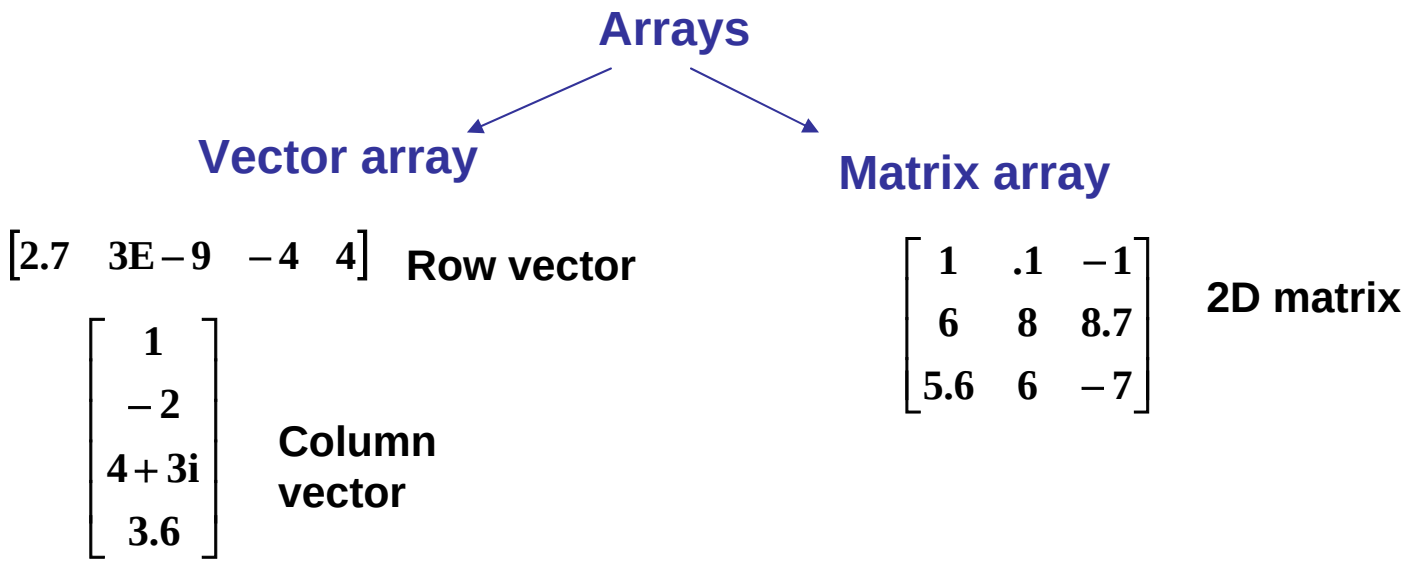
Scalars: Variables that represent single numbers, as considered to this point. Note that complex numbers are scalars, even though they have two components, the real part and the imaginary part.

Arrays: Variables that represent more than one number. Each number is called an **element** of the array. Rather than than performing the same operation on one number at a time, array operations allow operating on multiple numbers at once.

Row and Column Arrays: A row of numbers (called a row vector) or a column of numbers (called a column vector).

Two-Dimensional Arrays: A two-dimensional table of numbers, called a matrix.



Vettori

Consider computing $y = \sin(x)$ for $0 \leq x \leq \pi$. It is impossible to compute y values for all values of x, since there are an infinite number of values, so we will choose a finite number of x values. Consider computing

$$y = \sin(x), \quad \text{where } x = 0, 0.1\pi, 0.2\pi, \ldots, \pi$$

You can form a list, or **array** of the values of x, and then using a calculator you can compute the corresponding values of y, forming a second array y. These can be written down as:

x	0	0.1 π	0.2 π	0.3 π	0.4 π	0.5 π	0.6 π	0.7 π	0.8 π	0.9 π	π
y	0	.31	.59	.81	.95	1.0	.95	.81	.59	.31	0

Elements can be denoted by subscripts, e.g. x_1 is the first element in x y_5 is the fifth element in y. The subscript is the index, address, or location of the element in the array.

