```
>> C=[4 2 6; -2 8 10; 6 2 3];
>> D=[8 4 0];
>> Xc=D/C
Xc =
   -1.8049    0.2927    2.6341
>> Xd=D*inv(C)
Xd =
   -1.8049    0.2927    2.6341
```

Solving the form $XC = D$.

Solving by using right division: $X = D/C$.

Solving by using the inverse of C: $X=DC^{-1}$.

3.4 ELEMENT-BY-ELEMENT OPERATIONS

In Sections 3.2 and 3.3 it was shown that when the regular symbols for multiplication and division (* and /) are used with arrays, the mathematical operations follow the rules of linear algebra. There are, however, many situations that require element-by-element operations. These operations are carried out on each of the elements of the array (or arrays). Addition and subtraction are by definition already element-by-element operations, since when two arrays are added (or subtracted) the operation is executed with the elements that are in the same position in the arrays. Element-by-element operations can be done only with arrays of the same size.

Element-by-element multiplication, division, or exponentiation of two vectors or matrices is entered in MATLAB by typing a period in front of the arithmetic operator.

Symbol	Description	Symbol	Description
.*	Multiplication	./	Right division
.^	Exponentiation	.\	Left Division

If two vectors a and b are $a=[a_1\ a_2\ a_3\ a_4]$ and $b=[b_1\ b_2\ b_3\ b_4]$, then element-by-element multiplication, division, and exponentiation of the two vectors gives:

$$a.*b = [a_1*b_1 \;\; a_2*b_2 \;\; a_3*b_3 \;\; a_4*b_4]$$

$$a./b = [a_1/b_1 \;\; a_2/b_2 \;\; a_3/b_3 \;\; a_4/b_4]$$

$$a.\hat{}b = \left[(a_1)^{b_1} \;\; (a_2)^{b_2} \;\; (a_3)^{b_3} \;\; (a_4)^{b_4}\right]$$

If two matrices A and B are

$$A = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix} \quad \text{and} \quad B = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix}$$

then element-by-element multiplication and division of the two matrices give:

$$A\ .\!*\ B = \begin{bmatrix} A_{11}B_{11} & A_{12}B_{12} & A_{13}B_{13} \\ A_{21}B_{21} & A_{22}B_{22} & A_{23}B_{23} \\ A_{31}B_{31} & A_{32}B_{32} & A_{33}B_{33} \end{bmatrix} \qquad A\ ./\ B = \begin{bmatrix} A_{11}/B_{11} & A_{12}/B_{12} & A_{13}/B_{13} \\ A_{21}/B_{21} & A_{22}/B_{22} & A_{23}/B_{23} \\ A_{31}/B_{31} & A_{32}/B_{32} & A_{33}/B_{33} \end{bmatrix}$$

Element-by-element exponentiation of matrix A gives:

$$\mathrm{A}\ .\hat{}\ n = \begin{bmatrix} (A_{11})^n & (A_{12})^n & (A_{13})^n \\ (A_{21})^n & (A_{22})^n & (A_{23})^n \\ (A_{31})^n & (A_{32})^n & (A_{33})^n \end{bmatrix}$$

Element-by-element multiplication, division, and exponentiation are demonstrated in Tutorial 3-2.

Tutorial 3-2: Element-by-element operations.

```
>> A=[2 6 3; 5 8 4]
A =
     2     6     3
     5     8     4
```

Define a 2×3 array `A`.

```
>> B=[1 4 10; 3 2 7]
B =
     1     4    10
     3     2     7
```

Define a 2×3 array `B`.

```
>> A.*B
ans =
     2    24    30
    15    16    28
```

Element-by-element multiplication of array `A` by `B`.

```
>> C=A./B
C =
    2.0000    1.5000    0.3000
    1.6667    4.0000    0.5714
```

Element-by-element division of array `A` by `B`. The result is assigned to variable `C`.

Tutorial 3-2: Element-by-element operations. (Continued)

```
>> B.^3

ans =
     1      64    1000
    27       8     343
```

Element-by-element exponentiation of array B. The result is an array in which each term is the corresponding term in B raised to the power of 3.

```
>> A*B

??? Error using ==> *
Inner matrix dimensions must agree.
```

Trying to multiply A*B gives an error, since A and B cannot be multiplied according to linear algebra rules. (The number of columns in A is not equal to the number of rows in B.)

Element-by-element calculations are very useful for calculating the value of a function at many values of its argument. This is done by first defining a vector that contains values of the independent variable, and then using this vector in element-by-element computations to create a vector in which each element is the corresponding value of the function. One example is:

```
>> x=[1:8]
x =
   1    2    3    4    5    6    7    8
>> y=x.^2-4*x
y =
  -3   -4   -3    0    5   12   21   32
>>
```

Create a vector x with eight elements.

Vector x is used in element-by-element calculations of the elements of vector y.

In the example above $y = x^2 - 4x$. Element-by-element operation is needed when x is squared. Each element in the vector y is the value of y that is obtained when the value of the corresponding element of the vector x is substituted in the equation. Another example is:

```
>> z=[1:2:11]
z =
     1     3     5     7     9    11
>> y=(z.^3 + 5*z)./(4*z.^2 - 10)

 y =
   -1.0000    1.6154    1.6667    2.0323    2.4650    2.9241
```

Create a vector z with six elements.

Vector z is used in element-by-element calculations of the elements of vector y.

In the last example $y = \frac{z^3+5z}{4z^2-10}$. Element-by-element operations are used in this example three times: to calculate z^3 and z^2, and to divide the numerator by the denominator.