

## Intro to MATLAB

MATLAB is a programming language and a computing environment. MATLAB is short for **Matrix Laboratory** and is especially useful for vector and matrix computations. Octave Online uses the MATLAB language in a web-based environment. We'll look at some basic MATLAB commands and practice them in Octave Online.

Octave Online can be found at:

<https://octave-online.net>

Example 1: Creating a row vector.

This command creates a row vector. The semicolon suppresses any output.

```
>> v = [1 2 3];
```

To view any object type its name:

```
>> v
```

We could have typed the following to create and view the row vector.

```
>> v = [1 2 3]
```

Example 2: Creating a column vector.

```
>> u = [1; 2; 3]
```

Example 3: Calculating the length of a vector.

```
>> a = [1 2 3];
```

```
>> norm(a)
```

```
ans = 3.7417
```

Example 4: Calculating the dot product.

```
>> a = [1 2 3];
```

```
>> b = [3 2 1];
```

```
>> dot(a,b)
```

```
ans = 10
```

Example 5: The arccosine function.

```
>> acos(0.5)
ans = 1.0472
>> acosd(0.5)
ans = 60
```

Notice that the command `acos(0.5)` returns the angle in radians whereas `acosd(0.5)` returns the angle in degrees.

Example 6: Multiplying, Exponentiating and Dividing Real Numbers.

```
>> 237 * 143
ans = 33891
>> 123 ^ 2
ans = 15129
>> 237/143
ans = 1.6573
```

Example 7: Handling Fractions and Decimal Places.

**format rat** gives output as simplified fractions.

**format short** gives output to a few significant figures (typically five).

**format long** gives output to many significant figures (typically 16).

```
>> format rat
>> 65536/24
ans = 8192/3
```

```
>> format short
>> 65536/24
ans = 2730.7
```

```
>> 3456 * 5678
ans = 1.9623e+07
Meaning  $1.9623 \times 10^7$ 
```

```
>> format long
>> 65536/24
ans = 2730.666666666667
```

Example 8: Let's put together some of the previous concepts. Calculate the angle between  $\mathbf{u} = [9, 8, 7]$  and  $\mathbf{v} = [1, -3, 4]$ . Give your answer in radians.

Recall that the formula for the angle is  $\theta = \arccos\left(\frac{\mathbf{u} \cdot \mathbf{v}}{\|\mathbf{u}\| \|\mathbf{v}\|}\right)$ .

```
>> format short
>> u = [9 8 7];
>> v = [1 -3 4];
>> acos( dot(u,v) / ( norm(u) * norm(v) ) )
ans = 1.3867
```

Example 9: Calculating the cross product.

```
>> a = [1 2 3];
>> b = [3 2 1];
>> cross(a,b)
ans = -4 8 -4
```

Meaning the cross product is the vector  $[-4, 8, -4]$ .

Example 10: Creating a matrix.

We use semicolons to end each row, except the last row.

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

To suppress the output we would type:

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

Example 11: Matrix Operations.

Suppose we have the following two matrices:

```
>> A = [3 9; 1 6];
```

```
>> B = [8 2; -1 5];
```

Let's compute:  $2A$ ,  $\frac{1}{3}A$ ,  $A + B$ ,  $A - B$ ,  $AB$ ,  $A^2$ ,  $A^T$ .

Note that the command for  $A^T$  is  $A'$ .

```
>> 2*A
```

```
>> A/3
```

```
>> A+B
```

```
>> A-B
```

```
>> A*B
```

```
>> A ^ 2
```

```
>> A'
```

Example 12: Vector operations.

Vector operations are special cases of matrix operations.

Suppose we have the following vectors:

```
>> u = [7 8 9];
```

```
>> v = [3 -4 5];
```

Let's compute  $2\mathbf{u}$ ,  $\frac{1}{3}\mathbf{u}$ ,  $\mathbf{u} + \mathbf{v}$ ,  $\mathbf{u} - \mathbf{v}$ ,  $\mathbf{u}^T$ .

```
>> 2*u
```

```
>> u/3
```

```
>> u+v
```

```
>> u-v
```

```
>> u'
```

Example 13: Consider the plane passing through  $A = (2, 1, 0)$ ,  $B = (1, 2, 3)$ , and  $C = (4, 5, 6)$ . Find a normal vector to the plane.

Recall that  $\mathbf{n} = \vec{AB} \times \vec{AC}$ .

```
>> a = [2 1 0];
```

```
>> b = [1 2 3];
```

```
>> c = [4 5 6];
```

```
>> ab = b-a;
```

```
>> ac = c-a;
```

```
>> cross(ab, ac)
```

```
ans = -6 12 -6
```

Meaning a normal vector is  $[-6, 12, -6]$ .

Example 14: Calculating determinants.

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

```
>> det(A)
```

```
ans = -147
```

Example 15: Calculating the inverse of  $A$  (provided  $\det A \neq 0$ ).

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

```
>> inv(A)
```

Example 16: Solve the following system using  $A^{-1}$ .

$$\begin{aligned}9x + 2y &= 48 \\3x - 8y &= -36\end{aligned}$$

We'll use the formula  $\mathbf{x} = A^{-1}\mathbf{b}$ .

```
>> A= [9 2; 3 -8];  
>> b = [48; -36];  
>> inv(A)*b
```

The output is:

4

6

Meaning the solution is  $x = 4, y = 6$ .

Example 17: RREF of a Matrix.

```
>> A= [1 2 3; 3 2 1; 1 1 1];  
>> rref(A)
```

Example 18: Solve the system by finding the RREF:

$$\begin{aligned}9x + 2y &= 48 \\3x - 8y &= -36\end{aligned}$$

We build an augmented matrix with the constants in the last column.

```
>> A= [9 2 48; 3 -8 -36];  
>> rref(A)
```

The output is the following augmented matrix. Note that MATLAB does not draw the vertical bar before the last column.

1 0 4

0 1 6

Meaning the solution is  $x = 4, y = 6$ .

Example 19: Solve the system by finding the RREF:

$$\begin{aligned}3x + 6y &= 24 \\2x + 7y &= 25 \\4x + y &= 26\end{aligned}$$

We build an augmented matrix with the constants in the last column.

```
>> A = [3 6 24; 2 7 25; 4 1 26];
```

```
>> rref(A)
```

The output is the following augmented matrix. Note that MATLAB does not draw the vertical bar before the last column.

```
1 0 0
```

```
0 1 0
```

```
0 0 1
```

The last equation reads  $0x + 0y = 1$ .

The system has no solution.

Example 20: The concept of elementwise operations is important in computer science. Let's build a matrix  $A$  and observe the difference between  $A \wedge 2$  (usual square of a matrix) and  $A . \wedge 2$  (which squares each entry of  $A$ ).

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

```
>> A \wedge 2
```

```
>> A . \wedge 2
```