Creazione di vettori: lista esplicita

```
>> x=[0 .1*pi .2*pi .3*pi .4*pi .5*pi .6*pi .7*pi .8*pi .9*pi pi]
x =
  Columns 1 through 7
         0    0.3142    0.6283    0.9425    1.2566    1.5708    1.8850
  Columns 8 through 11
    2.1991    2.5133    2.8274    3.1416
```

MATLAB functions can be applied to vectors to compute a resulting vector:

```
>> y=sin(x)
y =
  Columns 1 through 7
         0    0.3090    0.5878    0.8090    0.9511    1.0000    0.9511
  Columns 8 through 11
    0.8090    0.5878    0.3090    0.0000
```

Indirizzamento di un elemento di un vettore:

A vector element is addressed in MATLAB with an integer index (also called a *subscript*) enclosed in parentheses. For example, to access the third element of x and the fifth element of y:

```
>> x(3)
ans =
    0.6283
```

```
>> y(5)
ans =
    0.9511
```

N.B.: differentemente dal linguaggio C, gli indici in Matlab cominciano da 1!

Elementi di matrici possono essere sia a sx che a ds di un assegnamento:

```
>> A = x(1)
>> y(11) = 0
```

Indirizzamento di un gruppo di elementi di un vettore:

Colon notation: Addresses a block of elements `(start:increment:end)`

- **Start: primo indice**
- **Increment: numero da aggiungere per avere l'indice successivo**
- **End: ultimo indice**

Note:

- ✓ ***start*, *increment* e *end* devono essere interi**
- ✓ ***Increment* può essere negativo**
- ✓ **gli indici devono essere positivi**
- ✓ **Se increment =1, si può omettere ed utilizzare (start:end)**

- `2:2:7` means "start with 2, count up by 2, and stop at 7."

```
>> x(2:2:7)
ans =
    0.3142    0.9425    1.5708
```

- `1:5` means "start with 1 and count up to 5."

```
>> x(1:5)
ans =
         0    0.3142    0.6283    0.9425    1.2566
```

- `3:-1:1` means "start with 3 and count down to 1."

```
>> y(3:-1:1)
ans =
    0.5878    0.3090         0
```

- `7:end` means "start with 7 and count up to the end of the vector."

```
>> x(7:end)
ans =
    1.8850    2.1991    2.5133    2.8274    3.1416
```

Creazione di vettori: altri metodi

1. Explicit list
2. Combining

- **Combining**: A vector can also be defined using another vector that has already been defined. For example:

```
>> B = [1.5, 3.1];
>> S = [3.0 B]
S =
    3.0000    1.5000    3.1000
```

3. Changing

- **Changing**: Values can be changed by referencing a specific address. For example,

```
>> S(2) = -1.0;
>> S
S =
    3.0000   -1.0000    3.1000
```

changes the second value in the vector `S` from 1.5 to −1.0.

4. Extending

- **Extending**: Additional values can be added using a reference to a specific address. For example, the following command:

```
>> S(4) = 5.5;
>> S
S =
    3.0000   -1.0000    3.1000    5.5000
```

extends the length of vector `S` from 3 to 4.

Applying the following command

```
>> S(7) = 8.5;
>> S
S =
    3.0000   -1.0000    3.1000    5.5000         0         0    8.5000
```

extends the length of `S` to 7, and the values of `S(5)` and `S(6)` are automatically set to zero because no values were given for them.

