
1 Octave for Chapter 1

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The templates in this section provide sample Octave code for vector operations. You can access our code through the link at the bottom of each template. Feel free to modify the code and experiment to learn more!

You can write your own code using Octave software or online Octave cells. To access Octave cells online, go to the [Sage Math Cell Webpage](#), select OCTAVE as the language, enter your code, and press EVALUATE.

To "save" or share your online code, click on the *Share* button, select *Permalink*, then copy the address directly from the browser window. You can store this link to access your work later or share this link with others. You will need to get a new Permalink every time you modify the code.

Octave Tutorial

Basic Operations

Template 1. Here are some basic vector operations.

```
% Define vectors v and w
v=[3;1;1;2;4];
w=[-2;1;0;3;-1];

% Find v+w
sum=v+w

% Find 5v
five_v=5*v

% Find the dot product of v and w
dot_v_w=dot(v,w)

% Find the length of v
length_v=norm(v)
```

[Link to code.](#)

Remark 1. • In Octave, we use % to add comments to our code. Octave does not execute anything that appears after % on the same line. It is always a good idea to make notes about your code for yourself and others.

- Note that lines 2 and 3 of our code have a semi-column at the end while lines 6, 9, 12, and 15 do not. Remove the semi-column from lines 2 and 3, add semi-columns to the other lines. Run the code. What happens?

Template 2. We can find the cross-product of two vectors in $\mathbb{R}^3$ as follows.

```
% Define vectors v and w
v=[3;1;1];
w=[-2;1;0];

% Find the cross product v x w
cross_v_w=cross(v,w)
```

[Link to code.](#)

Example 1. Find the angle between vectors $\mathbf{v} = \begin{bmatrix} 3 \\ 1 \\ 1 \\ 2 \\ 4 \end{bmatrix}$ and $\mathbf{w} = \begin{bmatrix} -2 \\ 1 \\ 0 \\ 3 \\ -1 \end{bmatrix}$.

Explanation. % Define vectors v and w

```
v=[3;1;1;2;4];
w=[-2;1;0;3;-1];

% Find the angle between v and w in radians and degrees.
% To do so, use the arccosine function acos()
angle_radians = acos(dot(v,w)/(norm(v)*norm(w)))
angle_degrees = rad2deg(angle_radians)
```

[Link to code.](#)

Sometimes it is useful to reference a single component of a vector.

Example 2. Given vector $\mathbf{v} = \begin{bmatrix} 1 \\ -2 \\ -5 \end{bmatrix}$, find the third component of $\mathbf{v}$.

Explanation. % Define vector v

```
v=[1;-2;-5];
```

```
% Find the third component of v
z=v(3)
```

[Link to code.](#)

Loops

In this section we will introduce one of the most fundamental concepts in programming, a *loop*. Loops are used to repeat a procedure multiple times. We will start with a simple *for* loop. Every time you perform the steps inside the loop, you come back to the beginning, and increase the index i by 1 until you reach the desired number of iterations.

Example 3. Here is an example of a loop. Try to guess the outcome of the loop, then run the code to verify your guess.

```
% Enter the starting value
n=10;

% At every iteration, n gets replaced with n+1
for i=1:10
    n=n+1
end
```

[Link to code.](#)

Example 4. Here is another loop. Try to guess the outcome of the loop, then run the code to verify your guess.

```
% Enter the first component of vector v
v(1)=1;

% Enter the second component of vector v
v(2)=1;

% we continue to assign values to vector components
for i=1:10
    v(i+2)=v(i)+v(i+1);
end
v
```

[Link to code.](#)

Do you recognize this famous sequence?

Octave Exercises

Problem 1 Use Octave to find the angle (in degrees and radians) between vectors

$$\mathbf{v} = \begin{bmatrix} 2 \\ -4 \\ 10 \\ -25 \end{bmatrix}, \quad \mathbf{w} = \begin{bmatrix} 5 \\ 3 \\ -20 \\ 11 \end{bmatrix}$$

Problem 2 Write Octave code to show that the points $A(1, -2, 3, 5)$, $B(-2, 0, 1, 1)$, $C(2, 4, -3, 2)$ are the vertices of a right triangle in $\mathbb{R}^4$.

Problem 3 Use vectors $\mathbf{v}$ and $\mathbf{w}$ from Template ?? to illustrate that the cross product of two vectors is orthogonal to both vectors. Pick another pair of vectors $\mathbf{v}$ and $\mathbf{w}$ and repeat the demonstration.

Problem 4 Write an Octave routine that allows the user to input three points and returns a normal vector to the plane containing these points. Your code might start as follows:

```

% Enter coordinates of point A
A=[1; 4; 6];

% Enter coordinates of point B
B=[-2; 3; 7]

% Enter coordinates of point C
C=[1; -2; 4]

% Normal vector to the plane containing A, B, C is given by

```

What type of user inputs (other than all zeros) would result in the computed normal vector of $\mathbf{n} = \mathbf{0}$? Explain this phenomenon geometrically.

Use your code to find an equation of a plane containing points $(-2, 4, 0)$, $(-1, 8, 1)$, $(3, -1, 2)$.

Problem 5 In this problem you will use the following definition of the dot product.

Definition 1. (??) Let $\mathbf{u}$ and $\mathbf{v}$ be vectors in $\mathbb{R}^n$. The dot product of $\mathbf{u}$ and $\mathbf{v}$, denoted by $\mathbf{u} \cdot \mathbf{v}$, is given by

$$\mathbf{u} \cdot \mathbf{v} = \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_n \end{bmatrix} \cdot \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix} = u_1 v_1 + u_2 v_2 + \dots + u_n v_n.$$

Question 5.1 Due to a false fire alarm, a programmer left line 10 of the following code unfinished. Finish the code so that it computes the dot product (dp) of two vectors. Note that this code uses Definition ?? directly, instead of relying on the built-in dot function.

```

% Define vectors v and w
v=[3; 6; -1; 7; 12];
w=[-2; 4; -3; 5; 11];

% Initialize the dot product (dp)
dp=0;

% Find the dot product v*w directly from the definition
for i=1:5
    dp=dp+;
end

% Print your answer
dp

% Check your answer
correct_answer=dot(v,w)

```

[Link to code.](#)

Why did we have to initialize dp? What would happen if we didn't?