How do vectors help us understand motion? It’s all about the DIFFERENCE ($\Delta$) vector

As we’ve seen, to use math to fully describe the position of an object, we must use a vector, because it tells us both the magnitude (distance) and direction of that position (measuring from agreed-upon zero points for both distance and angle). Without both pieces of information, we have just a number—a scalar—not sufficient to fully describe an object’s position.

Scalar vs. Vector

<table>
<thead>
<tr>
<th>Scalar</th>
<th>Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>(magnitude only)</td>
<td>(magnitude and direction)</td>
</tr>
<tr>
<td>Distance ($d$)</td>
<td>Position ($x$)</td>
</tr>
</tbody>
</table>

But motion is about change (the change of position, first and foremost).

**Question:** If an object starts at an initial position (call it $\text{position}_i$), then it moves to a final position (for $\text{position}_f$), how do we measure its change of position, $\Delta \text{position}$?

Well, start with something simpler—a non-vector situation. How would you measure the change in an simple (scalar) quantity? Suppose you start the day with a certain amount of money in your pocket, say, $23.00 (call this $\text{cash}_i$). Then at the end of the day, you have a different amount, say, $39.00 (call this $\text{cash}_f$). What was the change in your pocket money ($\Delta \text{cash}$)—and how do you calculate it?

You simply subtract: $\text{cash}_f - \text{cash}_i = \Delta \text{cash} \quad \text{In other words:} \quad \Delta \text{cash} = \text{cash}_f - \text{cash}_i$

Rearrange this (still saying the same thing): $\text{cash}_i + \Delta \text{cash} = \text{cash}_f \quad \text{In other words:} \quad \text{cash}_i + \Delta \text{cash} = \text{cash}_f$

What you start with, plus whatever change that happened, must result in what you end up with. Common sense, right?

*It's the same for vectors (such as position):* $\text{position}_i + \Delta \text{position} = \text{position}_f$

But we must keep in mind what it means to do vector addition: This is how we represent $\text{position}_i + \Delta \text{position} = \text{position}_f$: 

![Diagram](image-url)
This is the key to understanding all motion in Newtonian physics—that change ($\Delta$) vector.

In the **special case** where the motion is all along one line (an $x$-axis, for example), the diagram simplifies.

In this special case, there’s no need for any trig to figure things out—just add the magnitudes, using a simple $\pm$ sign to indicate direction.

Above, all three vectors would have $+$ signs associated with them, since they’re all pointing in the $+x$ direction. Not true below:

**Important note:** This is the only circumstance when we can do this simple addition of the vector magnitudes, together with their signs—when all three of the vectors (*initial*, *final* and $\Delta$) are **collinear** along the axis! That means you can do this only when combining $x$-axis vectors; or $y$-axis vectors.

But that’s the key to adding vectors in general. You can simply sum (using the above easy technique) the $x$-vectors (to get a resultant $x$-vector) and $y$-vectors (to get a resultant $y$-vector); then you build the final result from those two resultant vector components (see again part E of the Math Review if this technique is still hazy for you).

This is true for all vector summing—including the “sum that shows the change:” $\text{vector}_i + \Delta \text{vector} = \text{vector}_f$.

Representing vector quantities as free-floating arrows is one very good form of visual representation (the “$V$” in ODAVEST), but there are others that are also very useful for representing motion: **Motion Diagrams** and **Time Graphs**.

1. Read Sections 1.5-1.8 in the textbook.

2. Try Conceptual Questions 5 and 7 (page 28).