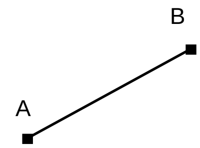
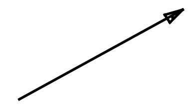
PhyzGuide: Vectors and Scalars

THE LADDER AND THE CARRIER

We will be measuring and manipulating many physical quantities throughout the year (e.g. velocity, force, temperature, electric charge, etc.). But before we get into the swing of things, we need to know some basic facts about physical quantities in general.

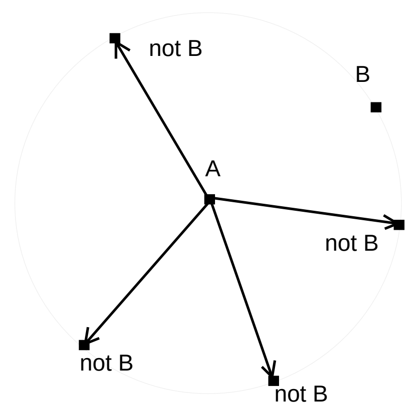


Physical quantities come in two flavors: **vectors** and **scalars.**



displacement vector: **s**

Many quantities cannot be adequately described in terms of a number alone. Consider displacement: If you were standing on a spot labeled **A** and walked 100m away from **A** to a spot labeled **B** (as shown to the right), it would *not* be adequate to describe your displacement as simply 100m. Why? Because not only did you move 100m, but you moved 100m in one specific *direction***.** If you wanted someone else standing on **A** to end up at **B**, would you tell him or her to simply walk 100m? I didn't think so. No, you'd have to tell the person exactly what direction to walk in. So displacement is a quantity that must be described in terms of *magnitude* (distance in this case) and *direction.*



Walking 100m from A in any direction will not lead you to B

Quantities that involve both magnitude and direction are called **vectors** (from Latin *vehere* meaning "to carry," implying displacement).

Scalars, on the other hand, are just numbers—no directional sense. A quantity that can be completely described in terms of a number (magnitude) is a **scalar** (from the Latin *scala* meaning "ladder," implying magnitude). Like someone on a ladder, a scalar quantity can go up or down—that is, get larger or smaller. Mass (not weight) has no directional sense: if your mass is 60kg, the quantity 60kg completely describes your mass.

Keep in mind that when they are used to measure physical quantities, vectors and scalars ***DO HAVE UNITS!!!***

VECTORS (magnitude & direction) *		**SCALARS (magnitude only)**	
displacement	velocity	distance	speed
momentum	torque	energy	rotational inertia
electric field	acceleration	electric charge	time
force		temperature	

*The magnitude part of a vector is often considered by itself: for example, we often think of "speed" as the magnitude of a velocity vector. (In a strict sense, this is not entirely true.) Speed considered by itself is a scalar. Distance is often considered the scalar part of a displacement vector.

PhyzGuide: Scalar Multiplication

Fun with vector math!

HOW MANY "DARYS" ARE THERE IN A QUANDARY?

So far, we have talked about vectors using the displacement vector as our example. It is fairly easy to convince ourselves of the directional nature of displacement, but what about that list of vectors we saw? How do we go about convincing ourselves that force can be treated as a vector and that we can use our knowledge of vectors to gain insight into the properties of force?

How 'bout we just play along and accept that force is a vector. If the book says it is, it *must* be. Besides, Mr. Baird wouldn't lead us down the wrong path. Yeah, let's just *accept* it. It's not like it's a big deal or anything.

Just writing that makes me want to **vomit!** Yet, I know that there are those among us who do think that way. You've been so conditioned that you'll accept what anyone says if it will improve the old GPA. It's time to derail that train of non-thought.

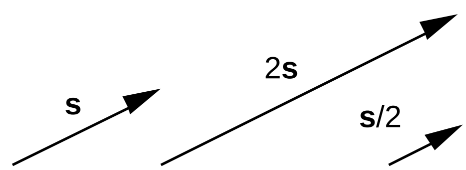
True, the future of society does not hinge on whether or not force is a vector. But the future of society *does* depend on your willingness to inquire. You can question contentions, or you can believe anything anyone ever tells you. You decide.

Getting back to the question of force, we run into a quandary: In order to be a vector, a quantity must comply with a lengthy list of vector properties. Yet the advantage of treating force as a vector was that we could assume that force, as a vector, had all the properties of a vector. *It's a catch-22.*

Fortunately, there *is* a way out.

Mathematicians have found some rules that can be used to find out if a quantity is a vector, without having to verify that it behaves in every way like a displacement vector.

Perhaps the most helpful rule is the "scalar multiplication rule." It works like this: Suppose you have a displacement vector **s**. What would you get if you doubled that vector? A vector with the same direction but twice the magnitude. (Remember "scalar" refers to magnitude only: multiplying a vector by a scalar does nothing to direction.)



SCALAR MULTIPLICATION
a vector multiplied (or divided) by a scalar results in a vector.

The result of multiplying (or dividing) a vector by a scalar is a vector. Scalar multiplication is the key to convincing ourselves that force belongs on a list of vectors.

First, is velocity a vector? By definition velocity is displacement divided by time. Displacement is a vector. Time is a scalar. So velocity is a vector divided by a scalar! Velocity is a vector.

The same process can be used to show that acceleration is a vector. (Acceleration is change in velocity divided by an interval of time.)

One of the rules of the universe relates acceleration to force and mass. Force is the product of mass and acceleration. Mass is a scalar. Acceleration is a vector. Force is a vector multiplied by a scalar. Force **is** a vector, and is entitled to all the rights and privileges that implies!

EXAMPLES of scalar multiplication: Given a displacement vector **s** = (3.0m, –12m)

2**s**= (2·3.0m, 2(–12m))
= (6.0m, –24.0m)

s/2= (1.5m, –6.0m)

3**s** = (9.0m, –36m)

s/3 = (1.0m, –4.0m)

–5**s** = (–15m, 60m)

2**s**/3 = (2.0m, –8.0m)

Aargh. I'm out of space. Ask about scalar multiplication of vectors in polar form in class!