Velocity and Acceleration

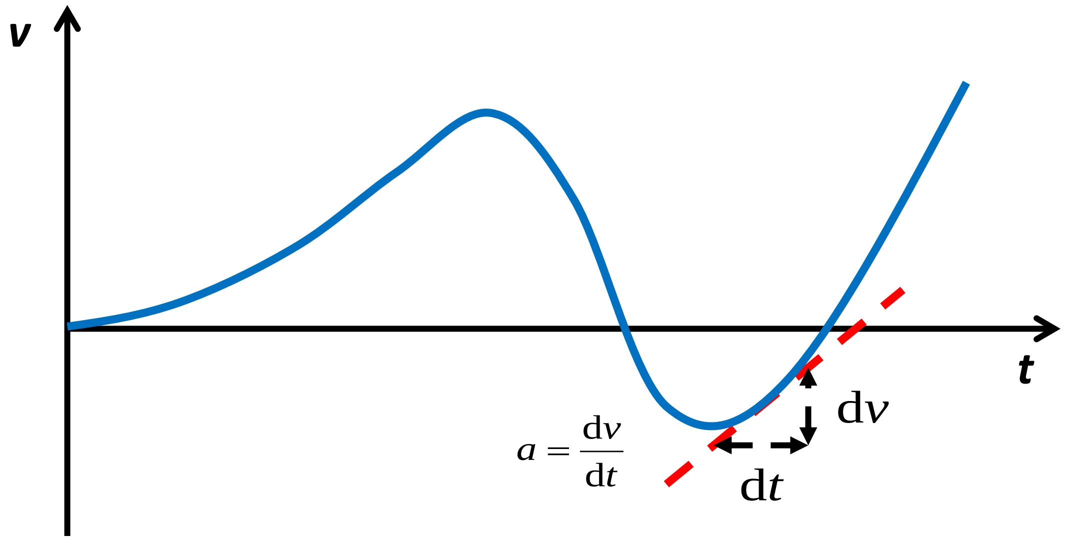
Last time, we defined **velocity** as a time derivative of a **position**:

$$v \underset{\Delta t \to 0}{=} \frac{\Delta x}{\Delta t} = \frac{\mathrm{d}x}{\mathrm{d}t}$$

Similarly, **acceleration** is the time derivative of **velocity**.

$$a = \frac{\mathrm{d}v}{\mathrm{d}t}$$

In other words, it is the rate of change of velocity, or local slope of the plot v(t) :



In 2D and 3D, one has to find a derivative of each of the vector components independently. For instance:

$$\vec{v}_{3D} = \left(\frac{\mathrm{d}x}{\mathrm{d}t}, \frac{\mathrm{d}y}{\mathrm{d}t}, \frac{\mathrm{d}z}{\mathrm{d}t} \right), \quad \text{magnitude (length) of this vector is instantaneous speed.}$$

Homework

In order to find the gravitational acceleration on an unknown planet, Astronauts performed a free fall experiment. An object was dropped from certain height, and the times were recorded with a help of photogates. The object moved by 10 cm downward between any two consecutives measurements (the moment of the first detection was arbitrary). The times (is sec) are presented below. Determine the acceleration g, and experimental error (i.e. standard deviation of the measured values of g). You are encouraged to use automatic tools. For instance, Google Sheets:

- Copy time data to a Google Scheets (or Microsoft Excel)
- Calculate Δt, V, g, at each time. For instance, if you enter ***'=A3-A2',*** the spreadsheet will automatically calculate the difference between the times recorder in cells A3 and A2. As you entered the formula once, you don't need to re-enter it for the rest of data, just click on the cell and "pull" the cursor down.
- Find the mean value (average) of g, and error (standard deviation). You may use built-in functions (insert>function>statistical), or simply enter: ***'=AVERAGE(…)', '=STDEV(…)'.*** Here '…' is cell range, like ***B2:B5***.

t, sec	Δ t, sec	v, m/s	g, m/s^2
0.5650			
0.6178			
0.6665			
0.7118			
0.7545			
0.7948			
0.8332			
0.8699			
0.9051			