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## 8. Adding vectors

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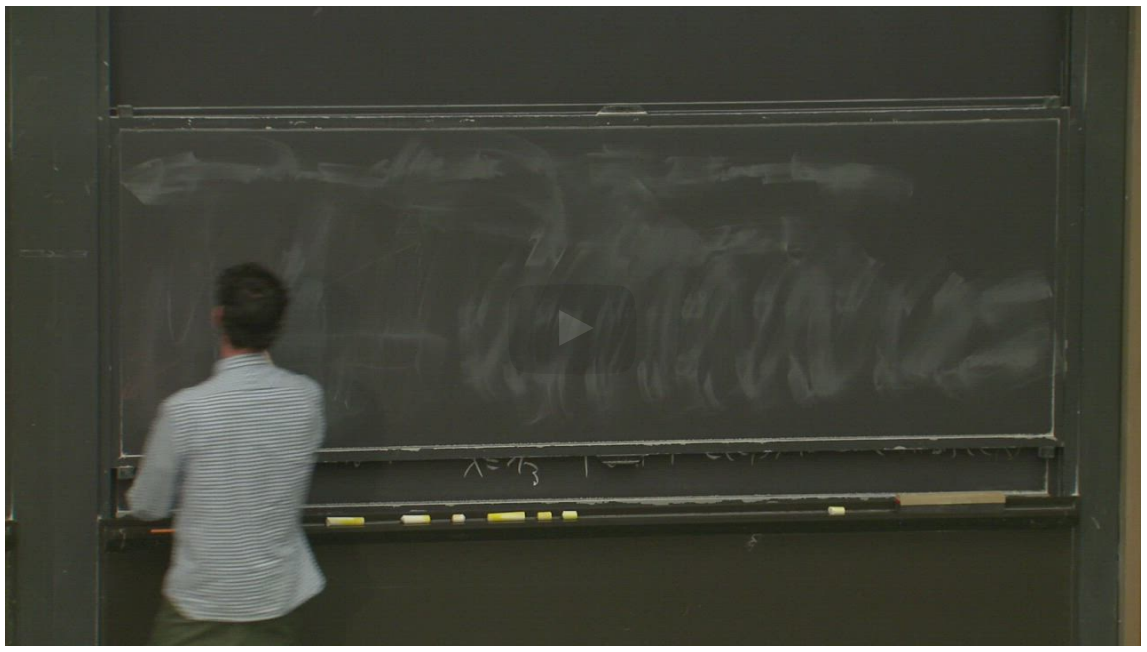
**Practice**

## Adding two vectors together



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Start of transcript. Skip to the end.

PROFESSOR: OK, so geometrically adding vectors

means the following thing.

So suppose I have a vector v, and then I have a vector w.

And I want to add them.

The first thing I do is I take w,

and I make a copy of w that starts at the end of v.

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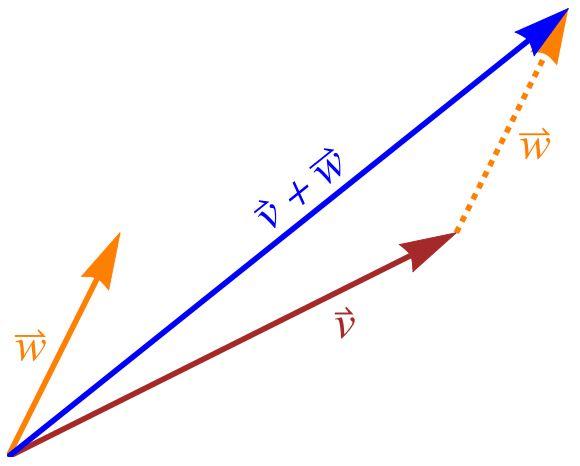
Geometrically, we can add two vectors $\vec{v}$ and $\vec{w}$ by making a copy of one vector and putting it at the end of the other as in the figure below.




The sum of the two vectors is the vector that starts at the tail of $\vec{v}$ and ends at the tip of the copy of $\vec{w}$.

By considering the components of these vectors, we can see how this picture corresponds to a computation.

