When a scalar (number) is added to (or subtracted from) an array, the scalar is added to (or subtracted from) all the elements of the array. Examples are:

```
>> VectA=[1 5 8 -10 2]
VectA =
     1     5     8   -10     2
>> VectA+4
ans =
     5     9    12    -6
>> A=[6 21 -15; 0 -4 8]
A =
     6    21   -15
     0    -4     8
>> A-5
ans =
     1    16   -20
    -5    -9     3
```

Define a vector named `VectA`.

Add the scalar 4 to `VectA`.

4 is added to each element of `VectA`.

Define a 2×3 matrix `A`.

Subtract the scalar 5 from `A`.

5 is subtracted from each element of `A`.

3.2 *Array Multiplication*

The multiplication operation * is executed by MATLAB according to the rules of linear algebra. This means that if A and B are two matrices, the operation $A*B$ can be carried out only if the number of columns in matrix A is equal to the number of rows in matrix B. The result is a matrix that has the same number of rows as A and the same number of columns as B. For example, if A is a 4×3 matrix and B is a 3×2 matrix:

$$A = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \\ A_{41} & A_{42} & A_{43} \end{bmatrix} \quad \text{and} \quad B = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \\ B_{31} & B_{32} \end{bmatrix}$$

then the matrix that is obtained with the operation $A*B$ has dimensions 4×2 with the elements:

$$\begin{bmatrix} (A_{11}B_{11} + A_{12}B_{21} + A_{13}B_{31}) & (A_{11}B_{12} + A_{12}B_{22} + A_{13}B_{32}) \\ (A_{21}B_{11} + A_{22}B_{21} + A_{23}B_{31}) & (A_{21}B_{12} + A_{22}B_{22} + A_{23}B_{32}) \\ (A_{31}B_{11} + A_{32}B_{21} + A_{33}B_{31}) & (A_{31}B_{12} + A_{32}B_{22} + A_{33}B_{32}) \\ (A_{41}B_{11} + A_{42}B_{21} + A_{43}B_{31}) & (A_{41}B_{12} + A_{42}B_{22} + A_{43}B_{32}) \end{bmatrix}$$

A numerical example is:

$$\begin{bmatrix} 1 & 4 & 3 \\ 2 & 6 & 1 \\ 5 & 2 & 8 \end{bmatrix} \begin{bmatrix} 5 & 4 \\ 1 & 3 \\ 2 & 6 \end{bmatrix} = \begin{bmatrix} (1 \cdot 5 + 4 \cdot 1 + 3 \cdot 2) & (1 \cdot 4 + 4 \cdot 3 + 3 \cdot 6) \\ (2 \cdot 5 + 6 \cdot 1 + 1 \cdot 2) & (2 \cdot 4 + 6 \cdot 3 + 1 \cdot 6) \\ (5 \cdot 5 + 2 \cdot 1 + 8 \cdot 2) & (5 \cdot 4 + 2 \cdot 3 + 8 \cdot 6) \end{bmatrix} = \begin{bmatrix} 15 & 34 \\ 18 & 32 \\ 43 & 74 \end{bmatrix}$$

The product of the multiplication of two square matrices (they must be of the same size) is a square matrix of the same size. However, the multiplication of matrices is not commutative. This means that if A and B are both $n \times n$, then $A * B \neq B * A$. Also, the power operation can be executed only with a square matrix (since $A*A$ can be carried out only if the number of columns in the first matrix is equal to the number of rows in the second matrix).

Two vectors can be multiplied only if they have the same number of elements, and one is a row vector and the other is a column vector. The multiplication of a row vector by a column vector gives a 1×1 matrix, which is a scalar. This is the dot product of two vectors. (MATLAB also has a built-in function, `dot(a,b)`, that computes the dot product of two vectors.) When using the `dot` function, the vectors `a` and `b` can each be a row vector or a column vector (see Table 3-1). The multiplication of a column vector by a row vector, each with n elements, gives an $n \times n$ matrix Multiplication of array is demonstrated in Tutorial 3-1.

Tutorial 3-1: Multiplication of arrays.

```
>> A=[1 4 2; 5 7 3; 9 1 6; 4 2 8]

A =
     1     4     2
     5     7     3
     9     1     6
     4     2     8
```

Define a 4×3 matrix `A`.

```
>> B=[6 1; 2 5; 7 3]

B =
     6     1
     2     5
     7     3
```

Define a 3×2 matrix `B`.

```
>> C=A*B

C =
    28    27
    65    49
    98    32
    84    38
```

Multiply matrix `A` by matrix `B` and assign the result to variable `C`.

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

Trying to multiply `B` by `A`, `B*A`, gives an error since the number of columns in `B` is 2 and the number of rows in `A` is 4.

```
>> F=[1 3; 5 7]

F =
     1     3
     5     7

>> G=[4 2; 1 6]
```

Define two 2×2 matrices `F` and `G`.

Tutorial 3-1: Multiplication of arrays. (Continued)

```
G =
     4     2
     1     6
>> F*G                              Multiply F*G
ans =
     7    20
    27    52
>> G*F                              Multiply G*F
ans =
    14    26                        Note that the answer for G*F is not the
    31    45                        same as the answer for F*G.
>> AV=[2 5 1]                       Define a three-element row vector AV.
AV =
     2     5     1
>> BV=[3; 1; 4]                     Define a three-element column vector BV.
BV =
     3
     1
     4
>> AV*BV                            Multiply AV by BV. The answer is a scalar.
ans =                               (Dot product of two vectors.)
    15
>> BV*AV                            Multiply BV by AV. The
ans =                               answer is a 3×3 matrix.
     6    15     3
     2     5     1
     8    20     4
>>
```

When an array is multiplied by a number (actually a number is a 1×1 array), each element in the array is multiplied by the number. For example:

```
>> A=[2 5 7 0; 10 1 3 4; 6 2 11 5]      Define a 3×4 matrix A.
A =
     2     5     7     0
    10     1     3     4
     6     2    11     5
>> b=3                                  Assign the number 3 to the variable b.
b =
     3
```