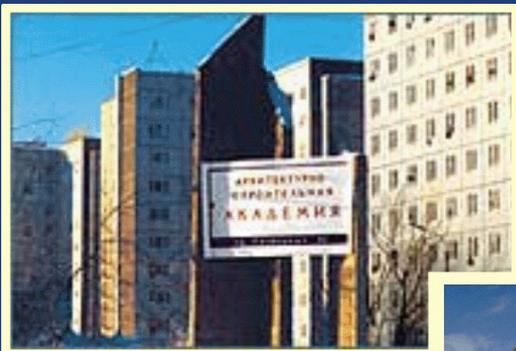


**ФЕДЕРАЛЬНОЕ АГЕНТСТВО ПО ОБРАЗОВАНИЮ**  
Федеральное государственное образовательное учреждение  
высшего профессионального образования



**Сибирский федеральный университет**





С. В. Якунина

# Математическое программное обеспечение

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Я49

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Подп. к использованию 01.09.2008

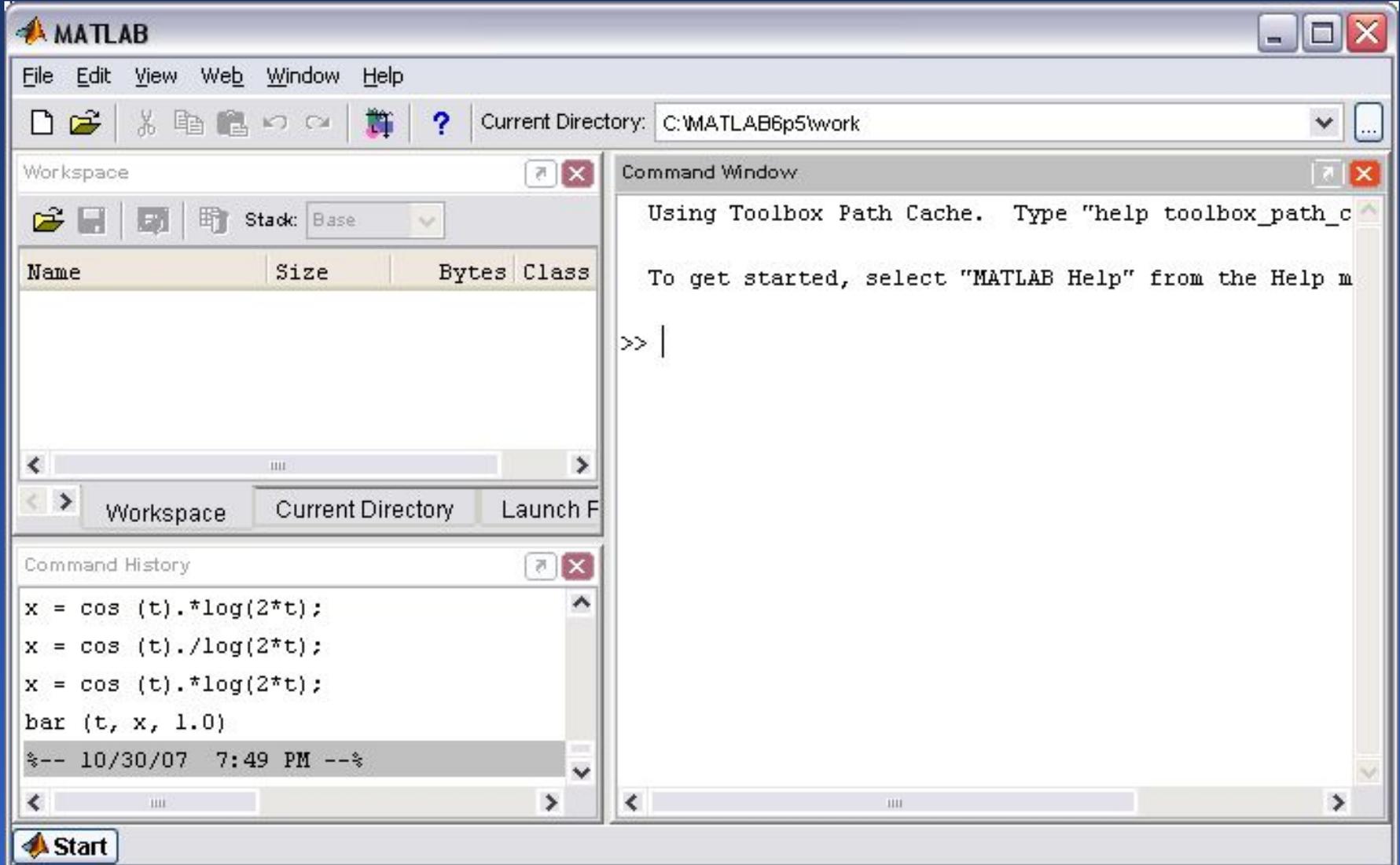
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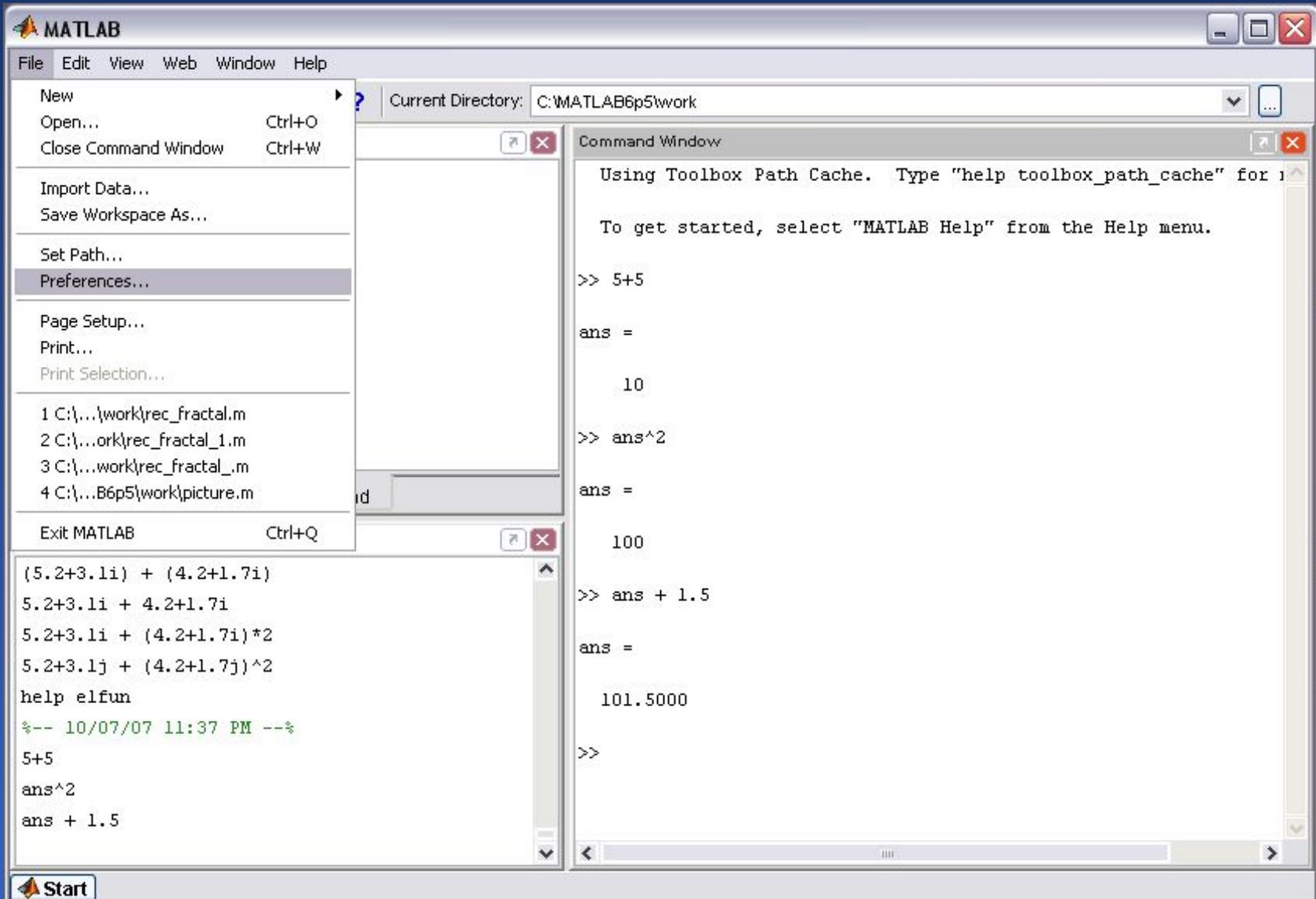
# Математические пакеты

- *MatLab – MATrix LABoratory* (матричная лаборатория). Эта система предназначена для осуществления любых численных расчетов и моделирования технических и физических систем, а также выполнения научных и инженерных расчетов при работе с массивами данных;
- *MathCAD* является интегрированной системой программирования, ориентированной на проведение математических и инженерно-технических расчетов.

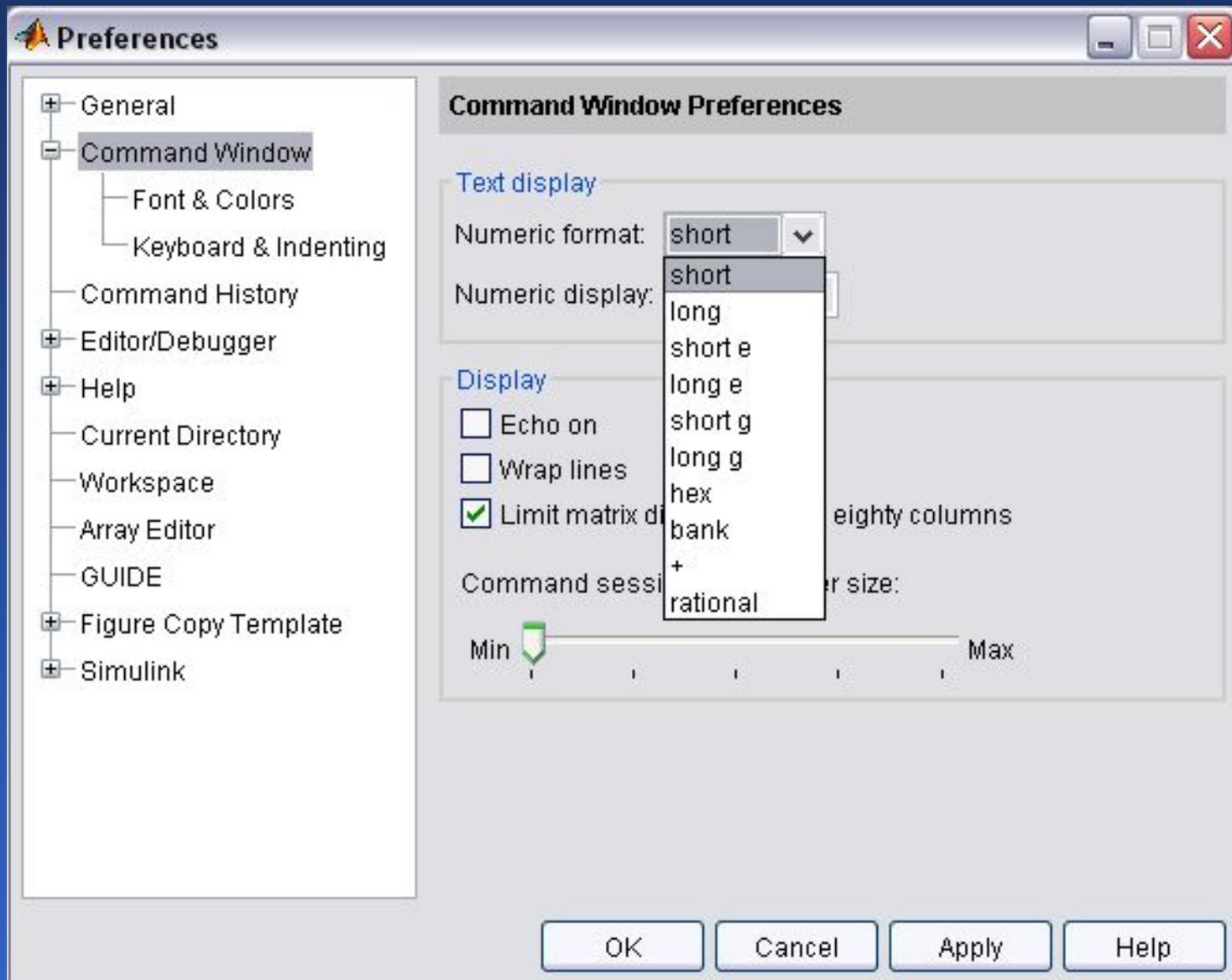
# Начало работы в *MatLab* из командной строки



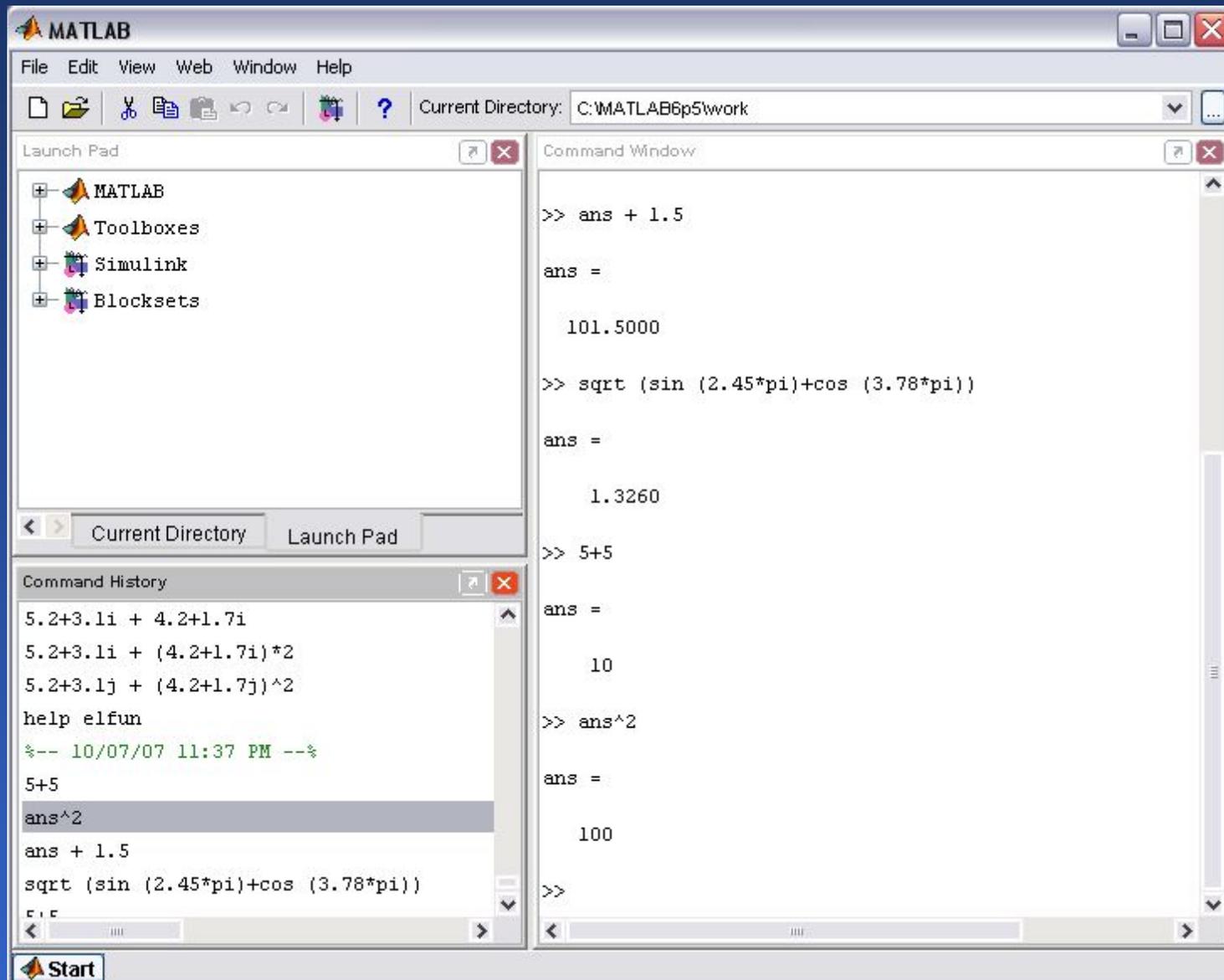
# Формат вывода результата вычислений



# Command Window Preferences



# Вычисление элементарных функций



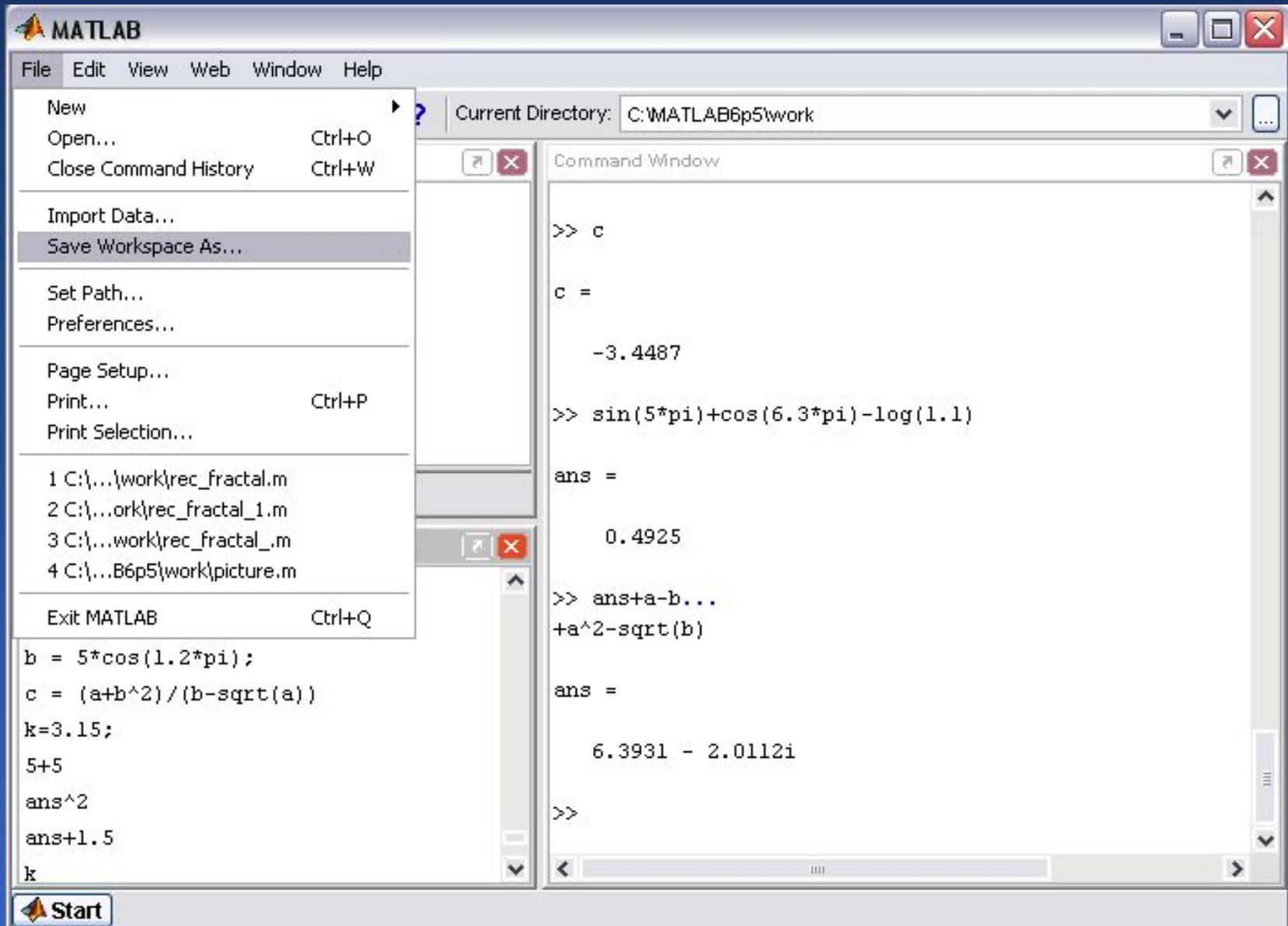
# Присвоение переменных

The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The Launch Pad on the left shows MATLAB, Toolboxes, Simulink, and Blocksets. The Command Window on the right displays the help for rounding and remainder functions:

fix	- Round towards zero.
floor	- Round towards minus infinity.
ceil	- Round towards plus infinity.
round	- Round towards nearest integer.
mod	- Modulus (signed remainder after division)
rem	- Remainder after division.
sign	- Signum.

The Command History on the left shows the following commands: -10/0, 0/0, help elfun, k=3.15, and k=3.15;. The Command Window shows the execution of k=3.15, resulting in k = 3.1500, and the execution of k=3.15; and two empty prompts >>.

# Сохранение рабочей среды



# Просмотр переменных

The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The Workspace window displays a table of variables:

Name	Size	Bytes	Class
a	1x1	8	double array
b	1x1	8	double array
c	1x1	8	double array
k	1x1	8	double array

A context menu is open over the 'k' variable, showing options like Open..., Graph, Select All, Import Data..., Save Selection As..., Save Workspace As..., Copy, Delete, Clear Workspace, and Rename. The Command Window shows the following commands and output:

```
-4.0451
>> c = (a+b^2)/(b-sqrt(a))
c =
-3.4487
>> k=3.15;
>> whos
Name      Size      Bytes  Class
a         1x1         8  double array
b         1x1         8  double array
c         1x1         8  double array
k         1x1         8  double array
Grand total is 4 elements using 32 bytes
>>
```

The Command History window shows the following commands:

```
k=3.15;
c = (a+b^2)/(b-sqrt(a))
a = 1/sin(0.5*pi);
b = 5*cos(1.2*pi);
c = (a+b^2)/(b-sqrt(a))
a = 1/sin(0.5*pi)
b = 5*cos(1.2*pi);
```

# Вектор-столбцы и вектор-строки

The image displays the MATLAB software interface. The **Workspace** window shows a table of variables:

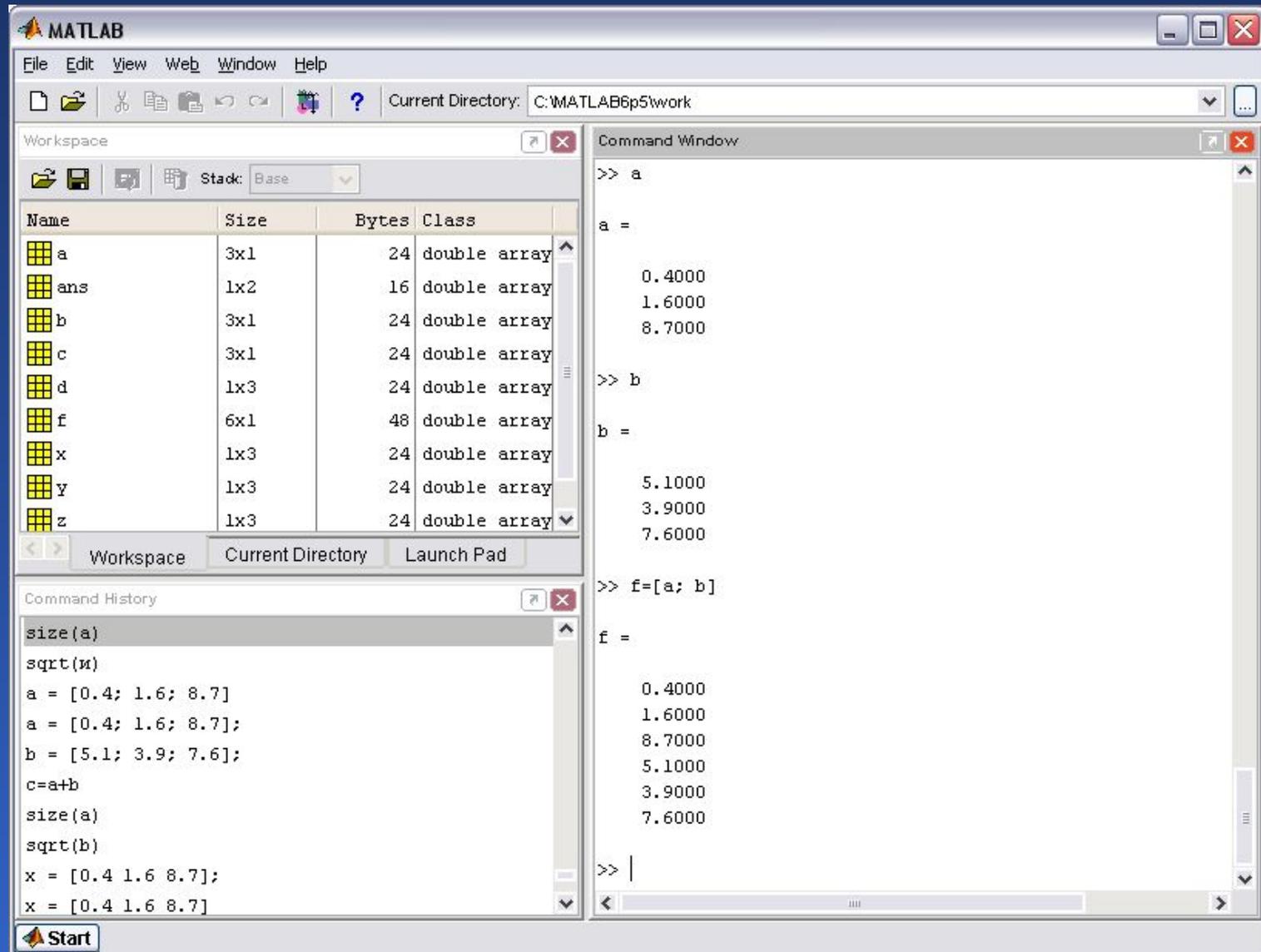
Name	Size	Bytes	Class
a	3x1	24	double array
ans	1x2	16	double array
b	3x1	24	double array
c	3x1	24	double array
d	1x3	24	double array
x	1x3	24	double array
y	1x3	24	double array
z	1x3	24	double array

The **Command Window** shows the following commands and outputs:

```
>> x = [0.4 1.6 8.7];  
>> x = [0.4 1.6 8.7]  
  
x =  
    0.4000    1.6000    8.7000  
  
>> x = [0.4, 1.6, 8.7]  
  
x =  
    0.4000    1.6000    8.7000  
  
>> x = [0.4, 1.6, 8.7];  
>> y = [5.1 3.9 7.6];  
>> z=x+y  
  
z =  
    5.5000    5.5000   16.3000  
  
>> size(x)  
  
ans =  
     1     3  
  
>> d=sin(z)  
  
d =  
   -0.7055   -0.7055   -0.5581  
  
>> |
```

The **Command History** window shows a list of previous commands, including `size(a)`, `sqrt(x)`, `a = [0.4; 1.6; 8.7]`, `b = [5.1; 3.9; 7.6]`, `c=a+b`, `size(a)`, `sqrt(b)`, and several assignments of `x`.

# Сцепление вектор-столбцов



The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The Workspace window displays a table of variables:

Name	Size	Bytes	Class
a	3x1	24	double array
ans	1x2	16	double array
b	3x1	24	double array
c	3x1	24	double array
d	1x3	24	double array
f	6x1	48	double array
x	1x3	24	double array
y	1x3	24	double array
z	1x3	24	double array

The Command Window shows the following commands and outputs:

```
>> a
a =
    0.4000
    1.6000
    8.7000

>> b
b =
    5.1000
    3.9000
    7.6000

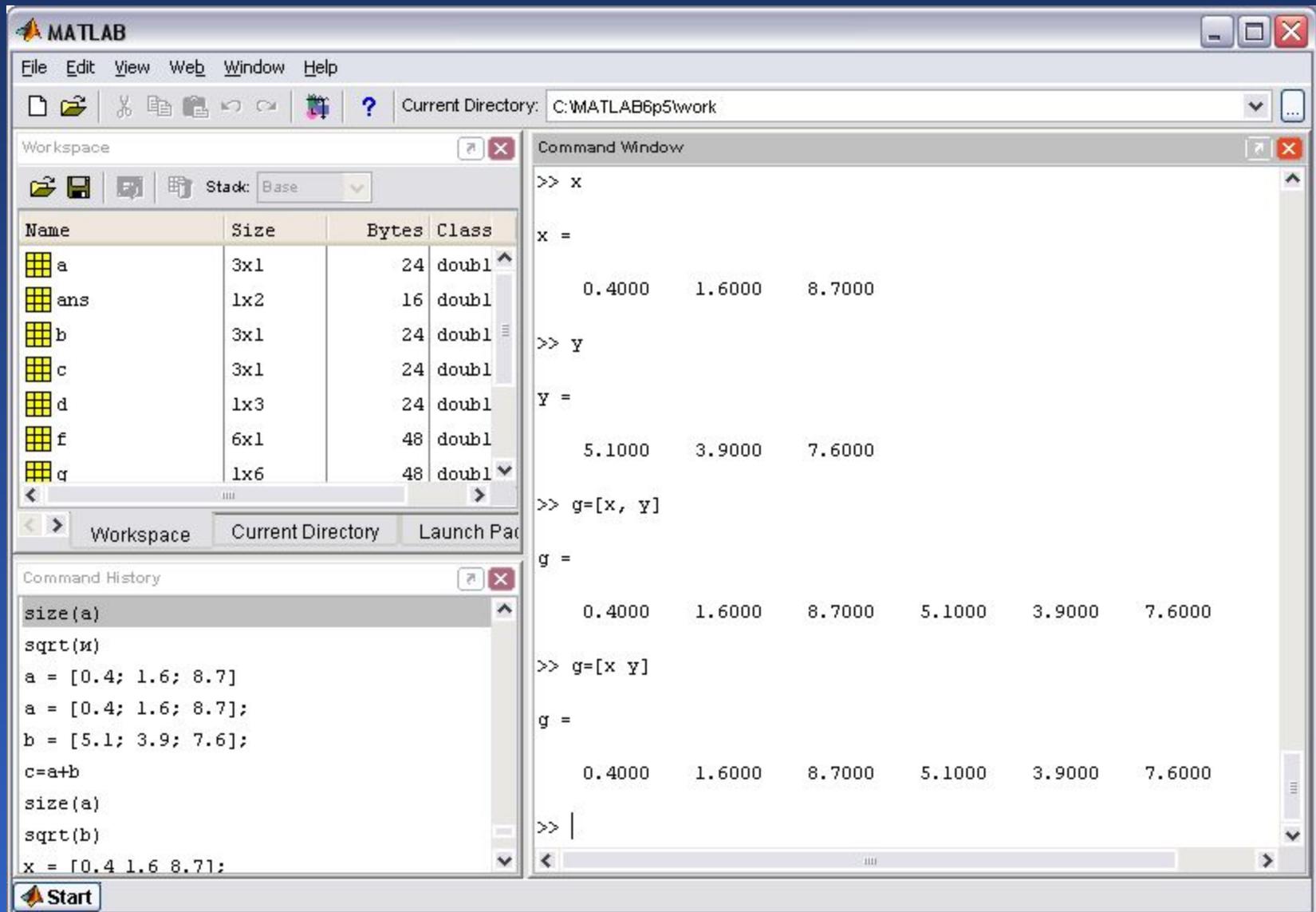
>> f=[a; b]
f =
    0.4000
    1.6000
    8.7000
    5.1000
    3.9000
    7.6000

>> |
```

The Command History window shows the following commands:

```
size(a)
sqrt(x)
a = [0.4; 1.6; 8.7]
a = [0.4; 1.6; 8.7];
b = [5.1; 3.9; 7.6];
c=a+b
size(a)
sqrt(b)
x = [0.4 1.6 8.7];
x = [0.4 1.6 8.7]
```

# Сцепление вектор-строк



The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The Workspace window displays a table of variables:

Name	Size	Bytes	Class
a	3x1	24	doubl
ans	1x2	16	doubl
b	3x1	24	doubl
c	3x1	24	doubl
d	1x3	24	doubl
f	6x1	48	doubl
g	1x6	48	doubl

The Command Window shows the following commands and outputs:

```
>> x
x =
    0.4000    1.6000    8.7000

>> y
y =
    5.1000    3.9000    7.6000

>> g=[x, y]
g =
    0.4000    1.6000    8.7000    5.1000    3.9000    7.6000

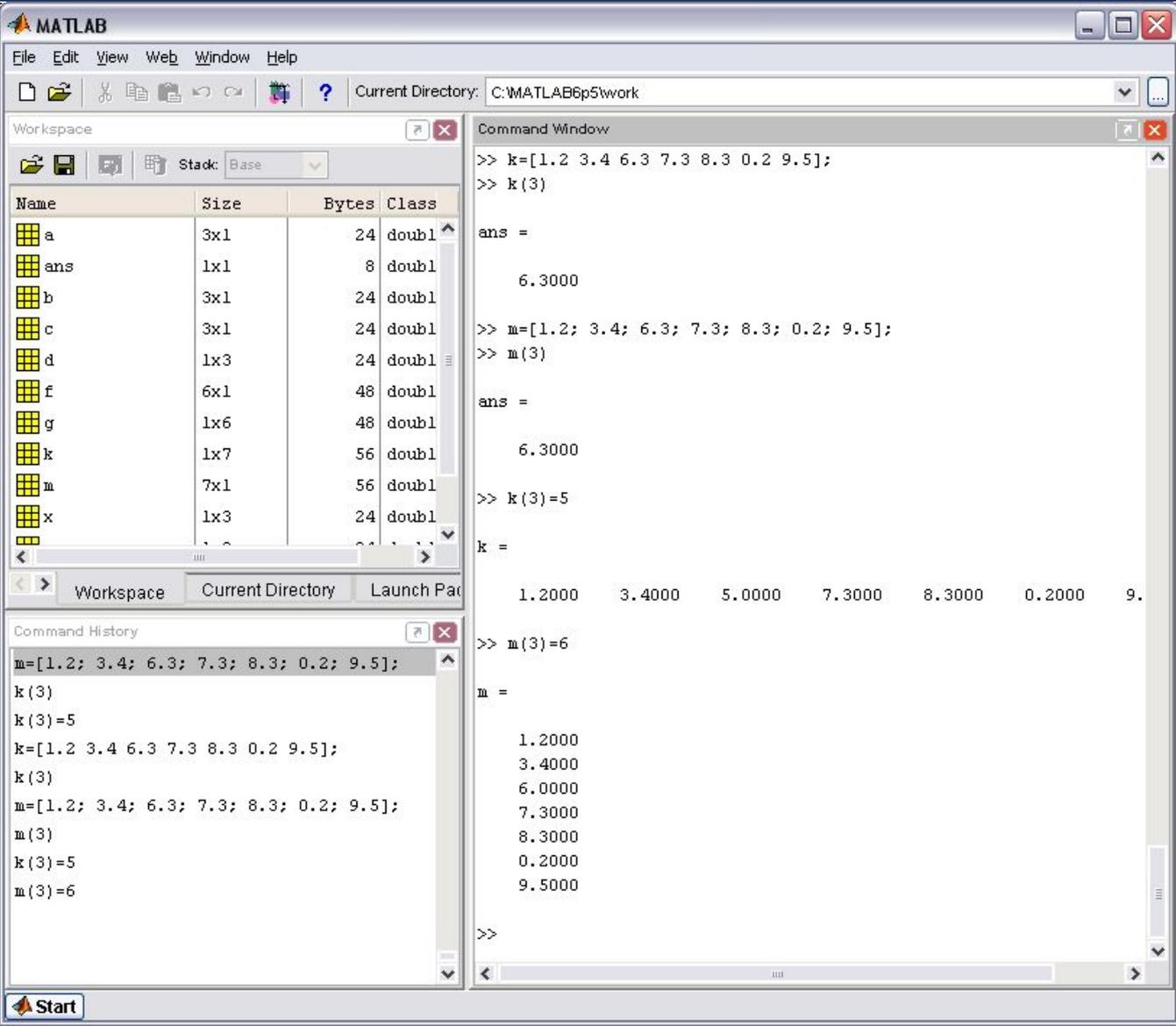
>> g=[x y]
g =
    0.4000    1.6000    8.7000    5.1000    3.9000    7.6000

>> |
```

The Command History window shows the following commands:

```
size(a)
sqrt(m)
a = [0.4; 1.6; 8.7]
a = [0.4; 1.6; 8.7];
b = [5.1; 3.9; 7.6];
c=a+b
size(a)
sqrt(b)
x = [0.4 1.6 8.7];
```

# Обращение к элементам вектора



The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The workspace window displays a table of variables:

Name	Size	Bytes	Class
a	3x1	24	doubl
ans	1x1	8	doubl
b	3x1	24	doubl
c	3x1	24	doubl
d	1x3	24	doubl
f	6x1	48	doubl
g	1x6	48	doubl
k	1x7	56	doubl
m	7x1	56	doubl
x	1x3	24	doubl

The Command Window shows the following commands and outputs:

```
>> k=[1.2 3.4 6.3 7.3 8.3 0.2 9.5];  
>> k(3)  
ans =  
    6.3000  
  
>> m=[1.2; 3.4; 6.3; 7.3; 8.3; 0.2; 9.5];  
>> m(3)  
ans =  
    6.3000  
  
>> k(3)=5  
k =  
    1.2000    3.4000    5.0000    7.3000    8.3000    0.2000    9.5000  
  
>> m(3)=6  
m =  
    1.2000  
    3.4000  
    6.0000  
    7.3000  
    8.3000  
    0.2000  
    9.5000  
  
>>
```

The Command History window shows the following commands:

```
m=[1.2; 3.4; 6.3; 7.3; 8.3; 0.2; 9.5];  
k(3)  
k(3)=5  
k=[1.2 3.4 6.3 7.3 8.3 0.2 9.5];  
k(3)  
m=[1.2; 3.4; 6.3; 7.3; 8.3; 0.2; 9.5];  
m(3)  
k(3)=5  
m(3)=6
```

# Индексация при помощи вектора

The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The workspace window displays a table of variables:

Name	Size	Bytes	Class
a	3x1	24	doubl
ans	1x1	8	doubl
b	3x1	24	doubl
c	3x1	24	doubl
d	1x3	24	doubl
f	6x1	48	doubl
m	1x6	48	doubl

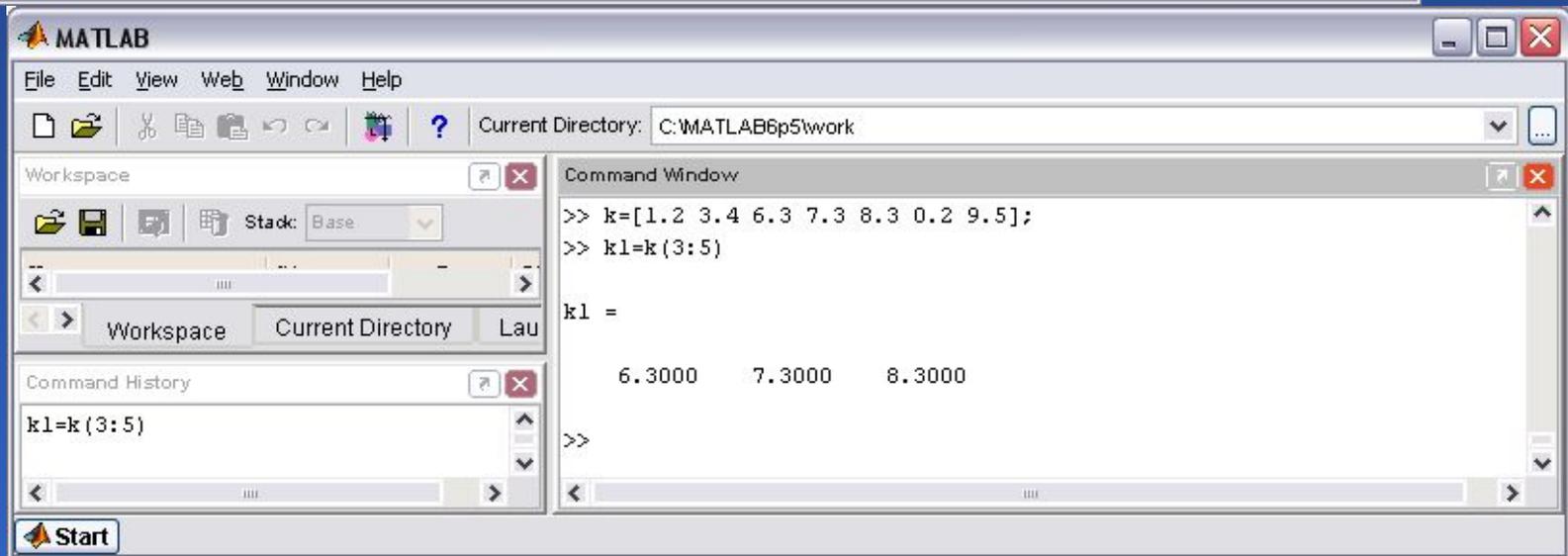
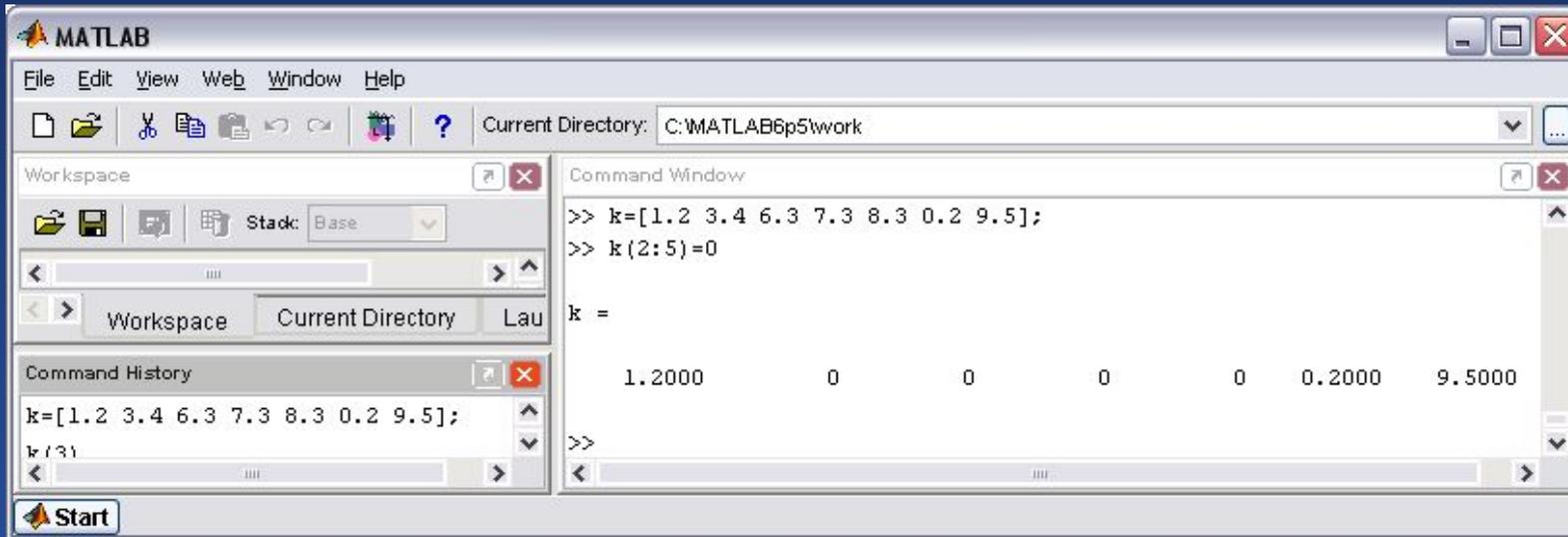
The Command Window shows the following code and output:

```
>> k=[1.2 3.4 6.3 7.3 8.3 0.2 9.5];  
>> o=[k(5); k(1); k(4)]  
  
o =  
  
    8.3000  
    1.2000  
    7.3000  
  
>> ind=[5; 1; 4];  
>> w=k(ind)  
  
w =  
  
    8.3000    1.2000    7.3000  
  
>> ind=[5 1 4];  
>> w=k(ind)  
  
w =  
  
    8.3000    1.2000    7.3000  
  
>> |
```

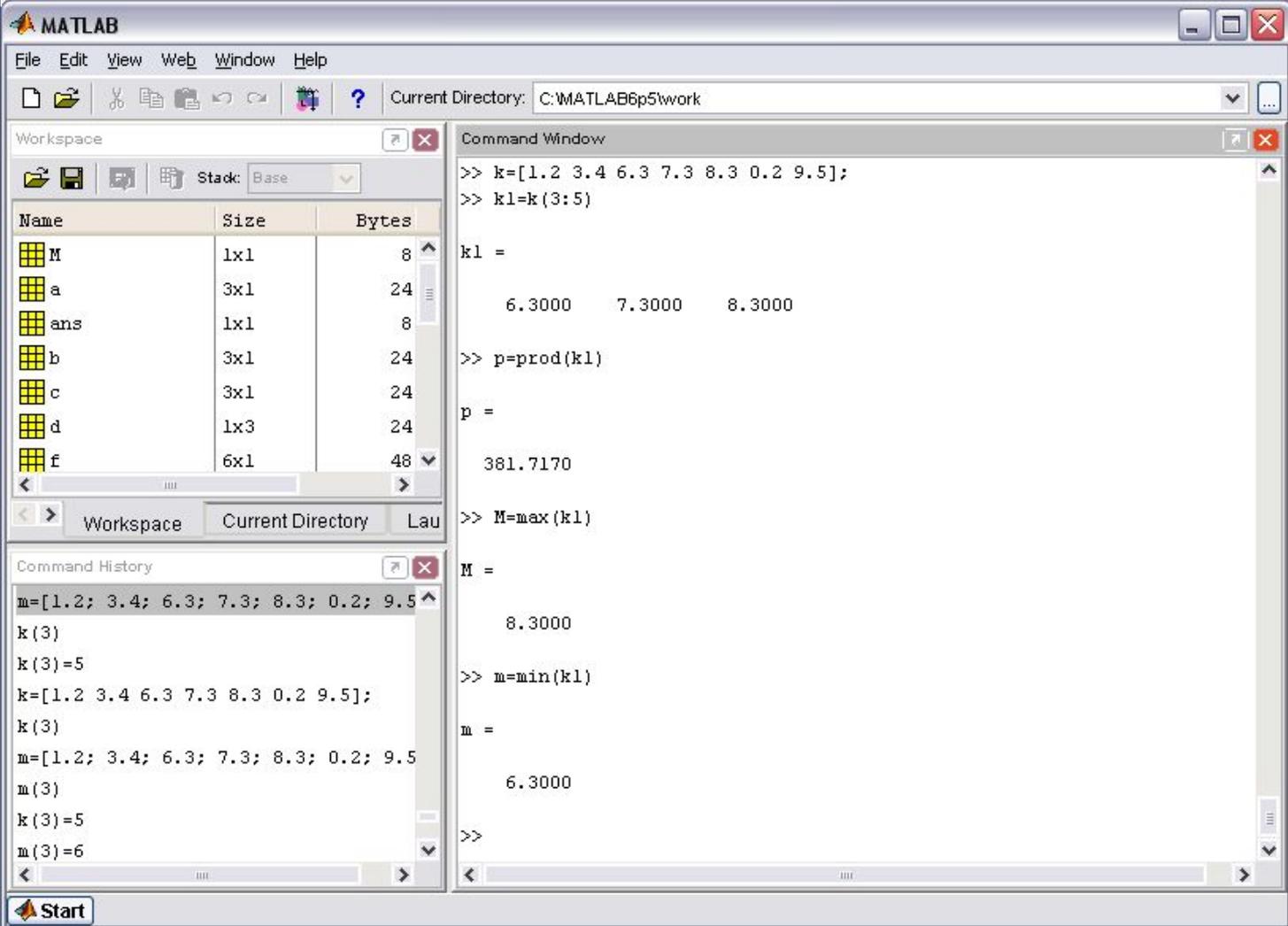
The Command History window shows the following commands:

```
m=[1.2; 3.4; 6.3; 7.3; 8.3; 0.2; 9.5];  
k(3)  
k(3)=5  
k=[1.2 3.4 6.3 7.3 8.3 0.2 9.5];  
k(3)  
m=[1.2; 3.4; 6.3; 7.3; 8.3; 0.2; 9.5];  
m(3)  
k(3)=5  
m(3)=6
```

# Индексация при помощи знака двоеточия



# Применение функций обработки данных к векторам. Нахождение минимума и максимума из элементов вектора



The image shows a MATLAB interface with three main panels: Workspace, Command Window, and Command History.

