Non-Relativistic Momentum and Energy

1-d

Imagine a particle moving back and forth along a line. At any given time, it has a velocity, v_x. The definition of v_x is

$$v_x = \frac{dx}{dt} = \lim_{\Delta t \to 0} \frac{x(t+\Delta t) - x(t)}{\Delta t}$$

Usually we draw the $+x$ direction to the right. If a particle is moving to the right, then $x(t+\Delta t) > x(t)$ (for positive Δt) and $v_x > 0$.

If it is moving to the left, then $x(t+\Delta t) < x(t)$ (for positive Δt) and $v_x < 0$

There are two extremely important properties of a particle that we can now define:

* Its momentum, $p_x \equiv m v_x$
* Its (kinetic) energy $KE \equiv \frac{1}{2} m v_x^2$

3-d

In 3-d, the momentum is

$$p_x \equiv m v_x$$
$$p_y \equiv m v_y$$
$$p_z \equiv m v_z$$

and the kinetic energy is

$$KE = \frac{1}{2} m \left(v_x^2 + v_y^2 + v_z^2\right)$$

Units

Momentum has mass times length divided by time in its definition. In SI units, its dimensions are

$$kg \frac{m}{s}$$

(kg ← kilogram, m ← meters, s ← second)

Kinetic energy has units

$$kg \frac{m^2}{s^2}$$

which is also the Joule

The eV (electron-Volt)

The SI unit of electric current is the Ampere (often just "amp") and the abbreviation is A (not to be confused with the Angstrom which has the abbreviation Å)!

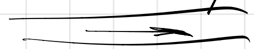
If 1 Ampere flows through a wire for 1 second, then 1 Coulomb of electric charge has gone by.

Unlike mass, charge can be positive or negative. When the Ampere and the Coulomb were defined, it was unknown what was flowing through the wire at a rate of 1 Ampere.

We now know that extremely small chunks of charge called electrons are what is flowing and these charges are negative.

The electron has charge $-e$ and $e = 1.6 \times 10^{-19}$ C. These are experimental facts, not definitions.

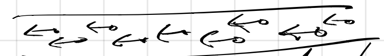
To have +1 Ampere flowing in a wire



(1 Coulomb / second) you must actually have

$$\frac{1}{1.6 \times 10^{-19}} = 6.2 \times 10^{18}$$

electrons flowing the opposite direction every second



Electrons, being negatively charged, like to flow toward higher "voltages." The unit of voltage is the Volt, abbreviated V.

In SI units, if 1 Coulomb goes to 1 Volt lower of voltage, this releases 1 J of energy.

Being negatively charged, and tiny, if one electron goes to 1 Volt lower of voltage, this requires 1.6×10^{-19} J of energy. This amount comes up so often it has a name, the "electron-Volt" abbreviated eV, and indeed $1 \text{ eV} = e \cdot 1\text{V}$.

YOU NOW HAVE THE ABSOLUTE MINIMUM YOU MUST KNOW ABOUT NON-RELATIVISTIC MOMENTUM AND ENERGY TO STUDY CHAPTER 7 THROUGH SECTION 7.6.