

# Lesson 13: Vectors in One Dimension

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Up to this point we have been focusing on the number crunching sort of questions you can do in physics.

- In this chapter the focus will start to be shifted toward more complicated problems that might not always be solved by just “plugging numbers into a formula.”
- For this reason, we will start to use **vector diagrams** as a way to organize our information and to help us solve our problems.
- As we start to use these diagrams, keep in mind that we are drawing diagrams that truly represent the motion of the object.

As we learned back in **Lesson 8**, just about anything you measure in Physics can be divided into two categories: **scalars** and **vectors**.

**Scalars:** Any measurement that is given as a single number, and nothing else. It has **magnitude**, but no direction.

**Vectors:** A measurement that is given as a number and a direction. It has **magnitude** and **direction**.

We often use arrows to represent vectors. In fact, for the rest of the course you should see them as being interchangeable; an arrow in a diagram is a vector.

- When you have several of these vectors drawn together, you have a vector diagram.
- Although vector diagrams are drawn for different reasons in different kinds of problems, the rules that govern how they are drawn are always the same.

## Vector Drawing Rules

1. **The vector is drawn pointing in the direction of the vector.** This is probably the key feature of what makes a vector a vector... *direction*. If an object is moving East, you better make sure that the arrow points East. Always remember that when a direction is written down with the magnitude of a measurement, the direction should appear in square brackets.
2. **The length of a vector is proportional to the magnitude of the measurement.** This just means that the bigger your measurement, the bigger your vector. If I wanted to show you a vector for a car moving at 10km/h [East], and another one moving at 20km/h [East], the second vector would be twice as big.
3. A vector can be picked up and moved around in a vector diagram, as long as when you place it in its new location it is still **the same size and pointing in the same direction**.

If you are extremely careful, you can even use the rules to draw all your vector diagrams to scale and solve them by measuring stuff without using physics formulas.

- I would caution you that calculations will usually give you more accurate answers than a diagram.

## Adding Vectors In One Dimension

One dimensional vector diagrams are the easiest ones to solve.

- The only thing you have to really watch out for is how you touch the vectors to each other in the diagram.

- To add vectors, the vectors must touch with the head of one (the pointy tip) touching the tail (nothing there) of the next vector.

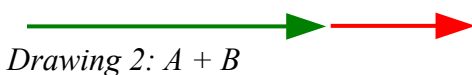
**Example 1:** Sketch a diagram that shows how you would add the following two vectors, **A** and **B**.



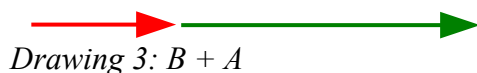
*Drawing 1: The original vectors A and B*

In the text book they call vectors that point in the same direction (like these two) **collinear**.

Right now **A** and **B** are not touching head-to-tail, so we will have to rearrange them. Keep in mind that I can pick up and move around the vectors as long as I make sure that when they are plunked back down they are still pointing the same direction and the same size.



Drawing 2 shows **A + B**. Notice how the vectors individually are still exactly the same, but they have been rearranged so that **A** is first and then touches **B** head-to-tail. If I wanted to draw **B + A** instead, it would look like Drawing 3.



You'll notice that it doesn't matter in what order I add the two vectors. **A + B = B + A**.

The idea that I get the same result when I add the vectors shown above is a very important one in Physics.

- It would be like if I told you that I was planning to walk 4 km East, and then another 6 km East. It would give me the same result (10 km East) as I would get by first walking 6 km and then 4 km.
- Since the end result is 10 km East, I would say my **resultant** is 10 km [E].
- A **resultant** is the sum total of two or more vectors added. It shows you what you would get as an end result of the other vectors put together.

**Example 2:** Sketch the resultant of the addition of the two vectors in Example 1.

Since we already figured out that **A + B = B + A** we can draw the resultant for either combination and get the same thing. We'll just go ahead and draw it for **A + B**.



The resultant is just another vector drawn as an arrow. The difference is that the **resultant** touches **tail-to-tail** and **head-to-head**. This is because the resultant has to start at the beginning (the tail of **A**) and finish at the end (the head of **B**). That's the only way for the resultant to show that it has the same overall result as the two original vectors.

There is an “old-school” way to remember what's happening with these vectors. It involves going back to my younger years playing the video game Pac Man.

- Let's assume that the original vectors **A** and **B** are showing where Pac Man was moving. Starting at the tail of **A**, Pac Man moves to the right. Then he continues along **B** a little more to the right.
- Overall, Pac Man has moved to the right a whole bunch... that's what the resultant shows us. Pac Man can follow the two individual vectors **A** and **B** to get from the beginning to the end, or he can just follow the one resultant and end up in the same place from the same beginning.

## Subtracting Vectors in One Dimension

This is where things get a bit more interesting.

- What we need to remember here is that in Physics a *negative* sign simply means “*in the opposite direction.*”
- We can take **A - B** and simply change it into **A + -B**.
  - The negative sign on the **B** just means that we will need to take the original vector **B** and point it in exactly the opposite direction (180° from where it's pointing right now.
  - Then we will simply add them just like we did in the previous diagrams (touching head-to-tail of course!) to get our resultant.
- The reason you may have to do subtraction of vectors is because some physics formulas require you to subtract vectors. For example,  $\Delta v = v_f - v_i$ .

**Example 3:** Sketch a vector diagram of **A - B**.

The most important thing to remember is that **A - B** is equal to **A + -B**. So, all we need to do is take the original vector for B and spin it around so it points in the opposite direction.



*Drawing 5: Vectors A and -B.*

Now we just add them head-to-tail and draw in our resultant.



*Drawing 6: The resultant of A + -B.*

Using the Pac Man analogy, You can see that if Pac Man moved to the right a lot (**A**), and then moved back the left a bit (**B**), then it would be the same if he'd moved to the right just a bit (**resultant**).

Be careful since subtraction is *not* commutative (that just means that  $A - B \neq B - A$ ).