**Workspace Panel:**

Name	Size	Bytes
M	1x1	8
a	3x1	24
ans	1x1	8
b	3x1	24
c	3x1	24
d	1x3	24
f	6x1	48

**Command Window:**

```
>> k=[1.2 3.4 6.3 7.3 8.3 0.2 9.5];  
>> k1=k(3:5)  
  
k1 =  
  
    6.3000    7.3000    8.3000  
  
>> p=prod(k1)  
  
p =  
  
    381.7170  
  
>> M=max(k1)  
  
M =  
  
    8.3000  
  
>> m=min(k1)  
  
m =  
  
    6.3000  
  
>>
```

**Command History:**

```
m=[1.2; 3.4; 6.3; 7.3; 8.3; 0.2; 9.5]  
k(3)  
k(3)=5  
k=[1.2 3.4 6.3 7.3 8.3 0.2 9.5];  
k(3)  
m=[1.2; 3.4; 6.3; 7.3; 8.3; 0.2; 9.5]  
m(3)  
k(3)=5  
m(3)=6
```

# Сортировка элементов вектора по возрастанию, убыванию и упорядочение элементов в порядке возрастания их модулей

The image shows the MATLAB software interface. The workspace window displays the following table:

Name	Size	Bytes
M	1x1	8
R	1x6	48
R1	1x6	48
R2	1x6	48

The Command Window shows the following commands and outputs:

```
>> j=[-1.1 -3.9 4.2 6.5 8.7 -3.1];  
>> R=sort(j)  
  
R =  
    -3.9000    -3.1000    -1.1000     4.2000     6.5000     8.7000  
  
>> R1=-sort(-j)  
  
R1 =  
     8.7000     6.5000     4.2000    -1.1000    -3.1000    -3.9000  
  
>> R2=sort(abs(j))  
  
R2 =  
     1.1000     3.1000     3.9000     4.2000     6.5000     8.7000  
  
>>
```

The Command History window shows the following commands:

```
m=[1.2; 3.4; 6.3; 7.3; 8.3; 0.2; 9.5]  
k(3)  
k(3)=5  
k=[1.2 3.4 6.3 7.3 8.3 0.2 9.5];  
k(3)  
m=[1.2; 3.4; 6.3; 7.3; 8.3; 0.2; 9.5]  
m(3)
```

# Поэлементные операции с векторами

The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The workspace window displays a table of variables:

Name	Size	Bytes
M	1x1	8
R	1x6	48
R1	1x6	48
R2	1x6	48
a	3x1	24
ans	1x1	8
b	3x1	24
c	3x1	24

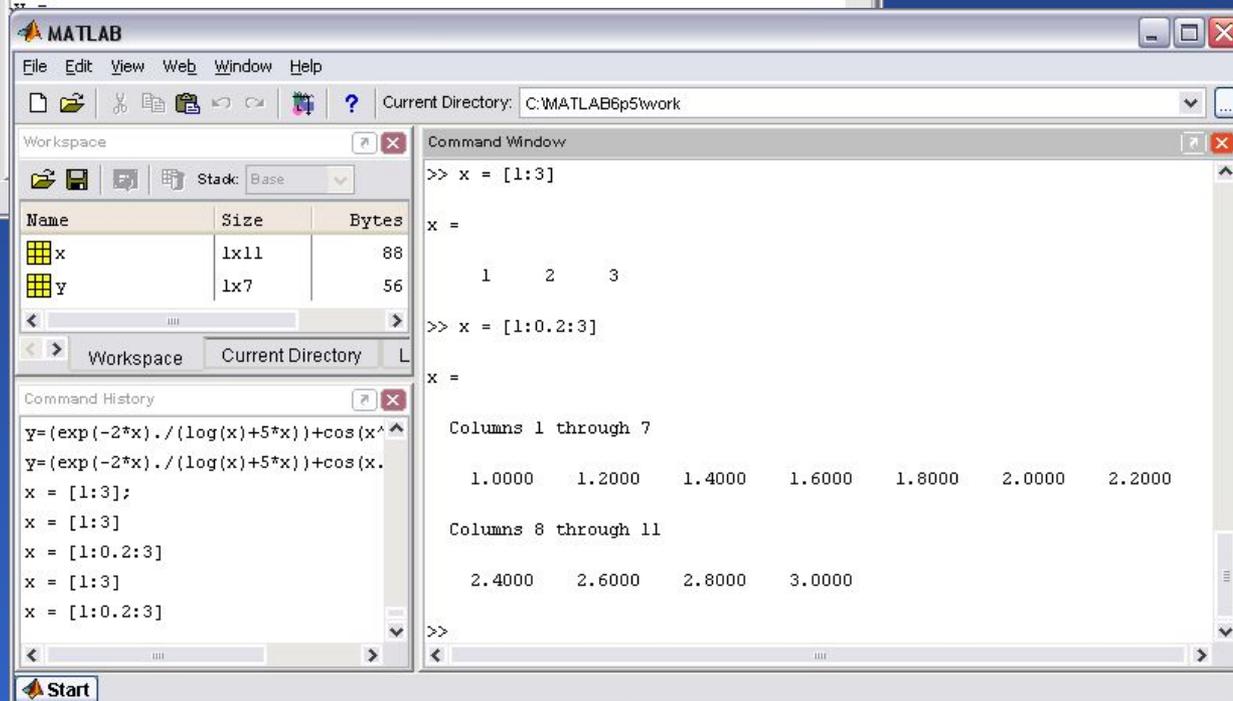
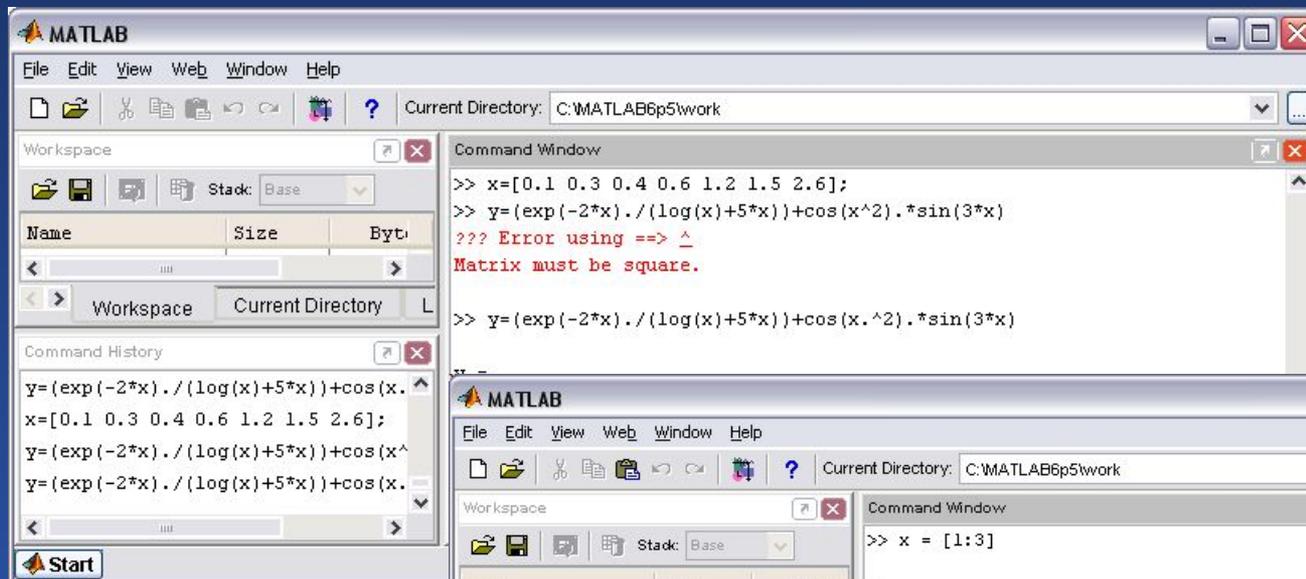
The Command Window shows the following commands and their outputs:

```
>> s=[1 2 3 4 5];  
>> s1=[6 7 8 9 10];  
>> ss=s.*s1  
ss =  
     6    14    24    36    50  
  
>> ss=s./s1  
ss =  
    0.1667    0.2857    0.3750    0.4444    0.5000  
  
>> ss=s.\s1  
ss =  
    6.0000    3.5000    2.6667    2.2500    2.0000  
  
>> ss=s.^s1  
ss =  
         1         128         6561         262144         9765625  
  
>> ss=s.^s1  
??? ss=s.^s1  
      |  
Error: "identifier" expected, "^" found.  
  
>>
```

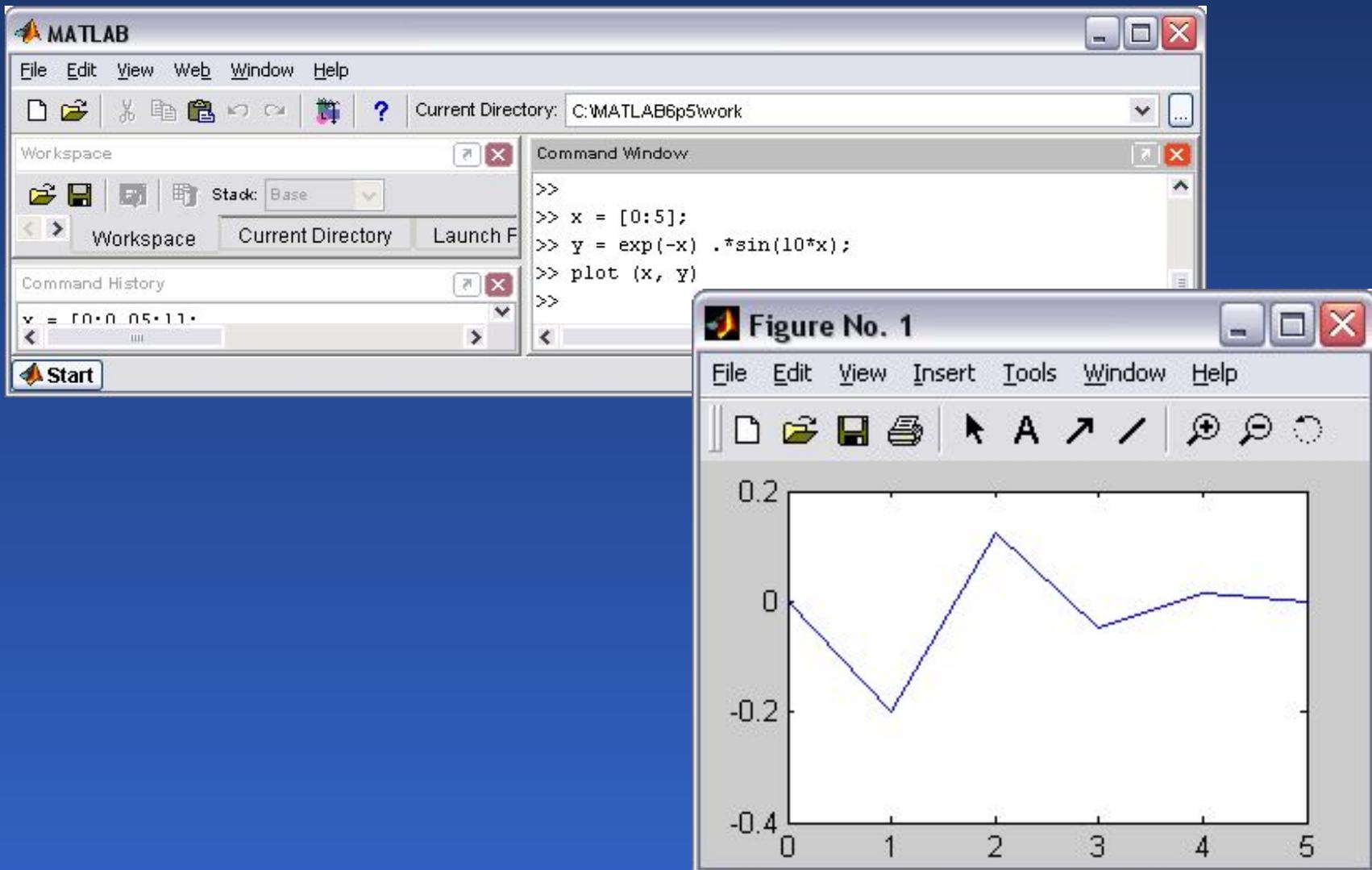
The Command History window shows the following commands:

```
m=[1.2; 3.4; 6.3; 7.3; 8.3; 0.2; 9.5];  
k(3)  
k(3)=5  
k=[1.2 3.4 6.3 7.3 8.3 0.2 9.5];  
k(3)  
m=[1.2; 3.4; 6.3; 7.3; 8.3; 0.2; 9.5];  
m(3)  
k(3)=5  
m(3)=6  
o=[k(5); k(1); k(4)]  
v=[m(3) (1) m(7)]  
ind=[3 1 7];
```

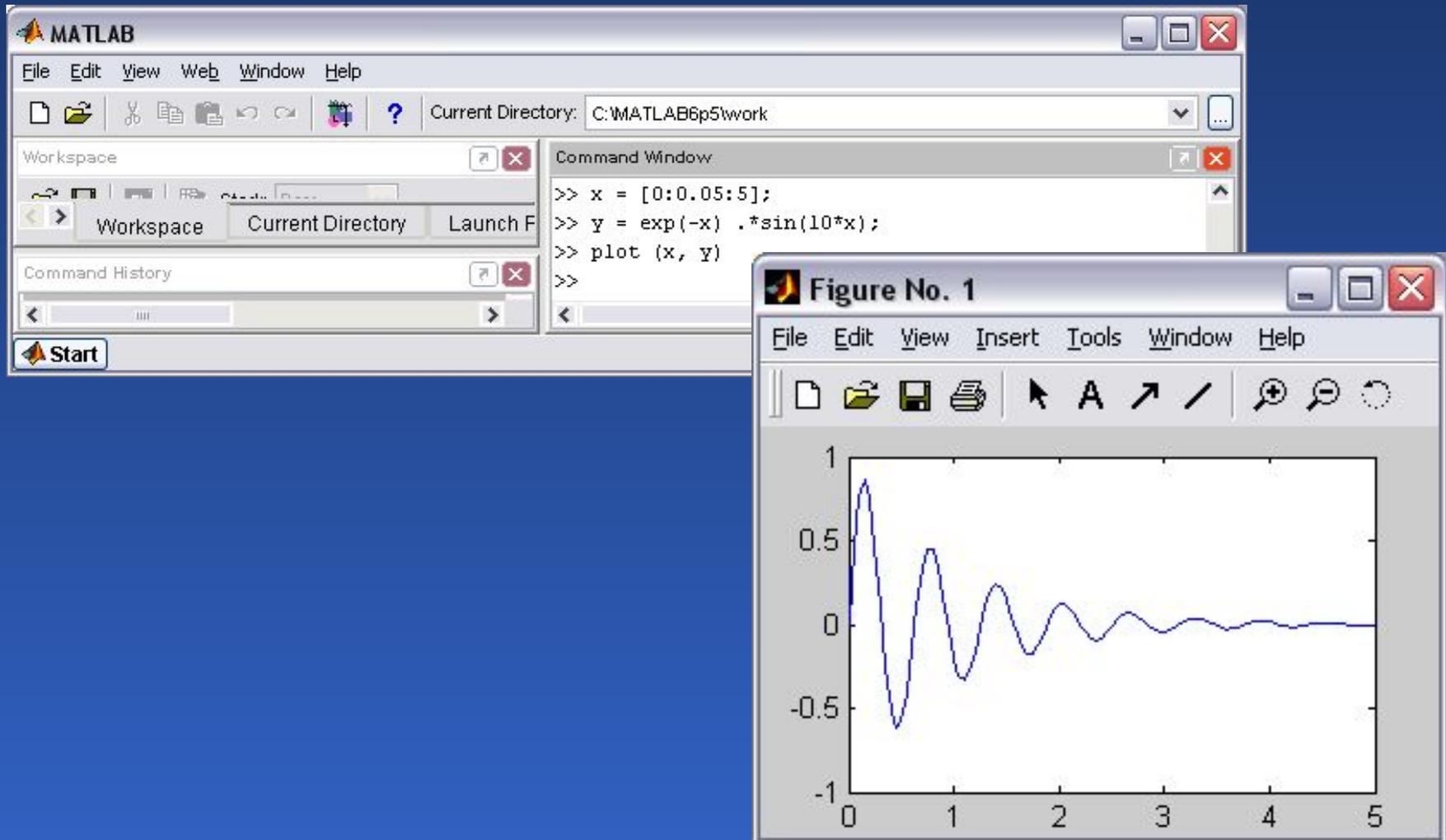
# Работа с массивами. Построение таблицы значений функции



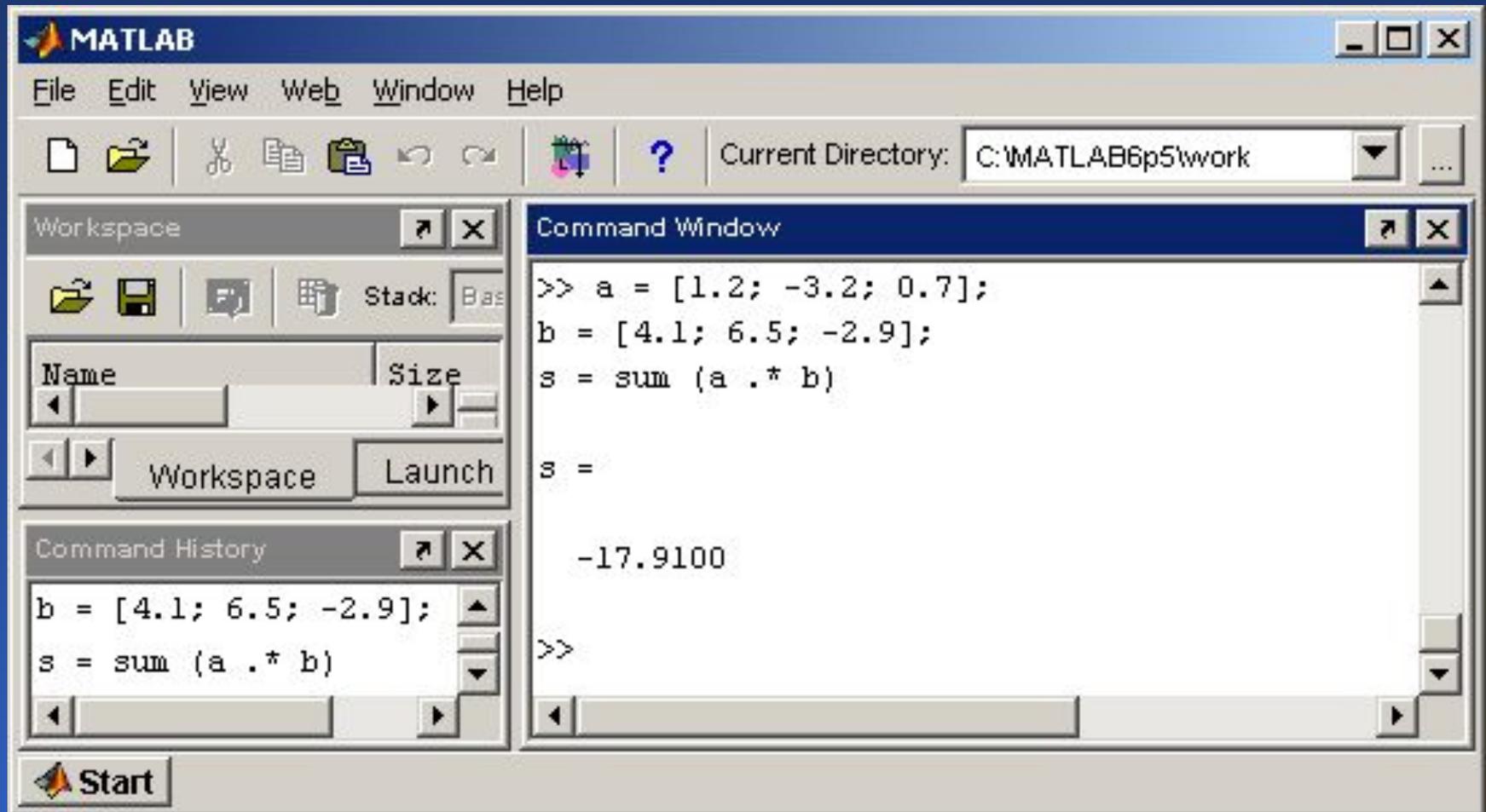
# Построение графиков функции одной переменной



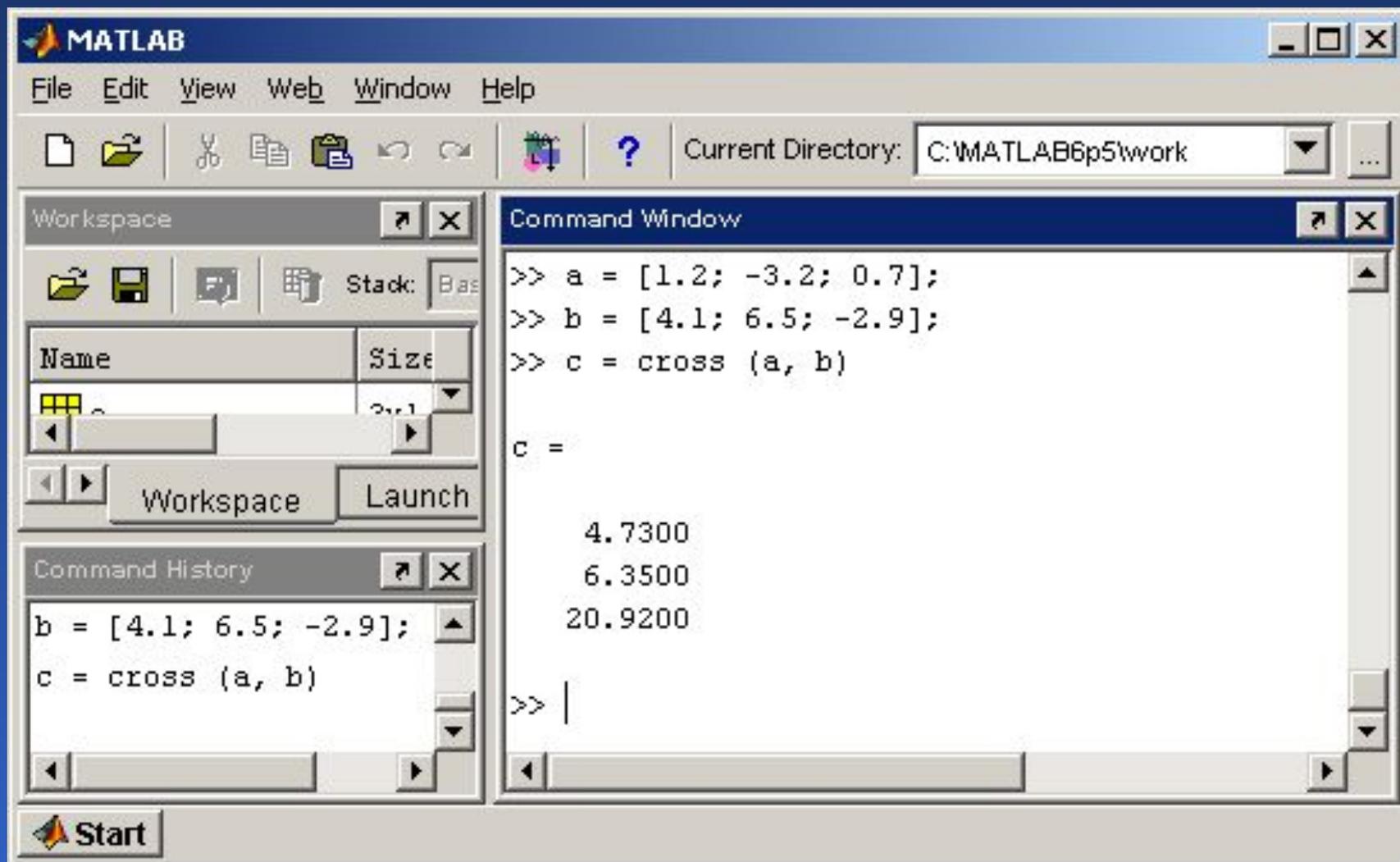
# Построение графиков функции одной переменной



# Скалярное произведение



# Векторное произведение



The image shows a screenshot of the MATLAB software interface. The main window is titled "MATLAB" and has a menu bar with "File", "Edit", "View", "Web", "Window", and "Help". Below the menu bar is a toolbar with various icons for file operations and a "Current Directory" field showing "C:\MATLAB6p5\work".

The interface is divided into several panes:

- Workspace:** A table showing the current workspace variables. It has columns for "Name" and "Size". A variable `c` is listed with a size of `3x1`. Below the table are "Workspace" and "Launch" buttons.
- Command Window:** A text area where MATLAB commands are entered and executed. The commands shown are:

```
>> a = [1.2; -3.2; 0.7];  
>> b = [4.1; 6.5; -2.9];  
>> c = cross (a, b)
```

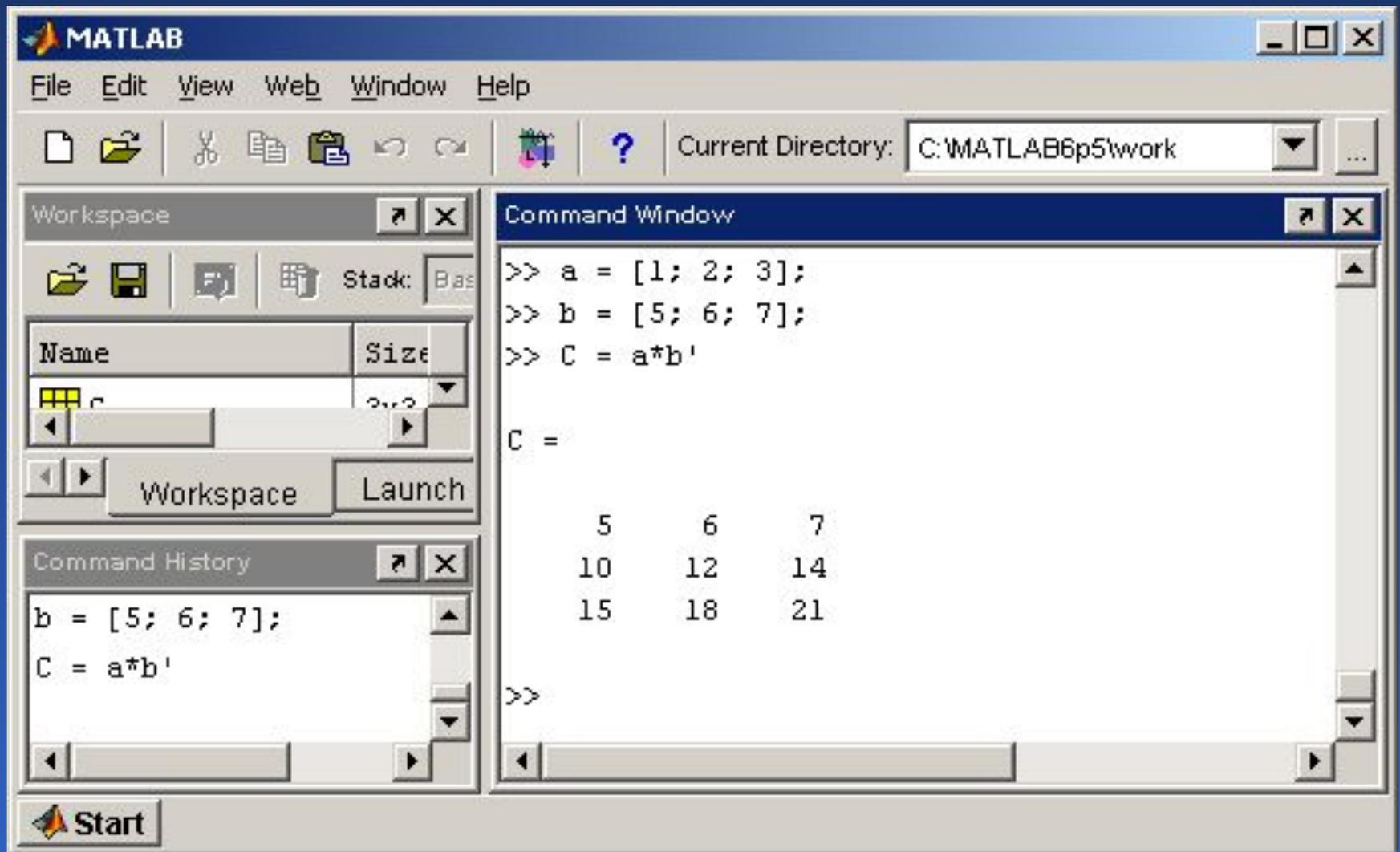
The output of the `cross` function is displayed as:

```
c =  
  
    4.7300  
    6.3500  
   20.9200
```
- Command History:** A list of previously executed commands, showing:

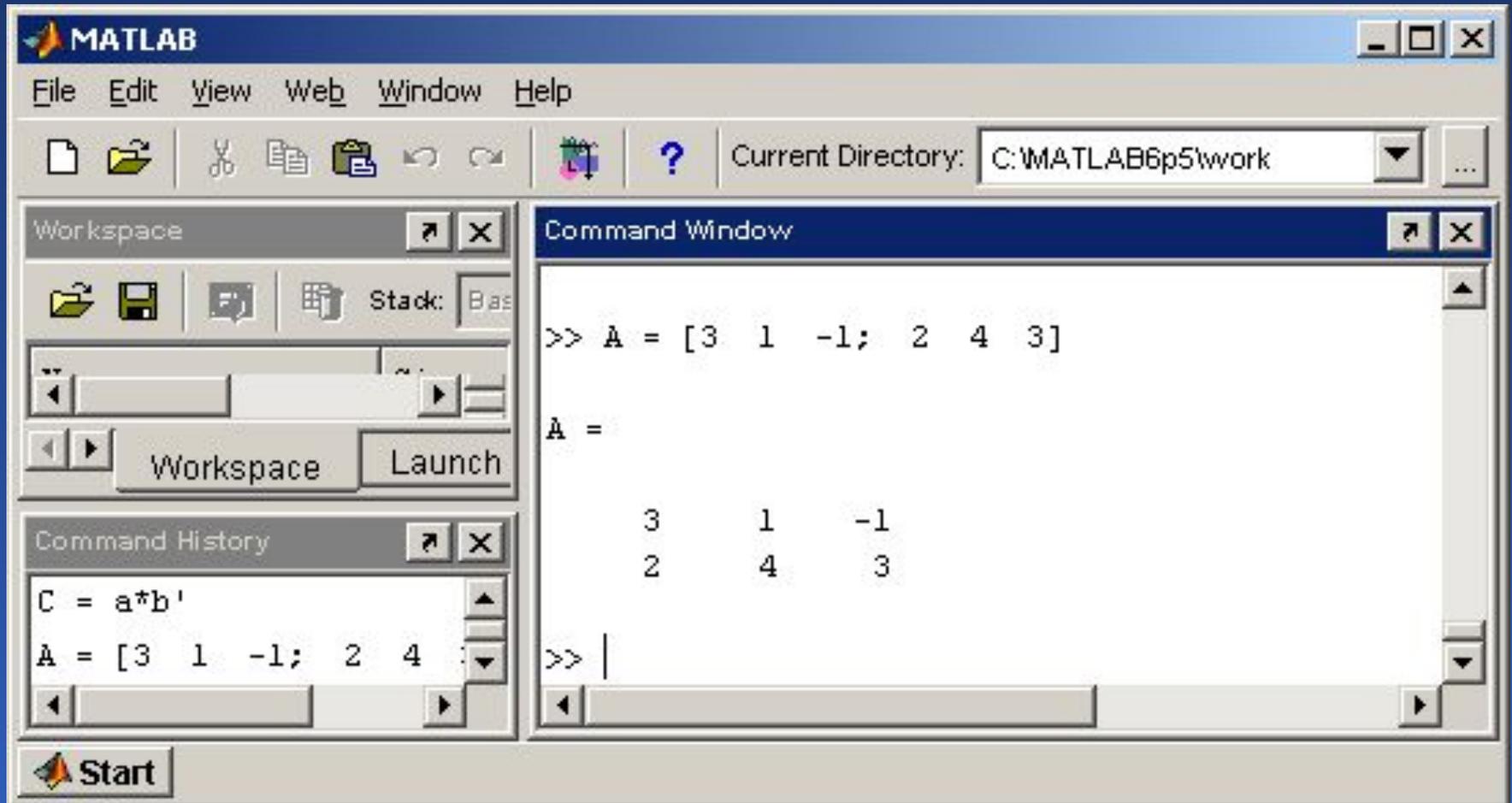
```
b = [4.1; 6.5; -2.9];  
c = cross (a, b)
```

At the bottom left of the MATLAB window is a "Start" button with the MATLAB logo.

# Матричное произведение



# Двумерные массивы и матрицы



# Обращение к элементам матриц

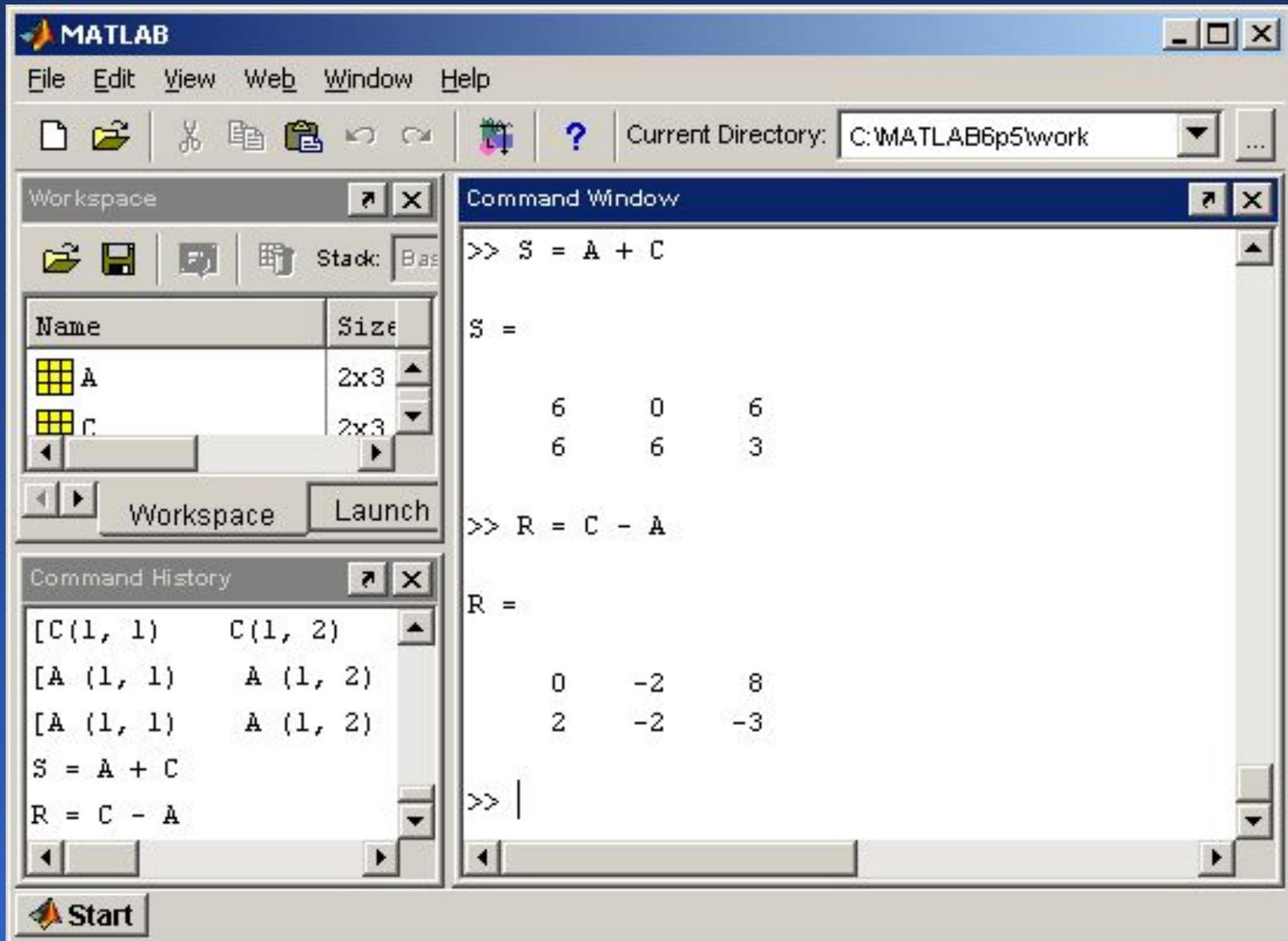
The image shows the MATLAB software interface. The main window has a menu bar (File, Edit, View, Web, Window, Help) and a toolbar. The current directory is set to C:\MATLAB6p5\work. The Workspace window shows a variable A of size 2x3. The Command Window shows the following code and output:

```
C =  
     3     -1     7  
     4      2     0  
  
>> C (2, 3)  
  
ans =  
  
     0  
  
>>
```

The Command History window shows the following commands and results:

```
A = [3 1 -1; 2 4 :  
C= [[3; 4] [-1; 2] [7;  
C (2, 3)
```

# Сложение и вычитание матриц



The image shows the MATLAB software interface. The main window is titled "MATLAB" and contains several panes:

- Workspace:** Displays a table of variables in the workspace.
- Command Window:** Shows the execution of MATLAB commands and their output.
- Command History:** Lists the commands entered in the Command Window.

**Workspace Table:**

Name	Size
A	2x3
C	2x3

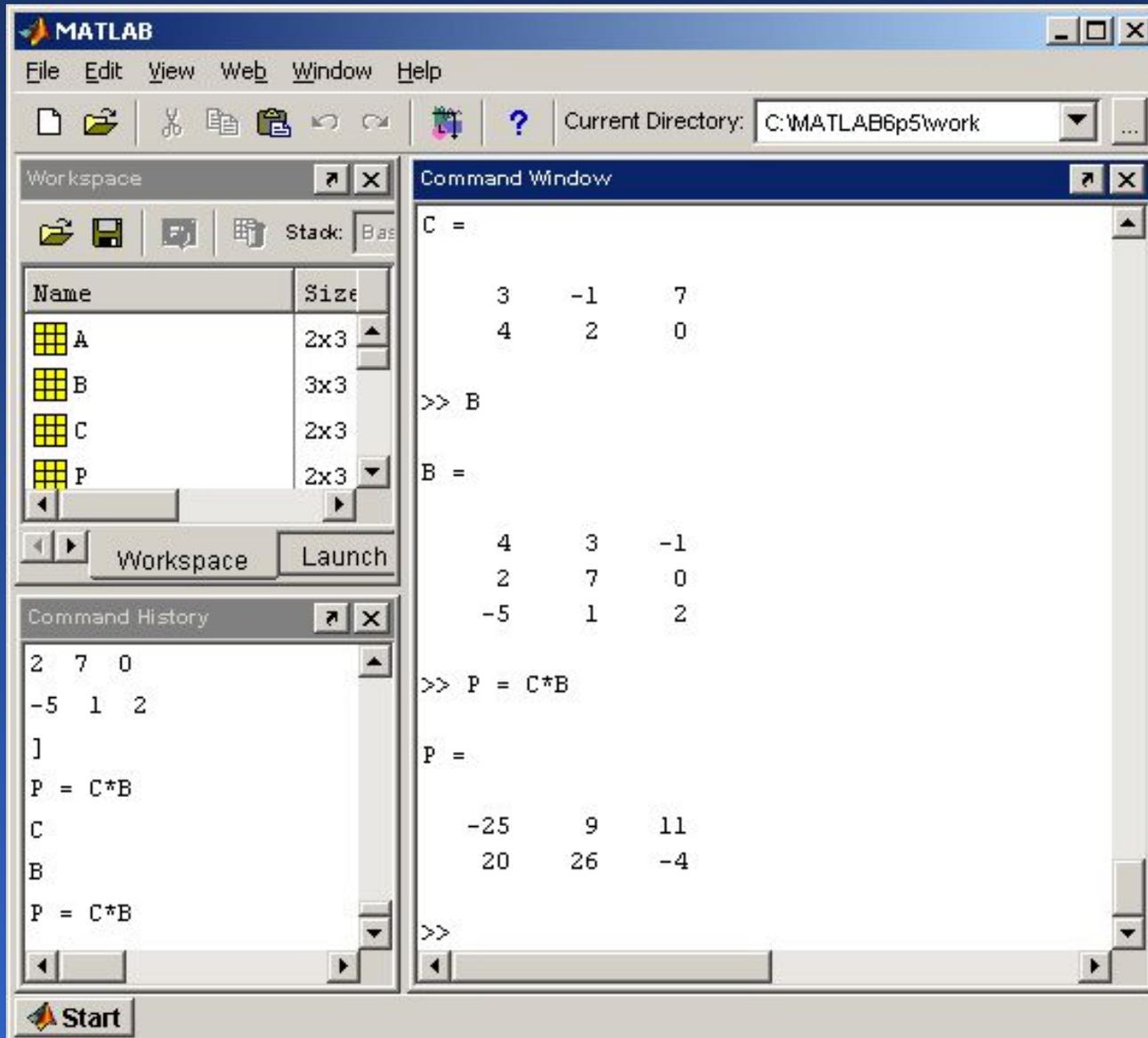
**Command Window Output:**

```
>> S = A + C  
  
S =  
  
     6     0     6  
     6     6     3  
  
>> R = C - A  
  
R =  
  
     0    -2     8  
     2    -2    -3  
  
>> |
```

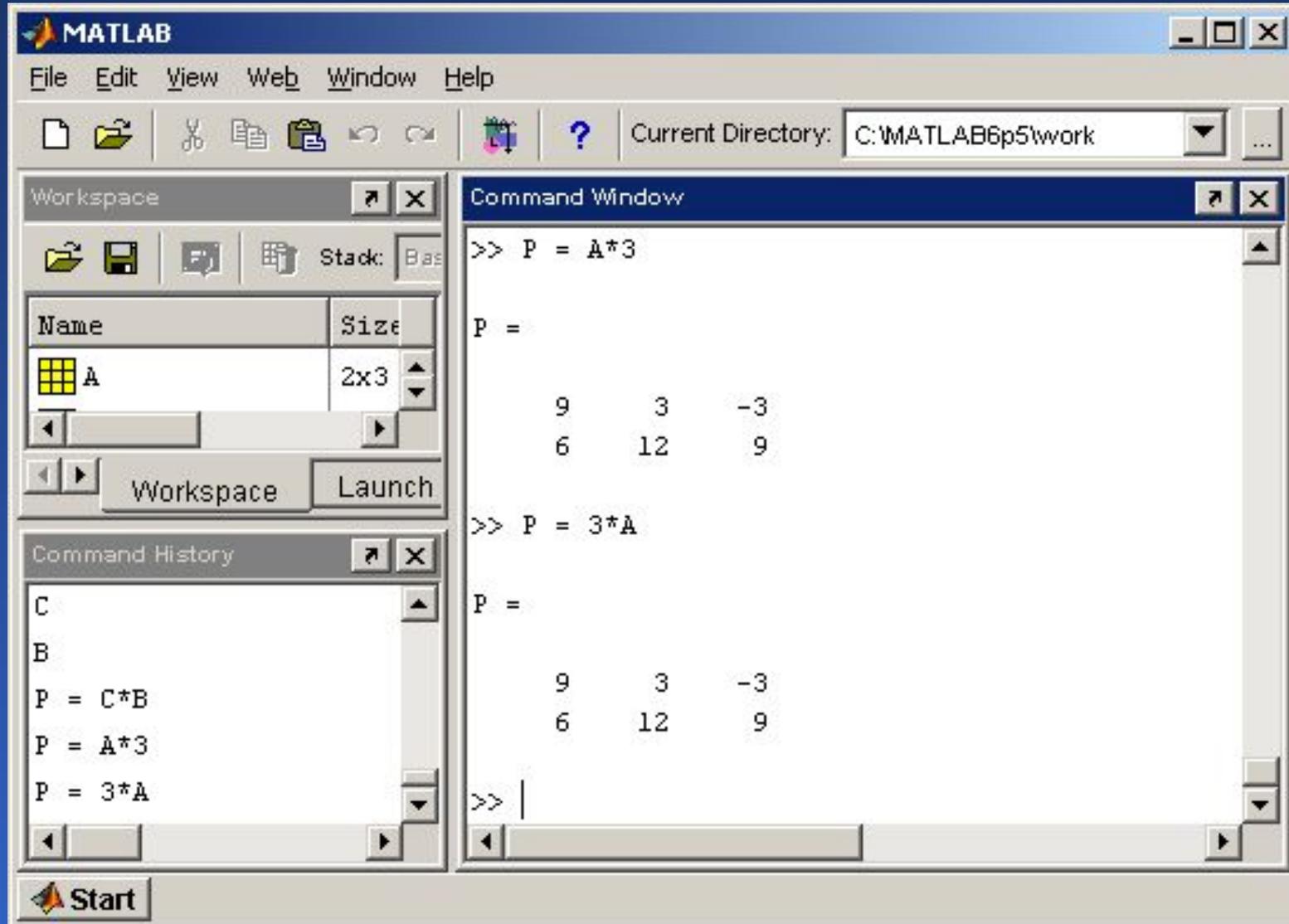
**Command History:**

```
[C(1, 1)    C(1, 2)]  
[A (1, 1)   A (1, 2)]  
[A (1, 1)   A (1, 2)]  
S = A + C  
R = C - A
```

# Умножение матриц



# Умножение матрицы на число



The image shows the MATLAB software interface. The main window is titled "MATLAB" and has a menu bar with "File", "Edit", "View", "Web", "Window", and "Help". Below the menu bar is a toolbar with various icons, including a question mark and a "Current Directory" field showing "C:\MATLAB6p5\work".

The interface is divided into several panes:

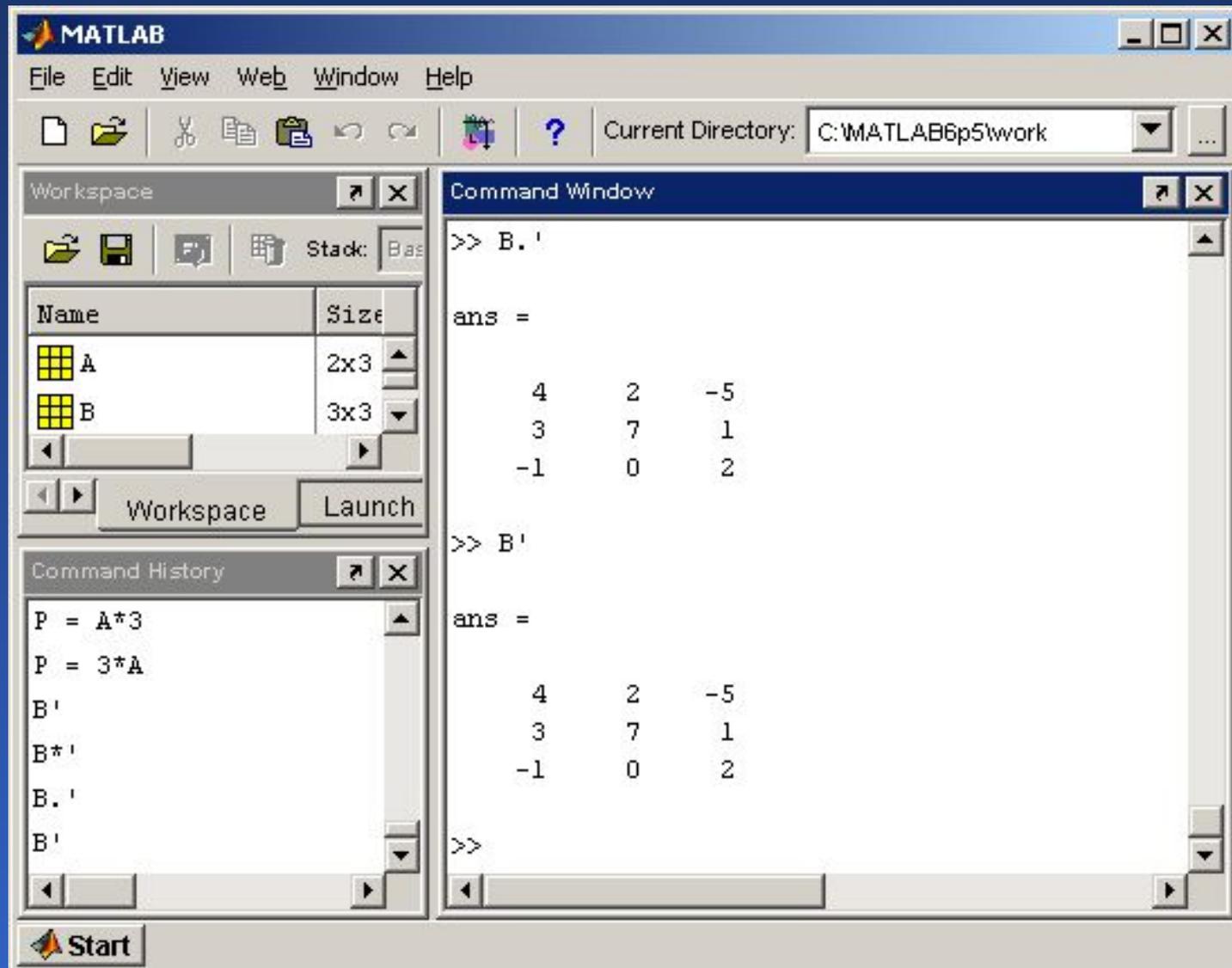
- Workspace:** Shows a table with two columns: "Name" and "Size". There is one entry: "A" with a size of "2x3".
- Command Window:** Contains the following text:

```
>> P = A*3  
  
P =  
  
     9     3    -3  
     6    12     9  
  
>> P = 3*A  
  
P =  
  
     9     3    -3  
     6    12     9  
  
>> |
```
- Command History:** Shows a list of commands entered in the Command Window:

```
C  
B  
P = C*B  
P = A*3  
P = 3*A
```

At the bottom left of the window is a "Start" button.

# Транспонирование вещественных матриц



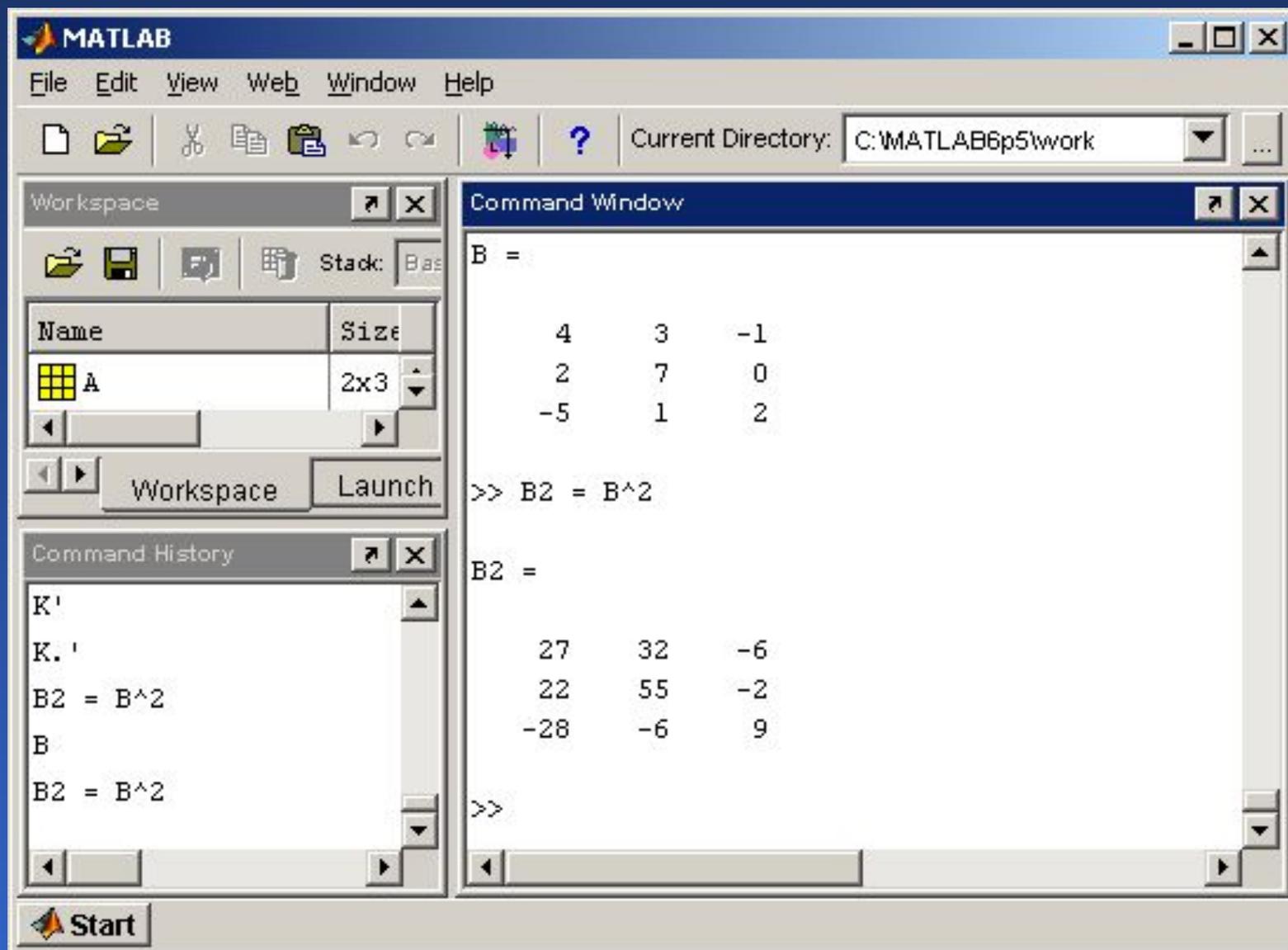
# Транспонирование матриц, содержащих комплексные числа

The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The toolbar contains icons for file operations and a 'Current Directory' dropdown set to 'C:\MATLAB6p5\work'. The 'Workspace' window on the left lists variables A (2x3), B (3x3), and C (2x3). The 'Command Window' on the right shows the following sequence of commands and outputs:

```
K =  
    1.0000 - 1.0000i    2.0000 + 3.0000i  
    3.0000 - 5.0000i    1.0000 - 9.0000i  
  
>> K'  
ans =  
    1.0000 + 1.0000i    3.0000 + 5.0000i  
    2.0000 - 3.0000i    1.0000 + 9.0000i  
  
>> K.'  
ans =  
    1.0000 - 1.0000i    3.0000 - 5.0000i  
    2.0000 + 3.0000i    1.0000 - 9.0000i  
  
>>
```

The 'Command History' window at the bottom left shows the commands: B', B\*.', B.', B', K = [1-i, 2+3i; 3-5i, ...], K', and K.'.

