Physics Laws

We have been treating positions as something we can get from a video (of a soccer game for example), or that we can get from an initial position and a list of velocities.

We have had equations like

$$x_{i+1} = x_i + (t_{i+1} - t_i)\, v_{i\to i+1}$$

These were a list

$v_{0\to 1} = 3\ m/s$

$v_{1\to 2} = 6\ m/s$

$\vdots$

Newton's genius was to realize that velocities obey a similar equation!

First, let me make the above equation simpler. Instead of writing

$v_{i\to i+1}$ MEANS SAME THING!

which helps you remember what it is and does, I am going to write just

v_i

So the equation — no change in meaning — now is just

$$x_{i+1} = x_i + (t_{i+1} - t_i)\, v_i$$

Newton realized that

$$v_{i+1} = v_i + (t_{i+1} - t_i)\, a_i$$

Or if you prefer the actual definition

$$a_i \equiv \frac{v_{i+1} - v_i}{t_{i+1} - t_i}$$

If it's just a definition and a rearrangement of a definition, then there is no physical law.

Newton realized though that the a_i are relatively simple to get and the physical law is the formula for the a_i.

The a_i are called accelerations.

At any given time the acceleration is given by

$$\underbrace{F}_{\text{called force}} = \underbrace{m}_{\text{called mass}}\, \overbrace{a}^{\text{acceleration}}$$

Summary of Physics Laws (so far)

$$x_{i+1} = x_i + (t_{i+1} - t_i)\, v_i$$

$$v_{i+1} = v_i + (t_{i+1} - t_i)\, a_i$$

Units

In the usual units, the x_i are measured in meters and the t_i are measured in seconds.

For the units to work out in the first equation, that means that the v_i have units $\frac{m}{s}$.

In the second equation, we make the same argument and learn that the a_i (the accelerations) have units $\frac{m}{s^2}$.

You don't have to work in the standard scientific units. For example acceleration could be measured in $\frac{ft}{s^2}$ and the equations would still be true.

Acceleration Example — Constant Acceleration

$$x_{i+1} = x_i + (t_{i+1} - t_i)\, v_i$$

$$v_{i+1} = v_i + (t_{i+1} - t_i)\, a$$

a constant
no need for subscript

An example would be a drag racer — provided:

* The engine puts constant torque on the wheels
* We don't have to worry about increasing air resistance.

In real life the engine torque peaks at a few thousand rpm and then starts decreasing, and meanwhile the air resistance increases as the speed increases.

With the power of computer simulation, you can easily model these effects, but for the moment we'll ignore them and focus on the nice easy constant acceleration problem.

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