January 19: Vectors of Physics

Objectives

- Distinguish between vector and scalar quantities.
- Carry out addition and scalar multiplication of vectors.
- Understand forces as vectors.

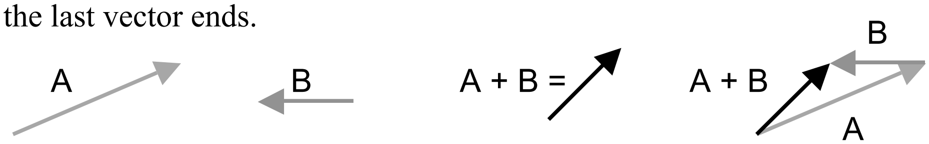
What's the point?

- How can we describe and define directional quantities?
- How do forces combine?

Vectors

Position, velocity, and acceleration are three examples of physical quantities that are **vectors**: specified by a **direction** in addition to a **magnitude**. Vectors are often represented visually by arrows, with their orientations representing the vectors' directions and their lengths representing the vectors' magnitudes.

Add vectors together head-to-tail, so that the next begins where the preceding one ends. Graphically, this means that the vector sum starts where the first vector starts and ends where the last vector ends.



Vectors can be conveniently represented as (x, y) or (x, y, z) components, each component being the vector's magnitude along a particular axis. To add vectors represented this way, add like coordinates together: $\vec{A} + \vec{B} = (A_x + B_x, A_y + B_y)$.

To subtract one vector from another, add its negative. The **negative** of a vector has the *same magnitude* but the *opposite direction*.

Vectors can be multiplied by **scalars** (quantities that do not have a direction). Multiply each component of the vector by the scalar quantity: $k\vec{A} = (kA_x, kA_y)$. **Scalar multiplication** changes the magnitude but not the direction of a vector, although multiplication by a negative scalar reverses the direction.

The magnitude of a vector represented by perpendicular components can be computed using the Pythagorean theorem; the magnitude of $\vec{A} = \sqrt{A_x^2 + A_y^2 + A_z^2}$.

Force vectors

Forces are vectors. The **net force** on an object is the vector sum of all the forces acting on it.

The converse of Newton's first law is that if an object is at rest or moves at constant velocity, there is *zero net force* acting on it. This condition is also known as **mechanical equilibrium**. If you know the directions and one of the magnitudes of the forces acting on an object in mechanical equilibrium, or if you know all of the forces but one, then finding the remaining quantities of the system is just an exercise in geometry.

Tension in a cable is a force *inward* in the direction of its length.