# Возведение матрицы в степень



The image shows the MATLAB software interface. The title bar reads "MATLAB". The menu bar includes "File", "Edit", "View", "Web", "Window", and "Help". The current directory is "C:\MATLAB6p5\work".

The **Workspace** window shows a table with the following data:

Name	Size
A	2x3

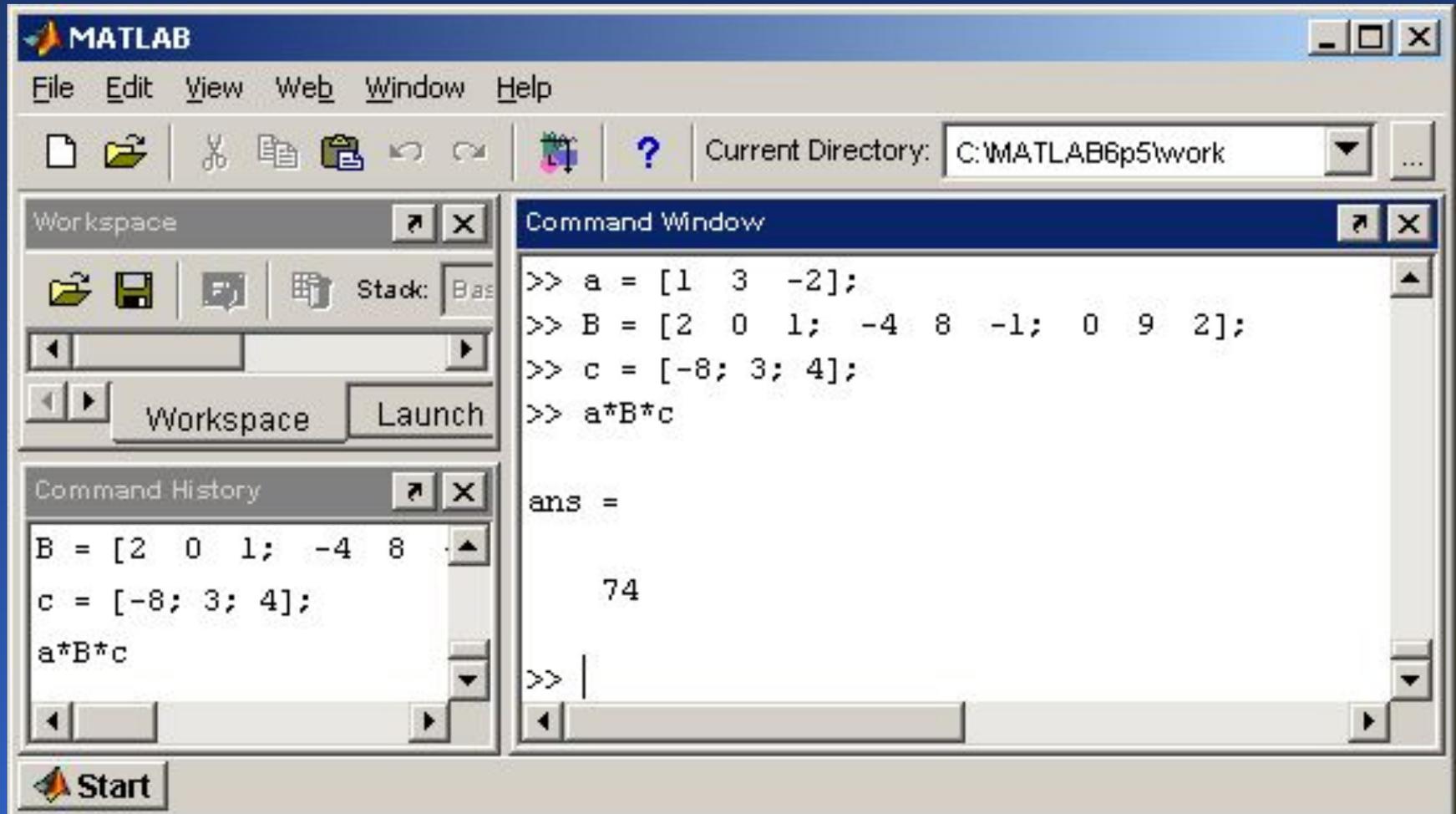
The **Command Window** displays the following text:

```
B =  
     4     3    -1  
     2     7     0  
    -5     1     2  
  
>> B2 = B^2  
  
B2 =  
     27     32    -6  
     22     55    -2  
    -28    -6     9  
  
>>
```

The **Command History** window shows the following commands:

```
K'  
K. '  
B2 = B^2  
B  
B2 = B^2
```

# Перемножение матрицы и вектора



The image shows the MATLAB software interface. The title bar reads "MATLAB". The menu bar includes "File", "Edit", "View", "Web", "Window", and "Help". The toolbar contains icons for file operations and a "Current Directory" field showing "C:\MATLAB6p5\work".

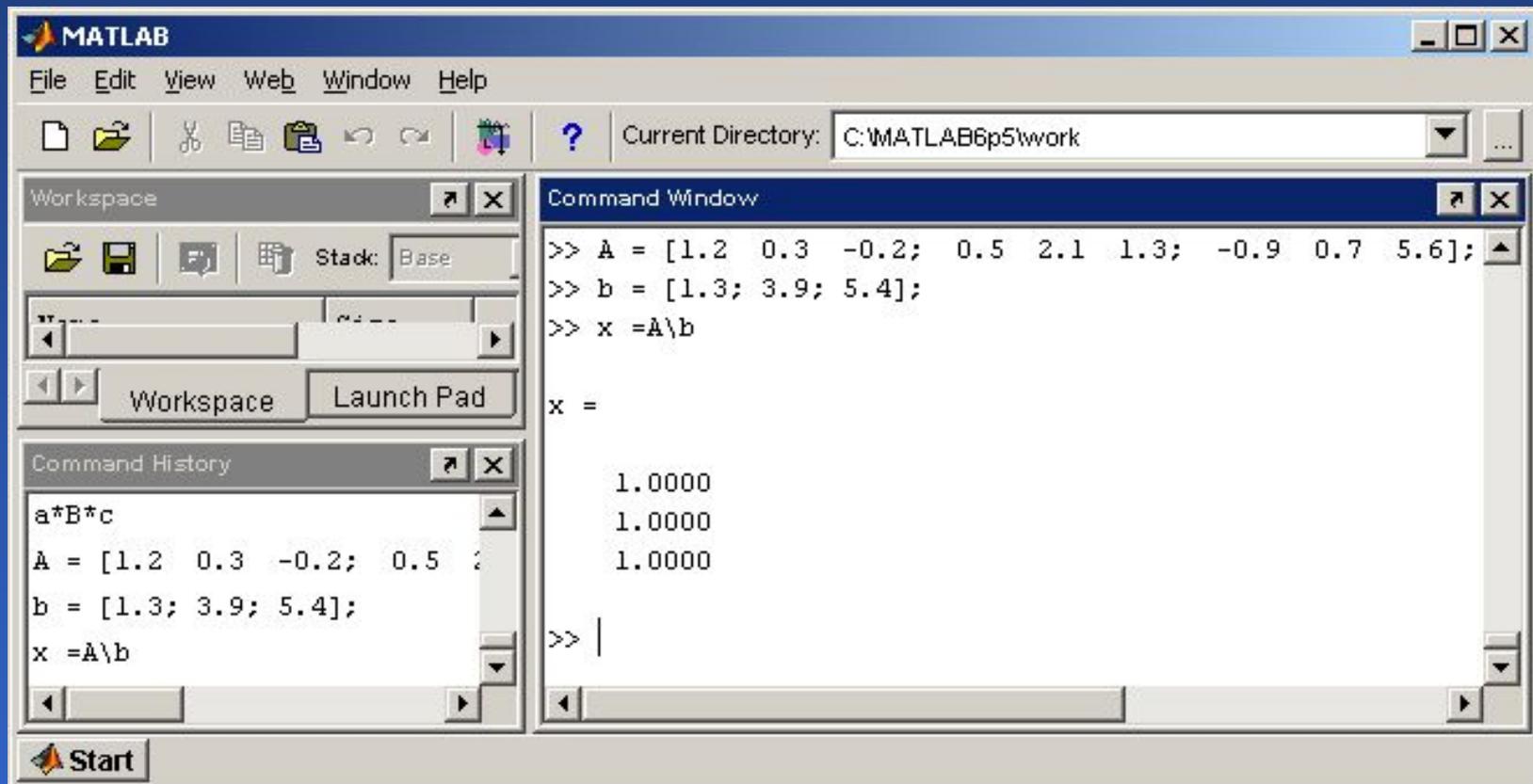
The "Workspace" window shows a stack with "Base" and "ans". The "Command History" window shows the following commands: "B = [2 0 1; -4 8 ...]", "c = [-8; 3; 4];", and "a\*B\*c".

The "Command Window" shows the following commands and output:

```
>> a = [1 3 -2];  
>> B = [2 0 1; -4 8 -1; 0 9 2];  
>> c = [-8; 3; 4];  
>> a*B*c  
  
ans =  
  
    74  
  
>> |
```

# Решение систем линейных уравнений

$$\begin{cases} 1,2x_1 + 0,3x_2 - 0,2x_3 = 1,3; \\ 0,5x_1 + 2,1x_2 + 1,3x_3 = 3,9; \\ -0,9x_1 + 0,7x_2 + 5,6x_3 = 5,4. \end{cases}$$

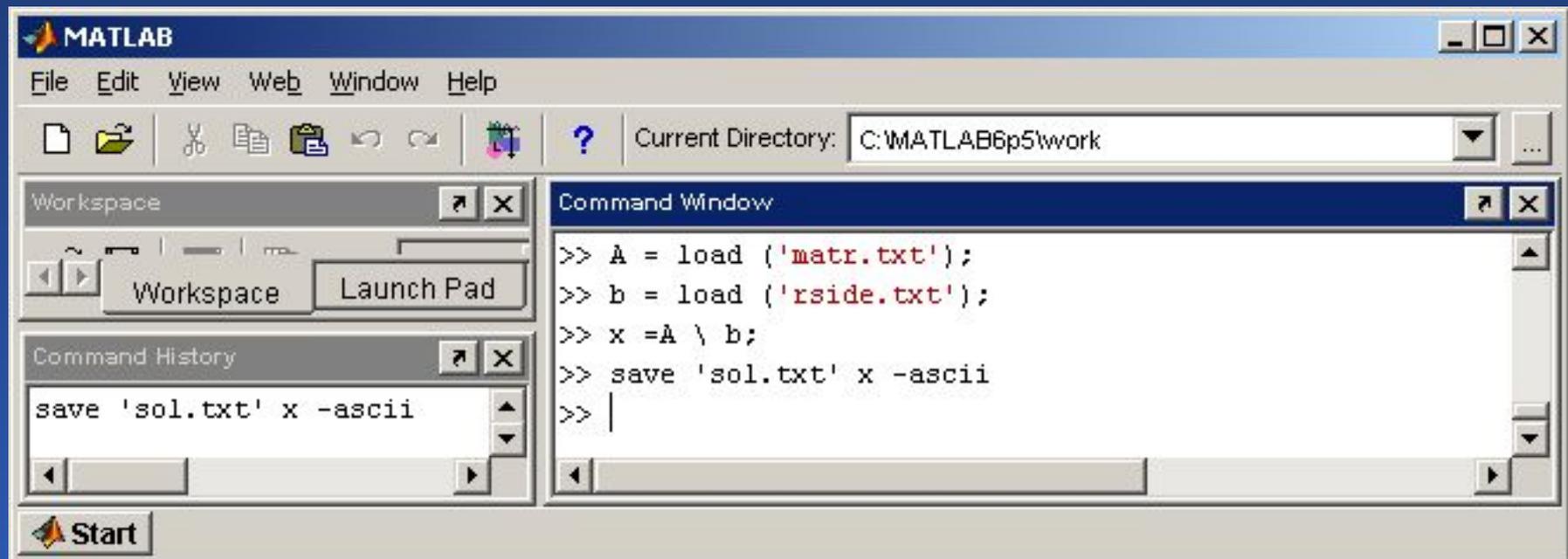


The image shows a screenshot of the MATLAB software interface. The main window is titled "MATLAB" and contains several panes. The "Command Window" pane on the right shows the following commands and output:

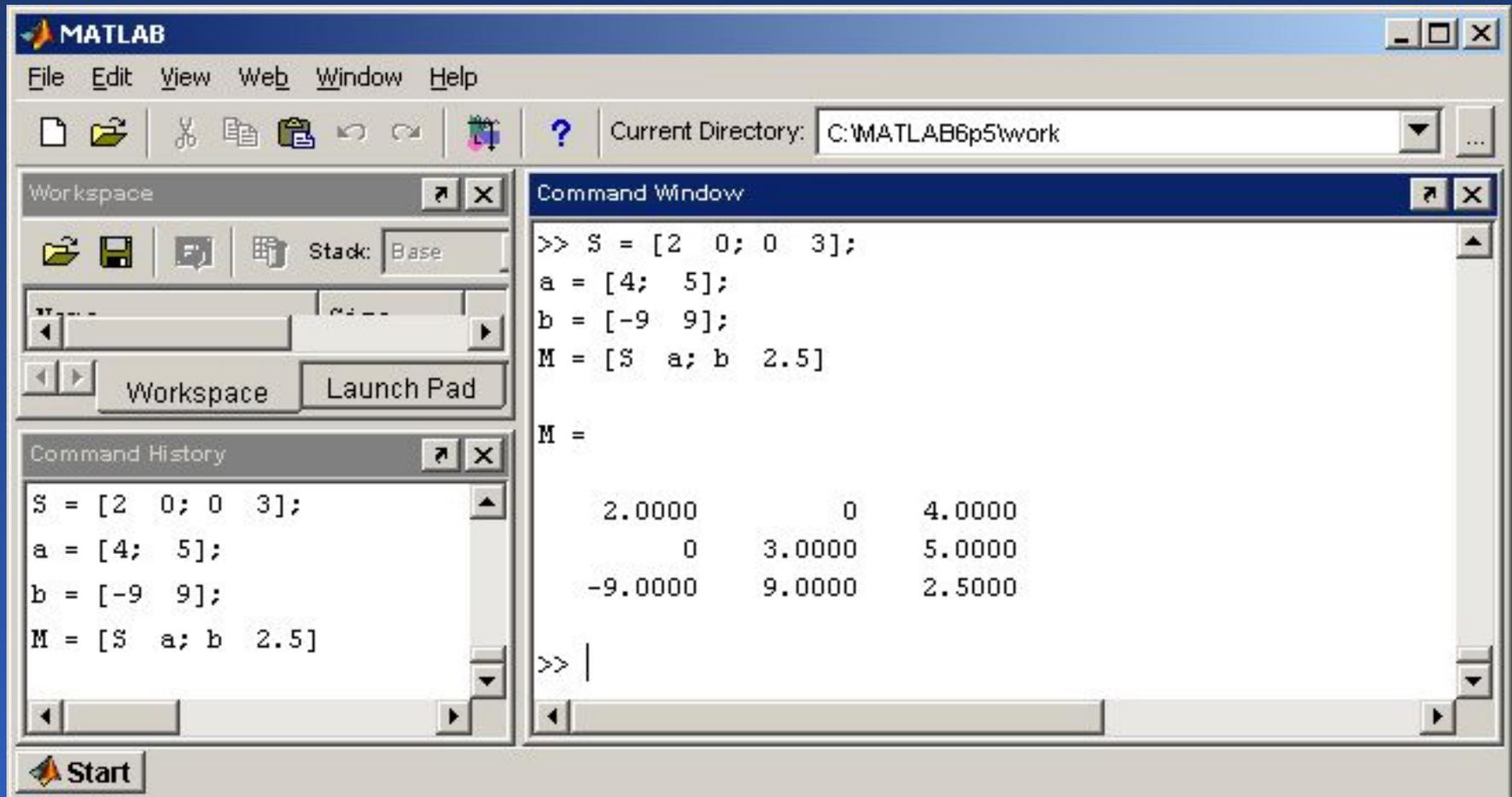
```
>> A = [1.2 0.3 -0.2; 0.5 2.1 1.3; -0.9 0.7 5.6];  
>> b = [1.3; 3.9; 5.4];  
>> x = A\b  
  
x =  
  
    1.0000  
    1.0000  
    1.0000  
  
>> |
```

The "Workspace" pane on the left shows the variables defined in the Command Window: `a*B*c`, `A = [1.2 0.3 -0.2; 0.5 2.1 1.3; -0.9 0.7 5.6];`, `b = [1.3; 3.9; 5.4];`, and `x = A\b`. The "Command History" pane at the bottom left also shows the same commands. The "Current Directory" is set to `C:\MATLAB6p5\work`.

# Считывание и запись данных

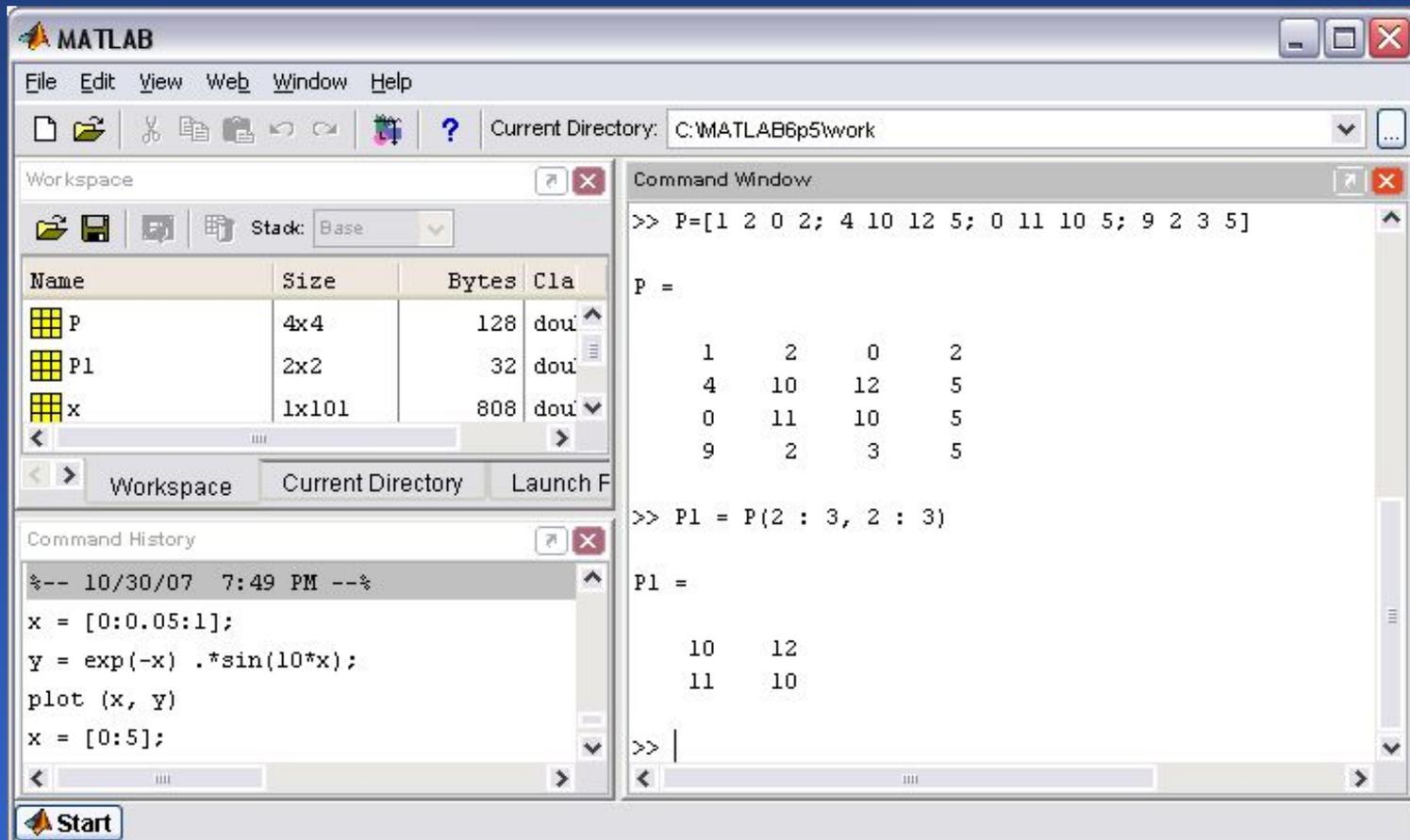


# Блочные матрицы

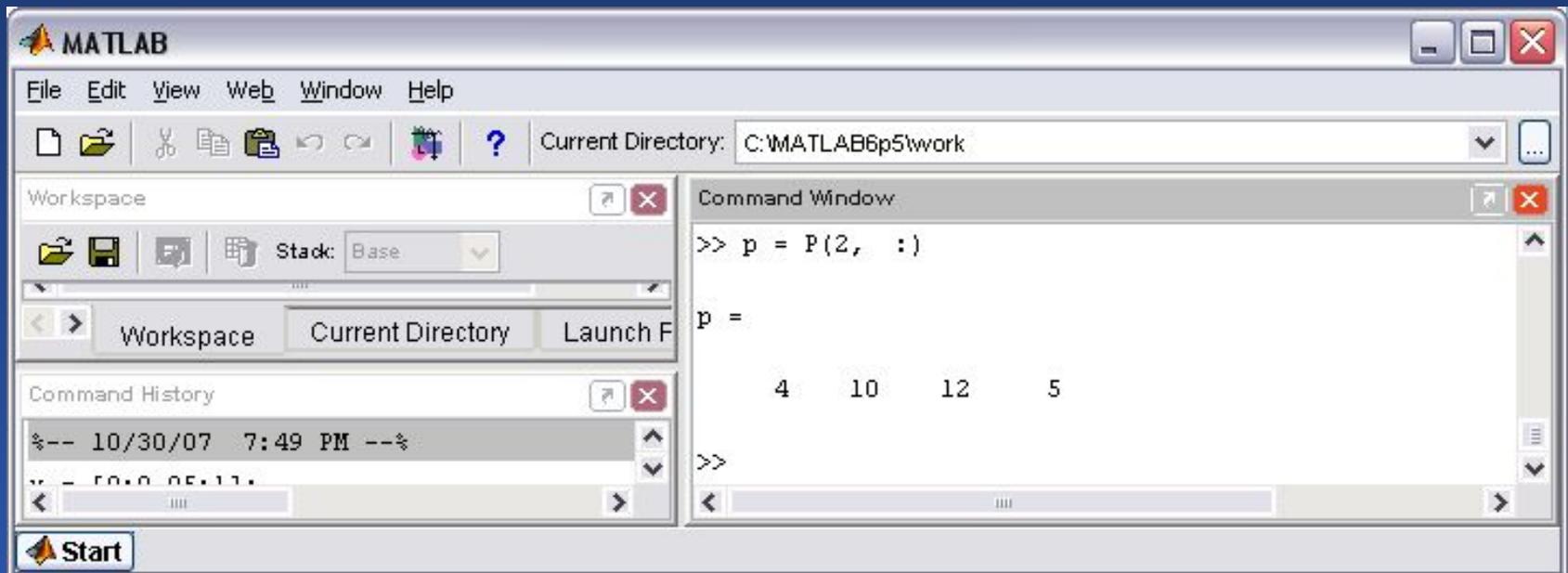


# Выделение блоков

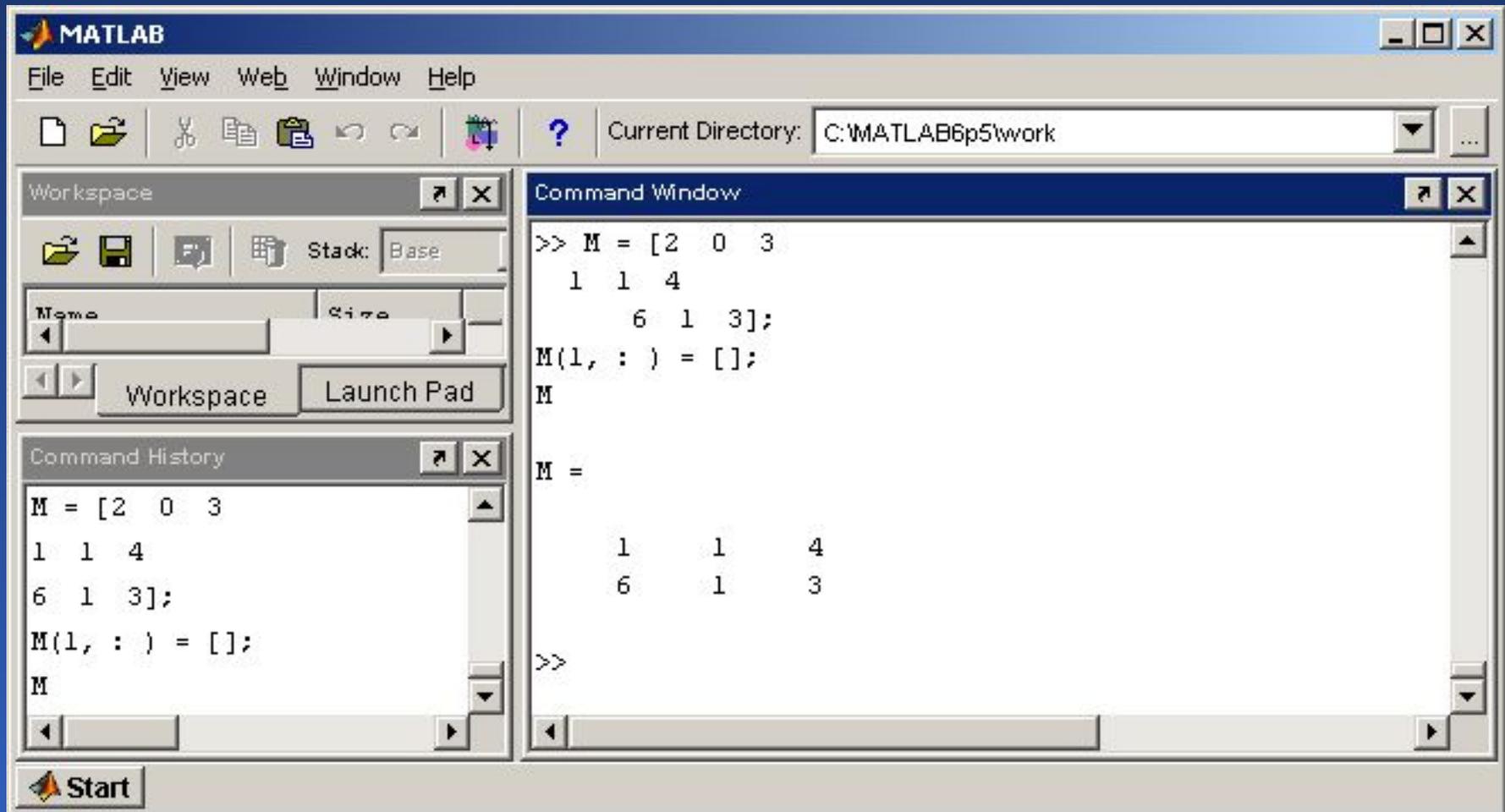
$$P = \begin{pmatrix} 1 & 2 & 0 & 2 \\ 4 & 10 & 12 & 5 \\ 0 & 11 & 10 & 5 \\ 9 & 2 & 3 & 5 \end{pmatrix}$$



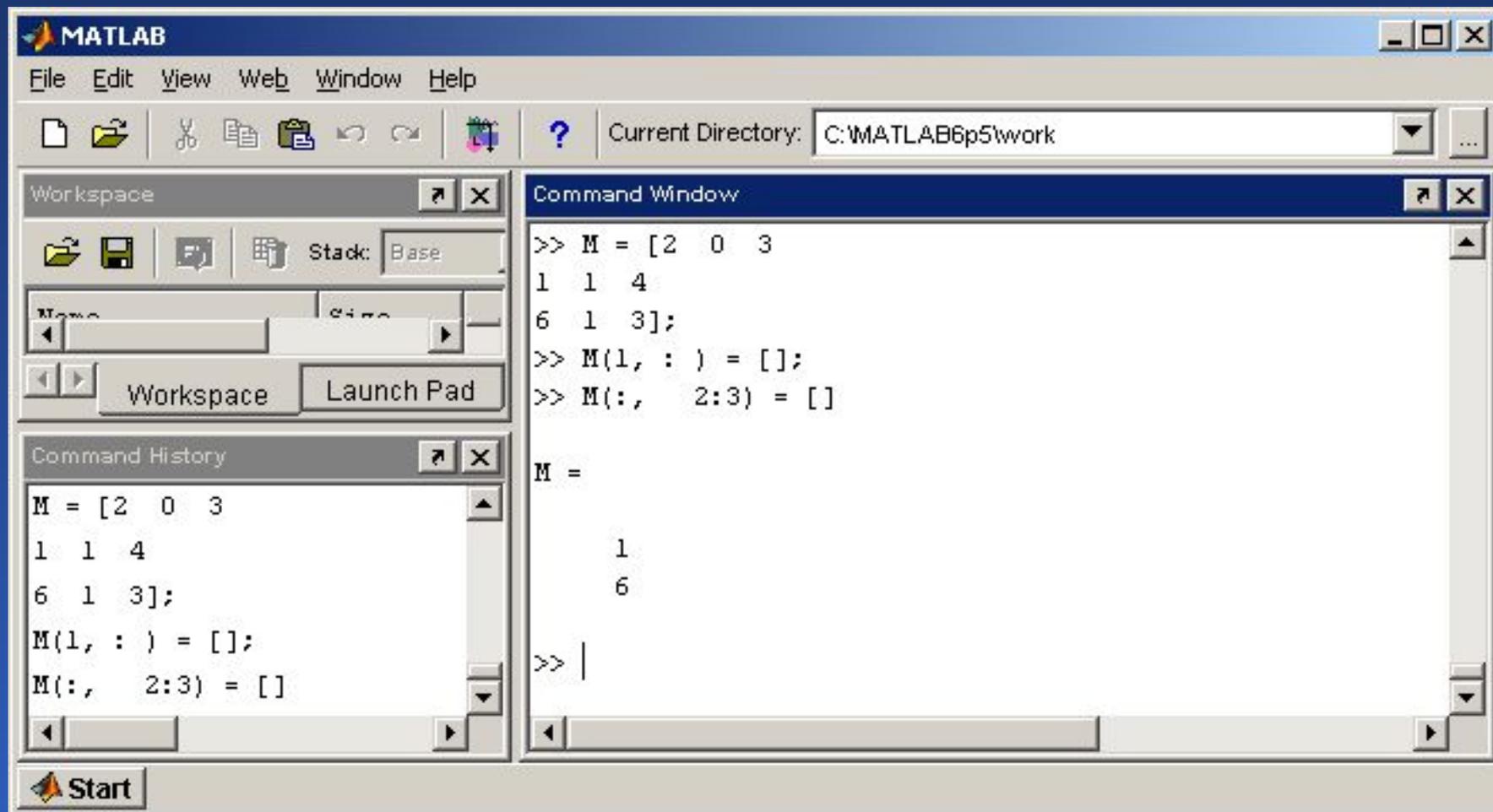
# Выделение из матрицы строки



# Удаление строк



# Удаление столбцов



# Заполнение матриц при помощи индексации

The image shows the MATLAB interface with three main windows: Workspace, Command Window, and Command History.

**Workspace Window:**

Name	Size	Bytes	Class
A	5x5	200	double
P	4x4	128	double
P1	2x2	32	double
p	1x4	32	double
x	1x101	808	double
Y	1x101	808	double

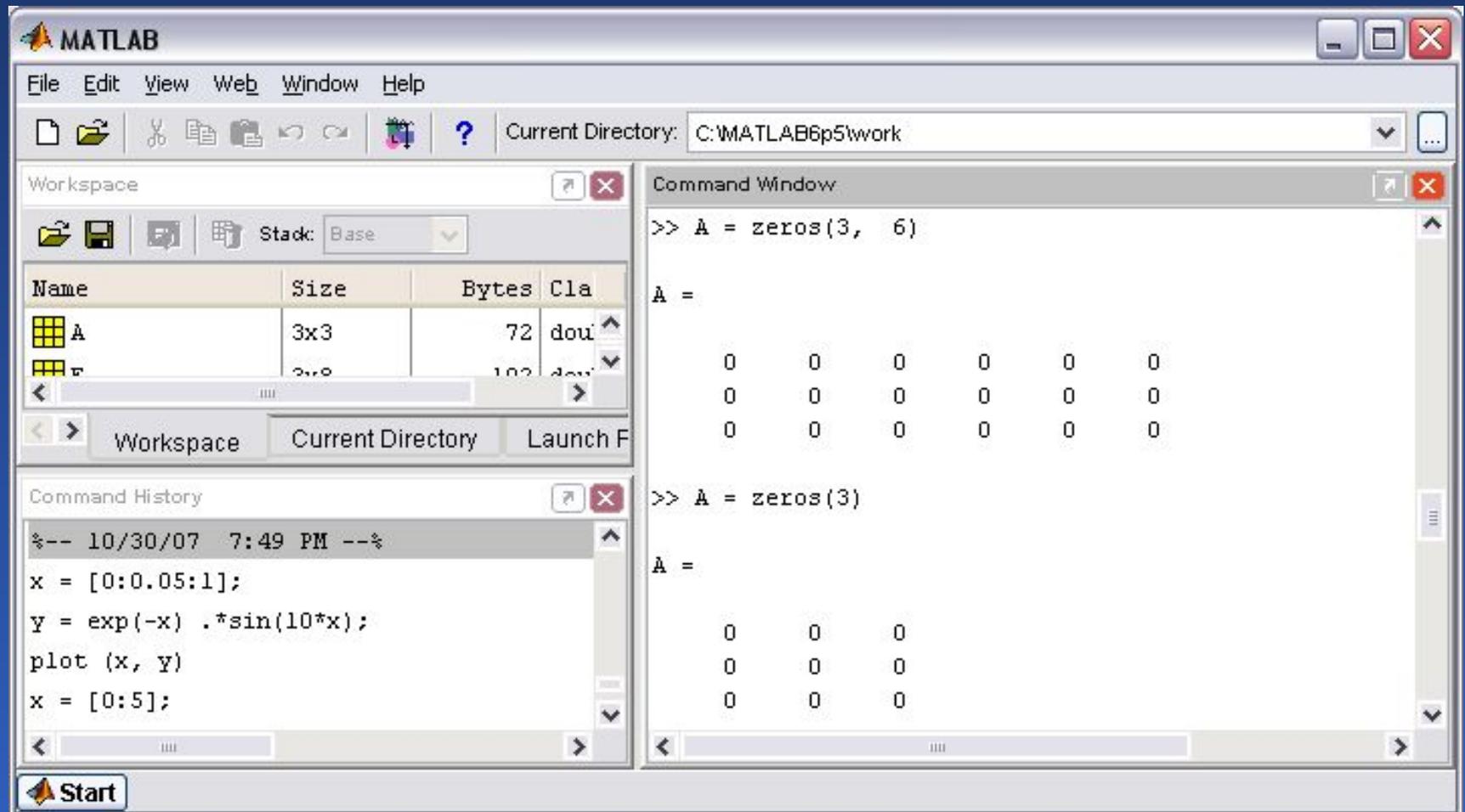
**Command Window:**

```
>> A(1:5, 1:5) = 0  
A =  
    0    0    0    0    0  
    0    0    0    0    0  
    0    0    0    0    0  
    0    0    0    0    0  
    0    0    0    0    0  
  
>> A(1, :) = 1  
A =  
    1    1    1    1    1  
    0    0    0    0    0  
    0    0    0    0    0  
    0    0    0    0    0  
    0    0    0    0    0  
  
>> A(end, 3:end) = -1  
A =  
    1    1    1    1    1  
    0    0    0    0    0  
    0    0    0    0    0  
    0    0    0    0    0  
    0    0   -1   -1   -1  
  
>> |
```

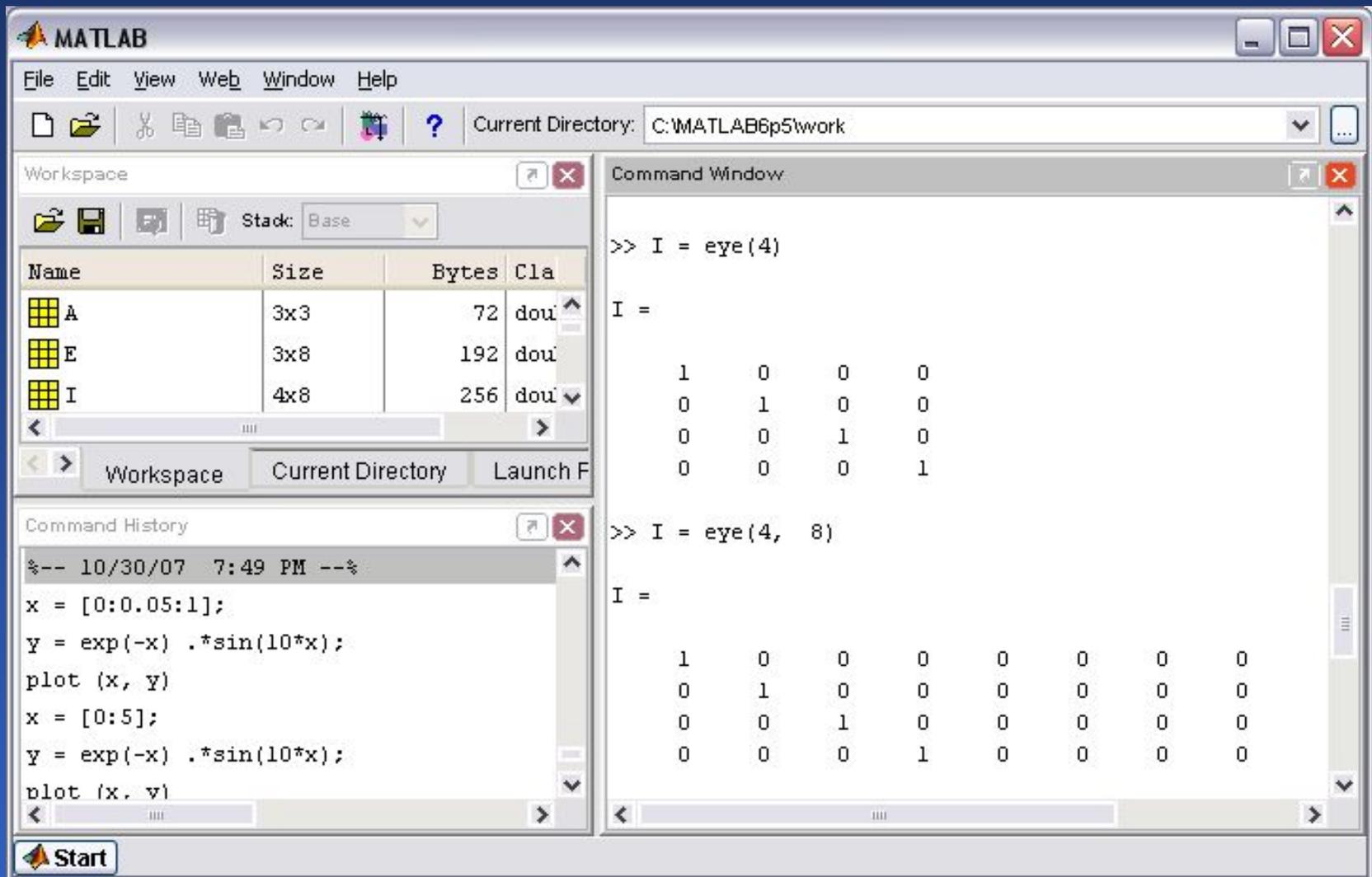
**Command History Window:**

```
%-- 10/30/07 7:49 PM --%  
x = [0:0.05:1];  
y = exp(-x) .*sin(10*x);  
plot (x, y)  
x = [0:5];  
y = exp(-x) .*sin(10*x);  
plot (x, y)  
x = [0:5];  
y = exp(-x) .*sin(10*x);  
plot (x, y)  
x = [0:0.05:5];
```

# Создание матриц специального вида



# Создание матриц специального вида



The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The workspace window displays three variables: A (3x3 matrix, 72 bytes), E (3x8 matrix, 192 bytes), and I (4x8 matrix, 256 bytes). The command window shows the execution of two commands: `I = eye(4)` and `I = eye(4, 8)`. The Command History window shows a sequence of commands: `x = [0:0.05:1];`, `y = exp(-x) .* sin(10*x);`, `plot(x, y)`, `x = [0:5];`, `y = exp(-x) .* sin(10*x);`, and `plot(x, y)`.

Name	Size	Bytes	Class
A	3x3	72	double
E	3x8	192	double
I	4x8	256	double

```
>> I = eye(4)
I =
     1     0     0     0
     0     1     0     0
     0     0     1     0
     0     0     0     1

>> I = eye(4, 8)
I =
     1     0     0     0     0     0     0     0
     0     1     0     0     0     0     0     0
     0     0     1     0     0     0     0     0
     0     0     0     1     0     0     0     0
```

```
%-- 10/30/07 7:49 PM --%
x = [0:0.05:1];
y = exp(-x) .* sin(10*x);
plot(x, y)
x = [0:5];
y = exp(-x) .* sin(10*x);
plot(x, y)
```

# Создание матриц специального вида

The image shows the MATLAB software interface. The Command Window displays the following commands and their outputs:

```
>> E = ones(3, 8)

E =

     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1

>> R = rand(3, 5)

R =

     0.9501     0.4860     0.4565     0.4447     0.9218
     0.2311     0.8913     0.0185     0.6154     0.7382
     0.6068     0.7621     0.8214     0.7919     0.1763

>> |
```

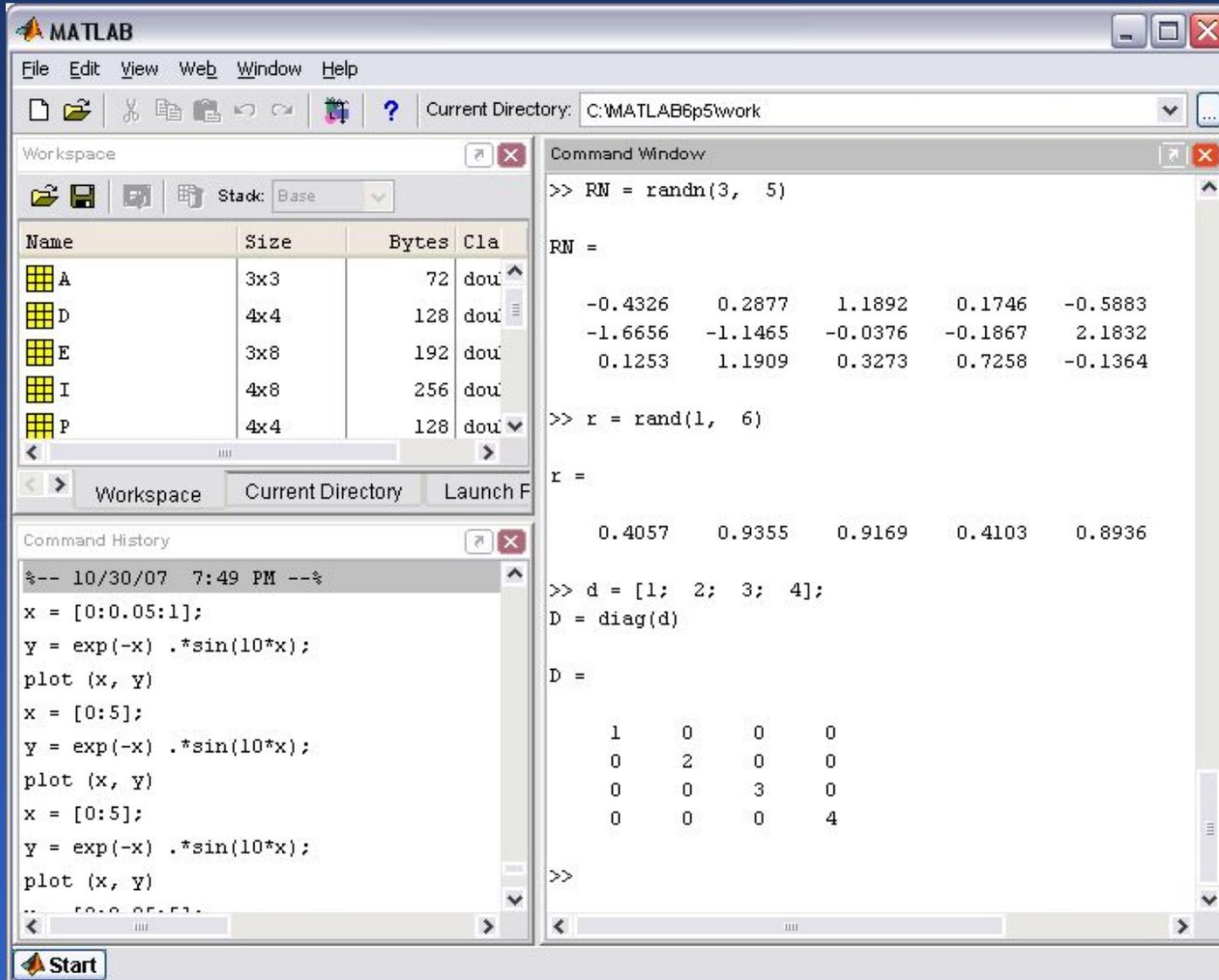
The Workspace window shows the following table:

Name	Size	Bytes	Class
A	3x3	72	double
E	3x8	192	double
R	3x5	120	double

The Command History window shows the following commands:

```
A = zeros(3, 6)
A = zeros(3)
I = eye(4)
I = eye(4, 8)
E = ones(3, 8)
R = rand(3, 5)
```

# Создание матриц специального вида



The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The workspace window displays a table of variables:

Name	Size	Bytes	Class
A	3x3	72	double
D	4x4	128	double
E	3x8	192	double
I	4x8	256	double
P	4x4	128	double

The Command Window shows the following commands and their outputs:

```
>> RN = randn(3, 5)
RN =
-0.4326    0.2877    1.1892    0.1746   -0.5883
-1.6656   -1.1465   -0.0376   -0.1867    2.1832
 0.1253    1.1909    0.3273    0.7258   -0.1364

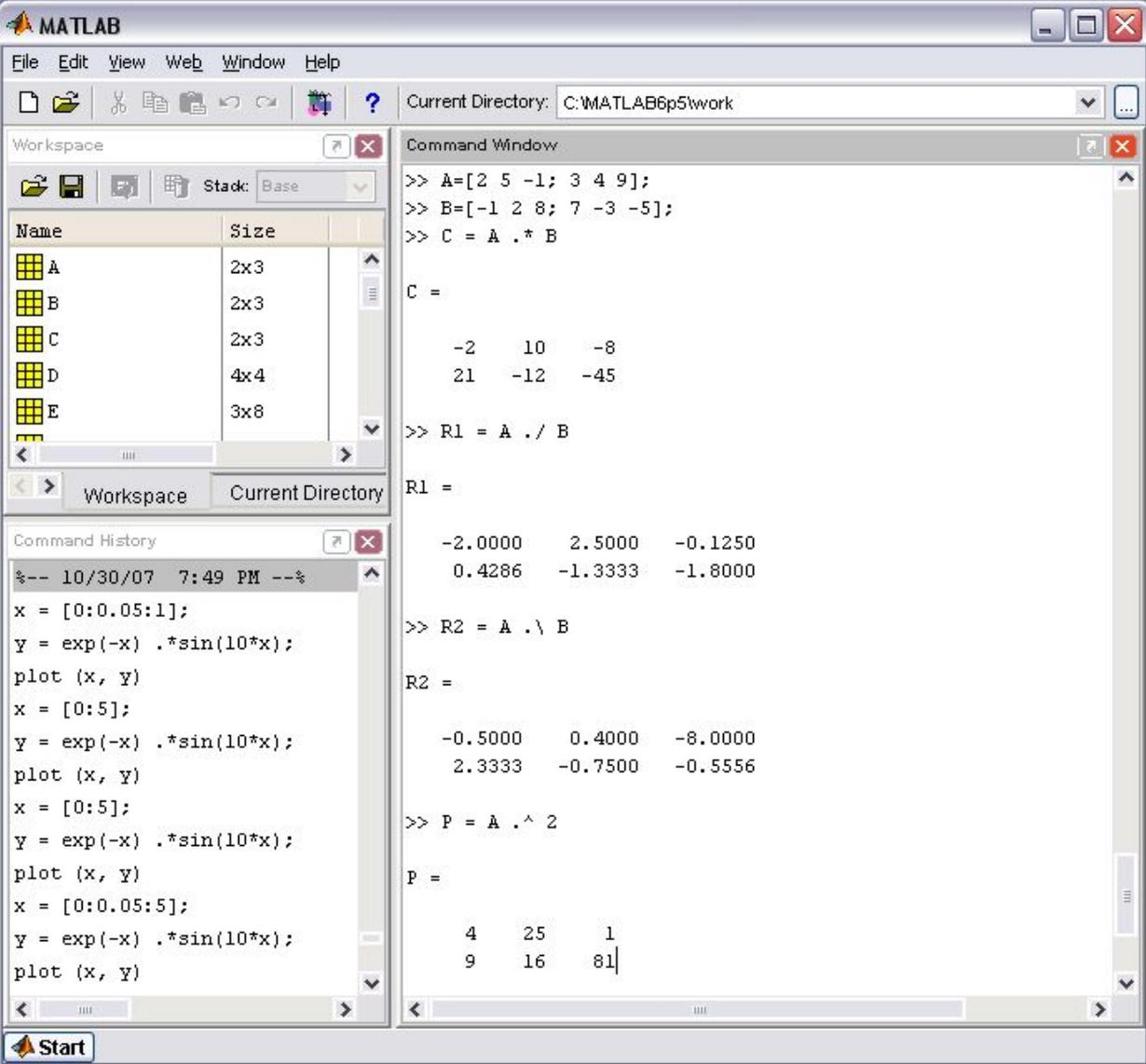
>> r = rand(1, 6)
r =
 0.4057    0.9355    0.9169    0.4103    0.8936

>> d = [1; 2; 3; 4];
D = diag(d)
D =
 1    0    0    0
 0    2    0    0
 0    0    3    0
 0    0    0    4
```

The Command History window shows the following commands:

```
%-- 10/30/07 7:49 PM --%
x = [0:0.05:1];
y = exp(-x) .*sin(10*x);
plot(x, y)
x = [0:5];
y = exp(-x) .*sin(10*x);
plot(x, y)
x = [0:5];
y = exp(-x) .*sin(10*x);
plot(x, y)
```

# Поэлементные операции с матрицами



The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The Workspace window displays a table of variables:

Name	Size
A	2x3
B	2x3
C	2x3
D	4x4
E	3x8

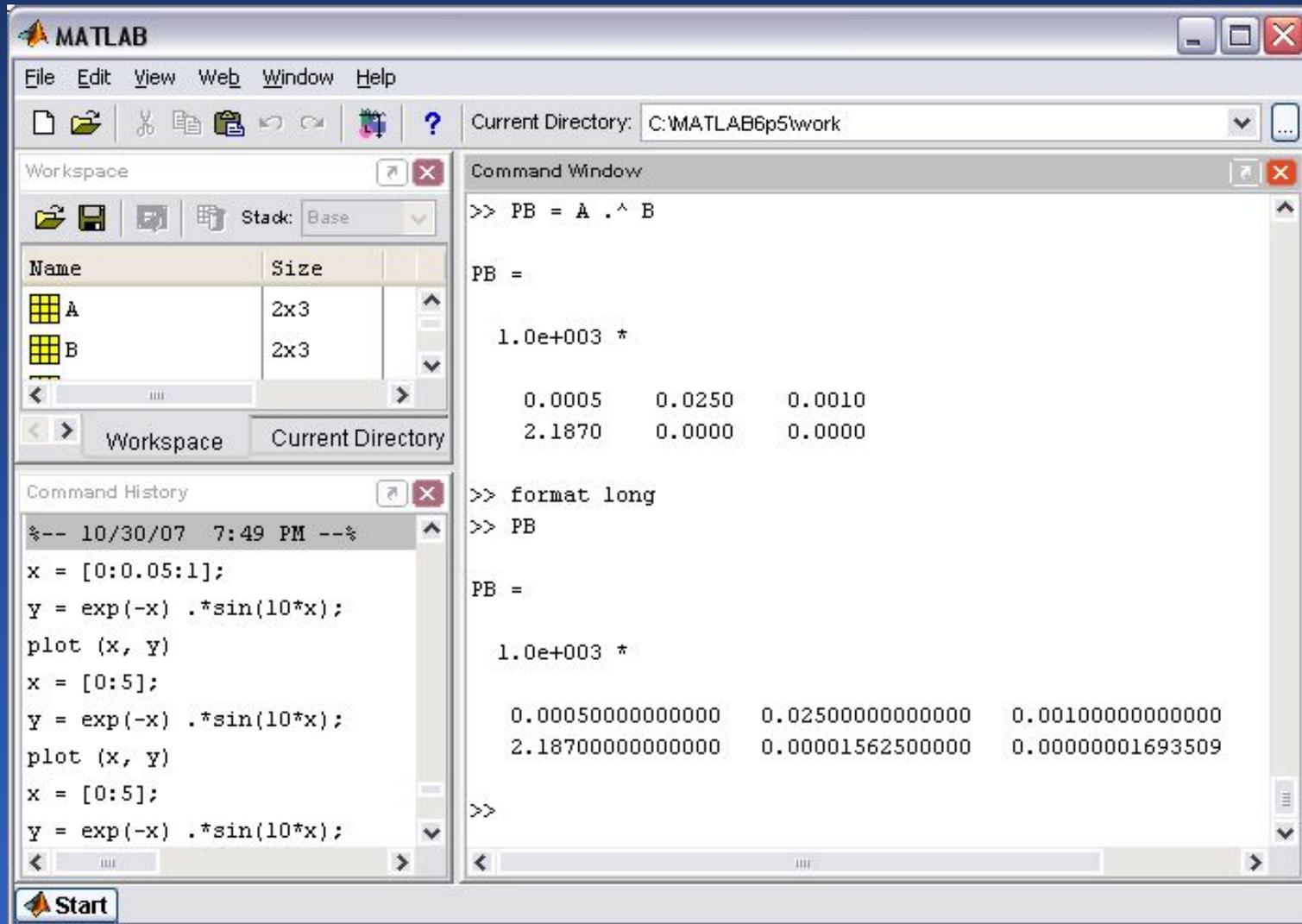
The Command Window shows the following commands and their outputs:

```
>> A=[2 5 -1; 3 4 9];  
>> B=[-1 2 8; 7 -3 -5];  
>> C = A .* B  
C =  
    -2    10    -8  
    21   -12   -45  
  
>> R1 = A ./ B  
R1 =  
   -2.0000    2.5000   -0.1250  
    0.4286   -1.3333   -1.8000  
  
>> R2 = A .\ B  
R2 =  
   -0.5000    0.4000   -8.0000  
    2.3333   -0.7500   -0.5556  
  
>> P = A .^ 2  
P =  
     4     25     1  
     9     16    81
```

The Command History window shows the following commands:

```
%-- 10/30/07 7:49 PM --%  
x = [0:0.05:1];  
y = exp(-x) .*sin(10*x);  
plot (x, y)  
x = [0:5];  
y = exp(-x) .*sin(10*x);  
plot (x, y)  
x = [0:5];  
y = exp(-x) .*sin(10*x);  
plot (x, y)  
x = [0:0.05:5];  
y = exp(-x) .*sin(10*x);  
plot (x, y)
```

# Поэлементные операции с матрицами



The screenshot shows the MATLAB environment with the following components:

- Current Directory:** C:\MATLAB6p5\work
- Workspace:** Contains variables A (2x3) and B (2x3).
- Command Window:** Shows the execution of the command `PB = A .* B` and the resulting matrix PB.
- Command History:** Shows the sequence of commands executed, including `x = [0:0.05:1];`, `y = exp(-x) .* sin(10*x);`, `plot(x, y)`, and `format long`.

