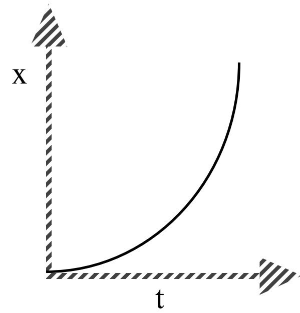
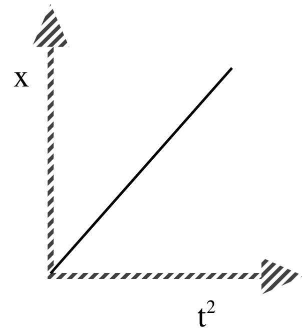
Post-lab discussion

From the lab, the students have the following graphs.





Focus the whiteboard discussion on their experimental procedure and the verbal interpretation of the parabolic x-t graph. Students should be able to describe that the displacement during each time interval increases over the previous time interval. Since the object travels greater distances in each successive time interval, the velocity is increasing.

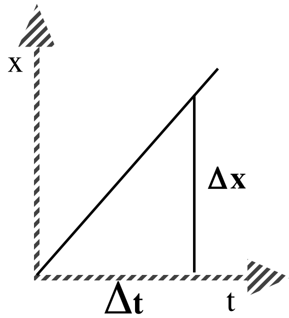
They should have also written an expression for the straight-line graph: $x = kt^2 + b$, where b --> 0. The units of the constant of proportionality (slope) are m/s^2, but k is **not** the acceleration of the object. Emphasize the x vs t^2 relationship and correct use of units, but stating that the slope has the units of acceleration would be premature, because that quantity has yet to be defined.

Post-lab extension

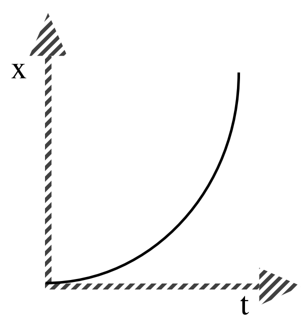
Discussion

Contrast the **x** vs **t** graph for this lab with the one obtained in unit II.

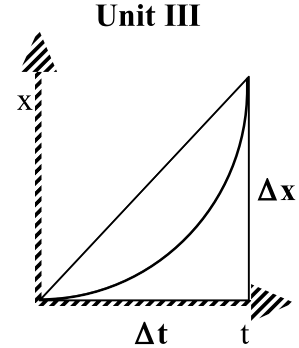
Unit II



Unit III



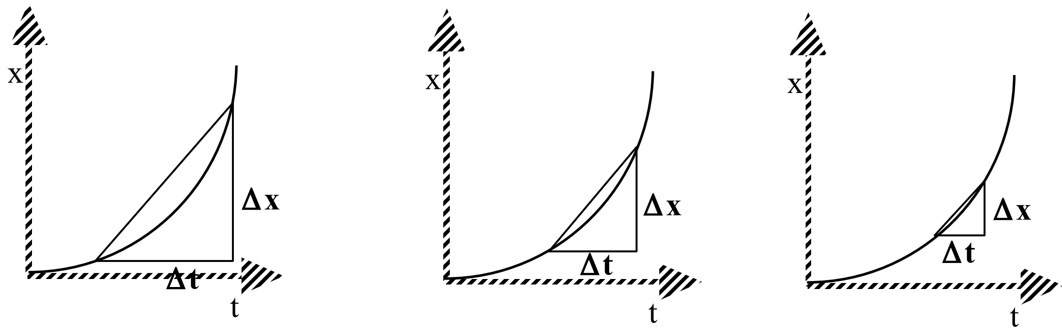
Unit III



One can speak of the average velocity as the slope of the graph (above left) because the slope of a straight line is constant. It doesn't matter which two points are used to determine the slope.

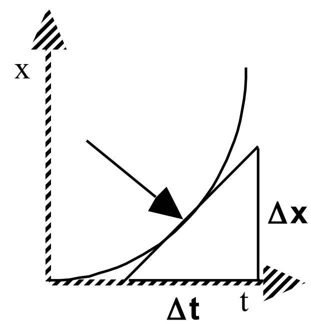
On the other hand, one could speak of the average velocity of the object in the graph at right, but since the object started very slowly and steadily increased its speed, the term average velocity has little meaning.

What would be more useful is to have a way of describing the object's speed at a given instant (or as Arons terms it: *clock reading*). To develop this idea, you must show that, as you shrink the time interval Δt over which you calculate the average velocity, the secant (line intersecting the curve at two points) more closely resembles the curve during that interval.



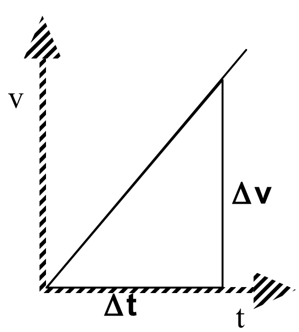
That is, the slope of the secant gives the average velocity for that interval. As the interval gets shorter and shorter, the secant more closely approximates the curve. Thus, the average velocity of this interval becomes a more and more reasonable estimate of how fast the object is moving *at any instant* during this interval.

As one shrinks the interval, Δt to zero, the secant becomes a tangent; the slope of the tangent is the average velocity at this instant, or simply the *instantaneous velocity* at that clock reading.



Student activity

Using the x-t graphs the students produced in the lab, students should construct at least five tangents to the curve and determine the slope of each tangent. This will be easier if the students have printed out full-page graphs of their data or replotted their data on a sheet of graph paper. The students should then make a new graph of instantaneous velocity vs time. An alternative is to have students enter their equations into a graphing calculator and have the calculator draw tangents and determine their slopes at five clock readings. (See TI-slope.doc or CASIO-slope.doc)



A plot of instantaneous velocity (v, instead of v-bar) vs time should yield a straight line. The slope of this line is $\frac{\Delta\vec{v}}{\Delta\vec{t}} \equiv \overline{a}$. That is, the change in velocity during a given time interval is defined to be the *average acceleration*. The equation for the line can be written as $\vec{v} = \vec{a}t + \vec{v}_0$, where $\vec{v}_0$ is the y-intercept. It is important to define the acceleration this way, and then show examples of **x** vs **t** graphs in which the acceleration is negative.