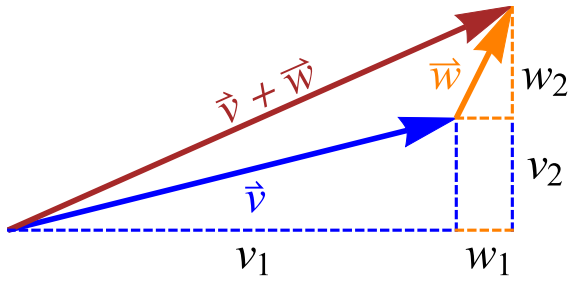



**Figure 14**: $\vec{v}+\vec{w}=(v_1+w_1, v_2+w_2)$

We can add two vectors by adding each of their components. For example, the vectors $\vec{v}=\langle v_1, v_2\rangle$ and $\vec{w}=\langle w_1, w_2\rangle$ add up to

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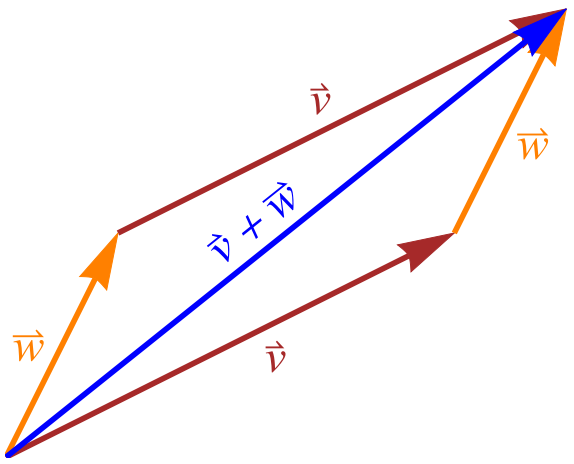
$$\vec{v} + \vec{w} = \langle v_1, v_2 \rangle + \langle w_1, w_2 \rangle = \langle v_1 + w_1, v_2 + w_2 \rangle.$$

**Example 8.1** Let $\vec{v} = \langle 3, -1 \rangle$ and $\vec{w} = \langle 0, 2 \rangle$. Then

$$\vec{v} + \vec{w} = \langle 3, -1 \rangle + \langle 0, 2 \rangle = \langle 3 + 0, -1 + 2 \rangle = \langle 3, 1 \rangle.$$

Note that vector addition is **commutative**. In other words, $\vec{v} + \vec{w} = \vec{w} + \vec{v}$. We can see a geometric proof of this by making a copy of the vectors $\vec{v}$ and $\vec{w}$ and placing them opposite each other to form a parallelogram. The sum $\vec{v} + \vec{w}$ forms the diagonal of this parallelogram and is equal to the sum $\vec{w} + \vec{v}$.




Subtracting two vectors with the same number of components can be done by subtracting each of their components. For example, the vectors $\vec{v} = \langle v_1, v_2 \rangle$ and $\vec{w} = \langle w_1, w_2 \rangle$ can be subtracted to yield

$$\vec{v} - \vec{w} = \langle v_1, v_2 \rangle - \langle w_1, w_2 \rangle = \langle v_1 - w_1, v_2 - w_2 \rangle.$$

Another way to think of vector subtraction is as vector addition after multiplication by the scalar $-1$. For example, given the vectors $\vec{v} = \langle v_1, v_2 \rangle$ and $\vec{w} = \langle w_1, w_2 \rangle$ we can write

$$\vec{v} - \vec{w} = \langle v_1, v_2 \rangle + (-1)\langle w_1, w_2 \rangle = \langle v_1, v_2 \rangle + \langle -w_1, -w_2 \rangle = \langle v_1 - w_1, v_2 - w_2 \rangle.$$

Adding and subtracting vectors comes up a lot in physics. For example, when you draw the forces acting on a block sitting on an inclined surface, you have gravity and the normal force. It turns out that these forces are vectors and adding them is done in the process we just described.