The Command Window output for `PB = A .* B` is:

```
>> PB = A .* B

PB =

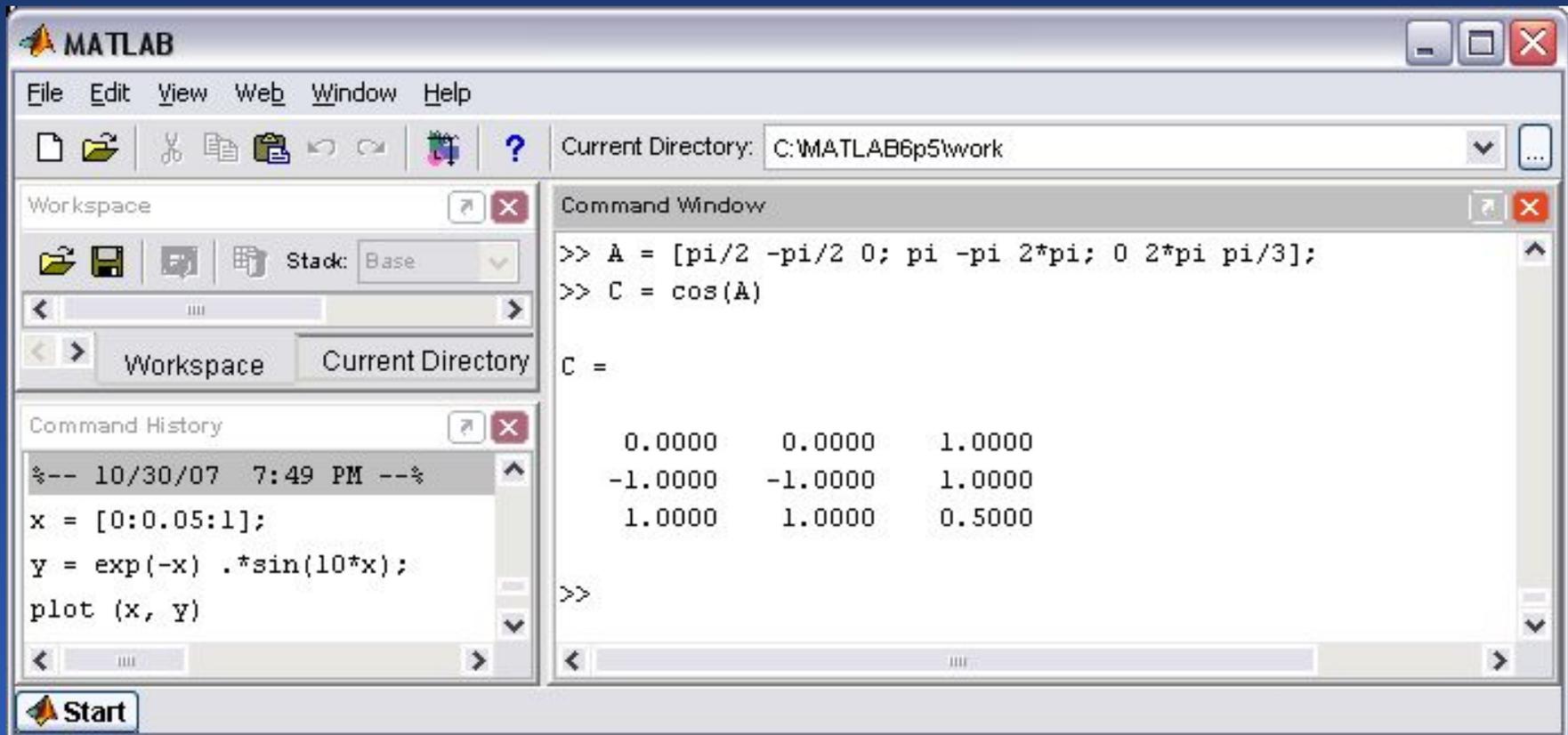
1.0e+003 *

    0.0005    0.0250    0.0010
    2.1870    0.0000    0.0000
```

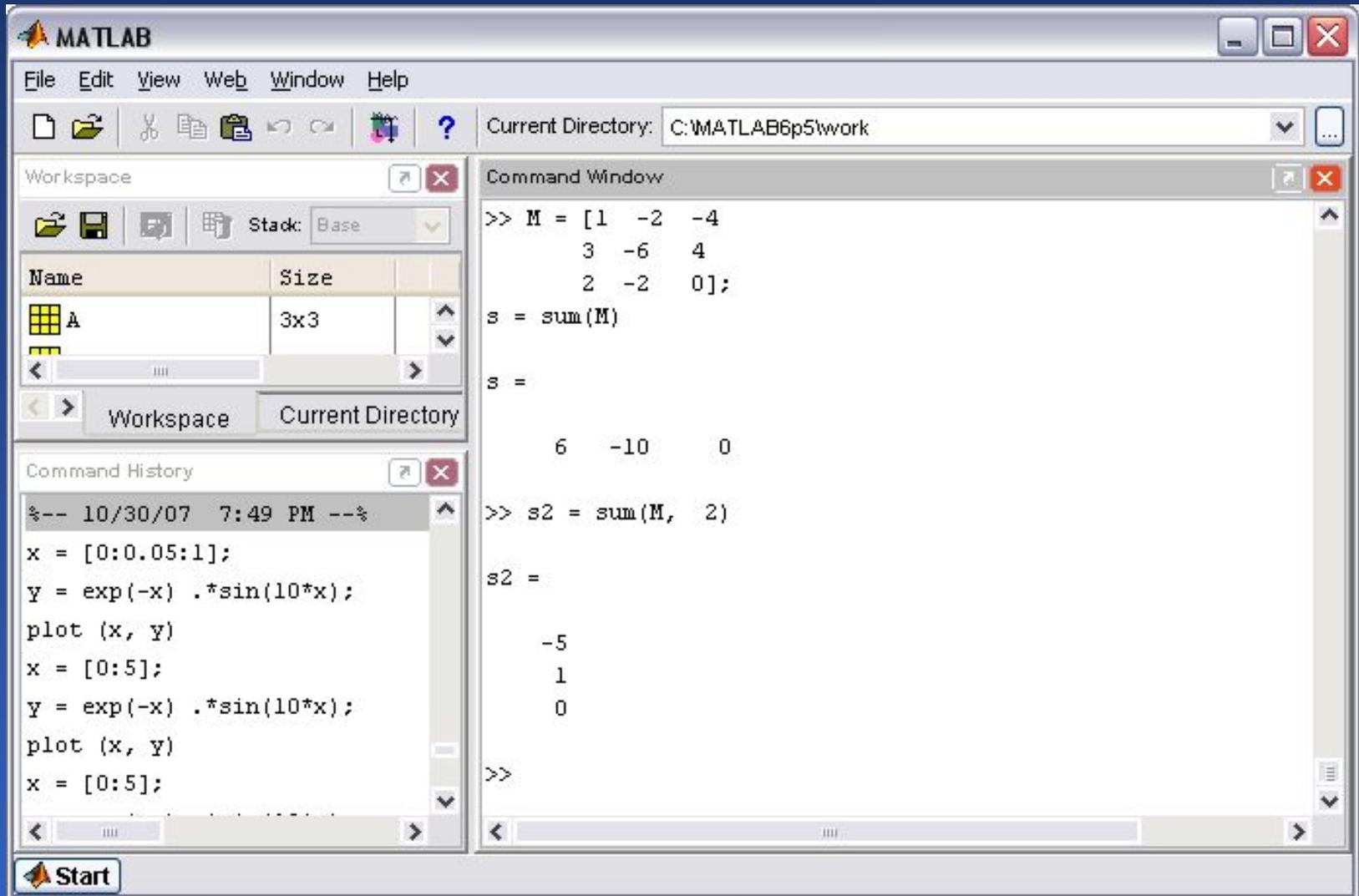
The Command History shows the following commands:

```
%-- 10/30/07 7:49 PM --%
x = [0:0.05:1];
y = exp(-x) .* sin(10*x);
plot(x, y)
x = [0:5];
y = exp(-x) .* sin(10*x);
plot(x, y)
x = [0:5];
y = exp(-x) .* sin(10*x);
```

# Вычисление математических функций от элементов матриц



# Применение функций обработки данных к матрицам



# Сортировка элементов матрицы в порядке возрастания и убывания

The image shows the MATLAB software interface. The Command Window displays the following commands and results:

```
>> MC = sort(M)

MC =

     1     -6     -4
     2     -2      0
     3     -2      4

>> MR = sort(M, 2)

MR =

    -4    -2     1
    -6     3     4
    -2     0     2
```

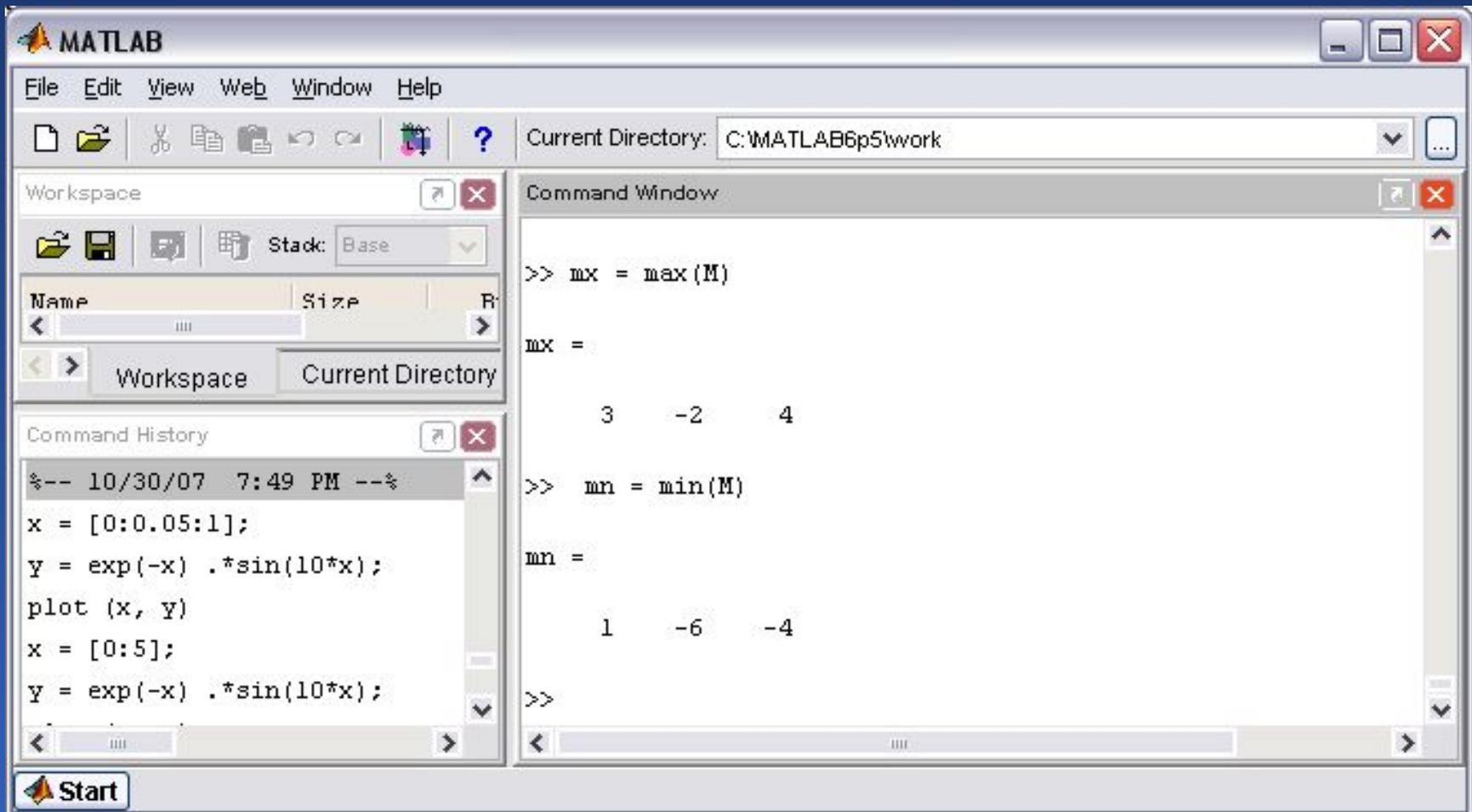
The Command History window shows the following code:

```
%-- 10/30/07 7:49 PM --%
x = [0:0.05:1];
y = exp(-x) .* sin(10*x);
plot(x, y)
x = [0:5];
y = exp(-x) .* sin(10*x);
plot(x, y)
```

The Workspace window shows a table with columns for Name and Size.

Name	Size

# Максимальные или минимальные элементы в соответствующих столбцах матрицы

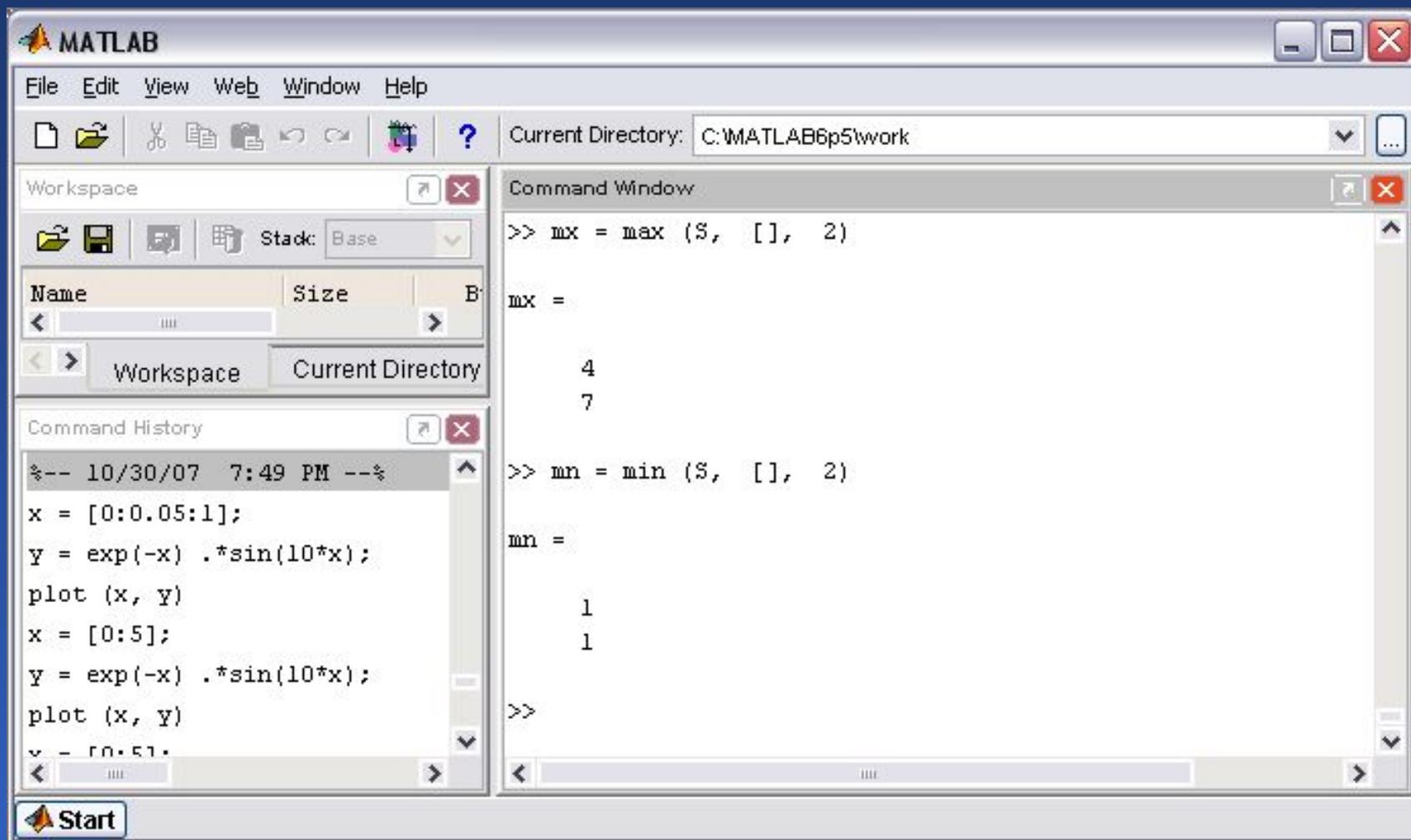


The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The workspace window shows a table with columns for Name, Size, and R. The command history window shows the following commands: `x = [0:0.05:1];`, `y = exp(-x) .* sin(10*x);`, `plot(x, y)`, `x = [0:5];`, and `y = exp(-x) .* sin(10*x);`. The command window shows the execution of `mx = max(M)` resulting in `mx = 3 -2 4` and `mn = min(M)` resulting in `mn = 1 -6 -4`.

Name	Size	R

```
>> mx = max(M)
mx =
     3    -2     4
>> mn = min(M)
mn =
     1    -6    -4
>>
```

# Максимальные или минимальные элементы в соответствующих столбцах матрицы



The image shows the MATLAB software interface. The top menu bar includes File, Edit, View, Web, Window, and Help. The current directory is C:\MATLAB6p5\work. The Workspace window shows a table with columns for Name, Size, and Browser. The Command Window displays the following code and output:

```
>> mx = max (S, [], 2)

mx =

     4
     7

>> mn = min (S, [], 2)

mn =

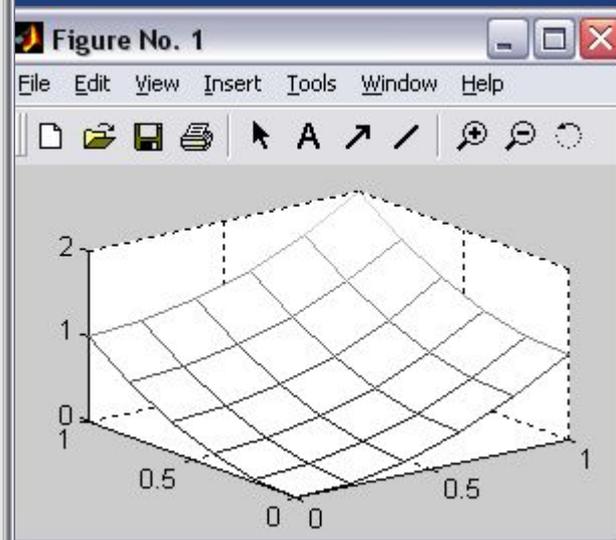
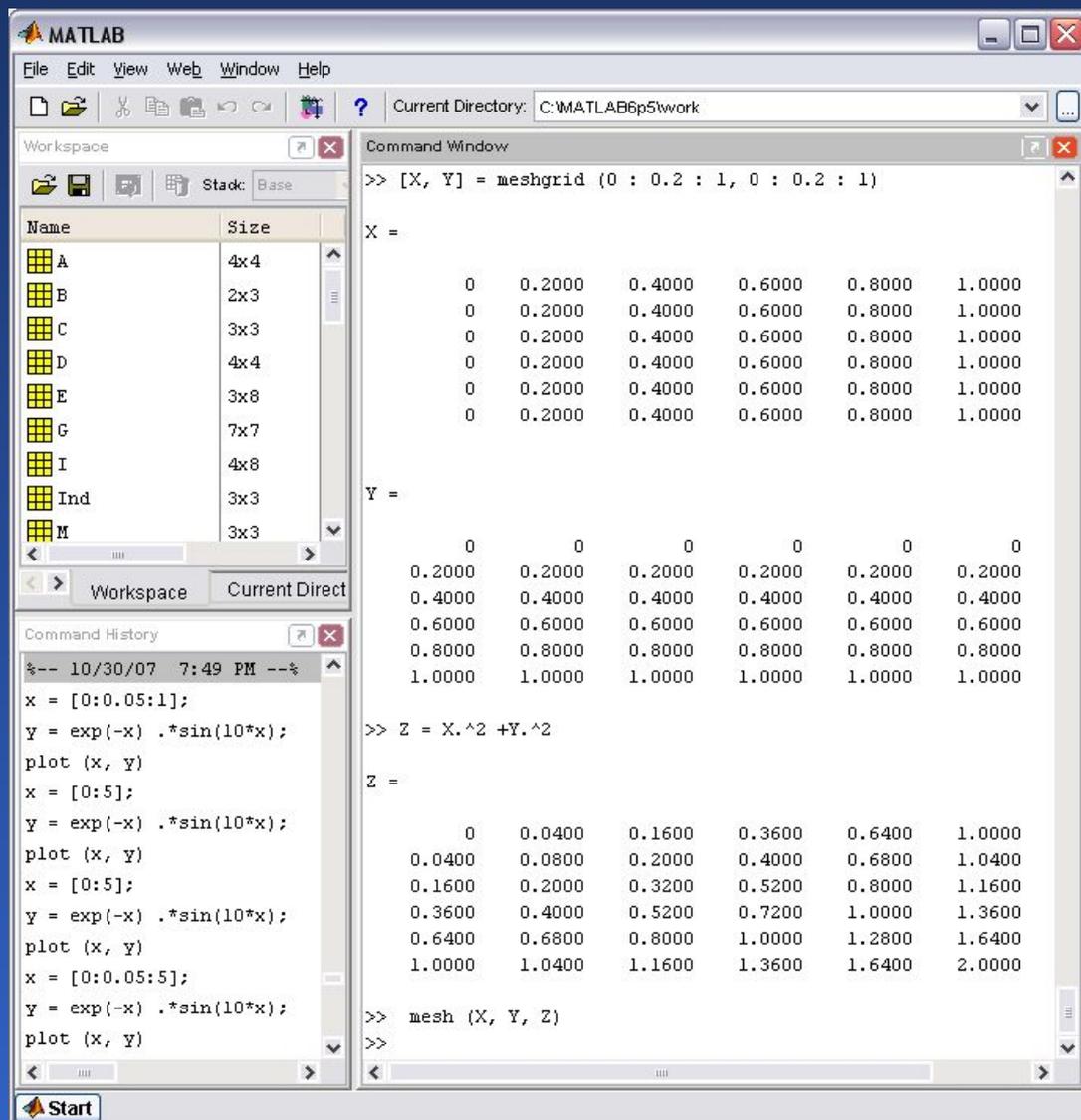
     1
     1

>>
```

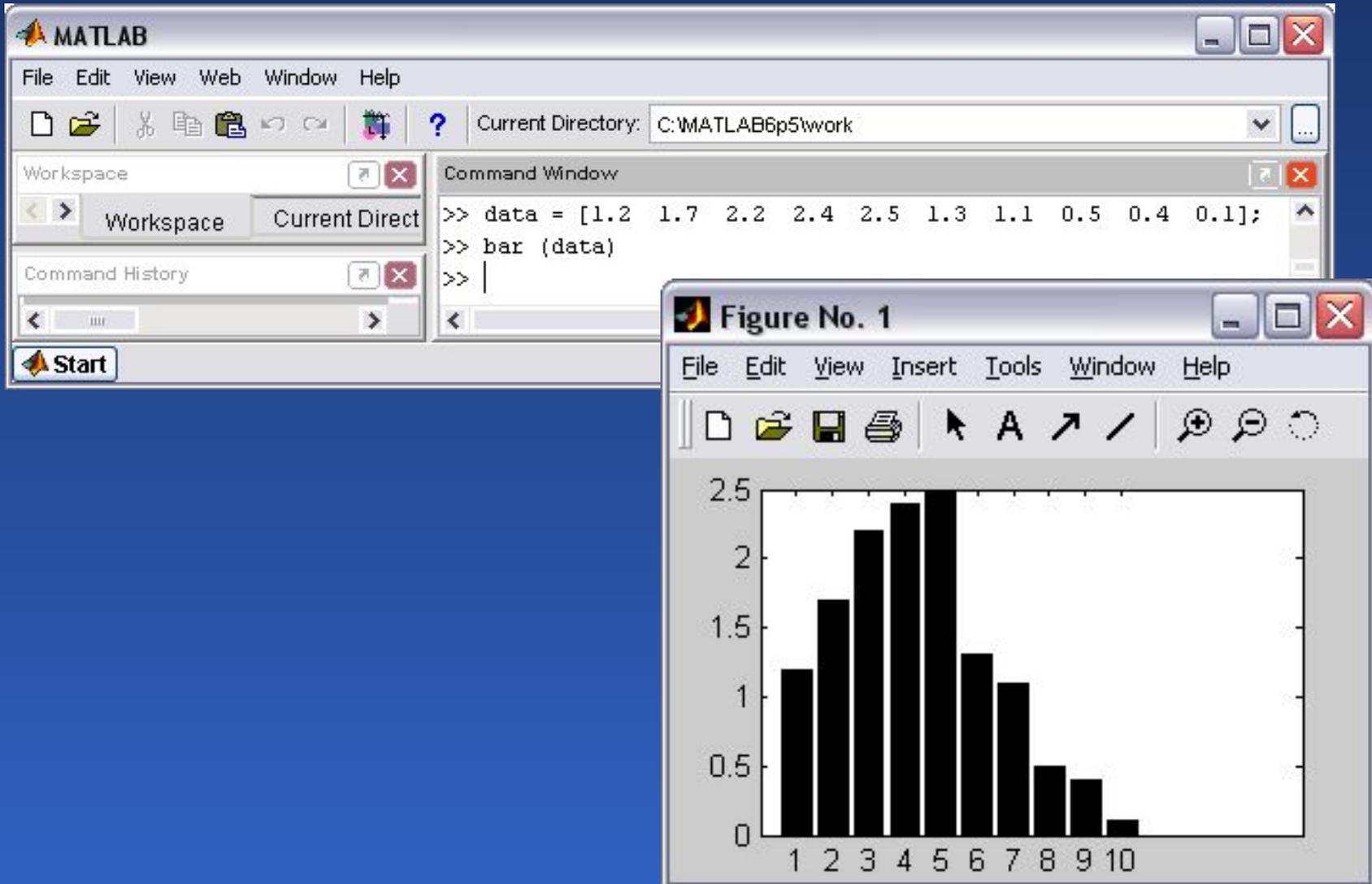
The Command History window shows the following commands:

```
%-- 10/30/07 7:49 PM --%
x = [0:0.05:1];
y = exp(-x) .*sin(10*x);
plot (x, y)
x = [0:5];
y = exp(-x) .*sin(10*x);
plot (x, y)
v = [0.5];
```

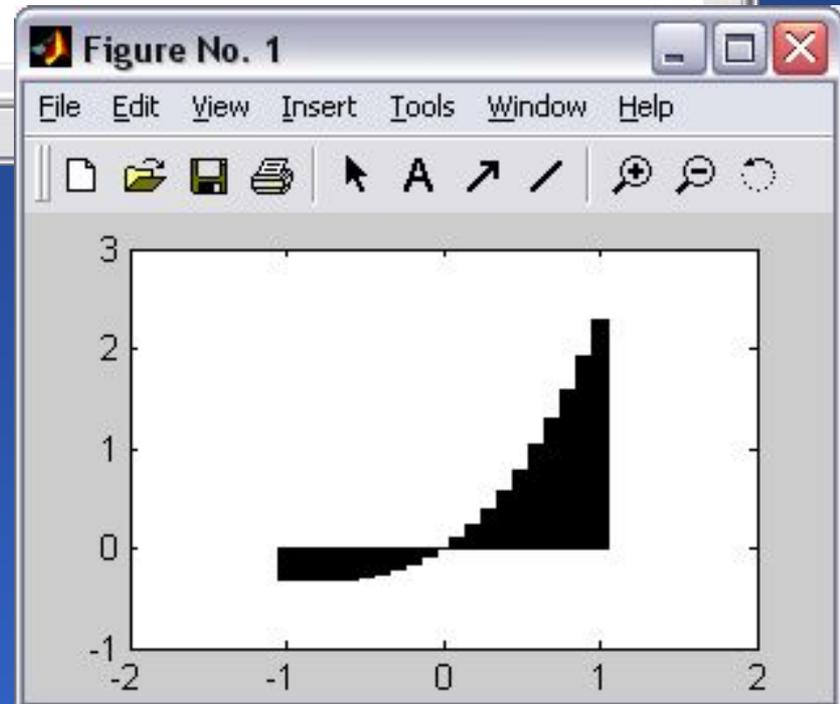
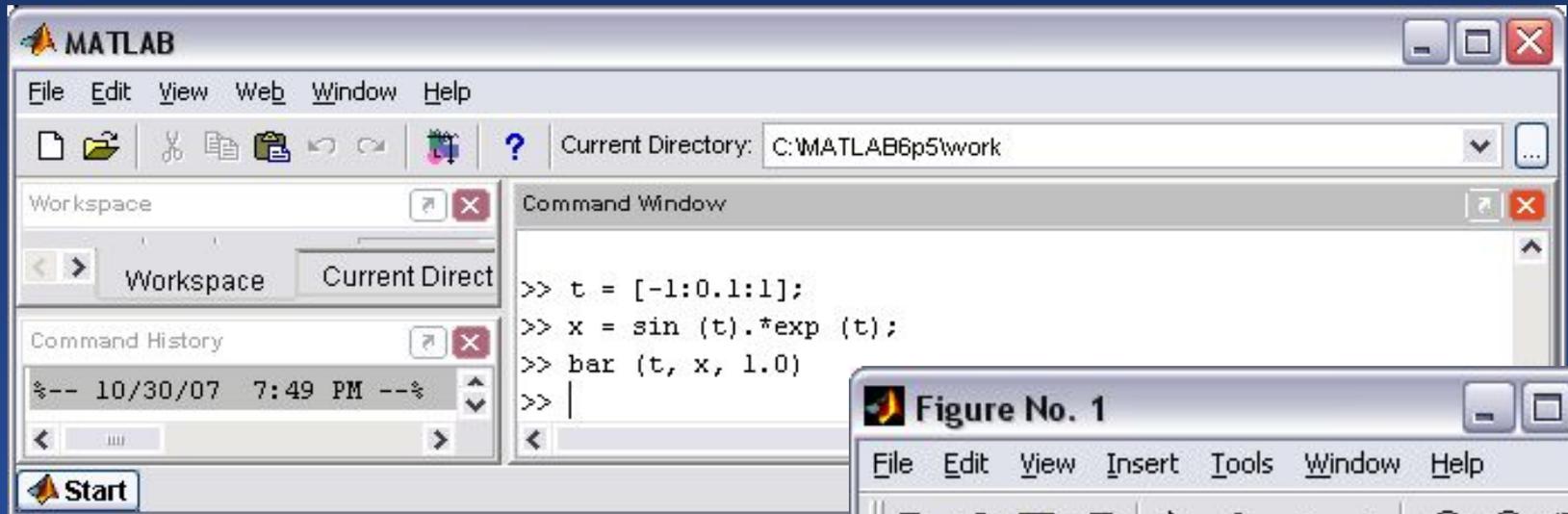
# Графики двух переменных



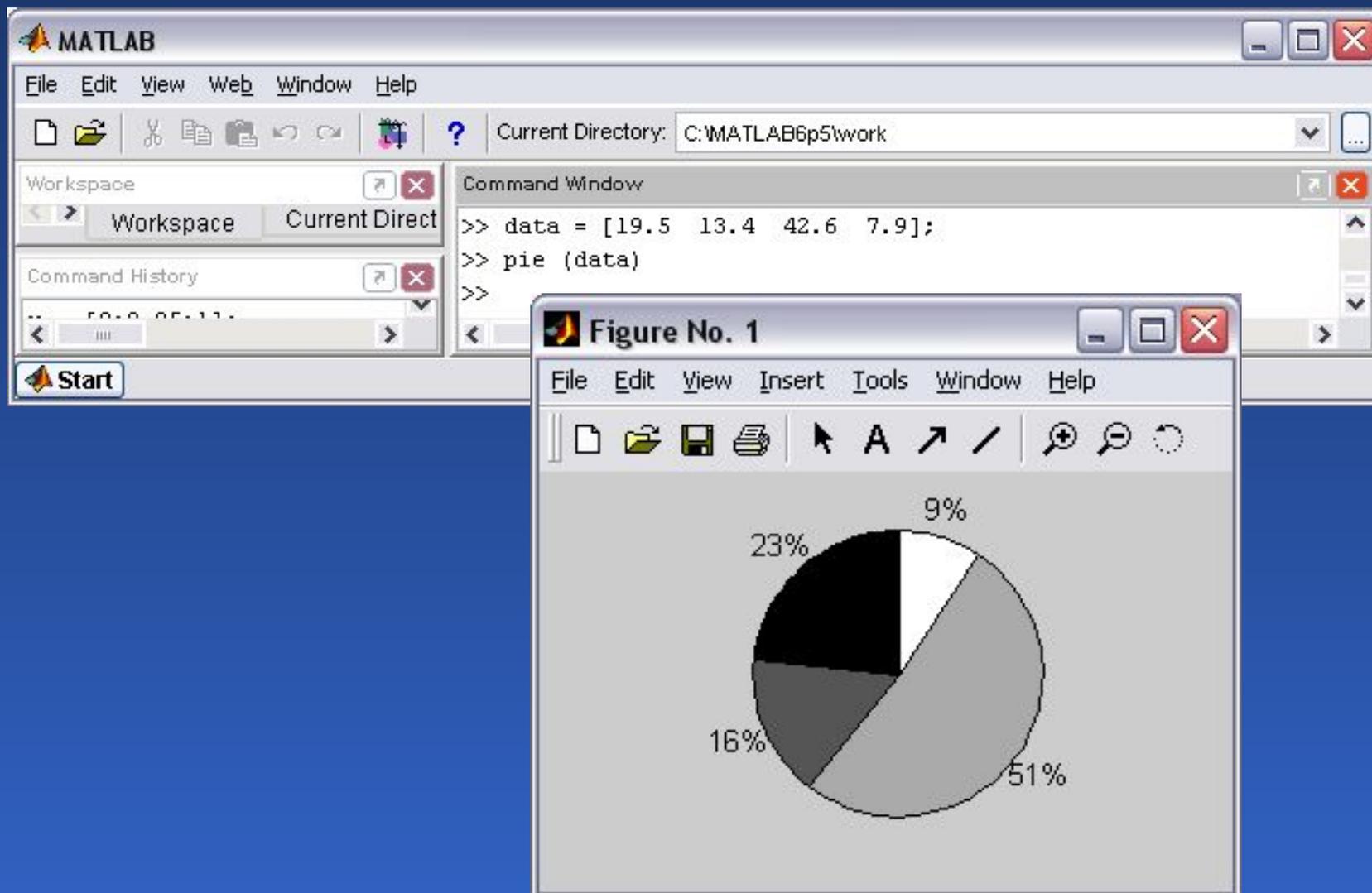
# Диаграммы векторных данных



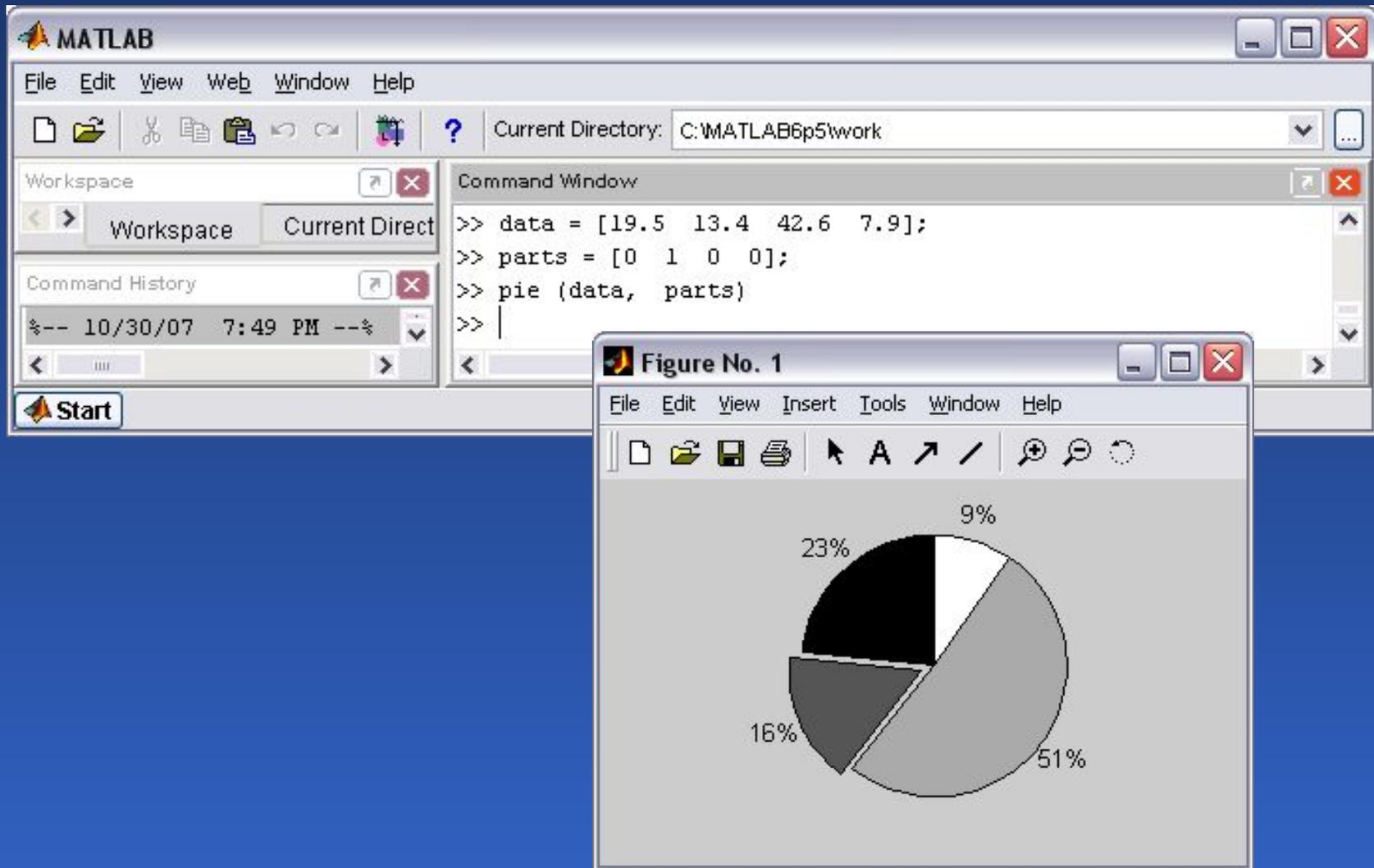
# Диаграммы векторных данных



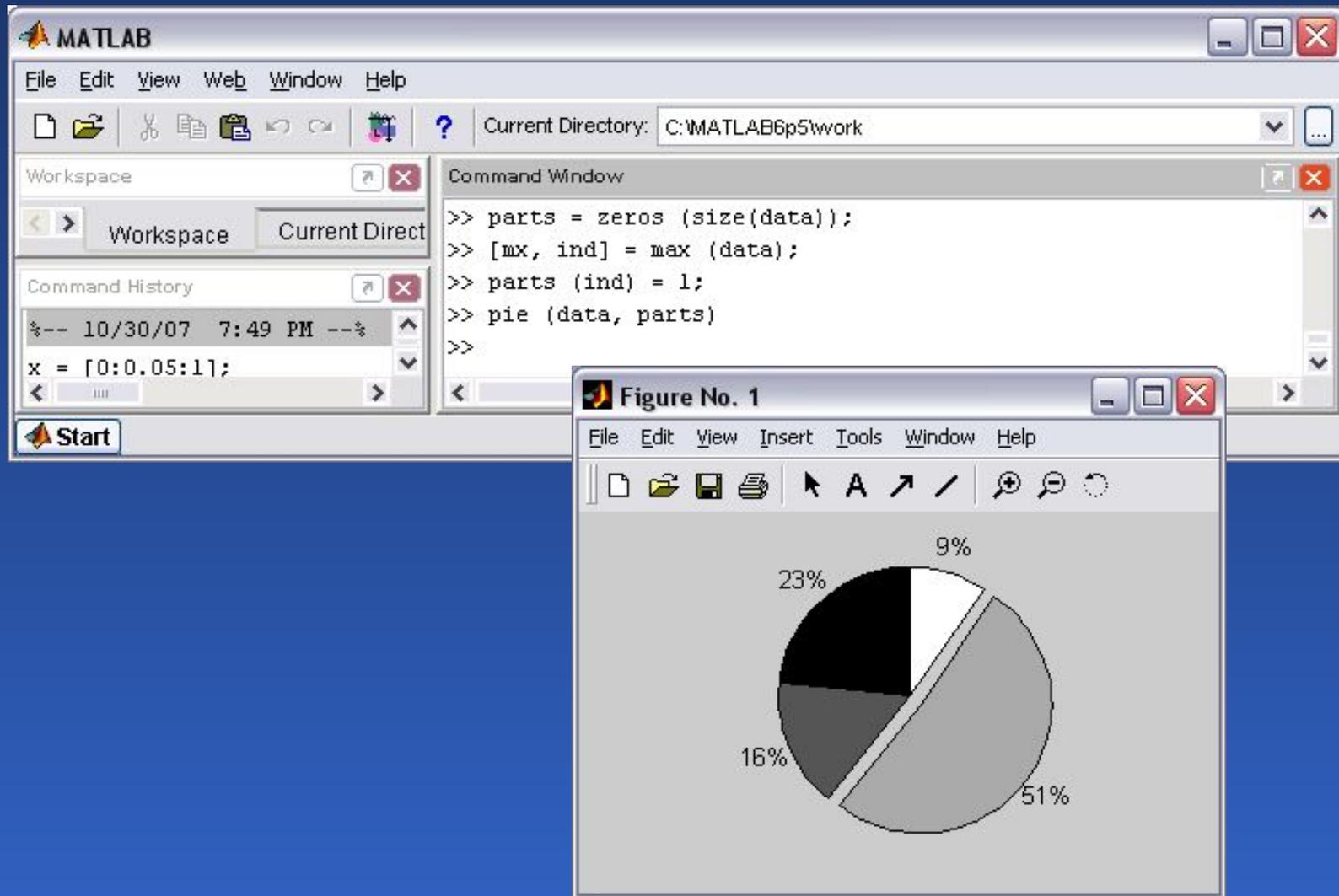
# Круговая диаграмма



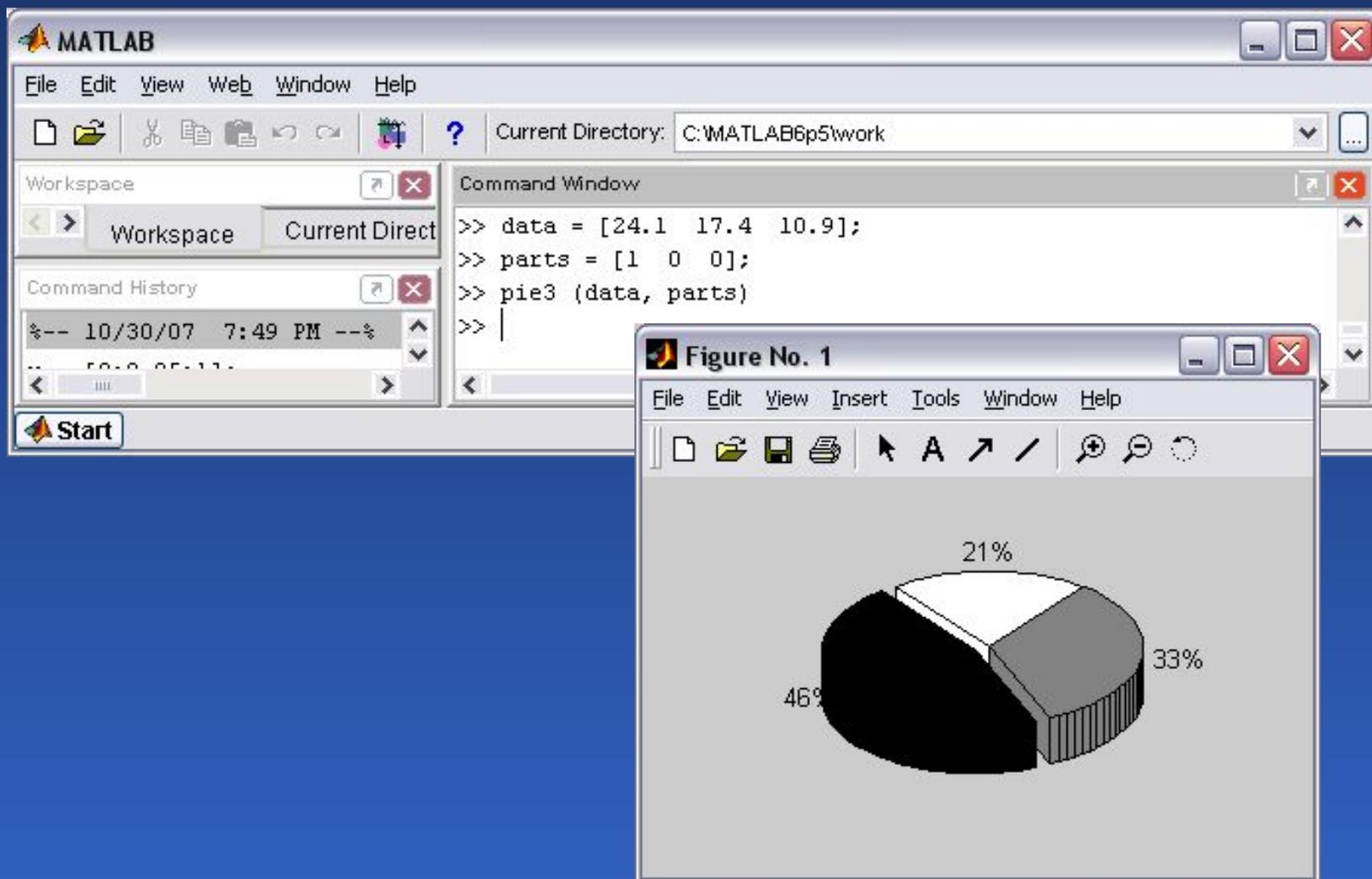
# Круговая диаграмма с отдельным сектором