5. colon notation

```
(start:increment:end)
```

N.B:

- ✓ ***start*, *increment* e *end* possono non essere interi e possono avere sia valori positivi che negativi**

```
>> x=(0:0.1:1)*pi
x =
  Columns 1 through 7
         0    0.3142    0.6283    0.9425    1.2566    1.5708    1.8850
  Columns 8 through 11
    2.1991    2.5133    2.8274    3.1416
```

>> z = (9.9 : -1.1 : -9.9) oppure: >> z = [9.9 : -1.1 : -9.9]

6. linspace function

- `linspace`: This function generates a vector of uniformly incremented values, but instead of specifying the increment, the number of values desired is specified. This function has the form:

  ```
  linspace(start,end,number)
  ```

  The increment is computed internally, having the value:

$$\texttt{increment} = \frac{\texttt{end} - \texttt{start}}{\texttt{number} - 1}$$

```
>> x=linspace(0,pi,11)
x =
  Columns 1 through 7
         0    0.3142    0.6283    0.9425    1.2566    1.5708    1.8850
  Columns 8 through 11
    2.1991    2.5133    2.8274    3.1416
```

In this example:

$$\texttt{increment} = \frac{\pi}{11 - 1} = 0.1\pi$$

Vettori colonna:

1. lista esplicita

A column vector, having one column and multiple rows, can be created by specifying it element by element, separating element values with semicolons:

```
>> c = [1;2;3;4;5]
c =
     1
     2
     3
     4
     5
```

oppure:

```
>> C1 = [1
2
3
4
5]
```

2. Trasposta di vettore riga

The **transpose** operator (') is used to transpose a row vector into a column vector

```
>> a = 1:5
a =
     1     2     3     4     5
>> b = a'
b =
     1
     2
     3
     4
     5
```

Nota: **l'operatore trasposta in un vettore di numeri complessi, genera un vettore trasposto, con i valori coniugati:**

```
>> a = [1+j 2-3j -3+4j]
a =
   1.0000+ 1.0000i   2.0000- 3.0000i  -3.0000+ 4.0000i
>> b = a'
b =
   1.0000- 1.0000i
   2.0000+ 3.0000i
  -3.0000- 4.0000i
```

per non eseguire la coniugazione, occorre anteporre . prima dell'operatore ':

```
>> c = a.'
c =
   1.0000+ 1.0000i
   2.0000- 3.0000i
  -3.0000+ 4.0000i
```

Matrici

- Begin with [, end with]
- Spaces or commas are used to separate elements in a row.
- A semicolon or Enter is used to separate rows.

>> A = [1 2 3; 4 5 6 ; 7 8 9] oppure: >> A = [1,2,3; 4,5,6; 7,8,9]

oppure: >> A = [1 2 3
4 5 6
7 8 9]

Indirizzamento elementi di matrice:

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

```
>> c1 = C(2,3)
```

La variabile c1 ha il valore dell'elemento riga 2, colonna 3 di C

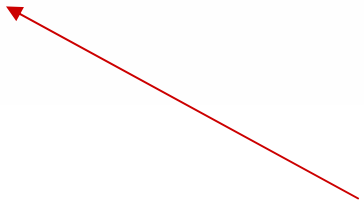
Creazione sotto_matrici

```
>>  D= [1 2 3; 4 5 6; 7 8 9; 10 11 12]
>> D_1 = D(:,2);     % vettore colonna
>> D_2 = D(:,2:3);  % matrice 4x2
>> D_3 = D(1:2,2:end)  % matrice 2x3
```

Operazioni su matrici elemento-per-elemento:

When two arrays have the same dimensions, addition, subtraction, multiplication, and division apply on an element-by-element basis. The notation for some operations is somewhat unconventional.

Operation	Algebraic Form	MATLAB
Addition	$a + b$	`a + b`
Subtraction	$a - b$	`a - b`
Multiplication	$a \times b$	`a.*b`
Division	$a \div b$	`a./b`
Exponentiation	a^b	`a.^b`



Per ottenere prodotto, divisione, elevamento di potenza, elemento-per-elemento di vettori e/o matrici, è necessario aggiungere il . prima dell'operatore (*,/,^)