**Spoiler: Vector addition in higher dimensions**

Consider two vectors with $n$ components each given by $\vec{v} = \langle v_1, v_2, \ldots, v_n \rangle$ and $\vec{w} = \langle w_1, w_2, \ldots, w_n \rangle$. Then the sum $\vec{v} + \vec{w}$ is given by

$$\vec{v} + \vec{w} = \langle v_1, v_2, \cdots, v_n \rangle + \langle w_1, w_2, \cdots, w_n \rangle = \langle v_1 + w_1, v_2 + w_2, \cdots, v_n + w_n \rangle.$$

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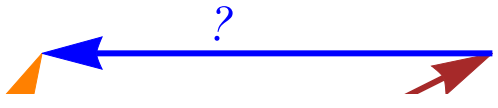
## Identify the operation on vectors

1/1 point (graded)

Consider the figure below.

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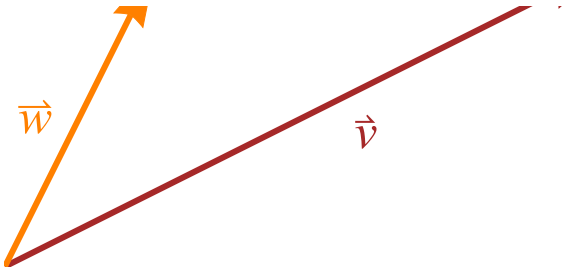


Which of the following operations describes the unknown (blue) vector?

(Choose one of the following.)

- ○ $\vec{v} - \vec{w}$
- ◉ $\vec{w} - \vec{v}$
- ○ $\vec{v} + \vec{w}$

✔

**Solution:**

Note that the unknown vector added to vector $\vec{v}$ is equal to the vector $\vec{w}$. Subtracting $\vec{v}$ from both sides we see that the unknown vector must be $\vec{w} - \vec{v}$.

Submit You have used 1 of 1 attempt

ℹ Answers are displayed within the problem

## Vector operations and graders

0 points possible (ungraded)
This problem is to help familiarize yourself with entering vectors or their scalar multiples into an automatically graded problem. It is ungraded.

In each of the following problems, perform the indicated operation using the values given.

(Enter your answer as a vector with two components inside square brackets, e.g., [1,1]. Note that the grader understands vector sums, e.g. type [1,1]+[1,1] for the vector [2,2]. Try entering the answer in multiple correct formats! Extra credit: Try using vector sums and scalar multiplication in your answer!)

| | | | |
|---|---|---|---|
| $\vec{v} = \langle -10, 7 \rangle, \vec{w} = \langle 6, -10 \rangle,$ | $\vec{v} + \vec{w} =$ | [-4,-3] | ✔ **Answer:** [-4,-3] |
| $\vec{v} = \langle -6, 3 \rangle, \vec{w} = \langle -13, -5 \rangle,$ | $\vec{w} - \vec{v} =$ | [-7,-8] | ✔ **Answer:** [-7,-8] |
| $\vec{u} = \langle -3, 8 \rangle, \vec{w} = \langle 3, 3 \rangle,$ | $\vec{u} + \vec{w} =$ | [0,11] | ✔ **Answer:** [0,11] |

**Solution:**

In order of the problems given, we have

$$\begin{aligned}\vec{v} + \vec{w} &= \langle -10, 7 \rangle + \langle 6, -10 \rangle = \langle -10 + 6, 7 - 10 \rangle = \langle -4, -3 \rangle \\ \vec{w} - \vec{v} &= \langle -13, -5 \rangle - \langle -6, 3 \rangle = \langle -13 - (-6), -5 - 3 \rangle = \langle -7, -8 \rangle, \\ \vec{u} + \vec{w} &= \langle -3, 8 \rangle + \langle 3, 3 \rangle = \langle -3 + 3, 8 + 3 \rangle = \langle 0, 11 \rangle.\end{aligned}$$

Submit You have used 1 of 25 attempts

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Answers are displayed within the problem

## 8. Adding vectors

**Topic:** Unit 2: Geometry of Derivatives / 8. Adding vectors

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|---|---|---|
| Thanks for the grader practice! | The ungraded practice with the grader is a nice bonus. Testing can be stressful. This takes the pressure off a bit so I can focus on s... | 2 |
| size contrasted with length | "Subtracting two vectors of the same size" do you mean the same number of elements? I do not think you defined "size" yet and aft... | 3 |
| Typo in Example 8.1? v incorrect? | NM | 2 |

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