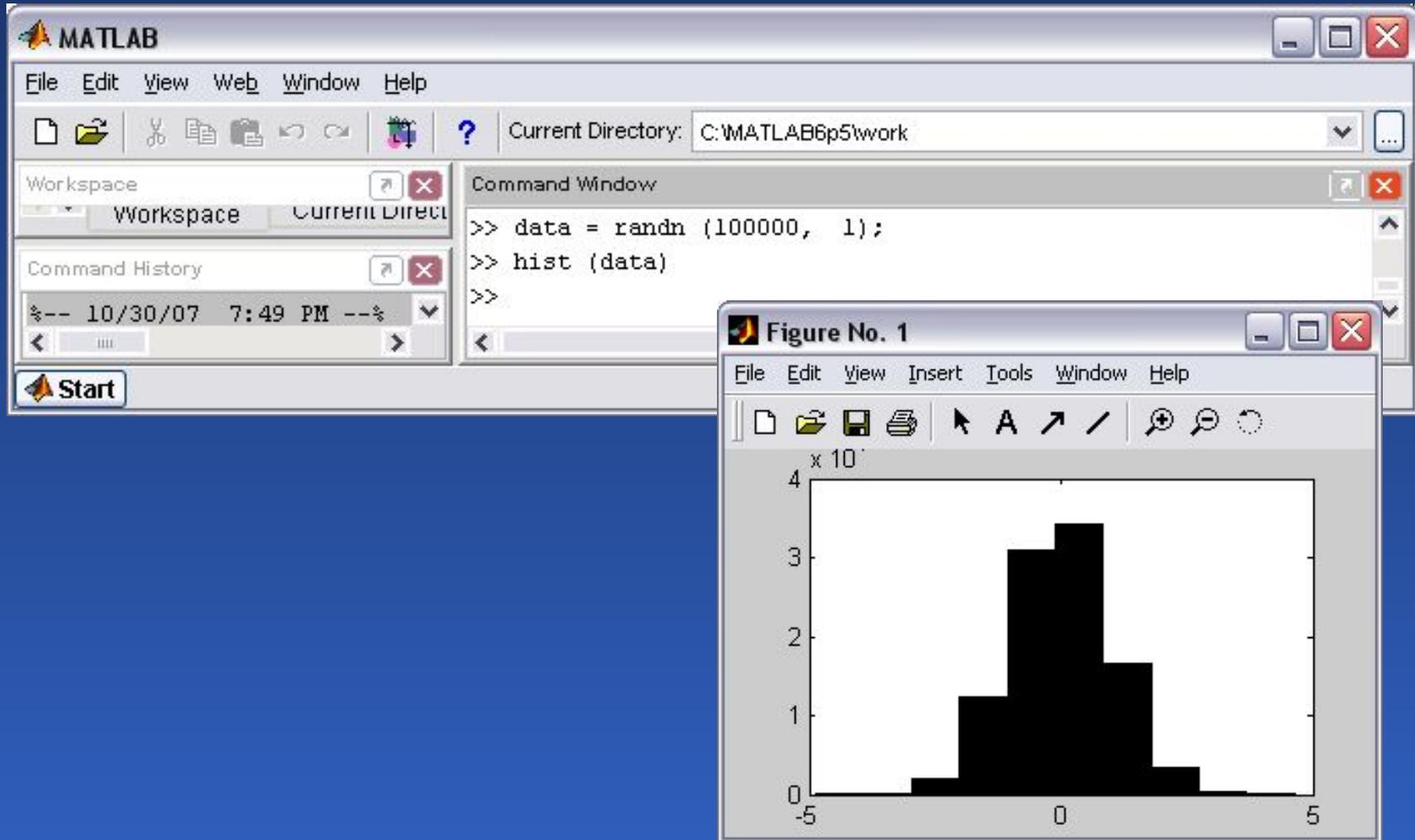
# Круговая диаграмма с максимальным сектором



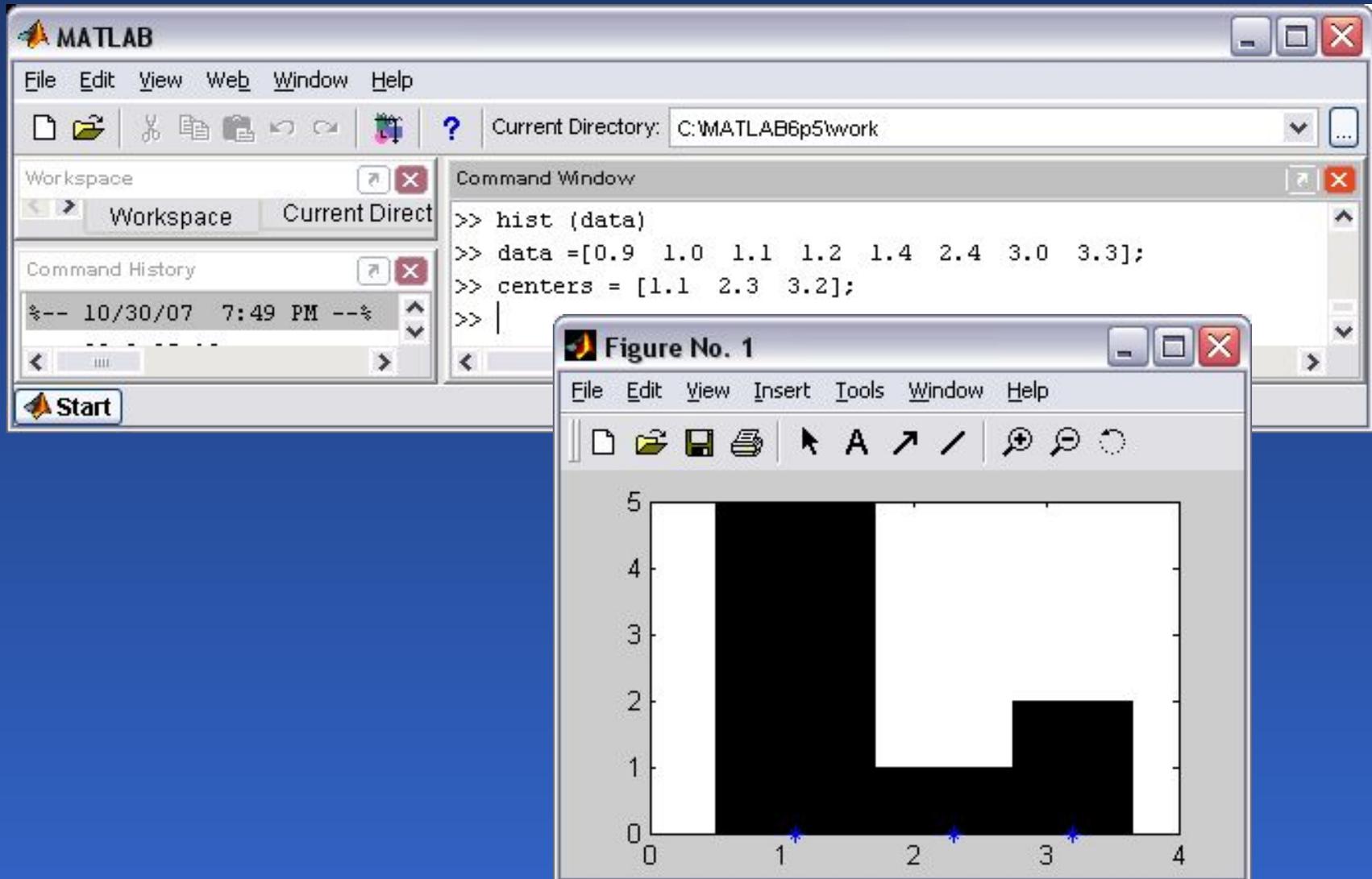
# Трёхмерная круговая диаграмма с максимальным сектором



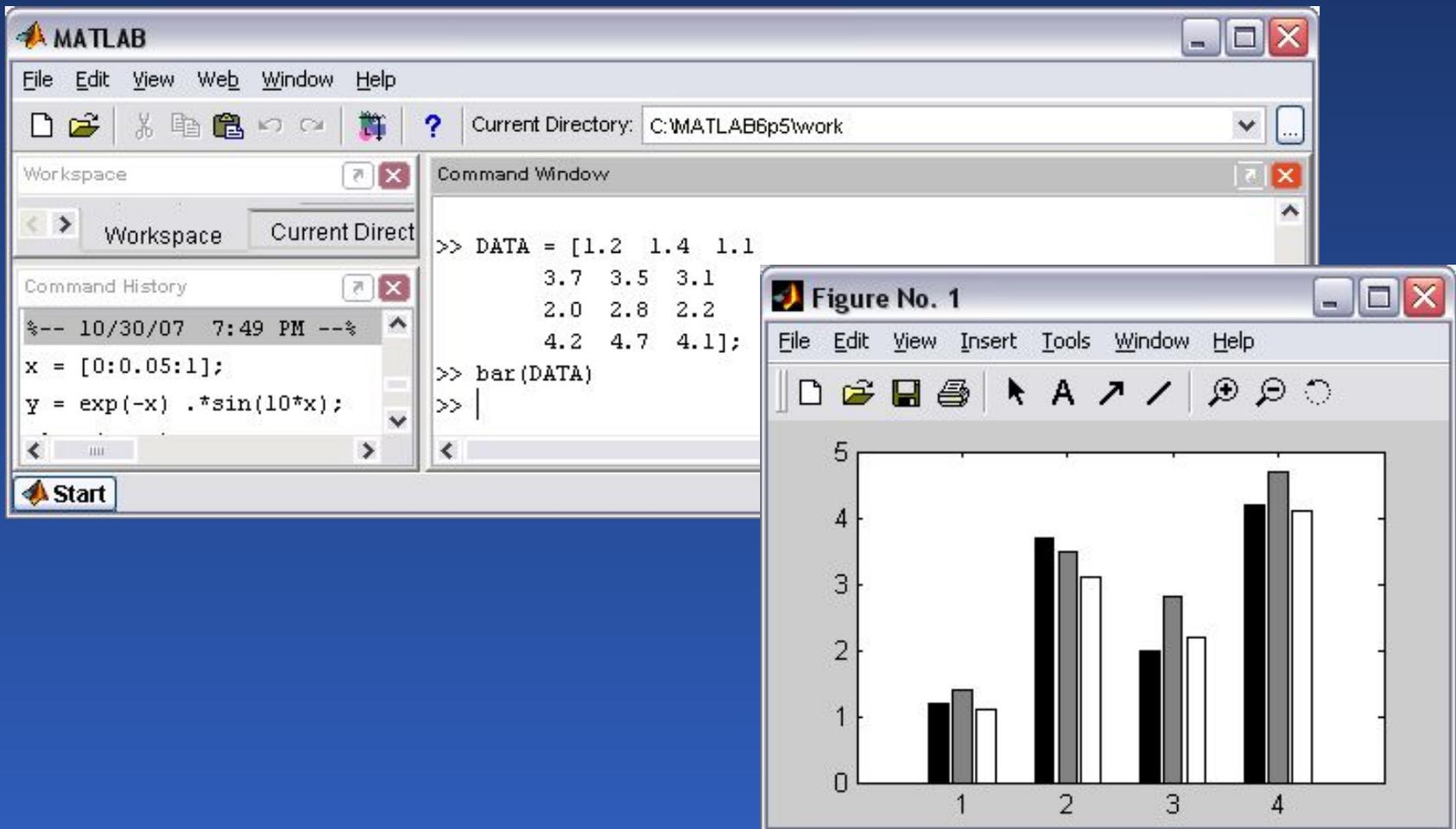
# Гистограммы векторных данных



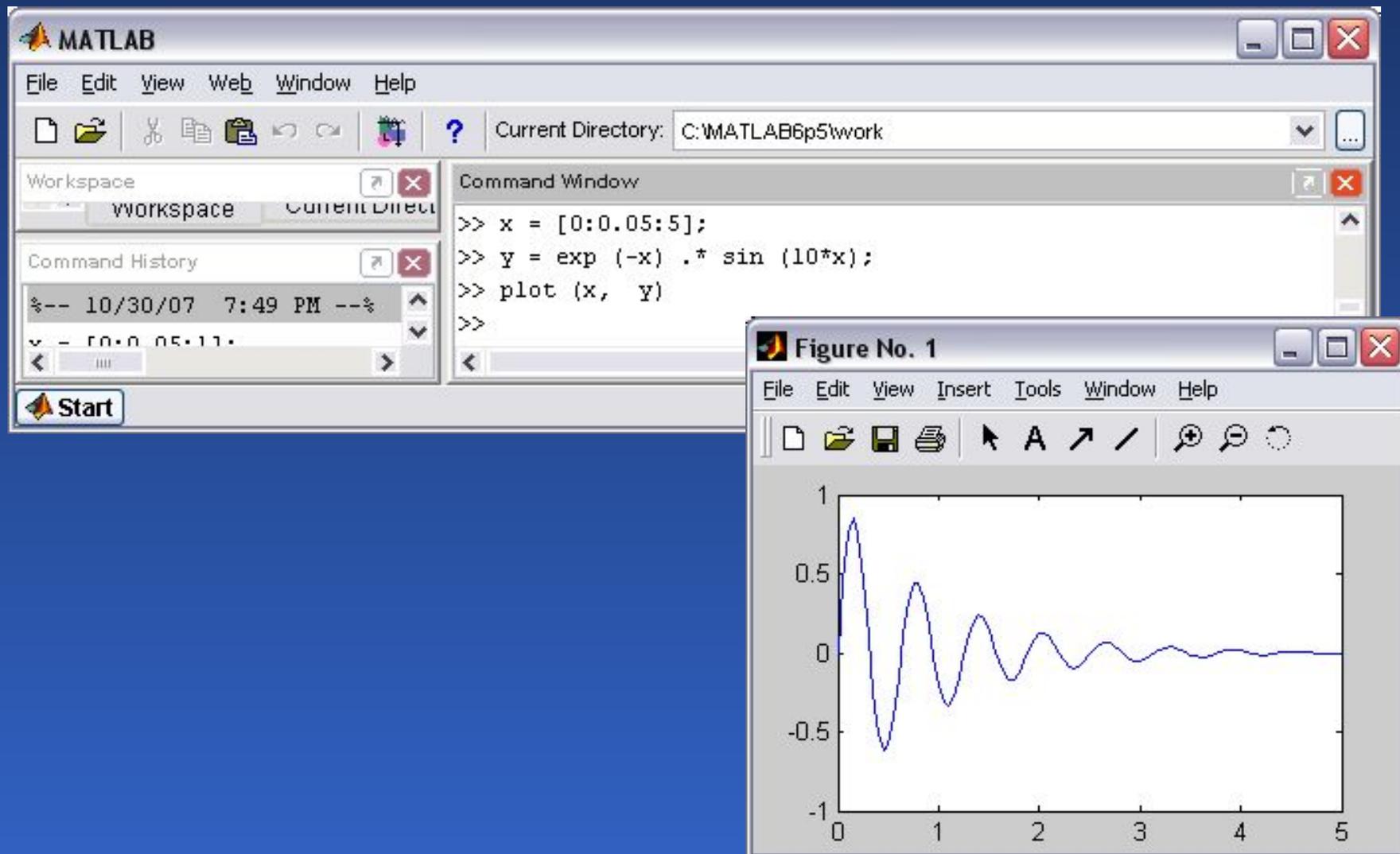
# Гистограмма векторных данных с центрами интервалов



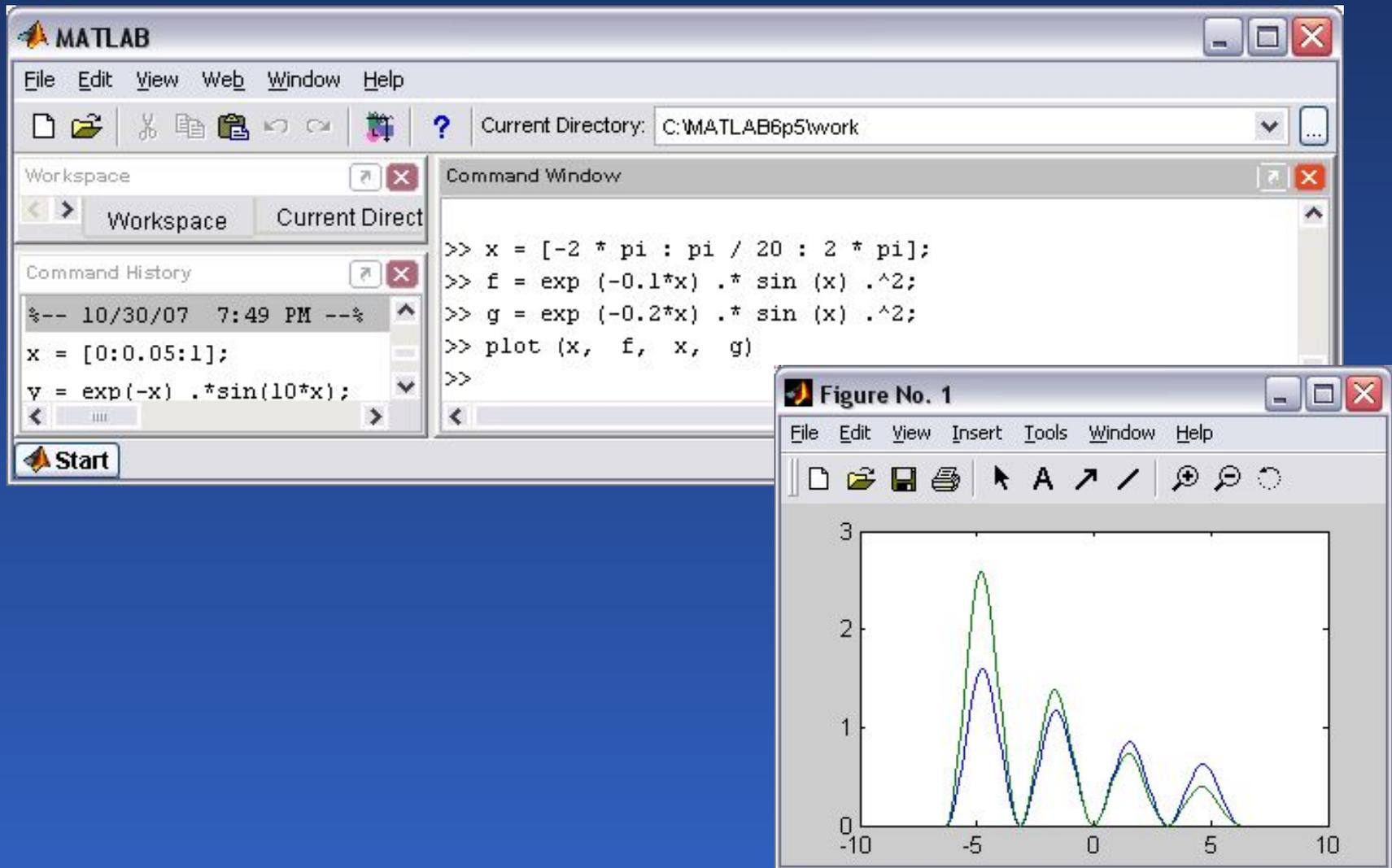
# Представление матричных данных



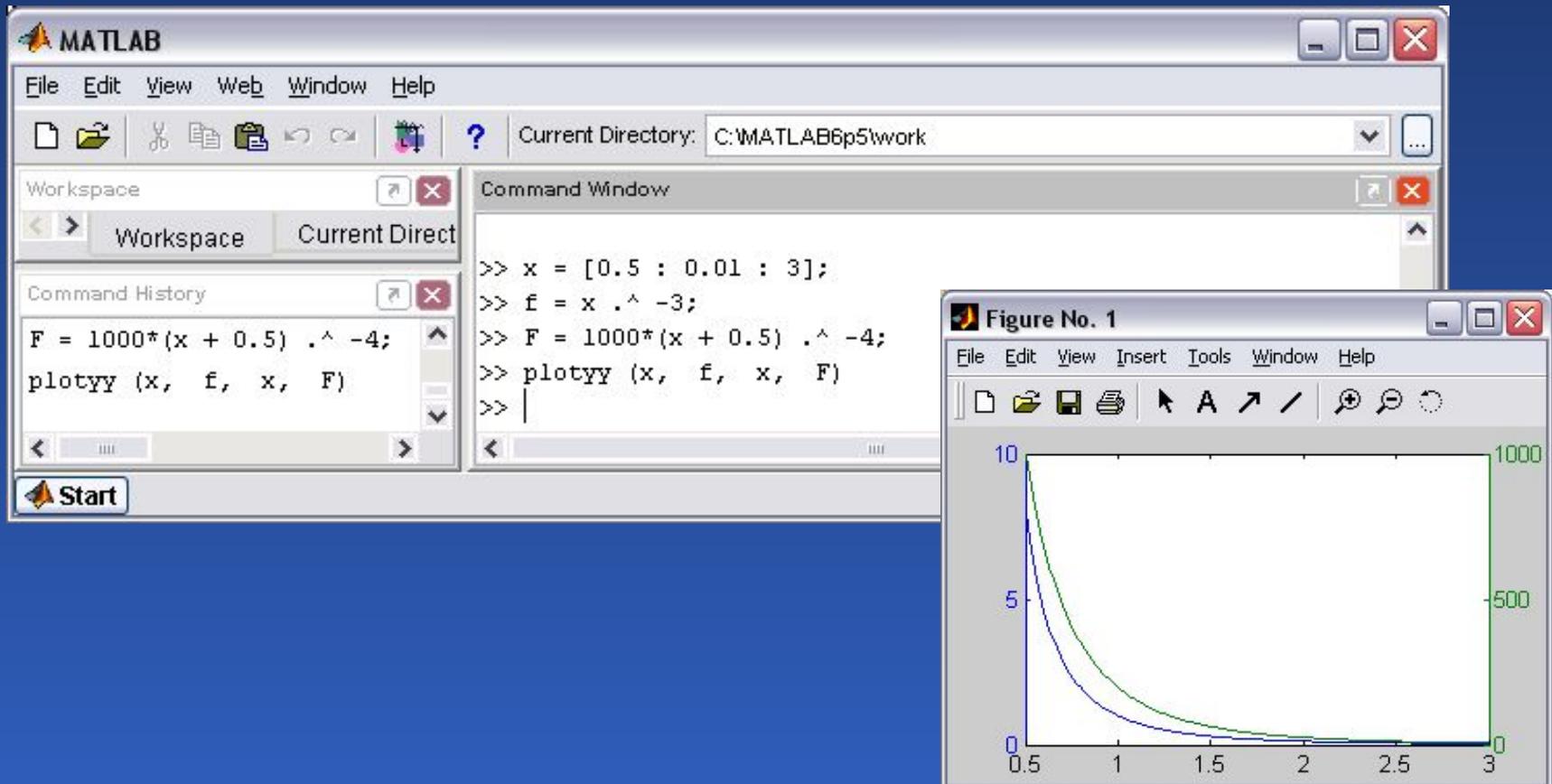
# Графики в линейном масштабе



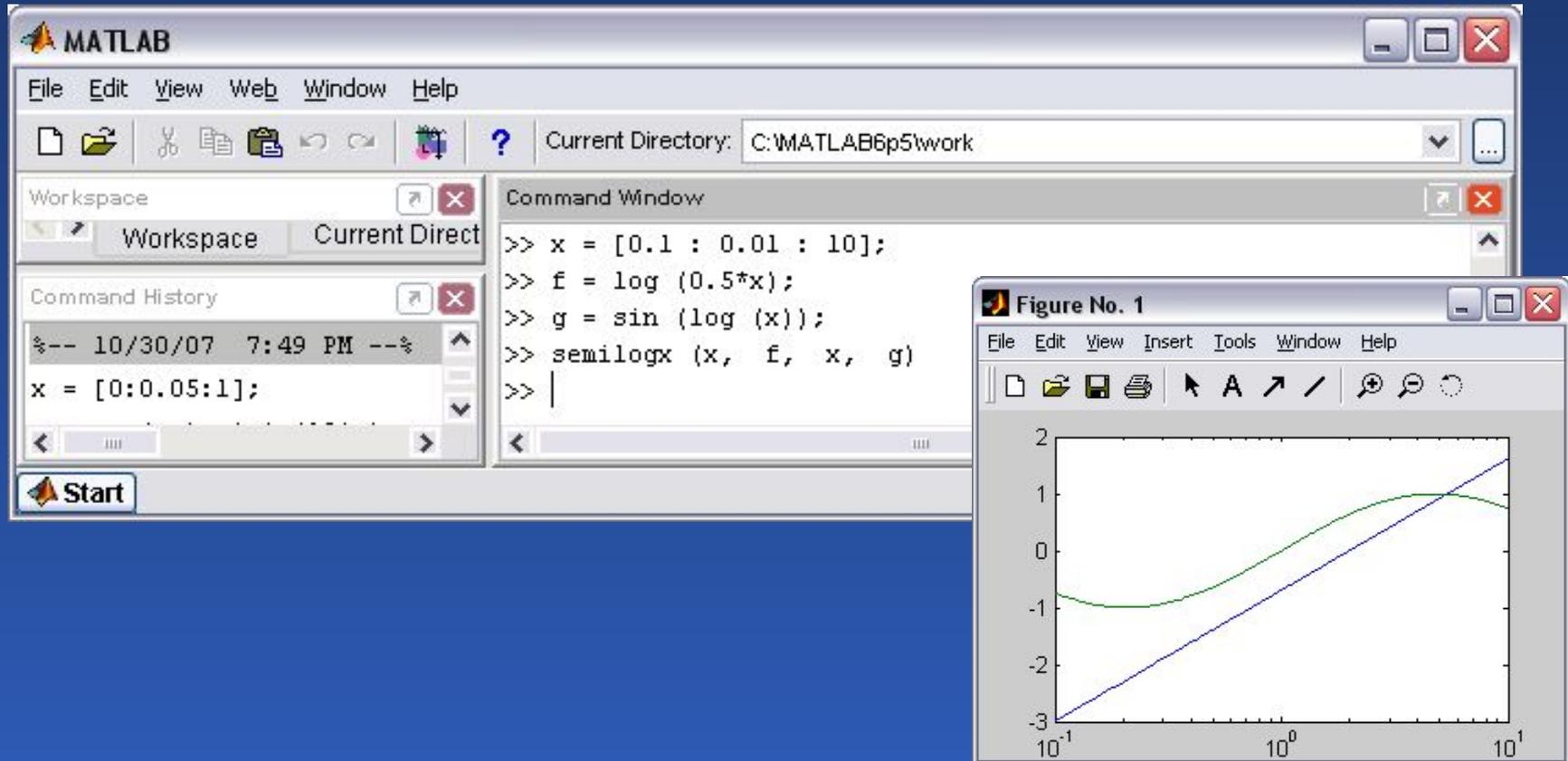
# Два графика на одних осях



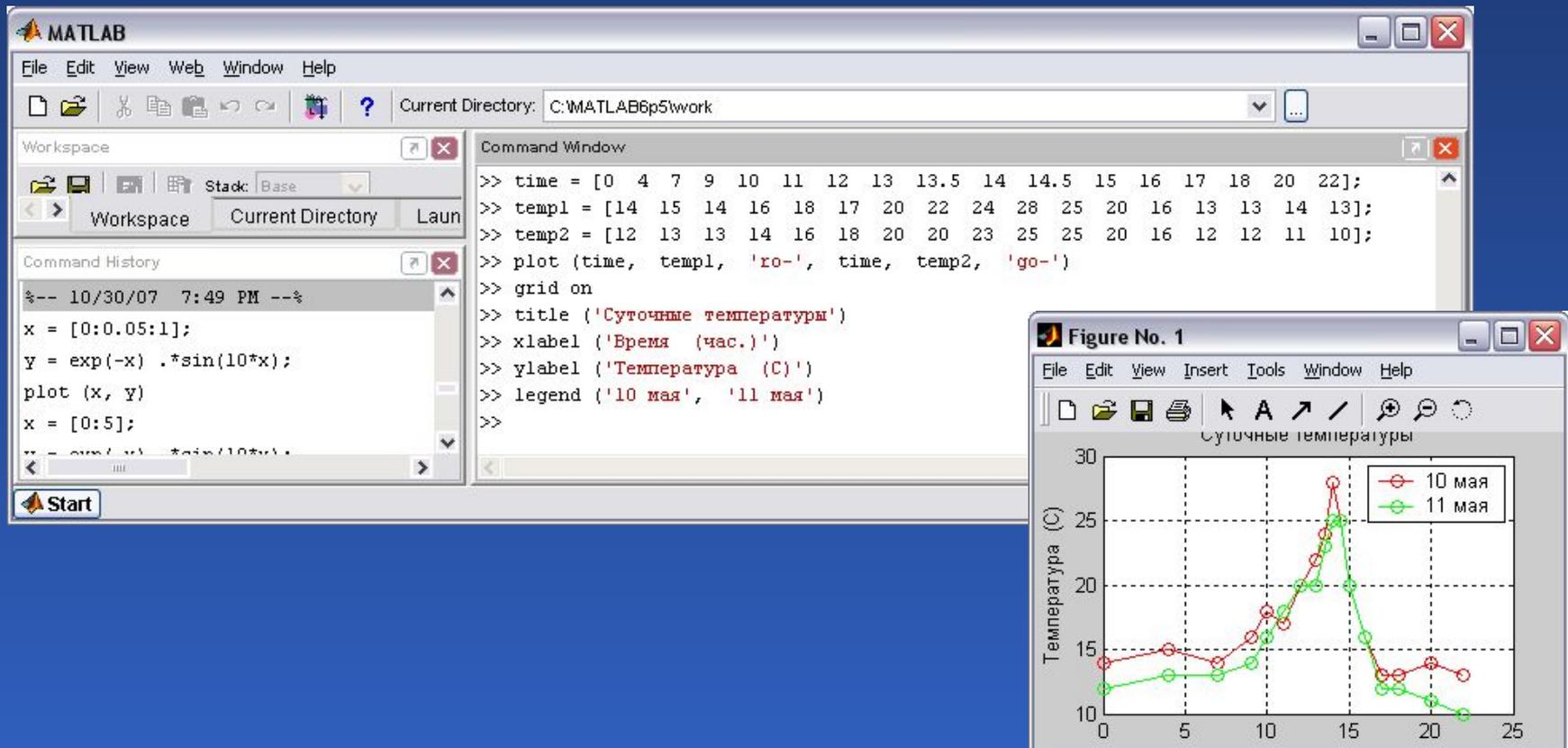
# Функция *plotyy* выводит графики в окно с двумя вертикальными осями, имеющими подходящий масштаб



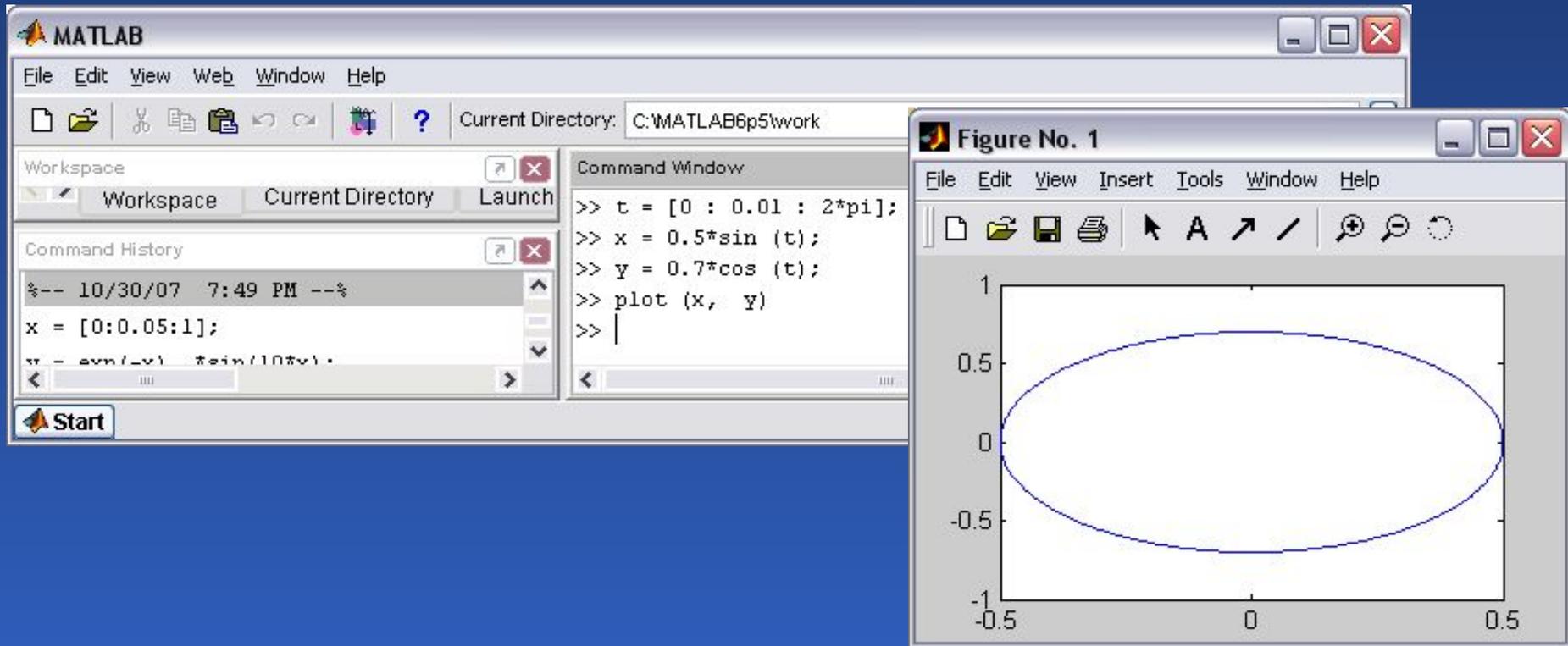
# Графики в логарифмических масштабах



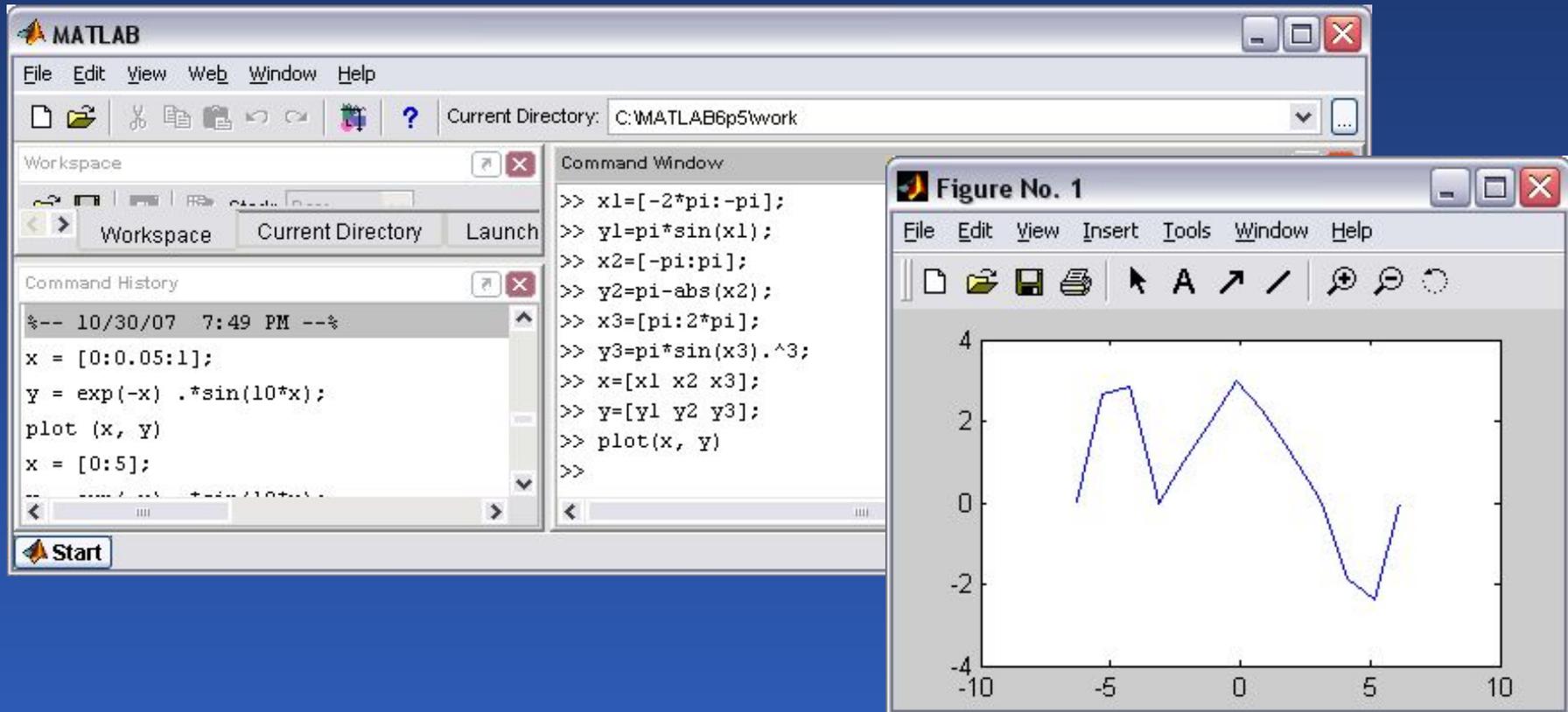
# Оформление графиков



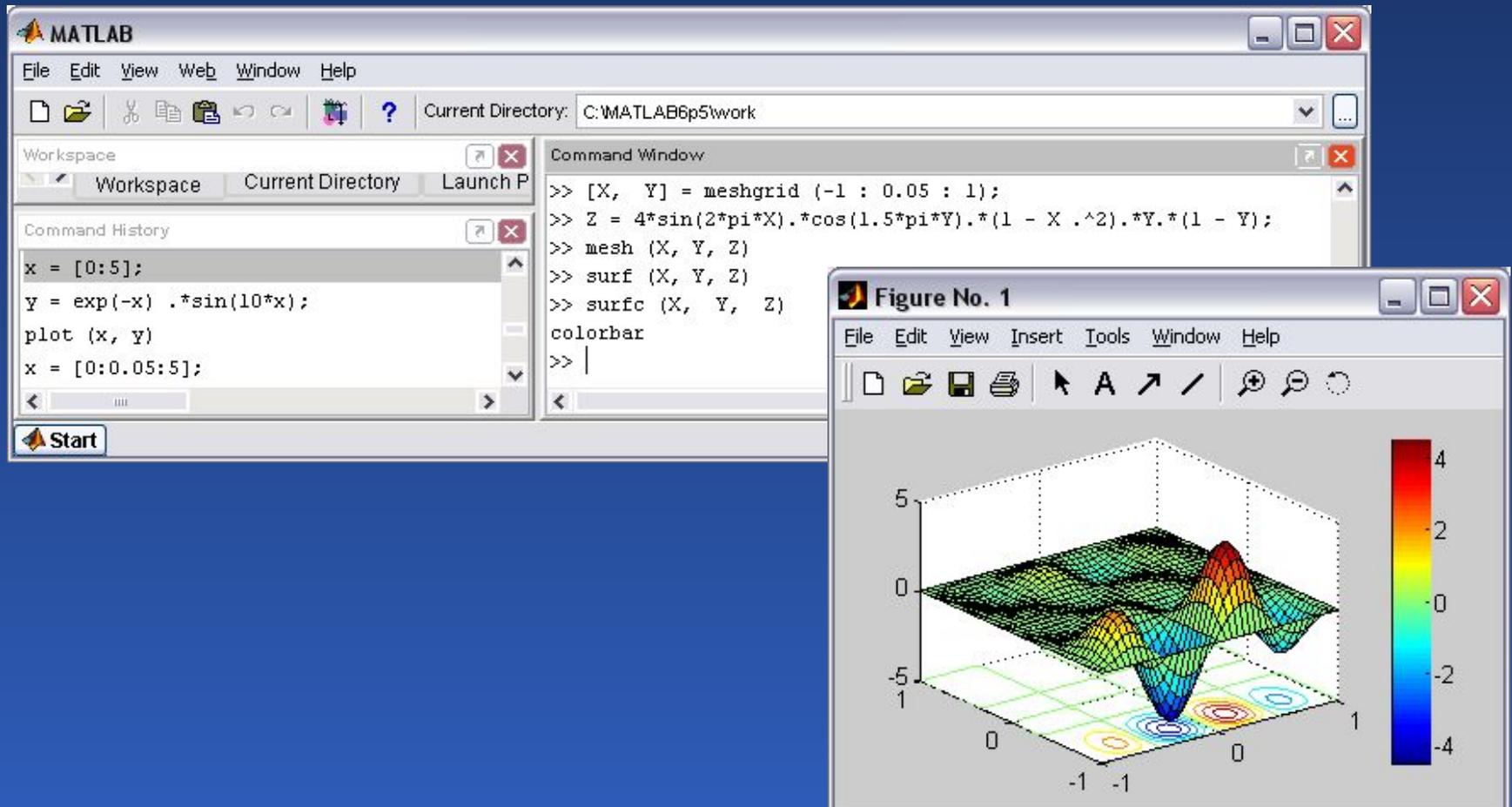
# Графики параметрических и кусочно-заданных функций



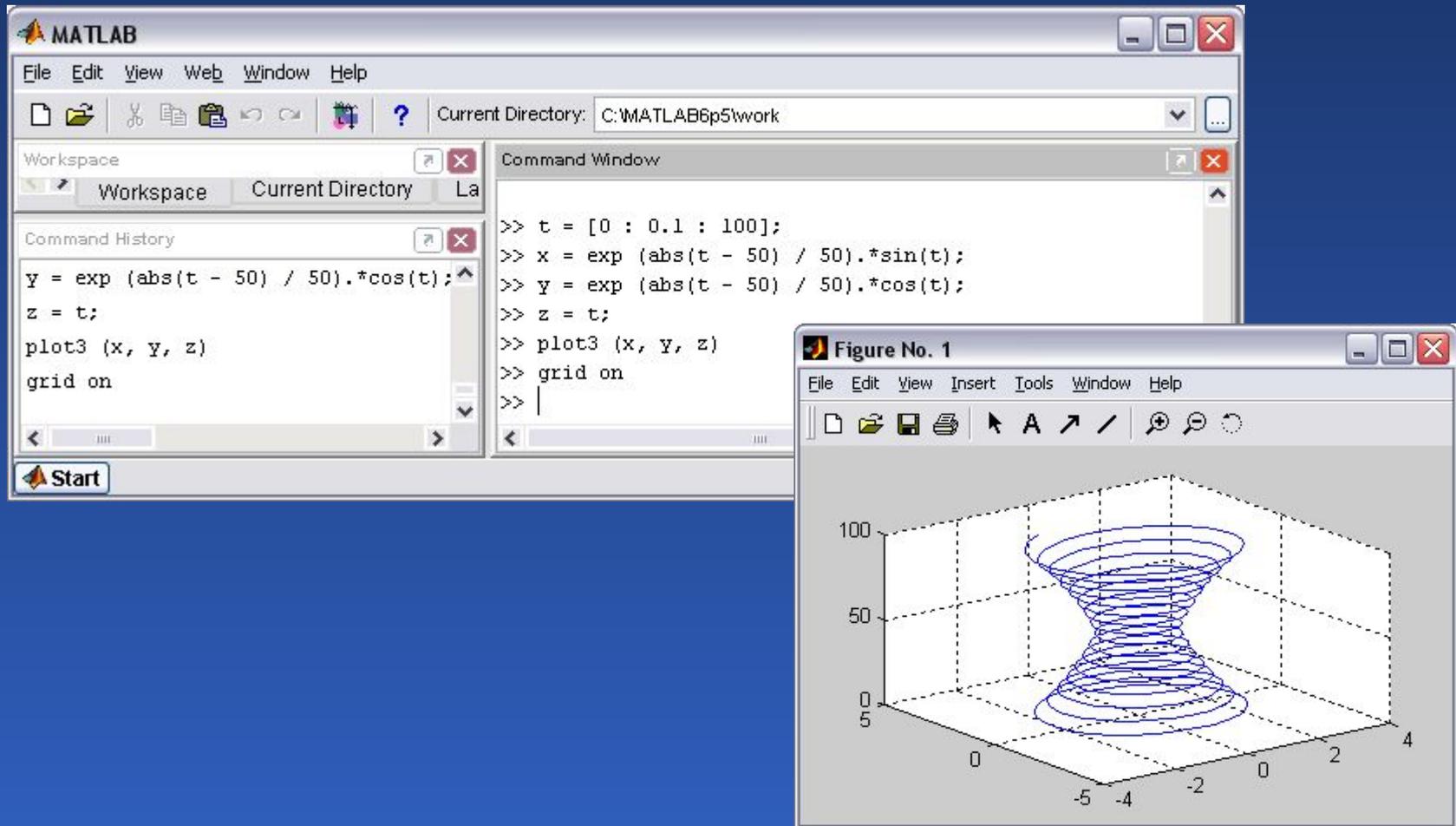
# Графики параметрических и кусочно заданных функций



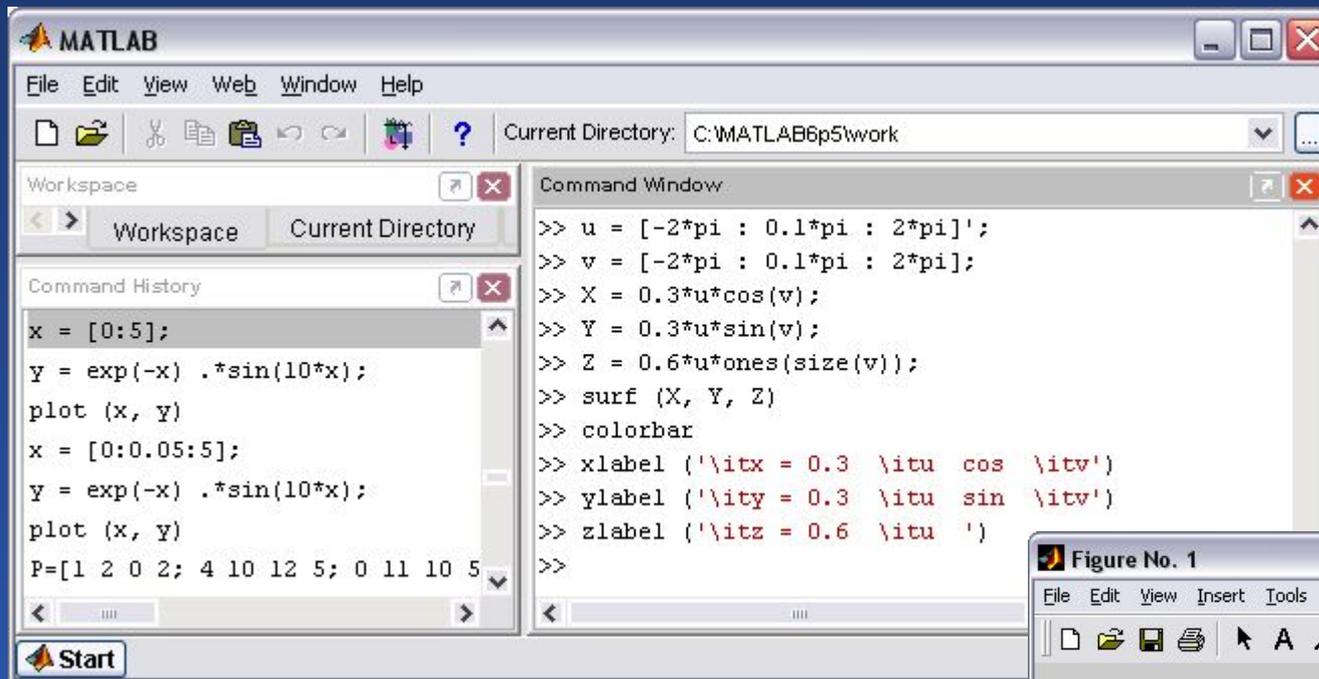
# Трёхмерные графики функций



# Построение параметрически заданных поверхностей и линий



# Построение параметрически заданных поверхностей и линий

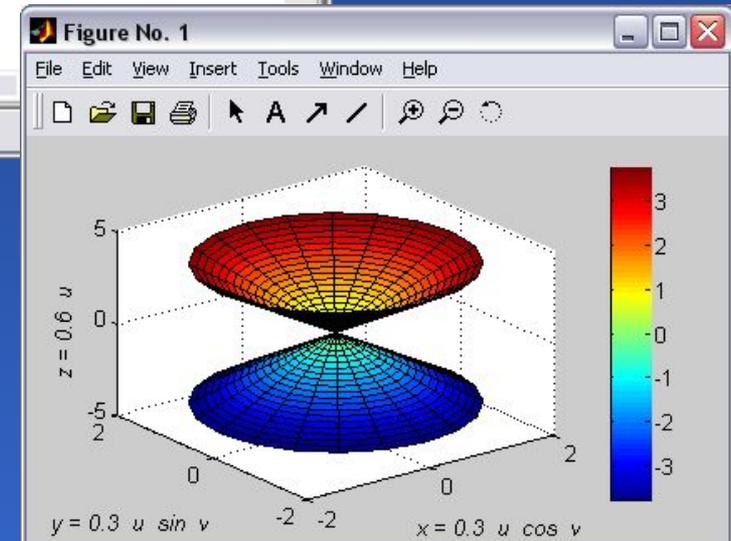


The image shows the MATLAB software interface. The Command Window contains the following code:

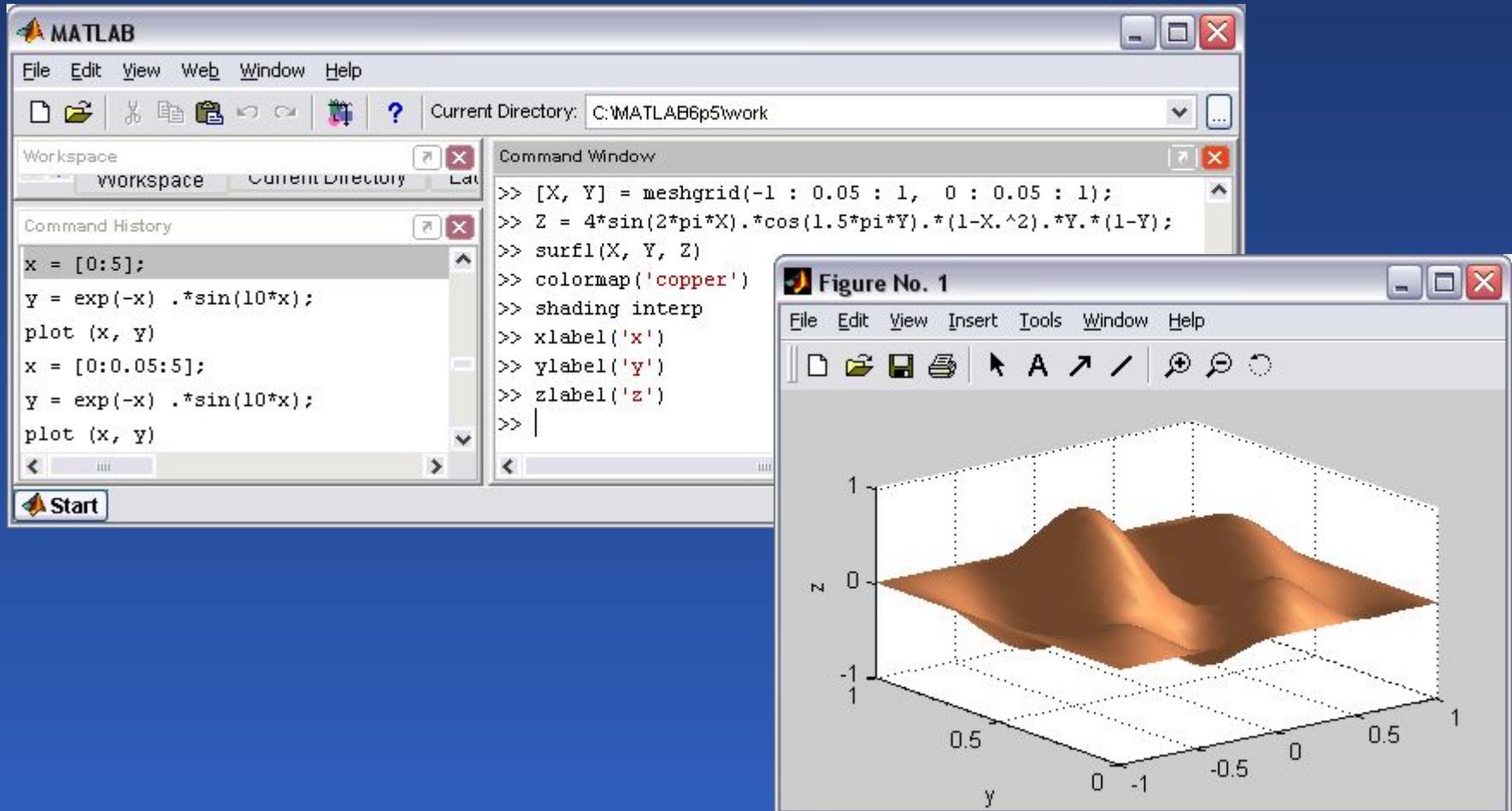
```
>> u = [-2*pi : 0.1*pi : 2*pi]';  
>> v = [-2*pi : 0.1*pi : 2*pi];  
>> X = 0.3*u*cos(v);  
>> Y = 0.3*u*sin(v);  
>> Z = 0.6*u*ones(size(v));  
>> surf (X, Y, Z)  
>> colorbar  
>> xlabel ('\itx = 0.3 \itu cos \itv')  
>> ylabel ('\ity = 0.3 \itu sin \itv')  
>> zlabel ('\itz = 0.6 \itu ')  
>>
```

The Command History window shows the following commands:

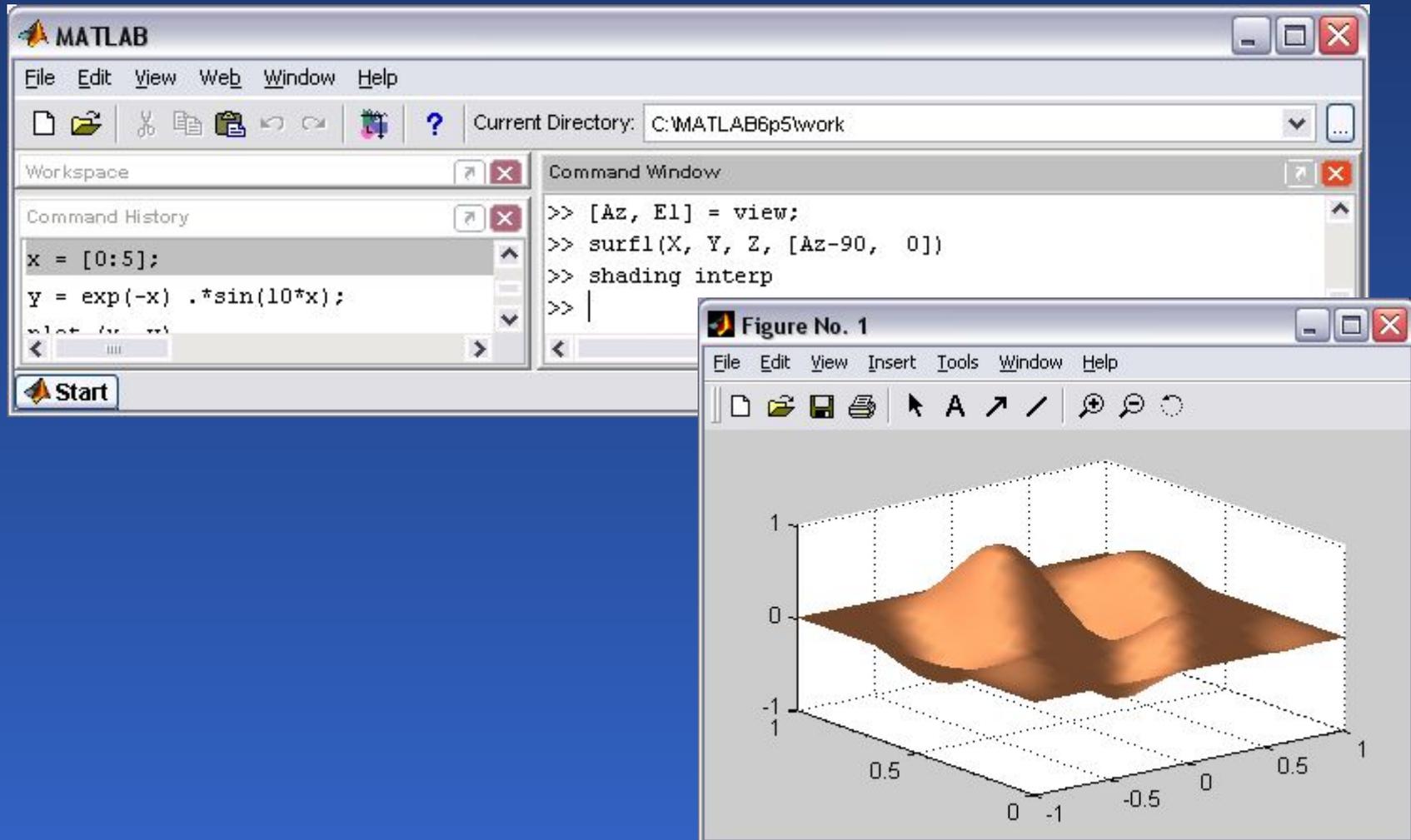
```
x = [0:5];  
y = exp(-x) .*sin(10*x);  
plot (x, y)  
x = [0:0.05:5];  
y = exp(-x) .*sin(10*x);  
plot (x, y)  
P=[1 2 0 2; 4 10 12 5; 0 11 10 5]
```



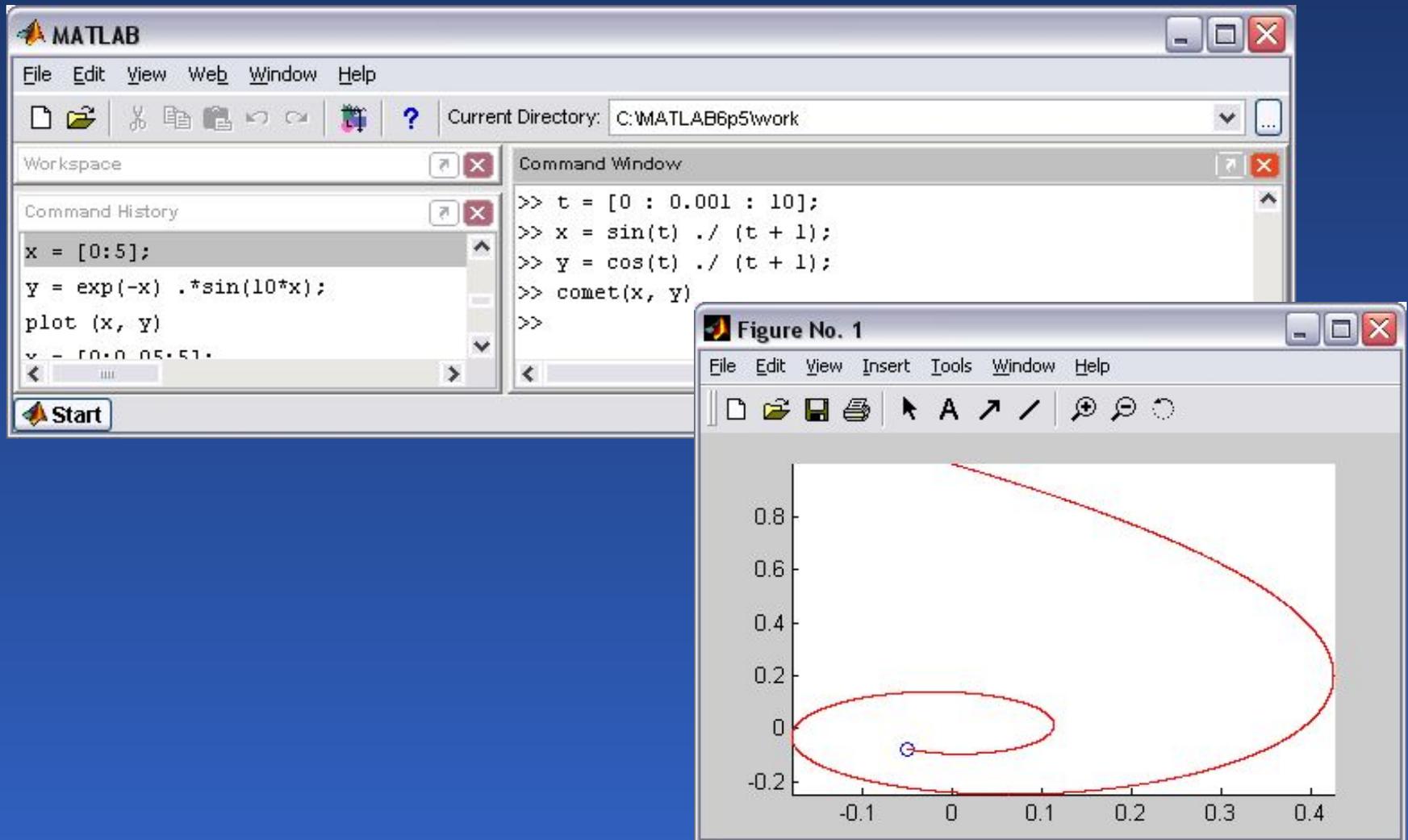
# Построение освещенной поверхности



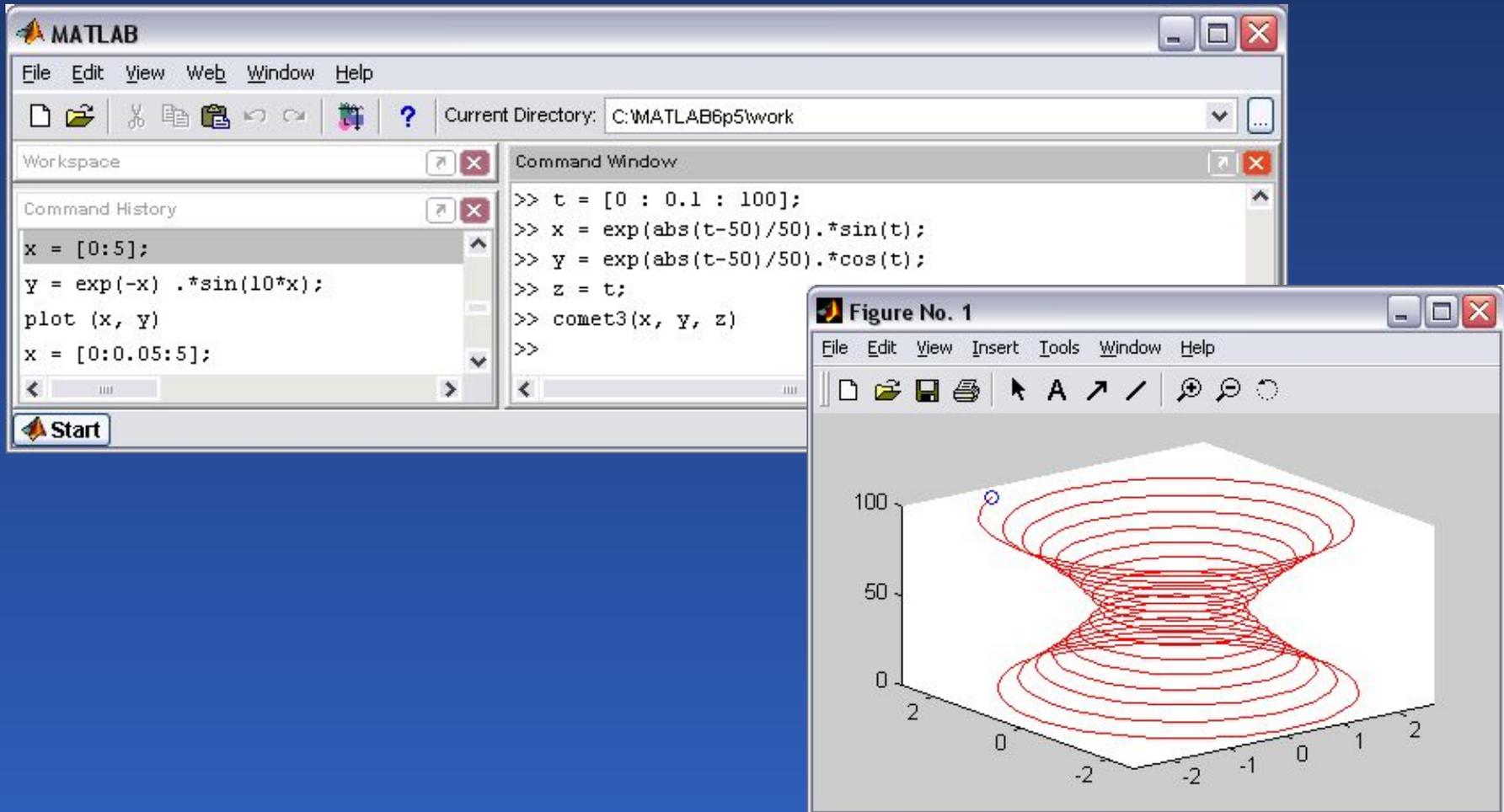
# Построение освещенной поверхности и изменение азимута источника на $-90^\circ$ по отношению к наблюдателю



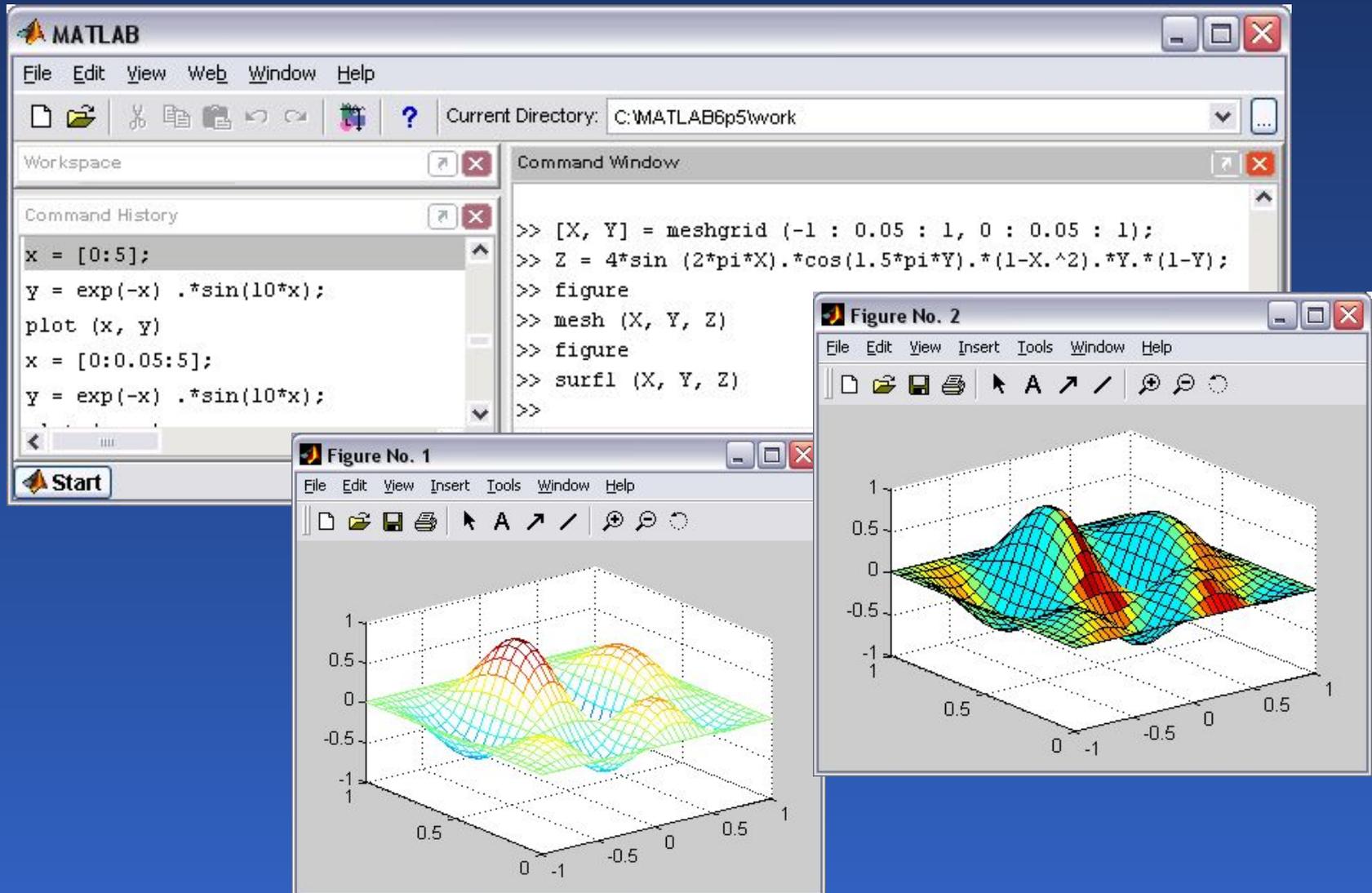
# Анимированные графики



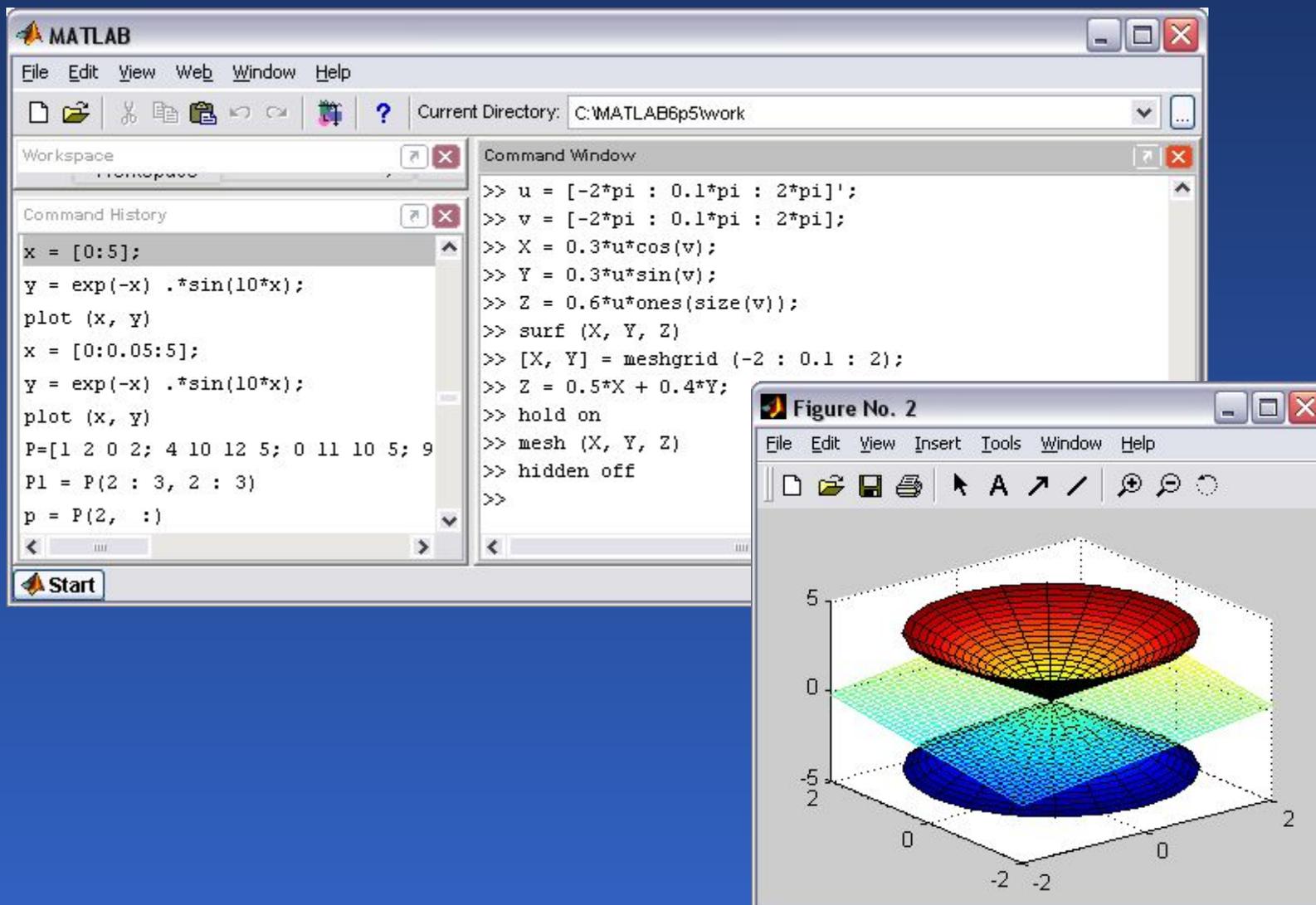
# Траектория движения точки, перемещающейся в пространстве



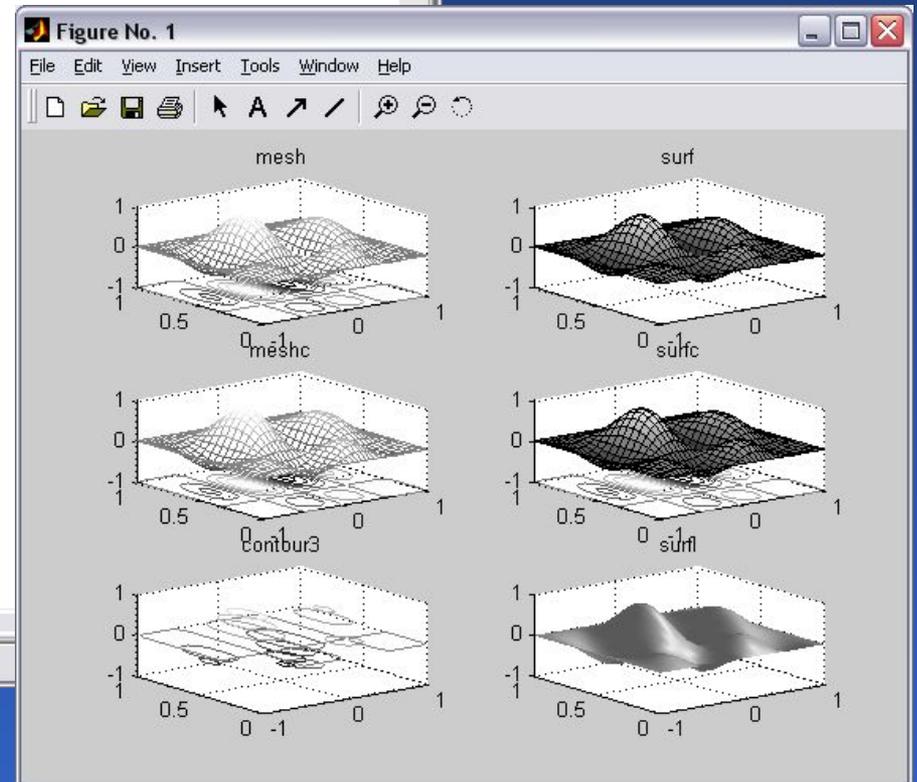
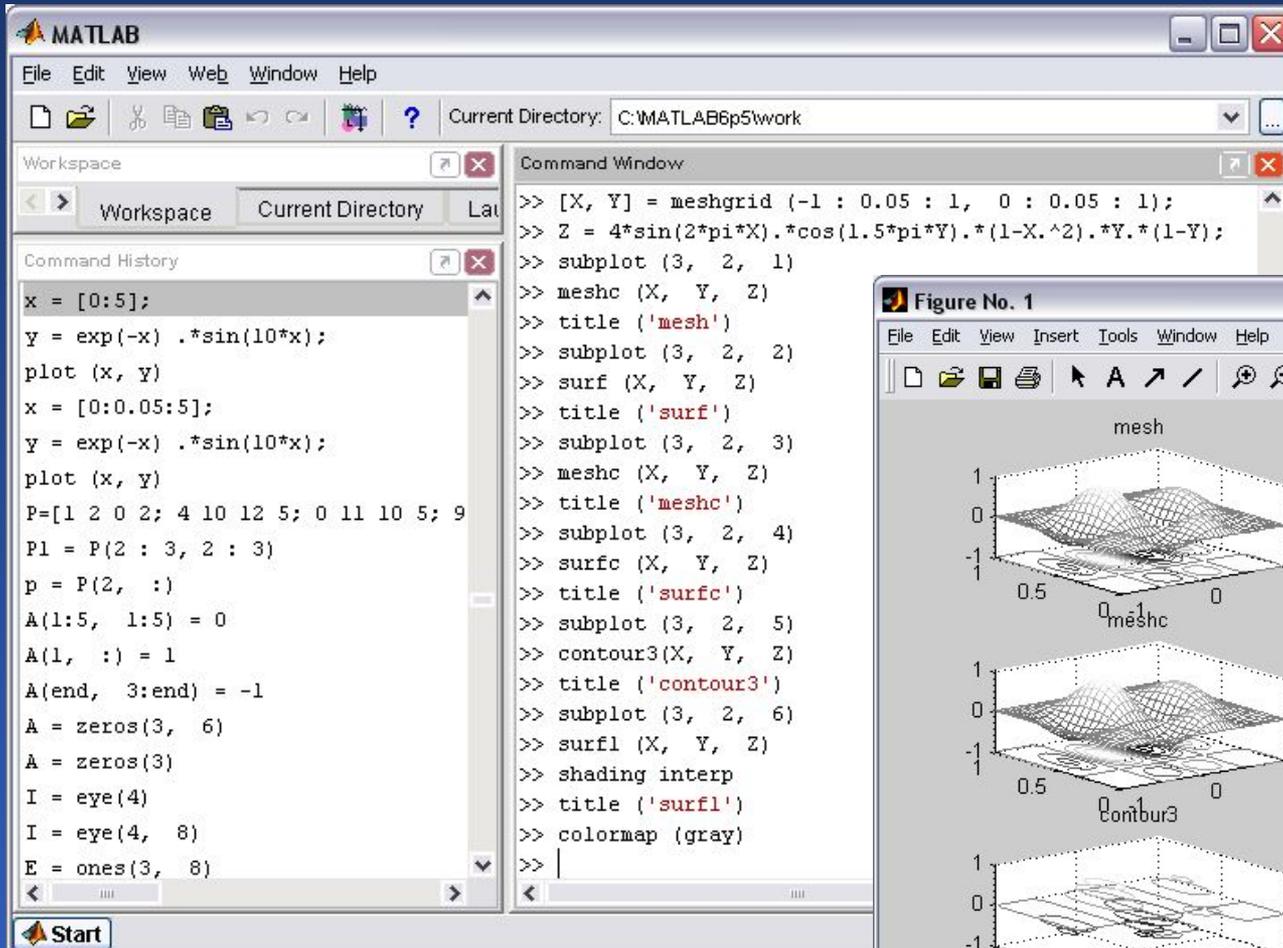
# Вывод графиков в отдельные окна



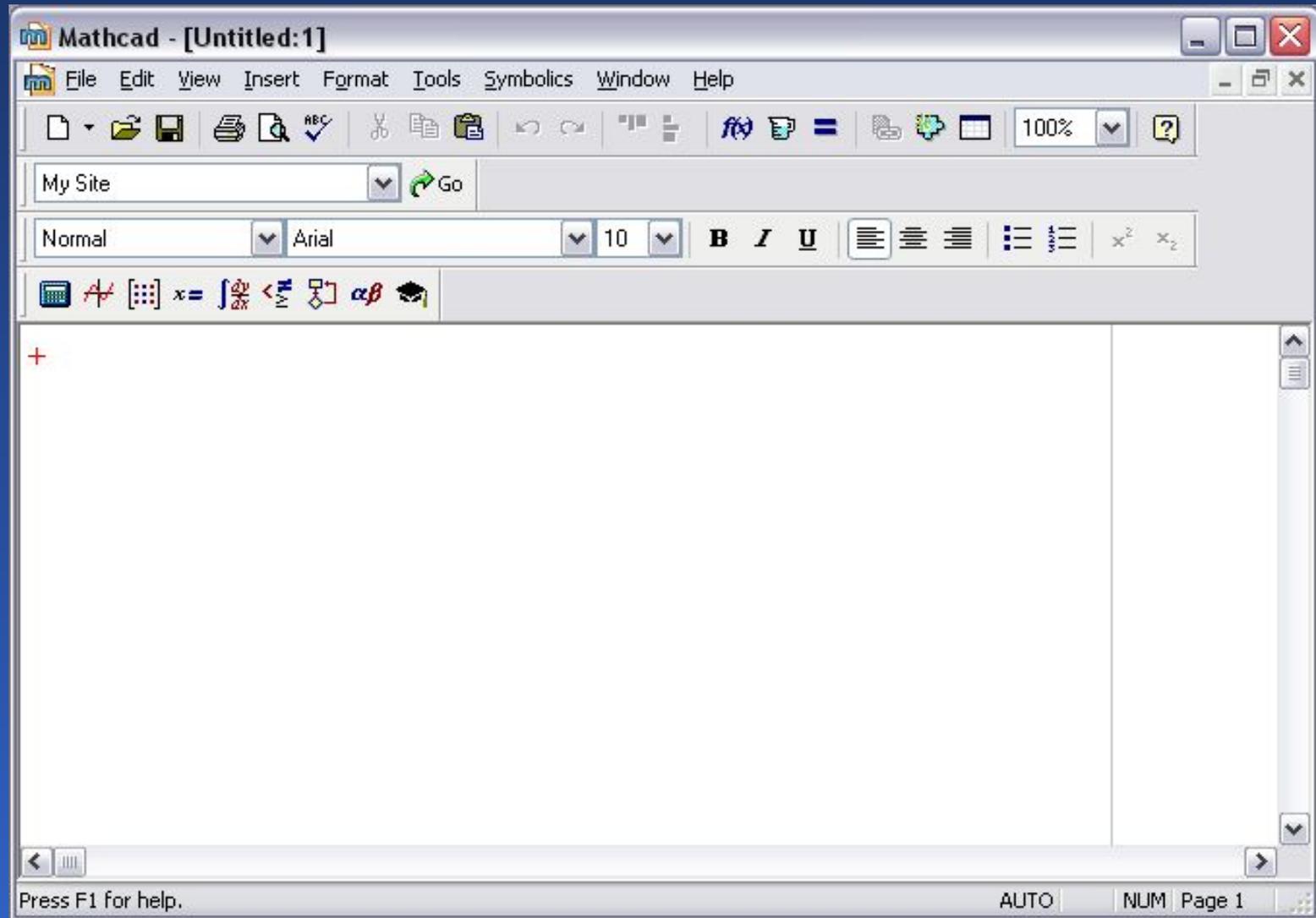
# Вывод нескольких графиков на одни оси



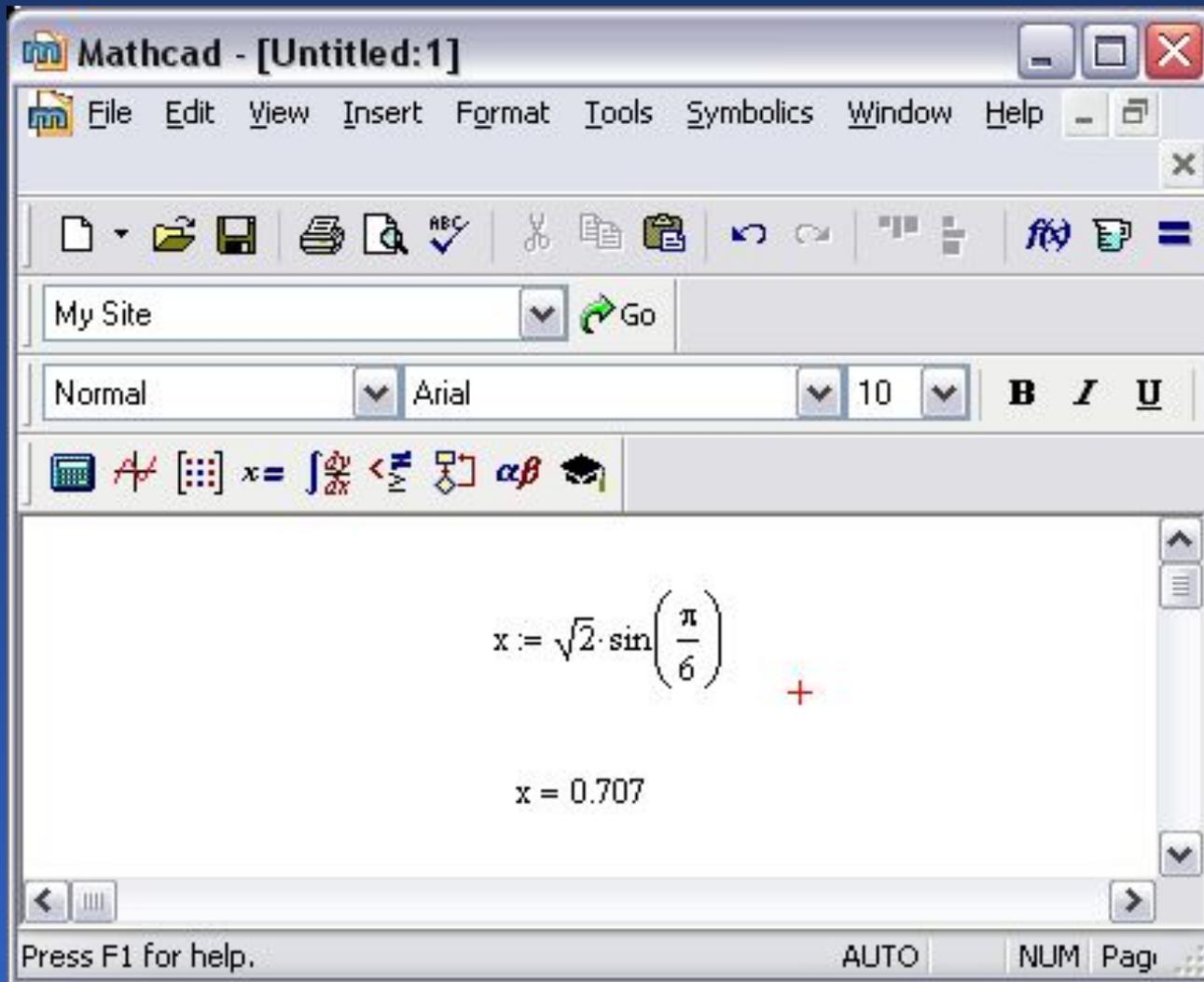
# Несколько графиков в одном графическом окне



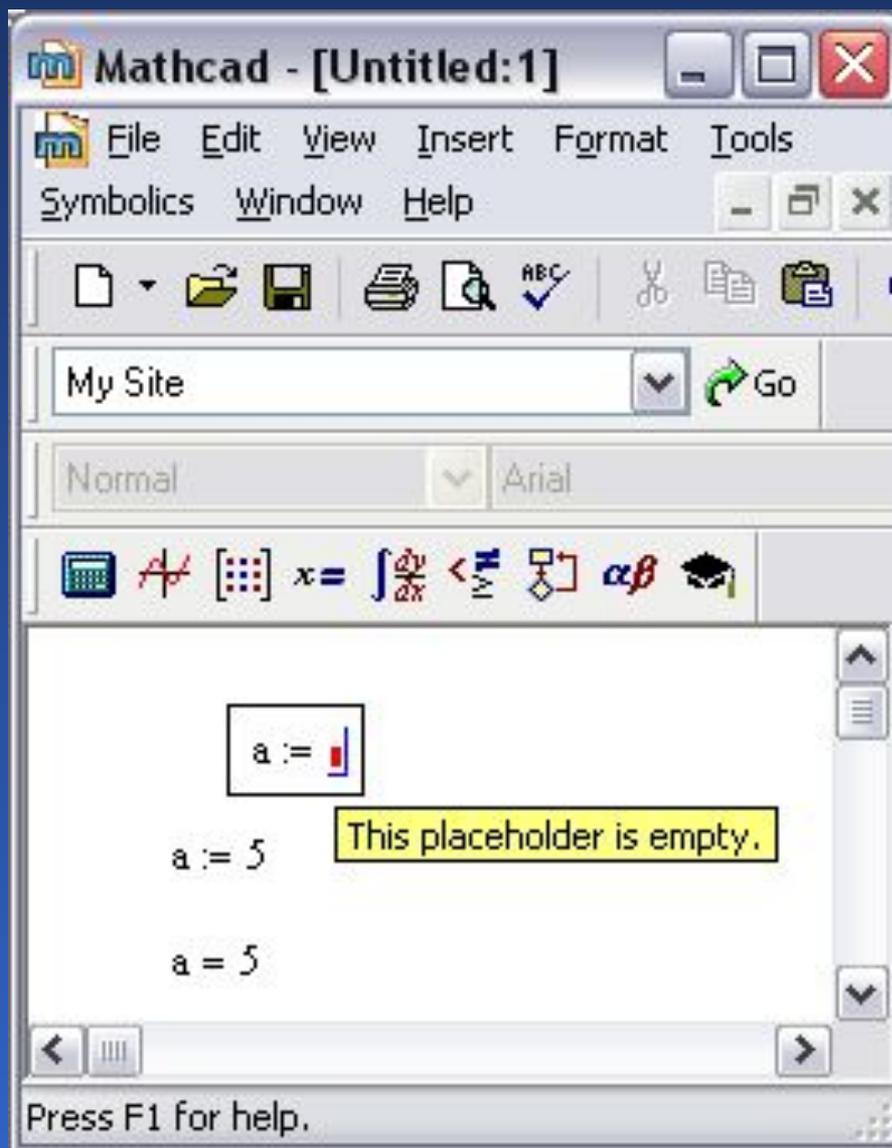
# Рабочее окно *MathCAD*



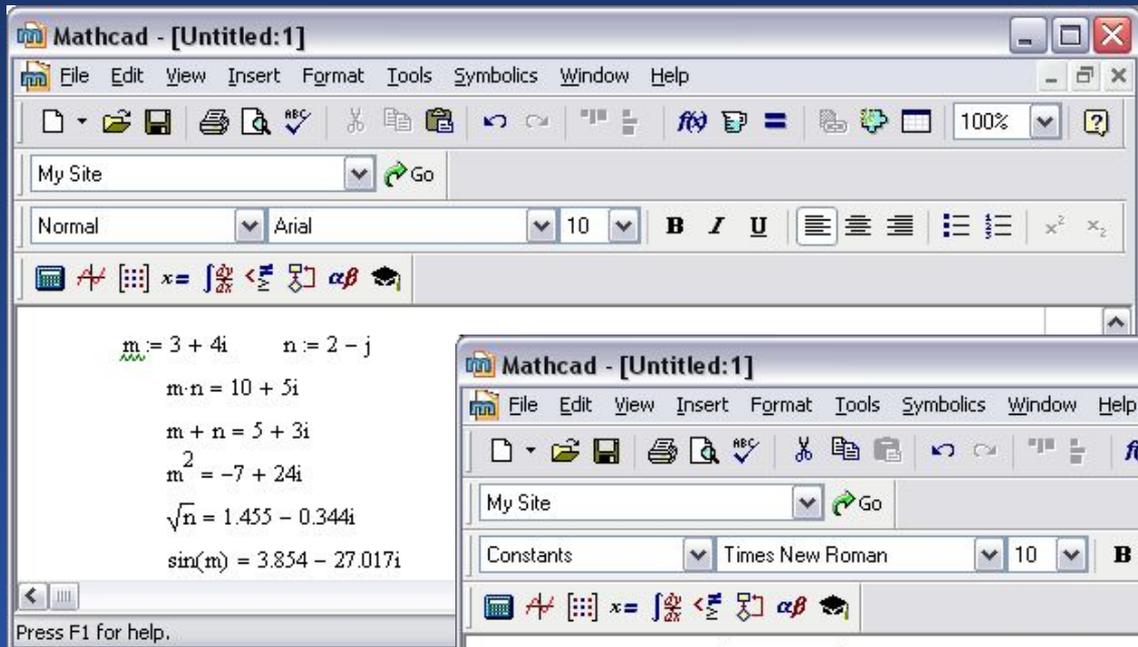
# Инициализация переменной



# Знак равенства



# Использование комплексных чисел



Mathcad - [Untitled:1]

File Edit View Insert Format Tools Symbolics Window Help

My Site

Normal Arial 10 B I U

$m := 3 + 4i$      $n := 2 - j$

$m \cdot n = 10 + 5i$

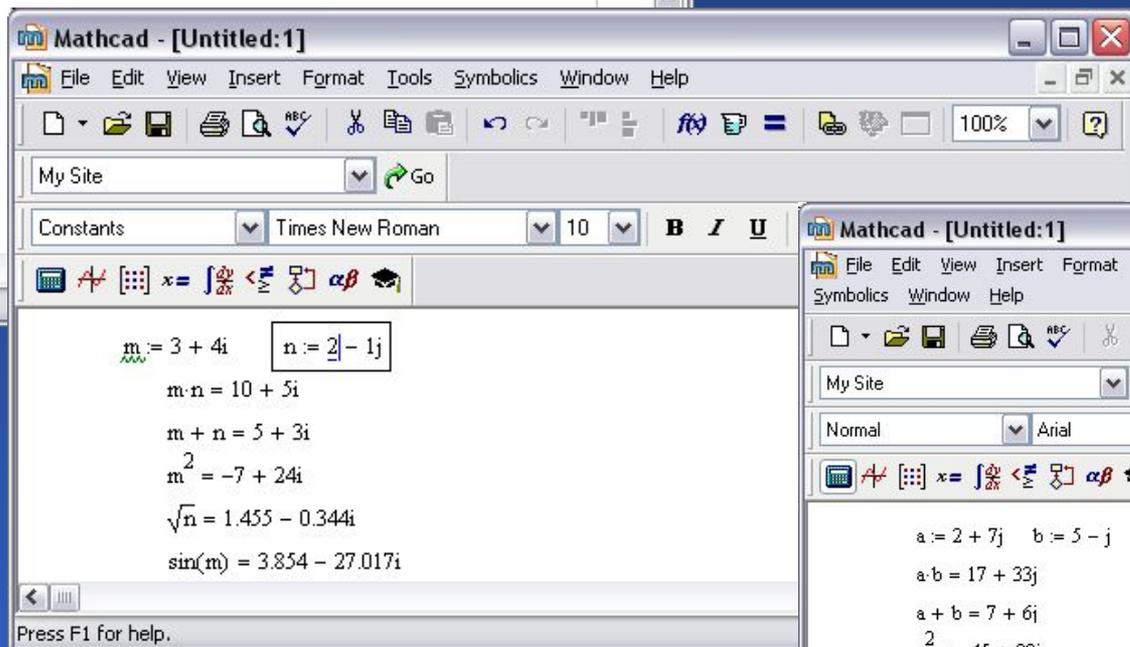
$m + n = 5 + 3i$

$m^2 = -7 + 24i$

$\sqrt{n} = 1.455 - 0.344i$

$\sin(m) = 3.854 - 27.017i$

Press F1 for help.



Mathcad - [Untitled:1]

File Edit View Insert Format Tools Symbolics Window Help

My Site

Constants Times New Roman 10 B I U

$m := 3 + 4i$      $n := 2 - 1j$

$m \cdot n = 10 + 5i$

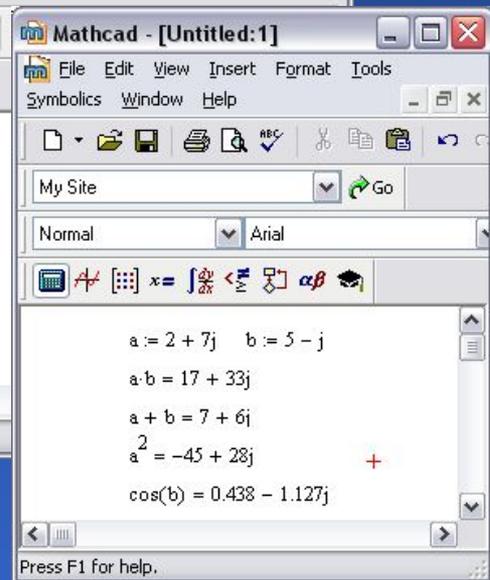
$m + n = 5 + 3i$

$m^2 = -7 + 24i$

$\sqrt{n} = 1.455 - 0.344i$

$\sin(m) = 3.854 - 27.017i$

Press F1 for help.



