|c|c} Ac_1 & Ac_2 & \cdots & Ac_k \end{array}\right]$

Transpose

- If A is an mxn matrix, then the transpose of A, denoted by A^T is an nxm matrix that is obtained by interchanging the rows and columns of A.
- If A=A^T, the matrix is said to be symmetric.

Trace

- If A is a square matrix of size nxn, then the trace of A, denoted by $tr(A)$, is the sum of entries of the main diagonal.

$$tr(A) = a_{11} + a_{22} + \cdots + a_{nn}$$

Matrix Algebra with MATLAB

- All variables in MATLAB are considered as matrices.
- A simple scalar is considered as a 1 x 1 matrix.
- For MATLAB variables containing higher dimensions, certain special rules are required to deal with them.

Entering a Matrix in MATLAB

$$\mathbf{A} = \begin{bmatrix} 2 \ -3 \ 5 \\ -1 \ 4 \ 6 \end{bmatrix}$$

MATLAB Format

```
>> A = [2 -3 5; -1 4 5]
A =
     2    -3     5
    -1     4     5
```

Entering a Row Vector in MATLAB

$$\mathbf{x} = [1\ 4\ 7]$$

MATLAB Format

```
>> x = [1 4 7]
x =
    1    4    7
```

Entering a Column Vector in MATLAB

$$\mathbf{x} = \begin{bmatrix} 1 \\ 4 \\ 7 \end{bmatrix}$$

MATLAB Format

```
>> x = [1; 4; 7]
x =
    1
    4
    7
```

Alternate Way to Enter a Column Vector

```
>> x = [1 4 7]'
x =
    1
    4
    7
```

Matrix Addition and Subtraction

Matrix addition and subtraction with MATLAB are achieved in the same manner as with scalars **provided** that the matrices have the same size. Typical expressions are shown below.

```
>> C = A + B
```

```
>> D = A - B
```

Error Messages

MATLAB has many error messages that indicate problems with operations. If the matrices have different sizes, the message is

??? Error using ==> ±

Matrix dimensions must agree.

Matrix Multiplication

Matrix multiplication with MATLAB is achieved in the same manner as with scalars **provided** that the number of columns of the first matrix is equal to the number of rows of the second matrix. A typical expression is

```
>> E = A*B
```

Elementwise Multiplication

Multiplies each **corresponding** element of A and B.

```
>> F=A.*B
```

```
>> F=B.*A
```

Elementwise Multiplication

If there are more than two matrices for which array multiplication is desired, the periods should follow all but the last one in the expression; e. g., A.*B.*C in the case of three matrices. Alternately, nesting can be used; e.g. (A.*B).*C for the case of three matrices.

Elementwise Operations

Example: Raising each element of A to the 3rd power

```
>> B = A.^3
```

Example: Enter the matrices below in MATLAB. They will be used in the next several examples.

$$\mathbf{A} = \begin{bmatrix} 2 & -3 & 5 \\ -1 & 4 & 6 \end{bmatrix} \qquad \mathbf{B} = \begin{bmatrix} 2 & 1 \\ 7 & -4 \\ 3 & 1 \end{bmatrix}$$

```
>> A = [2 -3 5; -1 4 6];

>> B = [2 1; 7 -4; 3 1];
```

Example: Determine the transpose of B and denote it as C.

```
>> C = B'

C =

     2     7     3
     1    -4     1
```

The 3 x 2 matrix has been converted to a 2 x 3 matrix.

Example: Determine the sum of A and C and denote it as D.

```
>> D = A + C

D =

     4     4     8
     0     0     7
```

Example: Determine the product of A and B with A first.

```
>> A*B

ans =

   -2   19
   44  -11
```

Example: Determine the product of B and A with B first.

```
>> B*A

ans =

     3    -2    16
    18   -37    11
     5    -5    21
```

Example: Determine the array product of A and C and denote it as E.

```
>> E = A.*C

E =

     4   -21    15
    -1   -16     6
```

MIDTERM 1
OCTOBER 24,
SATURDAY, 12:30-15:30