Mathcad - [Untitled:1]

File Edit View Insert Format Tools Symbolics Window Help

My Site

Normal Arial

$a := 2 + 7j$      $b := 5 - j$

$a \cdot b = 17 + 33j$

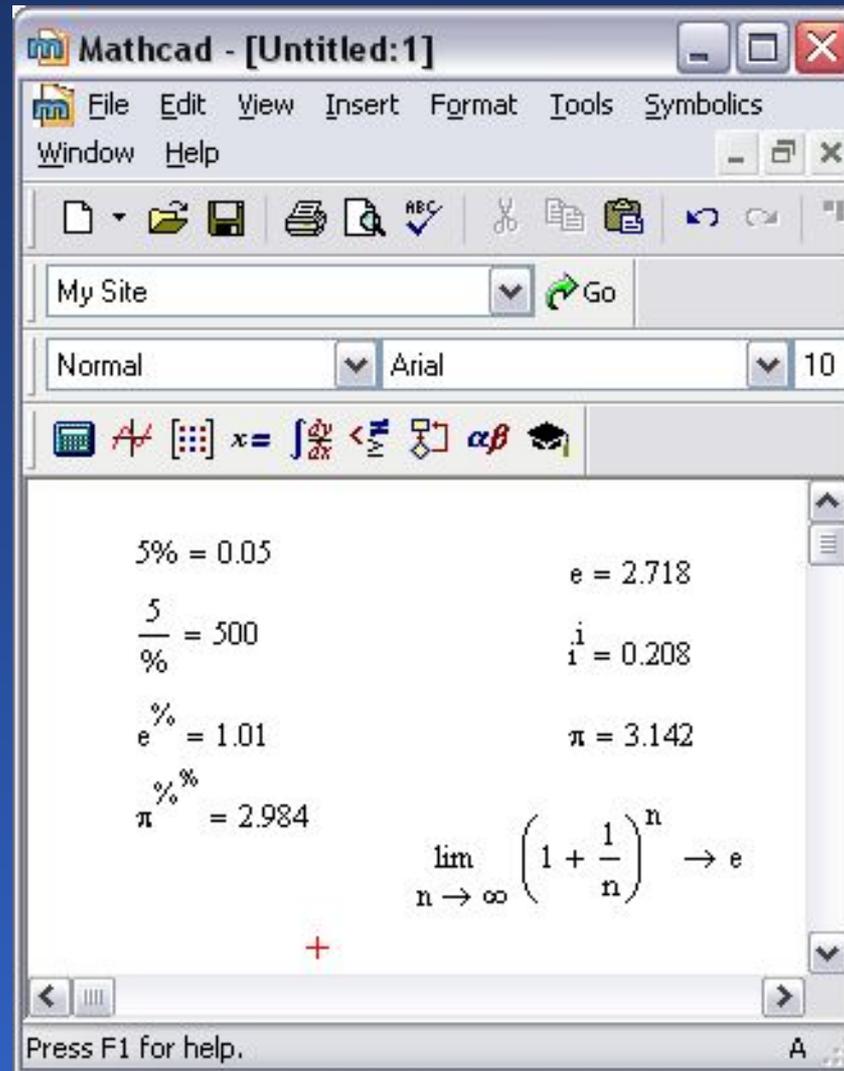
$a + b = 7 + 6j$

$a^2 = -45 + 28j$     +

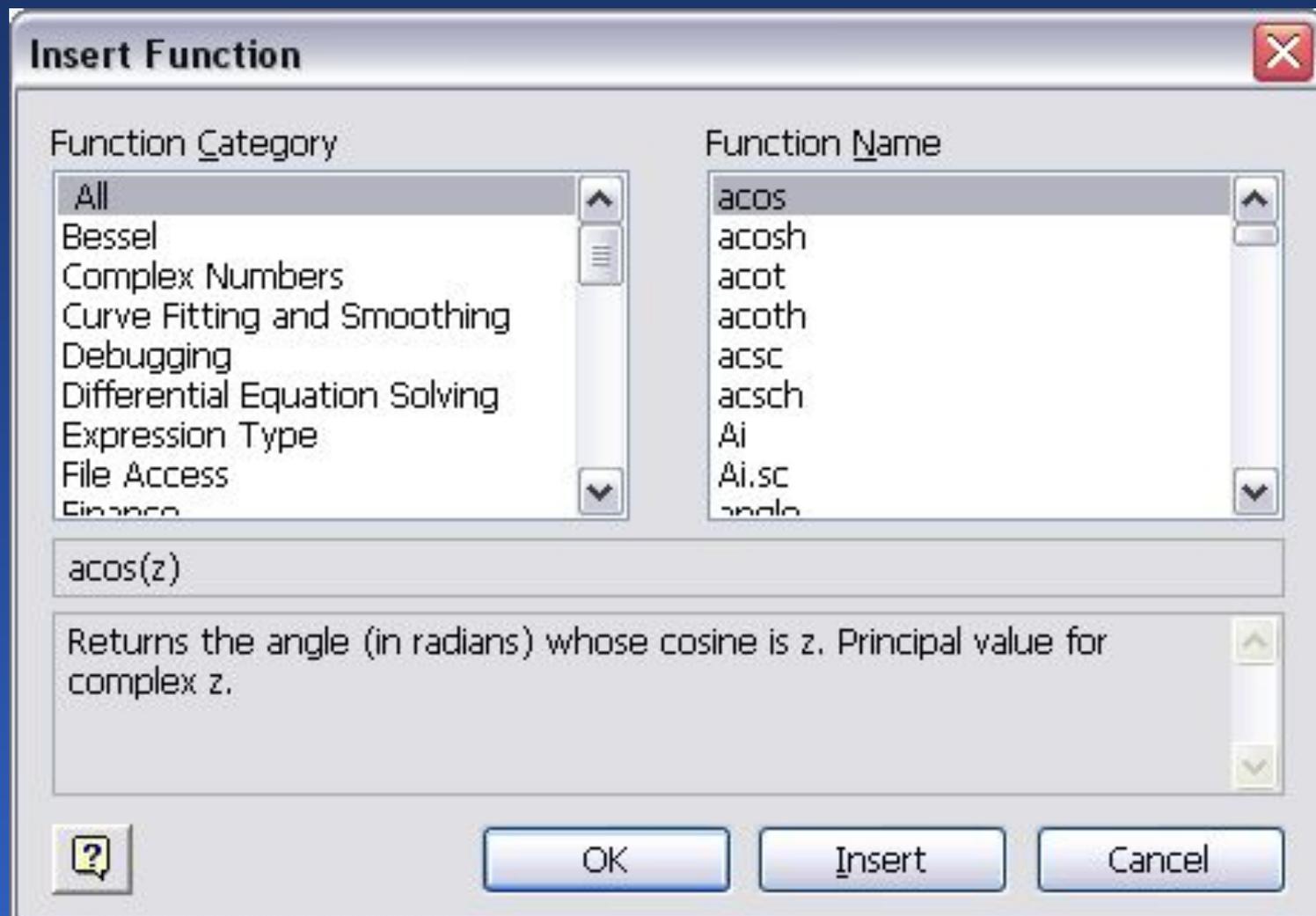
$\cos(b) = 0.438 - 1.127j$

Press F1 for help.

# Использование констант



# Вставка встроенных функций



# Математические функции

The screenshot shows the Mathcad software interface with the following content:

Mathcad - [Untitled:1]

File Edit View Insert Format Tools Symbolics Window Help

My Site Go

Normal Arial 10 B I U

$x = \int \frac{dy}{y}$   $\alpha\beta$

$\text{acos}(\cos(1)) = 1$      $\text{acoth}\left(\frac{e^2 + e^{-2}}{e^2 - e^{-2}}\right) = 2$      $\text{asech}\left(\frac{2}{e + e^{-1}}\right) = 1$      $\text{atanh}\left(\frac{e^3 - e^{-3}}{e^3 + e^{-3}}\right) = 3$

$\text{cosh}(\ln(2)) = 1.25$      $\cot\left(\frac{\pi}{4}\right) = 1$      $\exp(\ln(5)) = 5$      $\log(4,2) = 2$

$\Gamma(0.5) = 1.772$      $\ln(\Gamma(0.5)) = 0.572$      $\ln\Gamma(0.5) = 0.572$      $\log(100) = 2$

$\tan(1) = 1.557$      $\text{sech}(\ln(2)) = 0.8$      $\sinh(\ln(5)) = 2.4$      $\sin\left(\frac{\pi}{6}\right) = 0.5$

Press F1 for help.    AUTO    NUM    Page 1

# Работа с комплексными числами

The screenshot shows the Mathcad software interface with the following content:

Mathcad - [Untitled:1]

File Edit View Insert Format Tools Symbolics Window Help

My Site Go

Normal Arial 10 **B** *I* U

$x := 5$       $y := -6$

$z := x + y \cdot i$

$\text{signum}(z) = 0.64 - 0.768i$	$\text{csgn}(z) = 1$	$\text{Re}(z) = 5$
$\text{signum}(x) = 1$	$\text{csgn}(-z) = -1$	$\text{Im}(z) = -6$
$\text{signum}(y) = -1$	$\text{csgn}(-i \cdot y) = 1$	$\text{arg}(z) = -0.876$
$\text{signum}(0) = 1$	$\text{csgn}(0) = 0$	$ z  = 7.81$

$|z| \cdot \exp(-i \cdot \text{arg}(z)) = 5 + 6i$      +

Press F1 for help.     AUTO     NUM     Page 1

# Символьный результат

The screenshot shows the Mathcad software window titled "Mathcad - [Untitled:1]". The menu bar includes File, Edit, View, Insert, Format, Tools, Symbolics, and Window. The toolbar contains various icons for file operations, editing, and mathematical functions. The main workspace displays the following symbolic results:

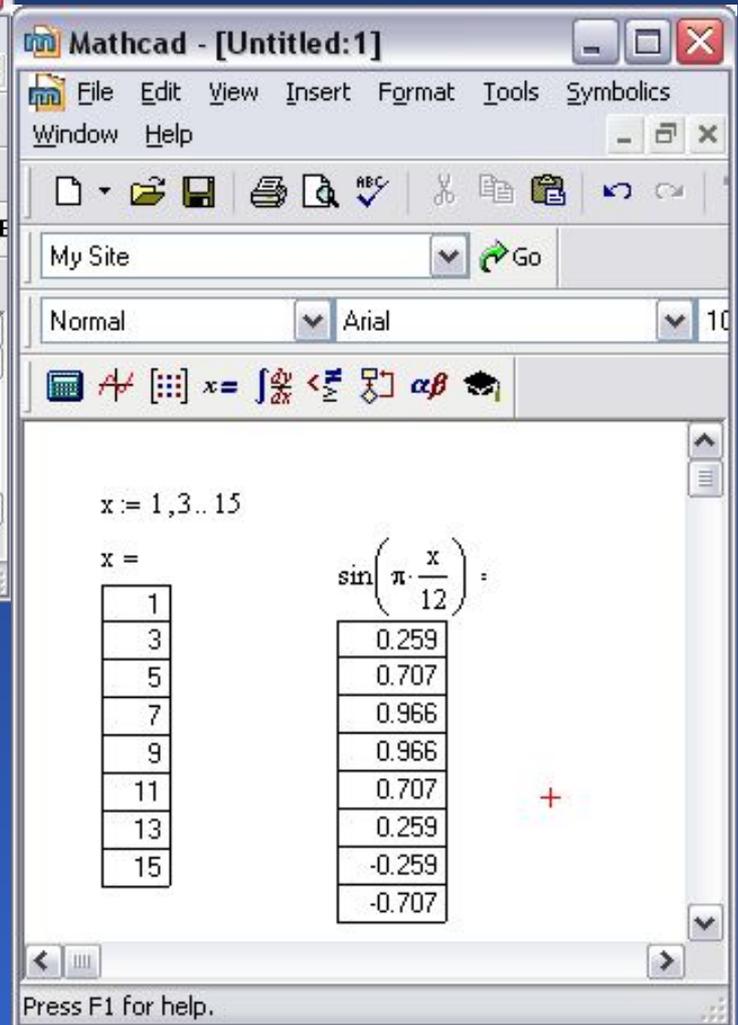
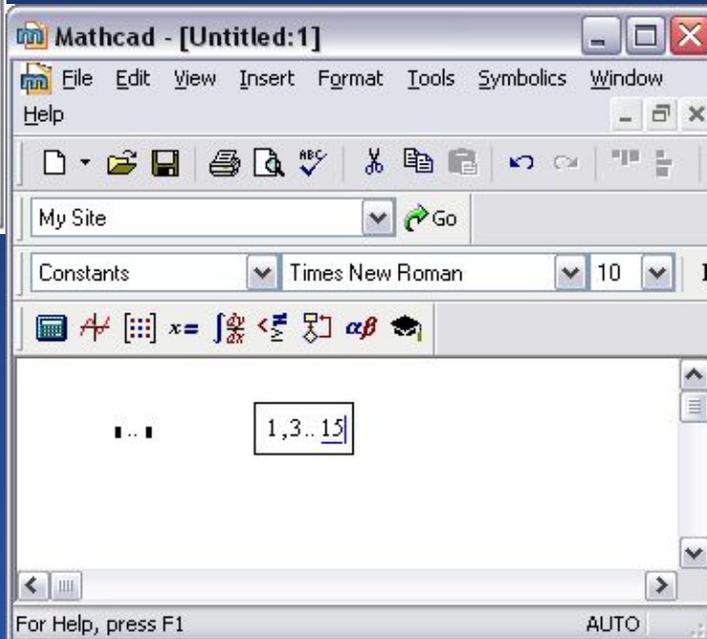
$$f(x) := 5 \cdot x^2$$
$$D(x, y) := x \cdot \sin\left(\frac{\pi}{2} \cdot y\right)$$
$$f(t) \rightarrow 5 \cdot t^2$$
$$D\left(b \cdot z, \frac{1}{t}\right) \rightarrow b \cdot z \cdot \sin\left(\frac{1}{2} \cdot \frac{\pi}{t}\right)$$

The status bar at the bottom indicates "Press F1 for help." and "AUTO".

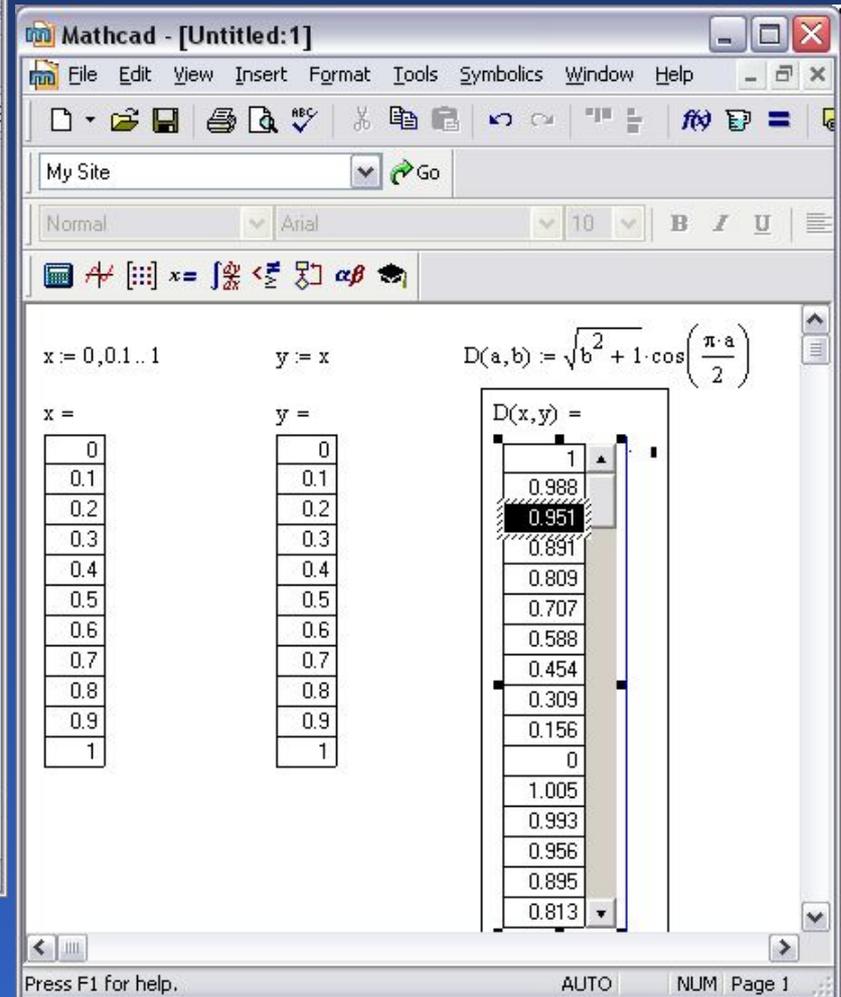
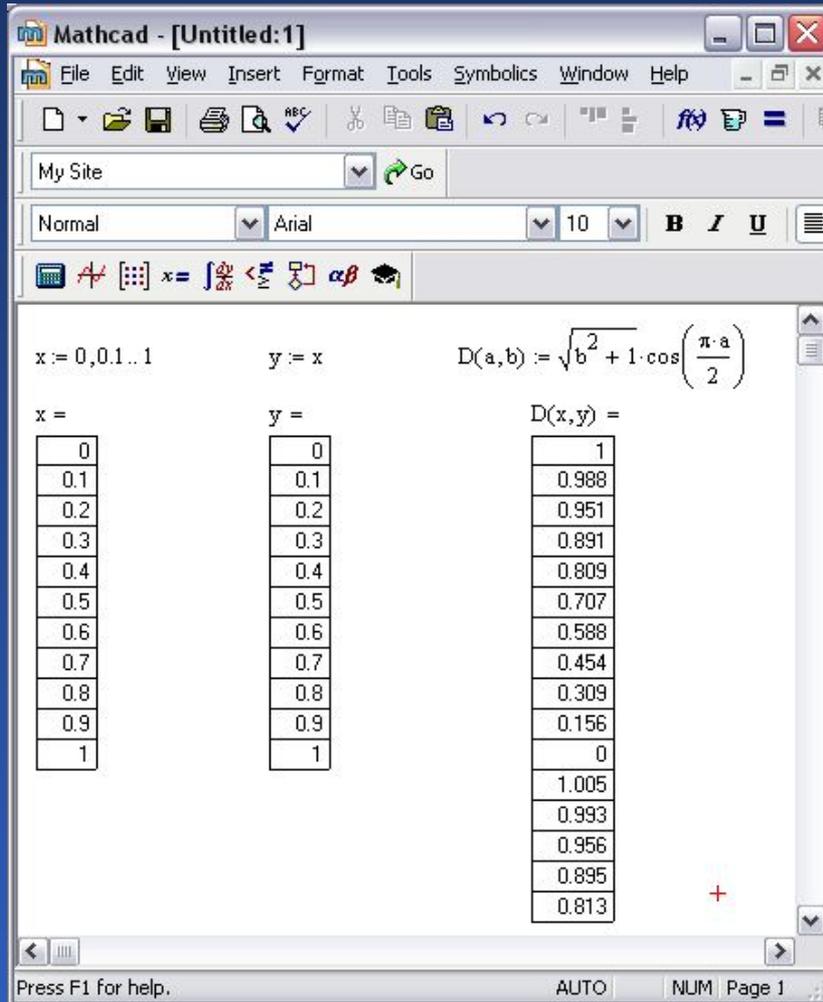
The "Symbolic" menu is open, displaying a list of symbolic operations and modifiers. The items are arranged in three columns:

$\rightarrow$	$\bullet \rightarrow$	Modifiers
float	complex	assume
solve	simplify	substitute
factor	expand	coeffs
collect	series	parfrac
fourier	laplace	ztrans
invfourier	invlaplace	invztrans
$m^T \rightarrow$	$m^{-1} \rightarrow$	$ m  \rightarrow$
explicit		

# Диапазон значений



# Функция двух переменных



# Матрицы и векторы. Создание массивов

The image displays the Mathcad software interface. In the foreground, the 'Insert Matrix' dialog box is open, showing 'Rows' set to 3 and 'Columns' set to 3. Behind it, another dialog box titled 'Matrix' is partially visible, showing various matrix-related symbols. The main window, titled 'Mathcad - [Untitled:1]', shows a menu bar (File, Edit, View, Insert, Format, Tools, Symbolics, Window, Help) and a toolbar. The worksheet area contains the following definitions:

$$A := \begin{pmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{pmatrix} \quad A := \begin{pmatrix} 1 & 2 & 3 \\ 3 & 4 & 5 \\ 5 & 6 & 7 \end{pmatrix} \quad B := \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} \quad C := (1 \ 2 \ 3)$$

The status bar at the bottom indicates 'Press F1 for help.', 'AUTO', 'NUM', and 'Page 1'.

# Векторы и матрицы

The screenshot shows a software window with a toolbar at the top containing icons for matrix input, vector input, and other mathematical symbols. The main workspace contains the following definitions and operations:

$$A := \begin{pmatrix} 1 & 2 & 3 \\ 3 & 4 & 5 \\ 5 & 6 & 7 \end{pmatrix} \quad B := \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} \quad C := (1 \ 2 \ 3)$$
$$A_{0,1} = 2 \quad B_{1,0} = 2 \quad C_{0,2} = 3$$
$$A_{2,2} := C_{0,1} \cdot A_{1,1} \quad B_1 = 2$$

A red plus sign is positioned below the second row of equations.

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

The bottom status bar includes the text "Press F1 for help.", "AUTO", "NUM", and "Page 1".

The 'Matrix' pop-up menu contains the following symbols and functions:

- Matrix input icon:  $\begin{bmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{bmatrix}$
- Scalar multiplication:  $\times_n$
- Inverse:  $\times^{-1}$
- Determinant:  $|\times|$
- Function with vector:  $f(\vec{M})$
- Subscript: Subscript [
- Dot product:  $\vec{a} \cdot \vec{b}$
- Cross product:  $\vec{a} \times \vec{b}$
- Summation:  $\Sigma U$
- Integration:  $\int \frac{a}{b}$

# Начальный индекс массива

Инициализация массивов

$$A := \begin{pmatrix} 1 & 2 & 3 \\ 3 & 4 & 5 \\ 5 & 6 & 7 \end{pmatrix} \quad B := \begin{pmatrix} 1 \\ 5 \\ 7 \end{pmatrix}$$

Пример обращения к элементам массива при  $\text{ORIGIN} := 0$

ORIGIN := 0

$$A_{1,1} = 4 \quad B_2 = 7$$
$$A_{2,2} = 7 \quad B_1 = 5$$

Пример обращения к элементам массива при  $\text{ORIGIN} := 1$

ORIGIN := 1

$$A_{1,1} = 1 \quad B_2 = 5$$
$$A_{2,2} = 4 \quad B_1 = 1$$

Пример обращения к элементам массива при  $\text{ORIGIN} := -2$

ORIGIN := -2

$$A_{-2,0} = 3 \quad B_{-2} = 1$$

Press F1 for help. AUTO N

# Определение массива

ORIGIN := 1

$N := 9$        $i := 1, 2.. N$        $j := 1, 2.. N$       +

$$a_{i,j} := \sqrt{i^2 + j^2}$$

a =

1.414	2.236	3.162	4.123	5.099	6.083	7.071	8.062	9.055
2.236	2.828	3.606	4.472	5.385	6.325	7.28	8.246	9.22
3.162	3.606	4.243	5	5.831	6.708	7.616	8.544	9.487
4.123	4.472	5	5.657	6.403	7.211	8.062	8.944	9.849
5.099	5.385	5.831	6.403	7.071	7.81	8.602	9.434	10.296
6.083	6.325	6.708	7.211	7.81	8.485	9.22	10	10.817
7.071	7.28	7.616	8.062	8.602	9.22	9.899	10.63	11.402
8.062	8.246	8.544	8.944	9.434	10	10.63	11.314	12.042
9.055	9.22	9.487	9.849	10.296	10.817	11.402	12.042	12.728

Press F1 for help.      AUTO      NUM      Page 1

# Вложенные массивы

The screenshot shows a software window with a toolbar at the top containing icons for a calculator, a red 'X', a grid, a derivative symbol  $x = \int \frac{dy}{dx}$ , a less-than sign, a greater-than sign, a box with a plus sign, Greek letters  $\alpha\beta$ , and a graduation cap. The main content area contains the following text and mathematical expressions:

ORIGIN := 1      индексы массивов начинаются с единицы

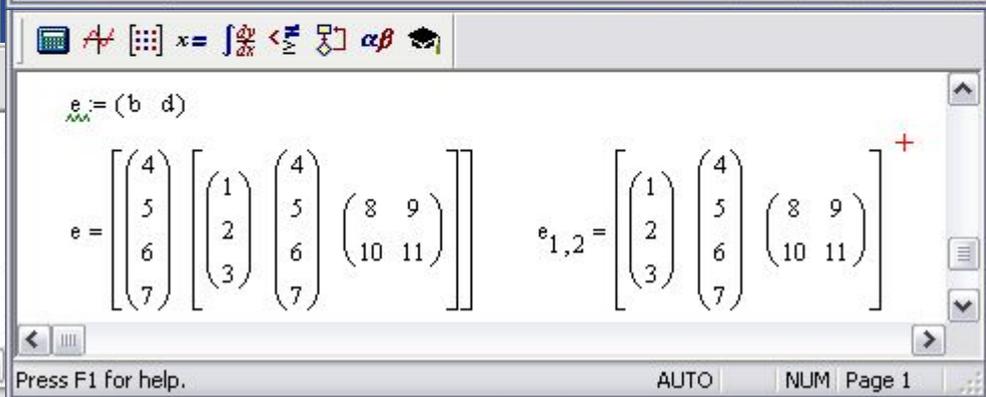
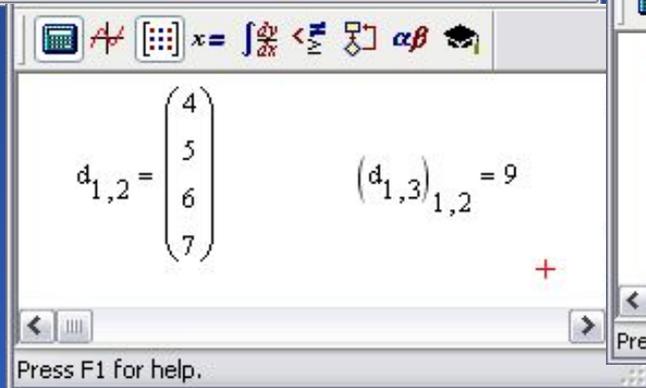
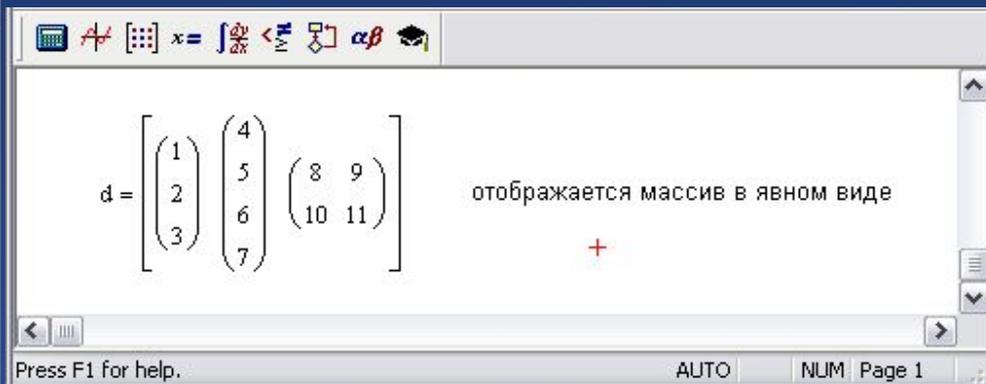
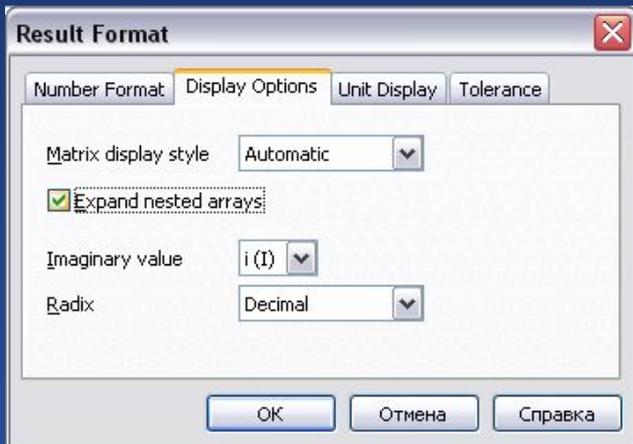
$a := \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$      $b := \begin{pmatrix} 4 \\ 5 \\ 6 \\ 7 \end{pmatrix}$      $c := \begin{pmatrix} 8 & 9 \\ 10 & 11 \end{pmatrix}$     инициализация массивов разных размерностей

$d := (a \ b \ c)$       инициализация вложенного массива      +

$d = \{ \{3,1\} \ \{4,1\} \ \{2,2\} \}$       отображается только структура вложенного массива без явного указания его элементов

At the bottom of the window, there is a status bar with the text "Press F1 for help.", a mode selector set to "AUTO", and page information "NUM Page 1".

# Вложенные массивы



# Операции с массивами

$$\underline{A} := \begin{pmatrix} 5 & 8 & 9 \\ 4 & 3 & 1 \end{pmatrix}$$

$$\underline{B} := \begin{pmatrix} 1 & 4 \\ 5 & 2 \\ 3 & 6 \end{pmatrix}$$

$$\underline{C} := \underline{A} \cdot \underline{B}$$

$$\underline{C} = \begin{pmatrix} 72 & 90 \\ 22 & 28 \end{pmatrix}$$

$$\underline{D} := \underline{B} \cdot \underline{A}$$

$$\underline{D} = \begin{pmatrix} 21 & 20 & 13 \\ 33 & 46 & 47 \\ 39 & 42 & 33 \end{pmatrix}$$

$$\underline{K} := \underline{C} \cdot 2$$

$$\underline{K} = \begin{pmatrix} 144 & 180 \\ 44 & 56 \end{pmatrix}$$

$$\underline{R} := \frac{\underline{D}}{5}$$

$$\underline{R} = \begin{pmatrix} 4.2 & 4 & 2.6 \\ 6.6 & 9.2 & 9.4 \\ 7.8 & 8.4 & 6.6 \end{pmatrix}$$

$$\underline{K} - \underline{C} = \begin{pmatrix} 72 & 90 \\ 22 & 28 \end{pmatrix}$$

$$\underline{R} + \underline{D} = \begin{pmatrix} 25.2 & 24 & 15.6 \\ 39.6 & 55.2 & 56.4 \\ 46.8 & 50.4 & 39.6 \end{pmatrix}$$

$$\underline{B}^2 = \begin{pmatrix} 21 & 12 \\ 15 & 24 \\ 33 & 24 \end{pmatrix}$$

$$\underline{R}^0 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Press F1 for help. AUTO NUM

# Транспонирование матриц



Mathcad - [Untitled:1]

File Edit View Insert Format Tools Symbolics Window Help

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Normal Arial 10 B I U

$A := \begin{pmatrix} 1 & 5 & 9 & 13 \\ 2 & 6 & 10 & 14 \\ 2 & 2 & 11 & 15 \\ 2 & 2 & 2 & 16 \end{pmatrix}$

$B := \begin{pmatrix} 2 & 3 & 3 \\ 1 & 2 & 3 \\ 1 & 1 & 2 \end{pmatrix}$

$C := \begin{pmatrix} 9 & 8 & 7 \\ 6 & 5 & 4 \\ 3 & 2 & 1 \\ 9 & 8 & 7 \end{pmatrix}$

$A^T = \begin{pmatrix} 1 & 2 & 2 & 2 \\ 5 & 6 & 2 & 2 \\ 9 & 10 & 11 & 2 \\ 13 & 14 & 15 & 16 \end{pmatrix}$

$B^T = \begin{pmatrix} 2 & 1 & 1 \\ 3 & 2 & 1 \\ 3 & 3 & 2 \end{pmatrix}$

$C^T = \begin{pmatrix} 9 & 6 & 3 & 9 \\ 8 & 5 & 2 & 8 \\ 7 & 4 & 1 & 7 \end{pmatrix}$

$(A \cdot C)^T = \begin{pmatrix} 183 & 210 & 198 & 180 \\ 155 & 178 & 168 & 158 \\ 127 & 146 & 138 & 136 \end{pmatrix}$

Press F1 for help. AUTO NUM Page 1

# Обращение матриц

The screenshot shows the Mathcad interface with a 'Matrix' palette open on the left. The main workspace contains the following mathematical expressions:

$$B := \begin{pmatrix} 2 & 3 & 3 \\ 1 & 2 & 3 \\ 1 & 1 & 2 \end{pmatrix}$$
$$E := \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$
$$B^{-1} = \begin{pmatrix} 0.5 & -1.5 & 1.5 \\ 0.5 & 0.5 & -1.5 \\ -0.5 & 0.5 & 0.5 \end{pmatrix}$$
$$B^{-1} \cdot B = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$
$$E^{-1} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

The interface includes a menu bar (File, Edit, View, Insert, Format, Tools, Symbolics, Window, Help), a toolbar with various icons, and a status bar at the bottom with the text 'Press F1 for help.', 'AUTO', 'NUM', and 'Page 1'.

# Векторное произведение

**Matrix**

Matrix palette containing symbols for matrix creation, inverse, determinant, vector functions, and matrix operations.

Mathcad - [Untitled:1]

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$A := \begin{pmatrix} 6 & 4 & 3 \\ 8 & 5 & 2 \\ 7 & 3 & 1 \end{pmatrix} \quad |A| = -15$

$D := \begin{pmatrix} 1 & 2 \\ 2 & 1 \end{pmatrix} \quad |D| = -3$

$B := \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} \quad C := \begin{pmatrix} 5 \\ 6 \\ 7 \end{pmatrix}$

$B \times C = \begin{pmatrix} -4 \\ 8 \\ -4 \end{pmatrix}$  векторное произведение

$B \cdot C = 38$  скалярное произведение

Press F1 for help. AUTO NUM Page 1

# Сумма элементов векторов

The screenshot displays a software window titled "Matrix" with a toolbar containing various mathematical symbols and functions. The main workspace shows the following definitions and calculations:

$$B := \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} \quad C := (9 \ 8 \ 7) \quad D := (6 \ 5 \ 4)$$
$$\sum B = 6 \quad \sum C = 24 \quad \sum (C + D) = 39$$

The interface includes a status bar at the bottom with the text "Press F1 for help.", "AUTO", and "NUM".

# Выделение строк и столбцов



Mathcad - [Untitled:1]

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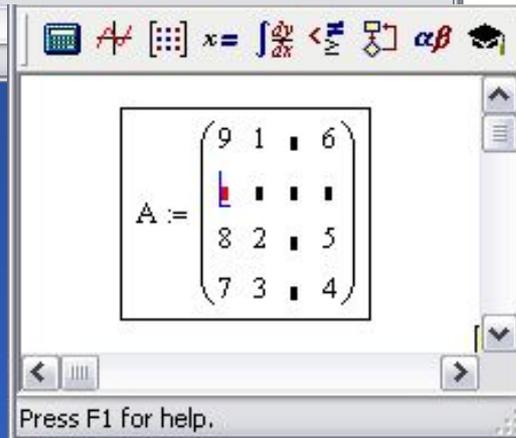
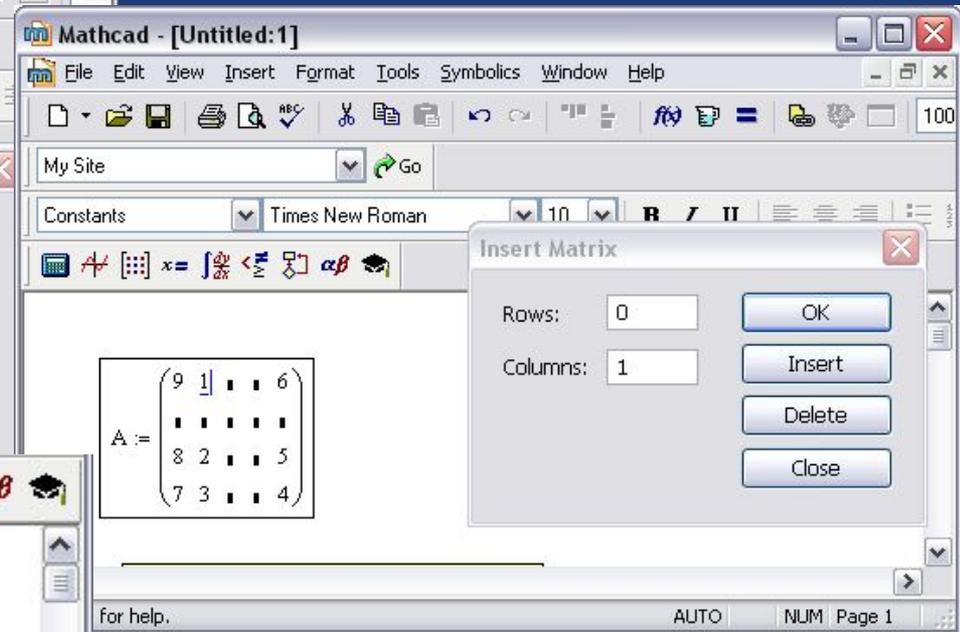
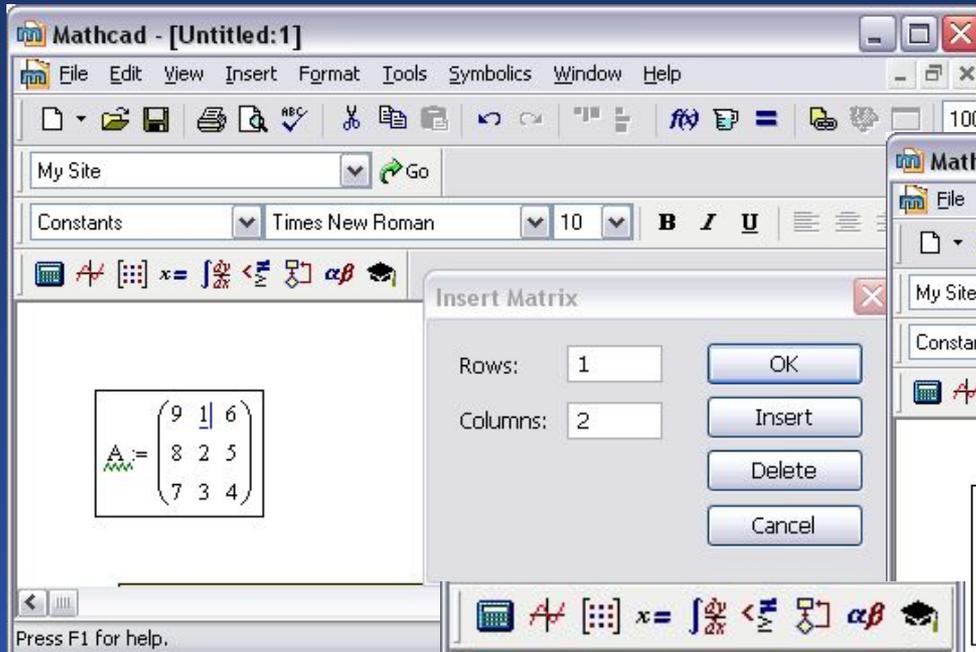
$A := \begin{pmatrix} 9 & 8 & 7 \\ 6 & 5 & 4 \end{pmatrix}$        $A^{(0)} = \begin{pmatrix} 9 \\ 6 \end{pmatrix}$        $A^{(1)} = \begin{pmatrix} 8 \\ 5 \end{pmatrix}$

$(A^T)^{(0)} = \begin{pmatrix} 9 \\ 8 \\ 7 \end{pmatrix}$        $(A^T)^{(1)} = \begin{pmatrix} 6 \\ 5 \\ 4 \end{pmatrix}$

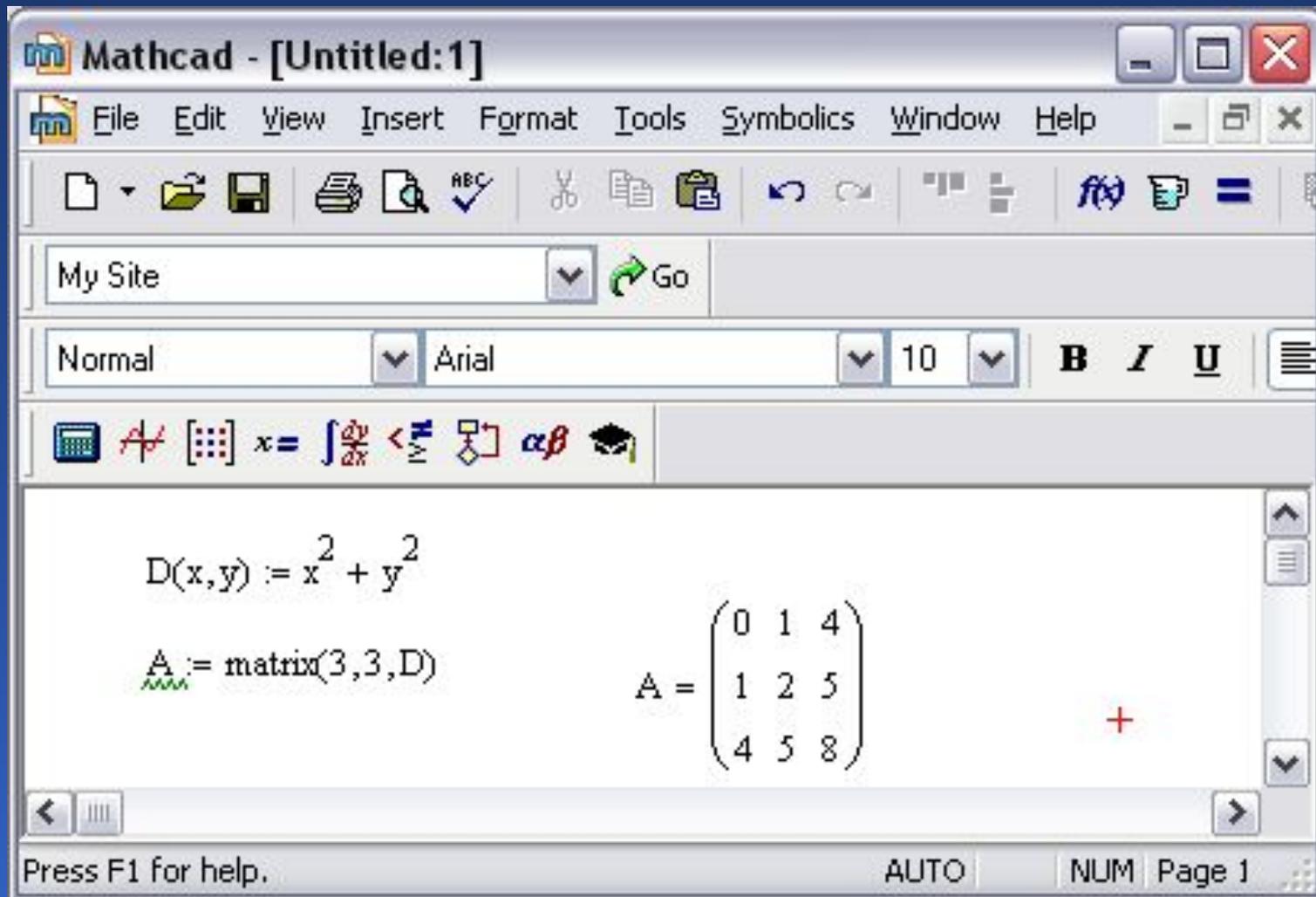
$(A^T)^{(0)T} = (9 \ 8 \ 7)$        $(A^T)^{(1)T} = (6 \ 5 \ 4)$

Press F1 for help.      AUTO      NUM Page 1

# Преобразование массивов



# Функции для работы с массивами. Функция *MATRIX*( )



# Функции для работы с массивами. Функции *STACK()* и *AUGMENT()*

Mathcad - [Untitled:1]

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$A := \begin{pmatrix} 9 & 6 & 1 \\ 8 & 5 & 2 \\ 7 & 4 & 3 \end{pmatrix}$       $B := (1 \ 2 \ 3)$       $C := \begin{pmatrix} 8 \\ 7 \\ 6 \end{pmatrix}$

$\text{stack}(A, B) = \begin{pmatrix} 9 & 6 & 1 \\ 8 & 5 & 2 \\ 7 & 4 & 3 \\ 1 & 2 & 3 \end{pmatrix}$       $\text{augment}(A, C) = \begin{pmatrix} 9 & 6 & 1 & 8 \\ 8 & 5 & 2 & 7 \\ 7 & 4 & 3 & 6 \end{pmatrix}$

$\text{stack}(\text{augment}(A, C), \text{stack}(A, B)^T)^T = \begin{pmatrix} 9 & 8 & 7 & 9 & 6 & 1 \\ 6 & 5 & 4 & 8 & 5 & 2 \\ 1 & 2 & 3 & 7 & 4 & 3 \\ 8 & 7 & 6 & 1 & 2 & 3 \end{pmatrix}$

Press F1 for help.     AUTO     NUM Page 1

# Функции для работы с массивами. Функция *SUBMATRIX()*

The screenshot shows the Mathcad interface with a worksheet containing the following content:

Matrix A:

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

Two examples of the *submatrix()* function are shown, each with a different *ORIGIN* setting:

ORIGIN := 1

$B := \text{submatrix}(A, 2, 4, 1, 3)$

$$B = \begin{pmatrix} 8 & 3 & 4 \\ 7 & 5 & 6 \\ 8 & 7 & 9 \end{pmatrix}$$

$C := \text{submatrix}(A, 1, 2, 1, 2)$

$$C = \begin{pmatrix} 9 & 1 \\ 8 & 3 \end{pmatrix}$$

ORIGIN := 0

$B := \text{submatrix}(A, 2, 4, 1, 3)$

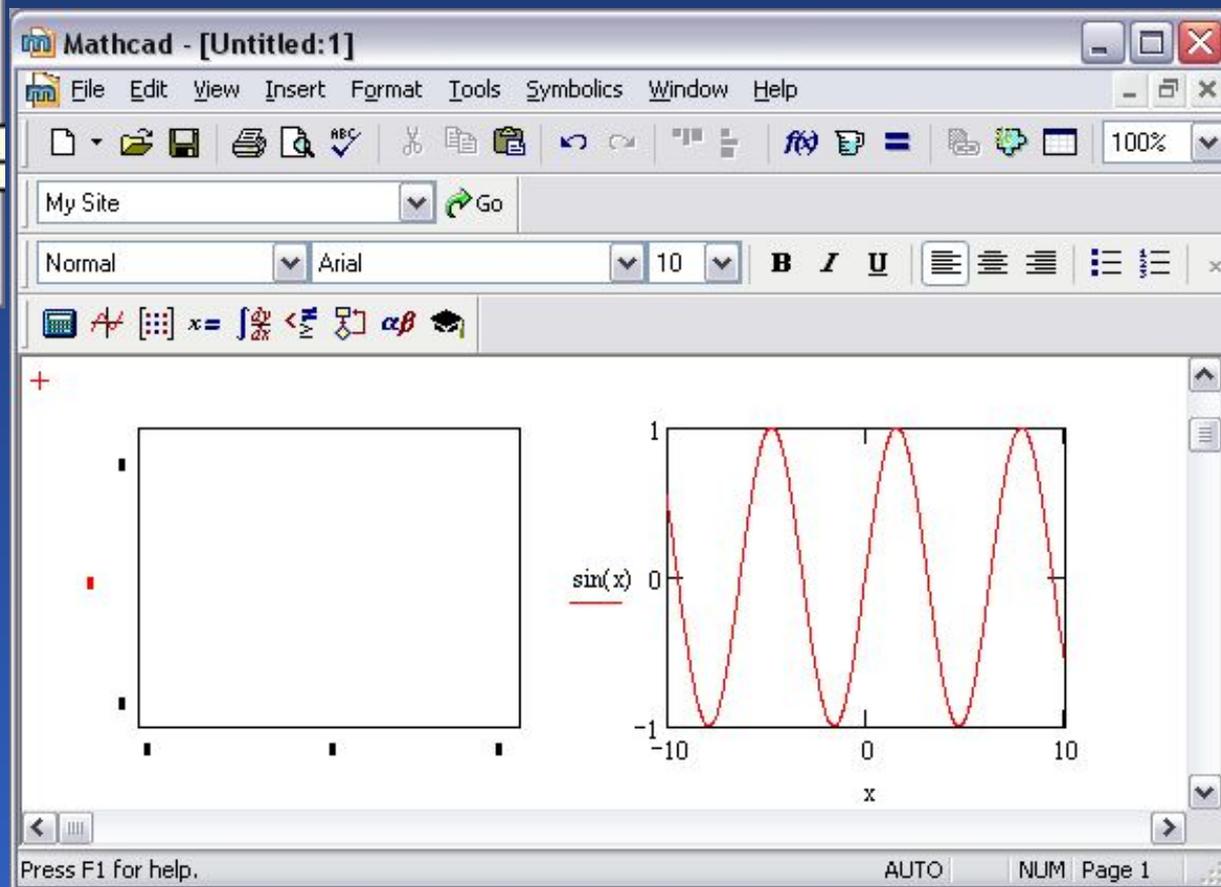
$$B = \begin{pmatrix} 5 & 6 & 4 \\ 7 & 9 & 3 \\ 2 & 5 & 7 \end{pmatrix}$$

$C := \text{submatrix}(A, 1, 2, 1, 2)$

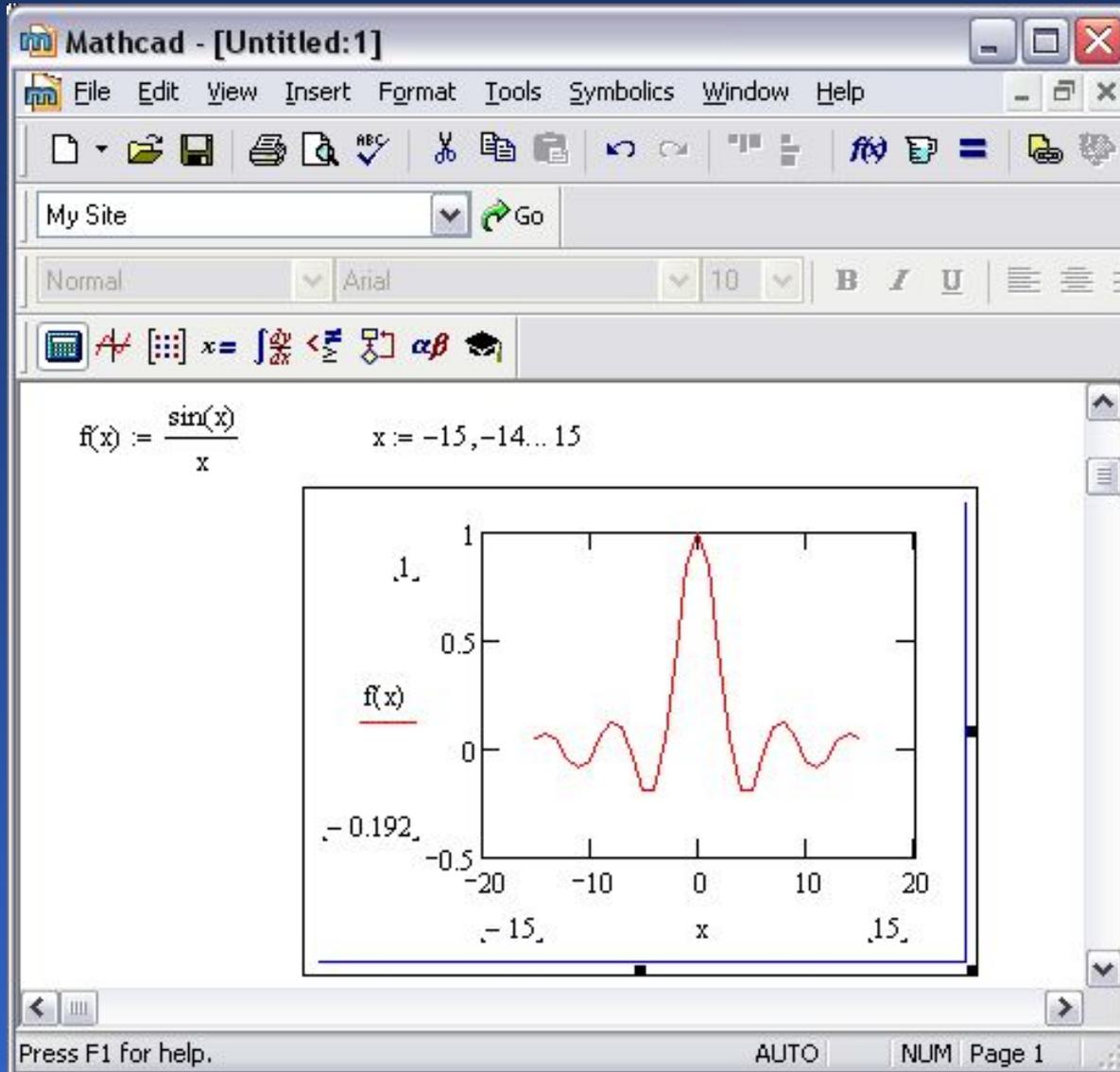
$$C = \begin{pmatrix} 3 & 4 \\ 5 & 6 \end{pmatrix}$$

The status bar at the bottom indicates "Press F1 for help.", "AUTO", "NUM", and "Page 1".

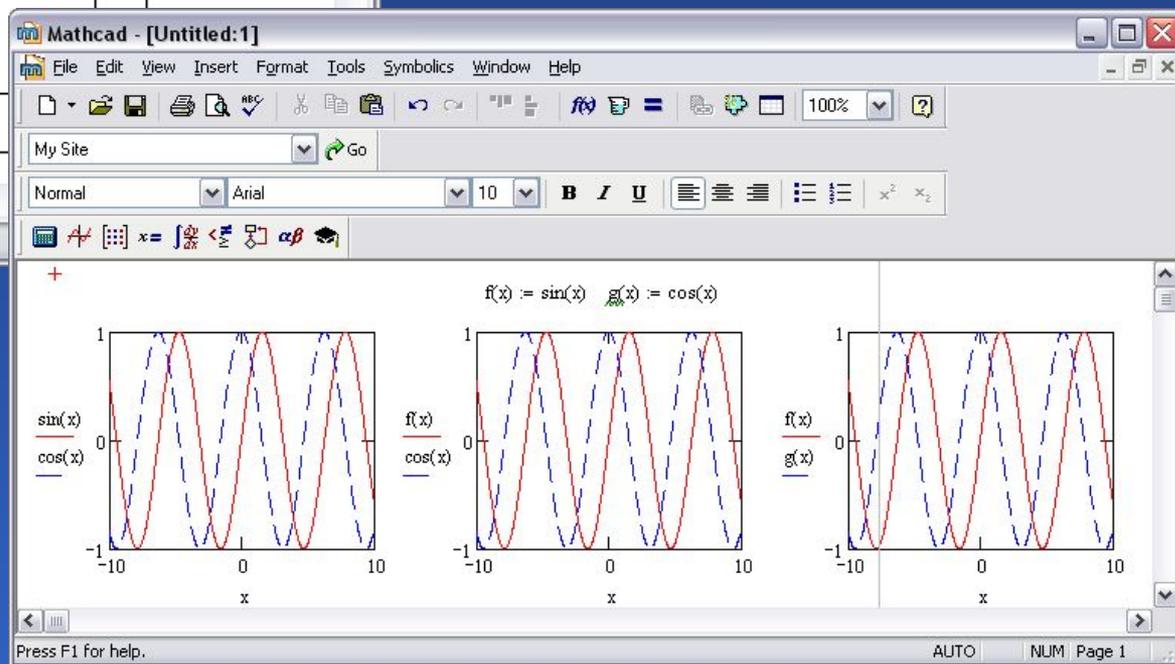
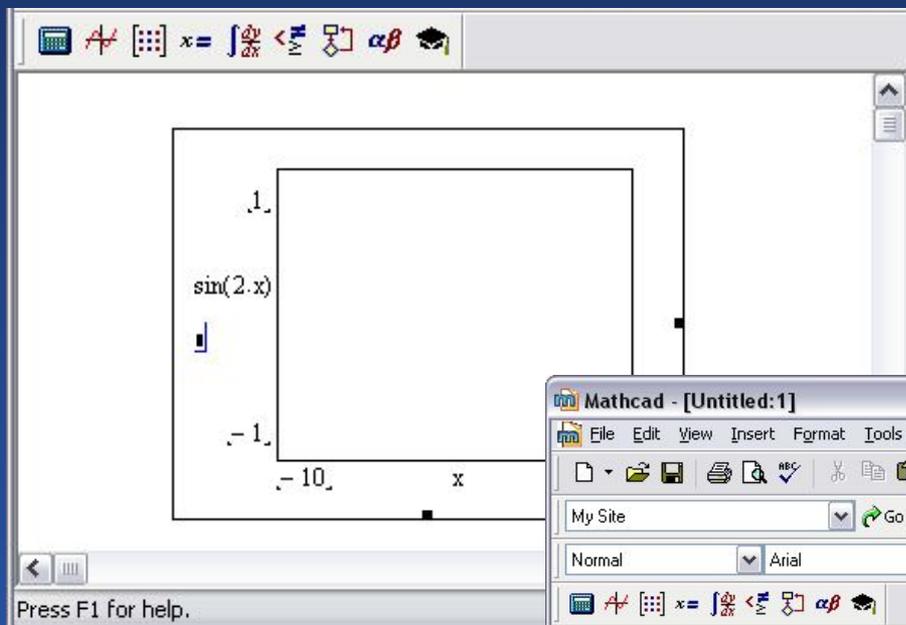
# Создание двумерных графиков



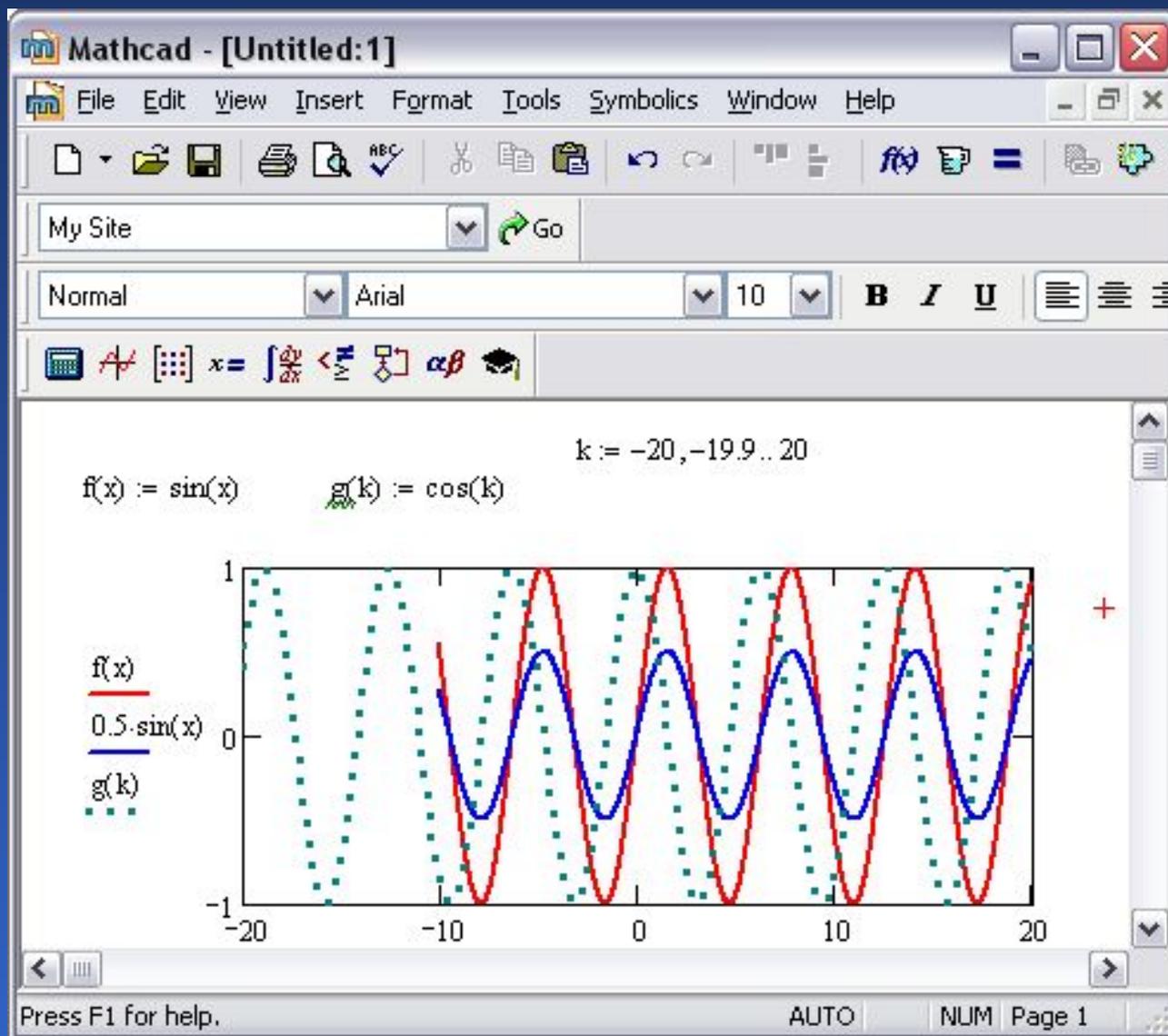
# Создание двумерных графиков



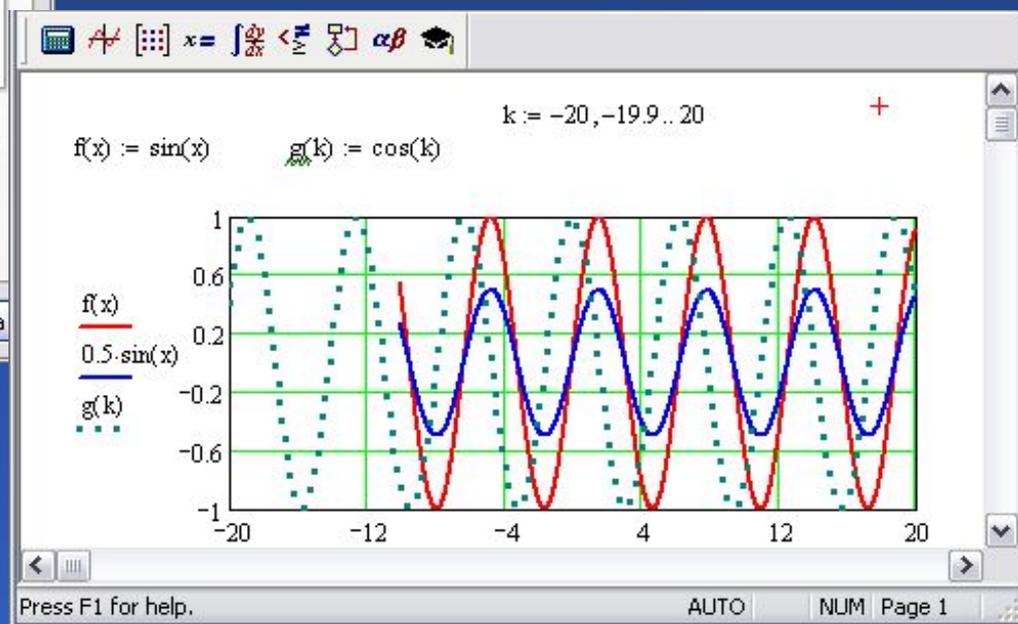
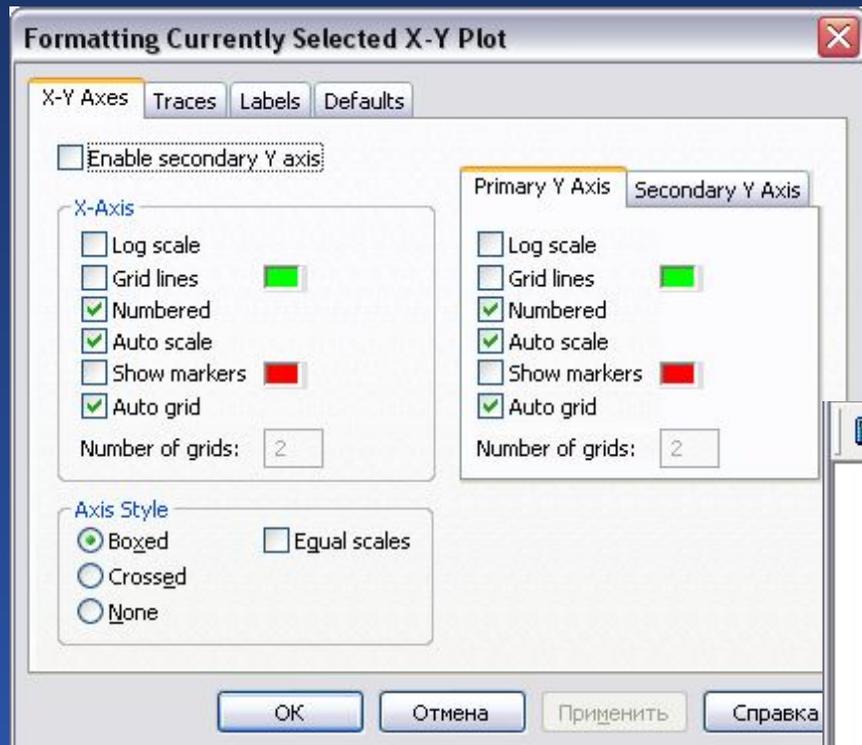
# Графики нескольких функций



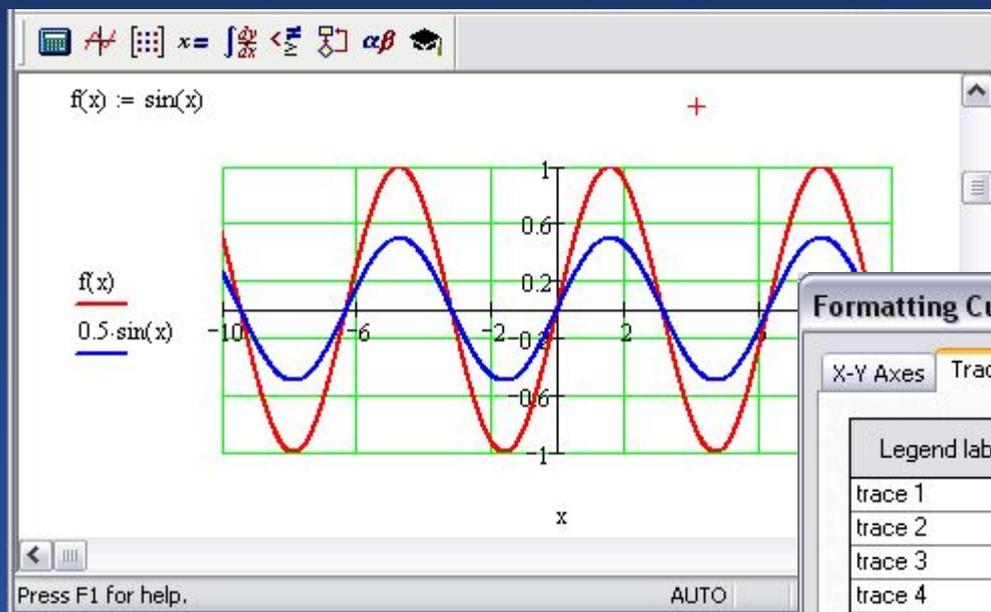
# Графики нескольких функций



# Настройка параметров графика



# Настройка параметров графика



### Formatting Currently Selected X-Y Plot

X-Y Axes Traces Labels Defaults

Legend label	Symbol Frequency	Symbol	Symbol Weight	Line	Line Weight	Co
trace 1	1		1	—	2	Red
trace 2	1		1	—	2	Blue
trace 3	1		1	....	4	Green
trace 4	1		1	- - - -	1	Magenta
trace 5	1		1	—	1	Cyan
trace 6	1		1	....	1	Brown
trace 7	1		1	- -	1	Black

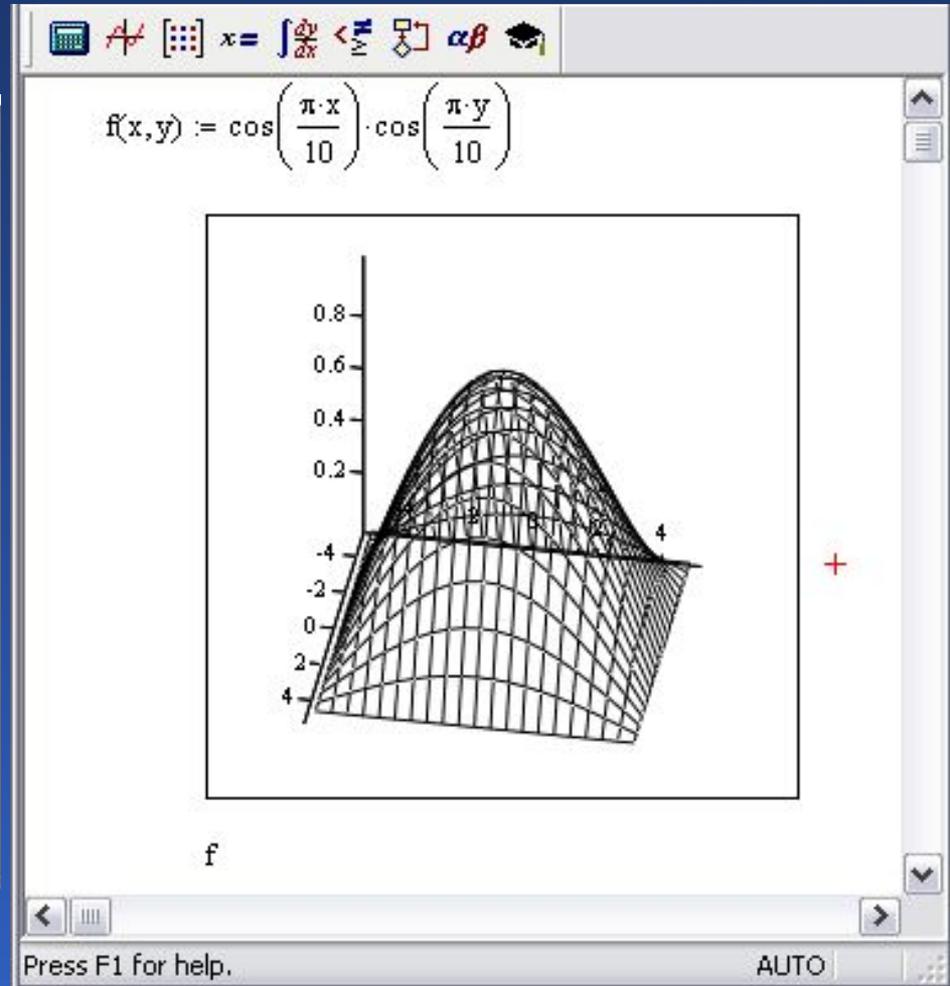
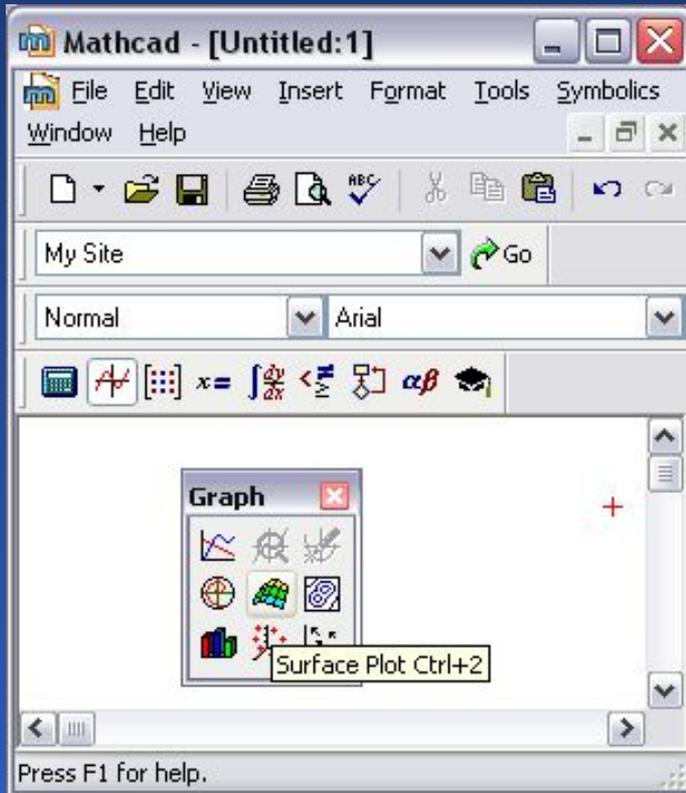
Hide arguments

Hide legend

Top-left  Top-right  
 Bottom-left  Bottom-right  
 Below

OK Отмена Применить Справка

# Создание трехмерных графиков. Создание поверхностей

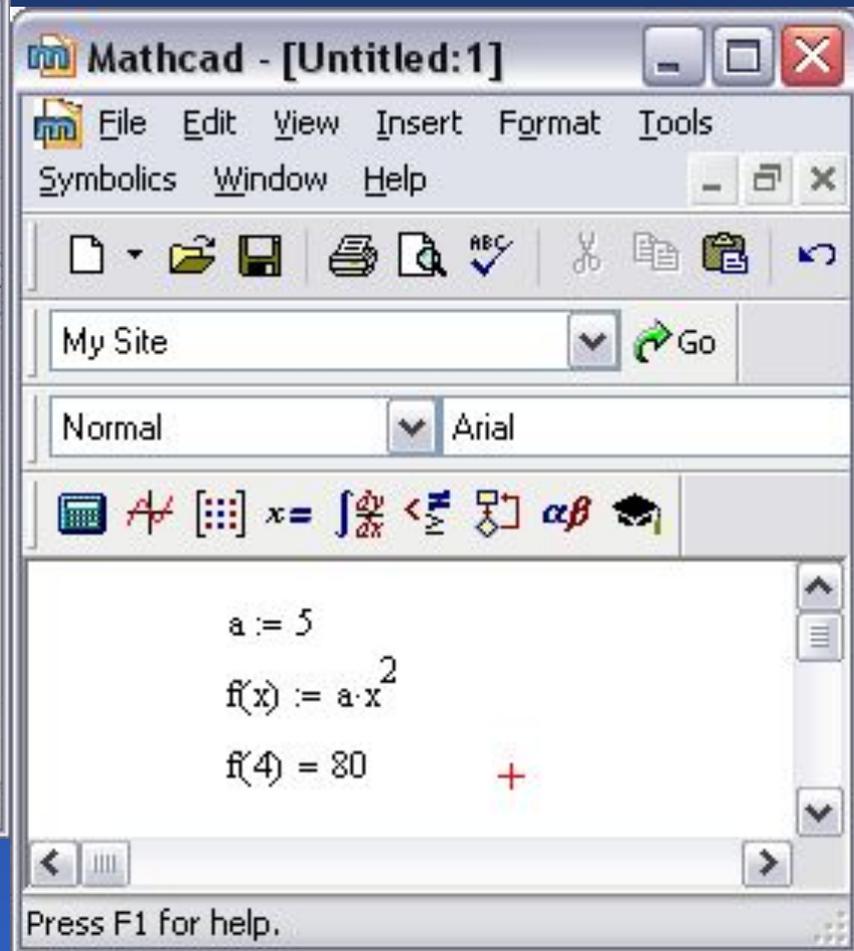
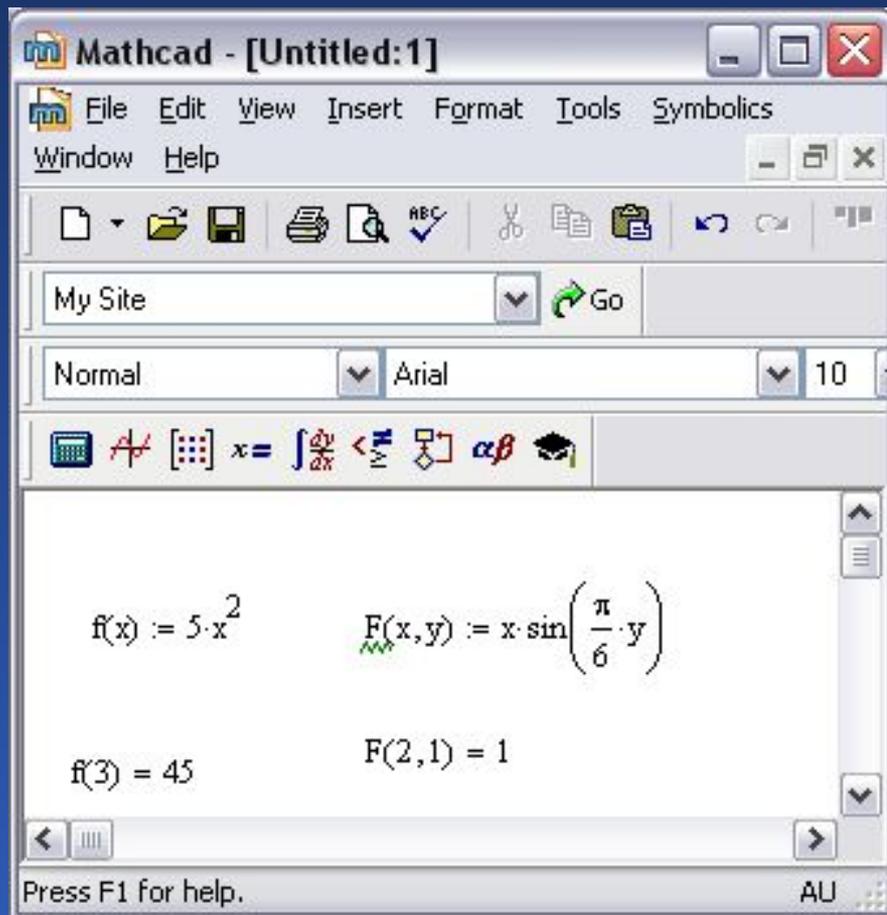


# Создание поверхностей

The screenshot displays the Mathcad interface with the following elements:

- Equation:**  $f(x, y) := \cos\left(\frac{\pi \cdot x}{10}\right) \cdot \cos\left(\frac{\pi \cdot y}{10}\right)$
- 3D Plot:** A wireframe surface plot of the function. The vertical axis is labeled 'f' and has tick marks at 0.6 and 0.8. The horizontal axes are labeled with '5' and '10'.
- 3-D Plot Format Dialog:** A dialog box with the following settings:
  - General:** Backplanes, Special, Advanced, QuickPlot Data
  - Plot 1:**
    - Range 1:** start: -10, end: 10, # of Grids: 50
    - Range 2:** start: -10, end: 10, # of Grids: 50
    - Coordinate System:** Cartesian (selected), Spherical, Cylindrical
  - Buttons:** OK, Отмена, Применить, Справка
- Footer:** Press F1 for help. AUTO NUM Page 1

# Собственные функции в *MathCAD*



# Основы программирования в *MathCAD*. Логические операторы

The screenshot displays the MathCAD software interface. On the left, two toolbars are visible: the 'Programming' toolbar and the 'Boolean' toolbar. The main workspace contains a code block with the following text:

```
i ← 3 = 9  
i ← i2  
i
```

The 'Programming' toolbar includes icons for 'Add Line', 'if', 'for', 'break', 'return', 'otherwise', 'while', 'continue', and 'on error'. The 'Boolean' toolbar includes icons for logical operators: '=', '<', '>', '≤', '≥', '≠', '¬', '∧', '∨', and '⊕'. The main workspace also features a toolbar with mathematical symbols like a calculator, a fraction, a matrix, a derivative, an integral, and a summation. The status bar at the bottom reads 'Press F1 for help.'

# Условный оператор

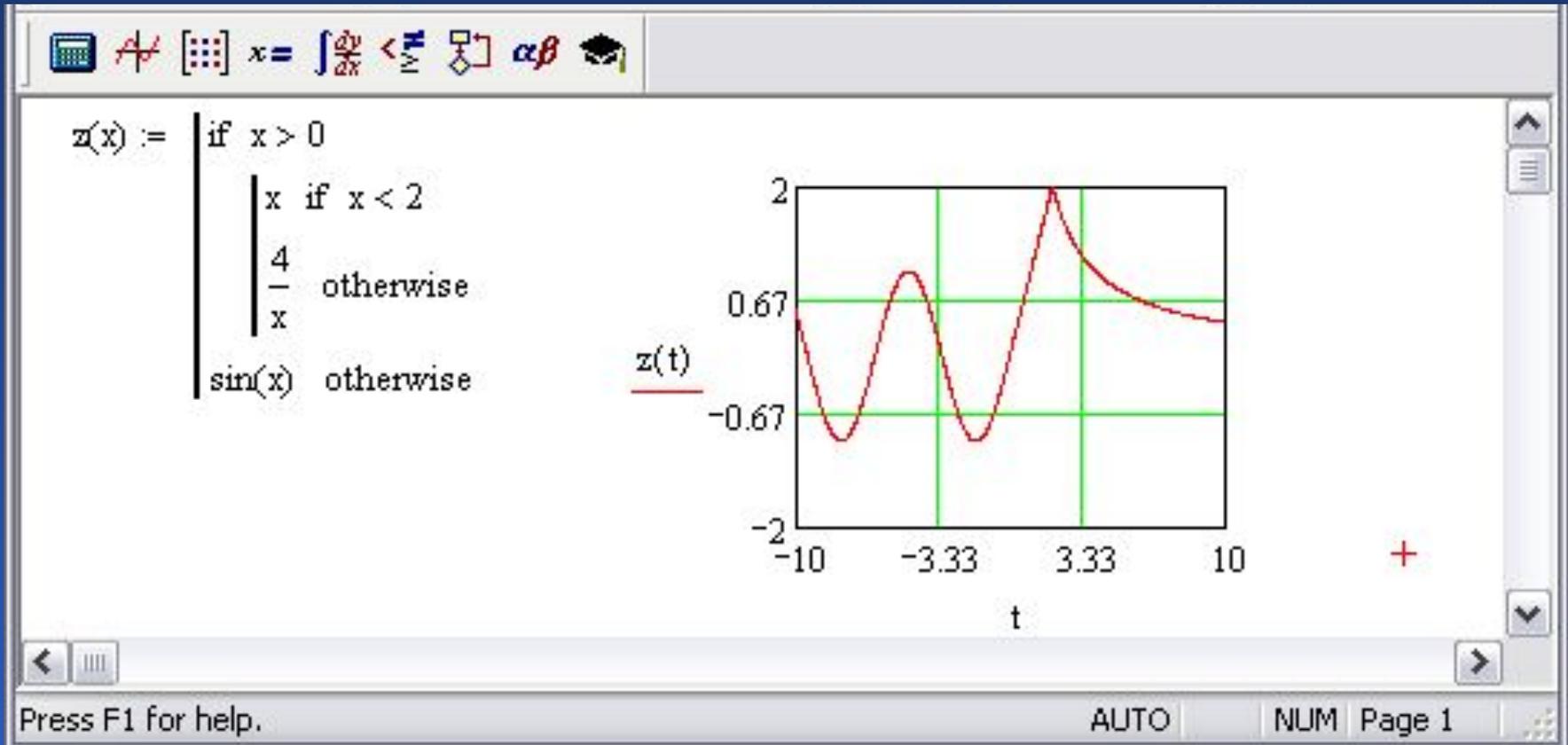
The image displays three screenshots of a mathematical software interface, likely a CAS (Computer Algebra System), demonstrating the use of conditional operators.

**Top Left Screenshot:** Shows a variable assignment  $x := 6$  and a function definition  $f(x) := \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{otherwise} \end{cases}$ . Below this, the variable  $x$  is updated to  $x := -2$ , and the function is re-evaluated:  $f(x) := \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{otherwise} \end{cases}$ .

**Top Right Screenshot:** Shows the function definition  $f(x) := \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{otherwise} \end{cases}$  and its evaluation at specific points:  $f(-1) = 0$  and  $f(5) = 1$ .

**Bottom Screenshot:** Shows a function definition  $F(x) := \begin{cases} -1 & \text{if } x < 0 \\ 1 & \text{if } x > 0 \\ 0 & \text{otherwise} \end{cases}$  and its evaluation at  $F(-1) = -1$ ,  $F(5) = 1$ , and  $F(0) = 0$ .

# Кусочно непрерывная функция



# Вложенные операторы

The screenshot shows a software window with a toolbar at the top containing icons for a calculator, eraser, grid, assignment, integration, inequality, set, Greek letters, and a graduation cap. The main area displays two functions defined with nested conditional operators:

$$T1(u) := \begin{cases} 3 & \text{if } u \geq 5 \\ 1 & \text{if } u \leq 1 \\ 2 & \text{otherwise} \end{cases}$$
$$T2(u) := \begin{cases} \text{if } u > 1 \\ \quad \begin{cases} 2 & \text{if } u < 5 \\ 3 & \text{otherwise} \end{cases} \\ 1 & \text{otherwise} \end{cases}$$

Below the definitions, the values of the functions are calculated for specific inputs:

$$\begin{array}{ll} T1(0) = 1 & T2(0) = 1 \\ T1(4) = 2 & T2(4) = 2 \\ T1(6) = 3 & T2(6) = 3 \end{array}$$

The bottom status bar contains the text "Press F1 for help.", "AUTO", "NUM", "Page 1", and a small grid icon.

# Арифметическое выражение в условии

The screenshot shows a software window with a toolbar at the top containing icons for a calculator, a fraction, a grid, an equals sign, a derivative symbol, less than or equal to, a box, Greek letters alpha and beta, and a graduation cap. The main area contains the following text:

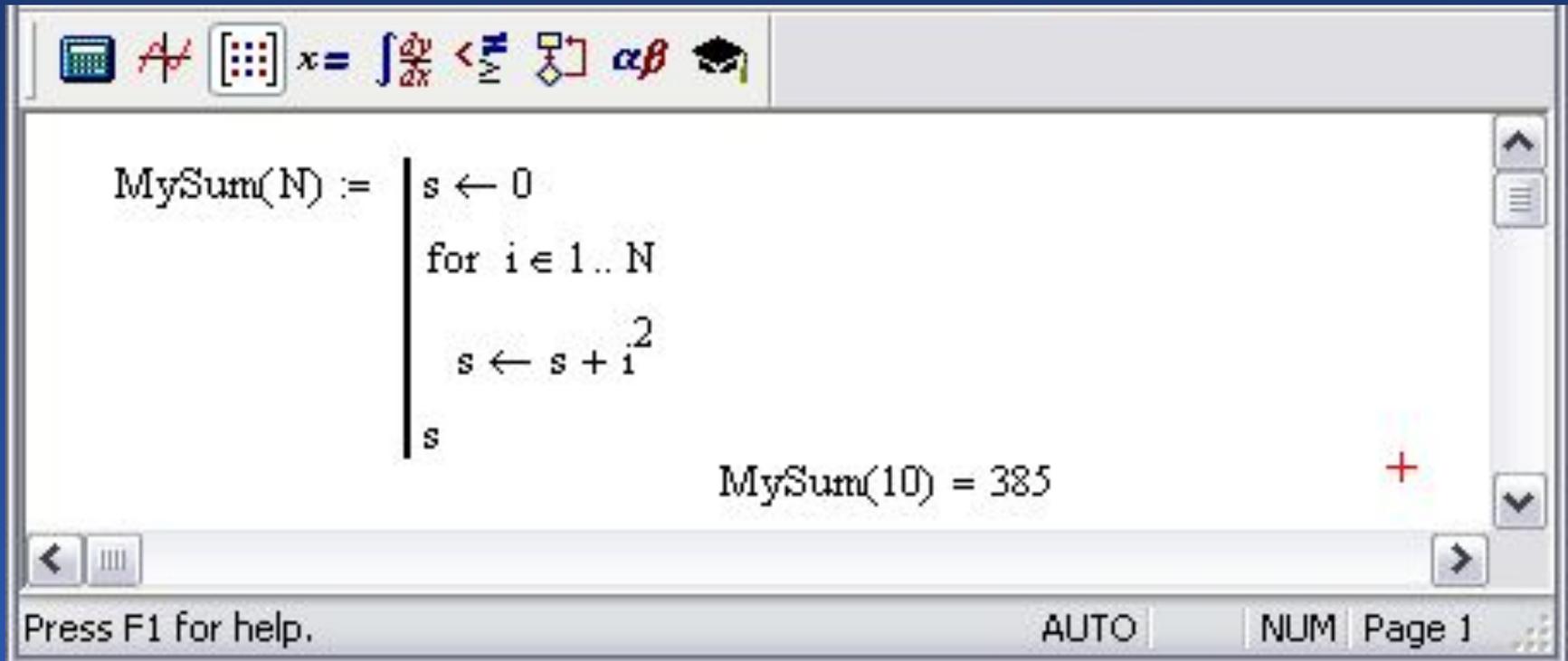
$$f(x) := \begin{cases} \text{"infinity"} & \text{if } \neg(x - 1) \\ \frac{1}{x - 1} & \text{otherwise} \end{cases}$$

Below the definition, three evaluations are shown:

$$f(2) = 1$$
$$f(1) = \text{"infinity"}$$
$$f(-4) = -0.2$$

The interface includes navigation arrows on the right and bottom, and a status bar at the bottom with the text "Press F1 for help.", "AUTO", "NUM", and "Page 1".

# Операторы циклов. Сумма квадратов



The screenshot shows a window with a toolbar at the top containing icons for a calculator, a red 'X', a grid, mathematical symbols like  $x =$ ,  $\int \frac{dy}{dx}$ ,  $<$ ,  $\geq$ , a box with a plus sign,  $\alpha\beta$ , and a graduation cap. The main area contains the following code:

```
MySum(N) :=  $\left\{ \begin{array}{l} s \leftarrow 0 \\ \text{for } i \in 1..N \\ \quad s \leftarrow s + i^2 \\ s \end{array} \right.$ 
```

Below the code, the result of the function is displayed:  $\text{MySum}(10) = 385$ . A red plus sign is visible to the right of the result. The bottom status bar contains the text "Press F1 for help.", "AUTO", "NUM", and "Page 1".

# Операторы циклов. Сумма квадратов с ограничением

```
MySum2(N) := 
$$\left| \begin{array}{l} s \leftarrow 0 \\ \text{for } i \in 1..N \\ \quad \left| \begin{array}{l} \text{continue if } i > 10 \\ s \leftarrow s + i^2 \end{array} \right. \\ s \end{array} \right.$$

```

MySum2(5) = 55      MySum2(10) = 385      M

Press F1 for help.

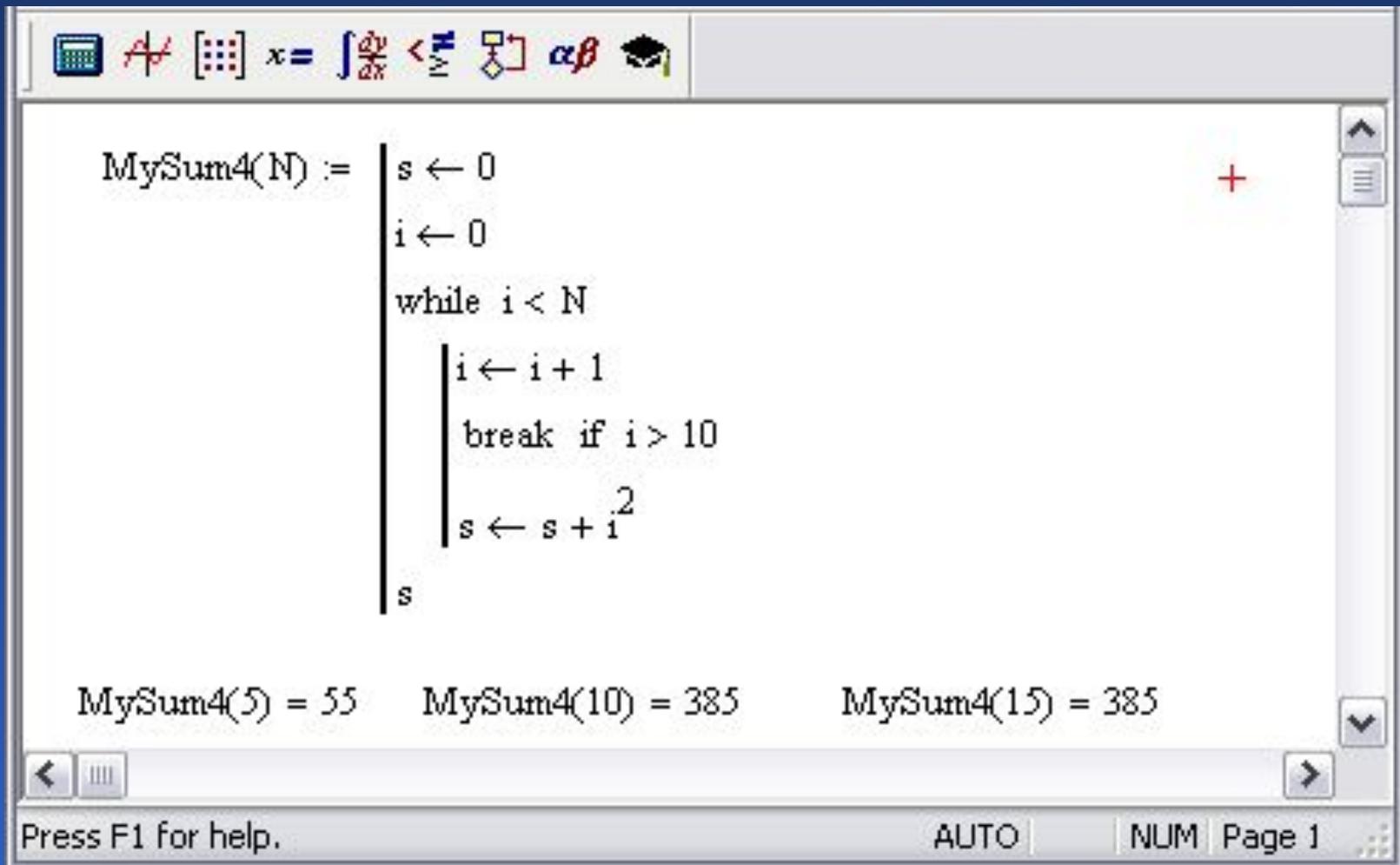
```
MySum3(N) := 
$$\left| \begin{array}{l} s \leftarrow 0 \\ i \leftarrow 0 \\ \text{while } i < N \\ \quad \left| \begin{array}{l} i \leftarrow i + 1 \\ s \leftarrow s + i^2 \end{array} \right. \\ s \end{array} \right.$$

```

MySum3(5) = 55      MySum3(10) = 385      MySum3(15) =  $1.24 \times 10^3$

Press F1 for help.      AUTO      NUM      Page 1

# Использование инструкции *break*



The screenshot shows a mathematical software interface with a toolbar at the top containing icons for a calculator, a pencil, a grid, a derivative symbol  $x = \int \frac{dy}{dx}$ , a less-than sign, a diamond, Greek letters  $\alpha\beta$ , and a graduation cap. The main workspace contains the following code:

```
MySum4(N) :=  $\left\{ \begin{array}{l} s \leftarrow 0 \\ i \leftarrow 0 \\ \text{while } i < N \\ \quad \left\{ \begin{array}{l} i \leftarrow i + 1 \\ \text{break if } i > 10 \\ s \leftarrow s + i^2 \end{array} \right. \\ s \end{array} \right.$ 
```

Below the code, three function calls are shown:  $\text{MySum4}(5) = 55$ ,  $\text{MySum4}(10) = 385$ , and  $\text{MySum4}(15) = 385$ . The interface also features a status bar at the bottom with the text "Press F1 for help.", "AUTO", "NUM", and "Page 1".

# Рекурсия. Двойной факториал

The screenshot shows a window with a toolbar at the top containing icons for a calculator, eraser, grid, assignment, integral, less than or equal to, greater than or equal to, square root, Greek letters alpha and beta, and a graduation cap. The main area contains the following text:

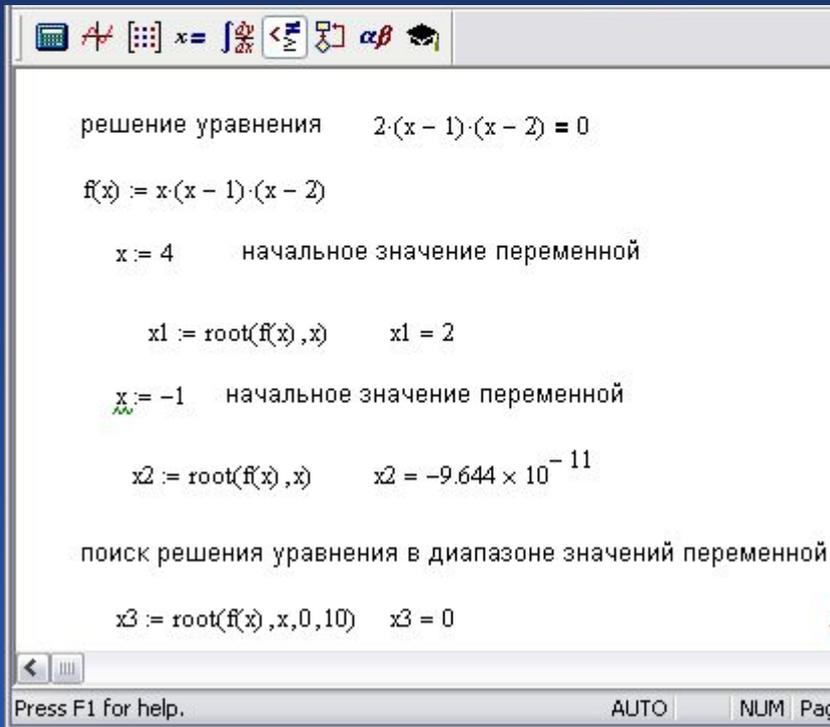
$$\text{Fact2}(n) := \begin{cases} n \cdot \text{Fact2}(n - 2) & \text{if } n > 2 \\ n & \text{otherwise} \end{cases}$$

Below the definition, the function is evaluated for two values:

$$\text{Fact2}(6) = 48 \quad \text{Fact2}(5) = 15$$

A red plus sign is visible to the right of the second evaluation. The bottom status bar includes the text "Press F1 for help.", "AUTO", "NUM", and "Page 1".

# Решение уравнений и систем



решение уравнения  $2 \cdot (x - 1) \cdot (x - 2) = 0$

$f(x) := x \cdot (x - 1) \cdot (x - 2)$

$x := 4$  начальное значение переменной

$x1 := \text{root}(f(x), x) \quad x1 = 2$

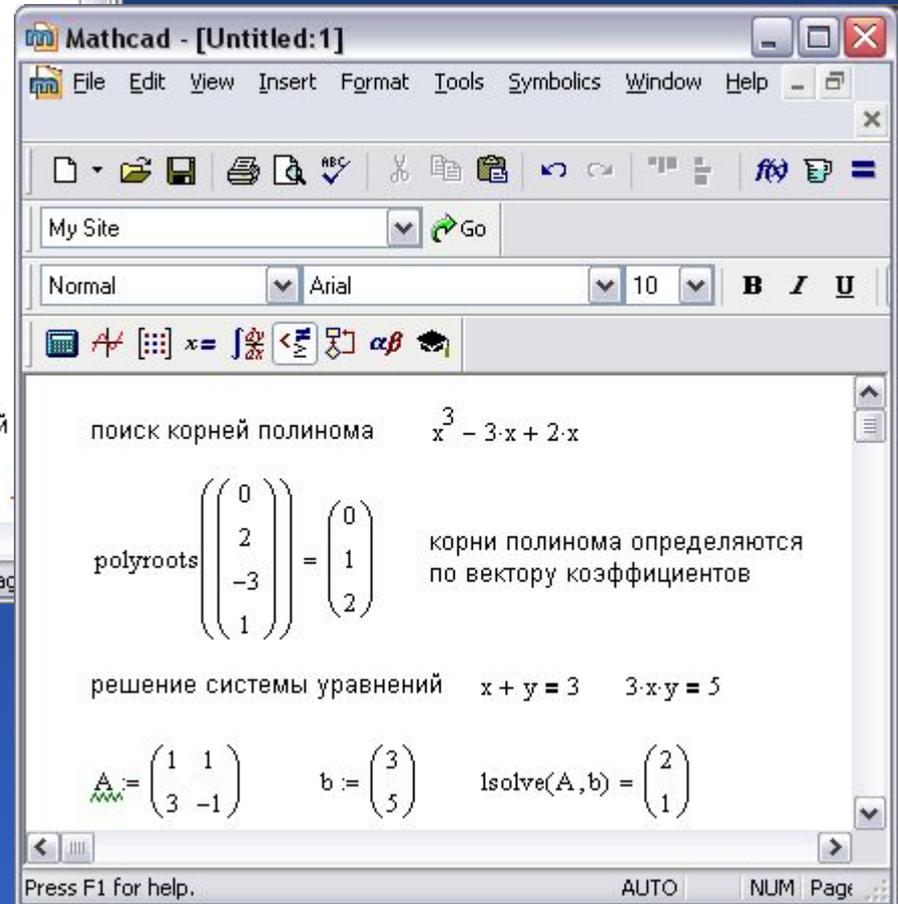
$x := -1$  начальное значение переменной

$x2 := \text{root}(f(x), x) \quad x2 = -9.644 \times 10^{-11}$

поиск решения уравнения в диапазоне значений переменной

$x3 := \text{root}(f(x), x, 0, 10) \quad x3 = 0$

Press F1 for help. AUTO NUM Page



Mathcad - [Untitled:1]

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поиск корней полинома  $x^3 - 3 \cdot x + 2 \cdot x$

$\text{polyroots} \left( \begin{pmatrix} 0 \\ 2 \\ -3 \\ 1 \end{pmatrix} \right) = \begin{pmatrix} 0 \\ 1 \\ 2 \end{pmatrix}$  корни полинома определяются по вектору коэффициентов

решение системы уравнений  $x + y = 3 \quad 3 \cdot x \cdot y = 5$

$A := \begin{pmatrix} 1 & 1 \\ 3 & -1 \end{pmatrix} \quad b := \begin{pmatrix} 3 \\ 5 \end{pmatrix} \quad \text{lsolve}(A, b) = \begin{pmatrix} 2 \\ 1 \end{pmatrix}$

Press F1 for help. AUTO NUM Page

# Решение нелинейной системы

**Boolean**

= < > ≤ ≥

Equal to Ctrl+= ⊕

**Mathcad - [Untitled:1]**

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$x := 1 \quad y := 0$  начальные значения переменных

Given

$x^2 + y^2 = 1$  система уравнений

$3-x - 4y = 0$

$\text{Find}(x,y) = \begin{pmatrix} 0.8 \\ 0.6 \end{pmatrix}$  решение системы уравнений

Press F1 for help. AUTO NUM Page

# Аналитические выкладки в MathCAD

- Формирование символьной матрицы

$$\text{MForm}(N, M, A) := \left| \begin{array}{l} \text{for } j \in 1..N \\ \quad \text{for } k \in 1..M \\ \quad \quad z_{j,k} \leftarrow A_{j,k} \\ z \end{array} \right. \quad I := \text{MForm}(N, M, a) \rightarrow \begin{pmatrix} a_{1,1} & a_{1,2} & a_{1,3} & a_{1,4} \\ a_{2,1} & a_{2,2} & a_{2,3} & a_{2,4} \\ a_{3,1} & a_{3,2} & a_{3,3} & a_{3,4} \end{pmatrix}$$

- Формирование символьного вектора

$$\text{VForm}(N, A) := \left| \begin{array}{l} \text{for } j \in 1..N \\ \quad z_j \leftarrow A_j \\ z \end{array} \right. \quad X := \text{VForm}(N, x) \rightarrow \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$$