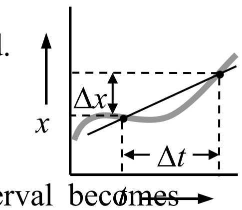
PHYS 1210 Discussion Work Sheet 1
Position, Velocity, and Acceleration

Concepts

Average velocity is the ratio of how far an object moves to the time elapsed.

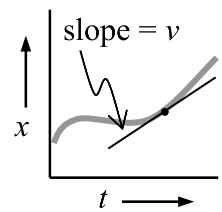
$$v_{avg} = \Delta x/\Delta t$$



On a plot of position vs. time, v_{avg} is the slope of the secant line connecting the starting and ending events.

Instantaneous velocity is the limit of average velocity as the time interval becomes infinitesimally brief. It is the velocity at a particular instant of time.

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$



On a of position-time plot, v is the slope of the tangent line at that particular instant. Conversely, the area under a velocity-time plot is the change in position, $\int_0^t v dt = \Delta x$

Average acceleration is the rate of the change of an object's velocity.

$$A_{avg} = \Delta x/\Delta t$$

On a plot of velocity vs. time, a_{avg} is the slope of the secant line connecting the starting and ending events.

Instantaneous acceleration is the limit of average acceleration as the time interval becomes infinitesimally brief. It is the acceleration at a particular instant of time.

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt} = \frac{d^2 x}{dt^2}; \qquad \int_0^t a dt = \Delta v$$

On a of velocity-time plot, a is the slope of the tangent line at that particular instant. Conversely, the area under an acceleration-time plot is the change in velocity.

Kinematic Formulas

When velocity is constant, dx/dt is the same for any time interval. Then $x = x_0 + vt$.

When acceleration is constant, $v = v_0 + at$; $x = x_0 + v_0 t + \frac{1}{2} a t^2$.

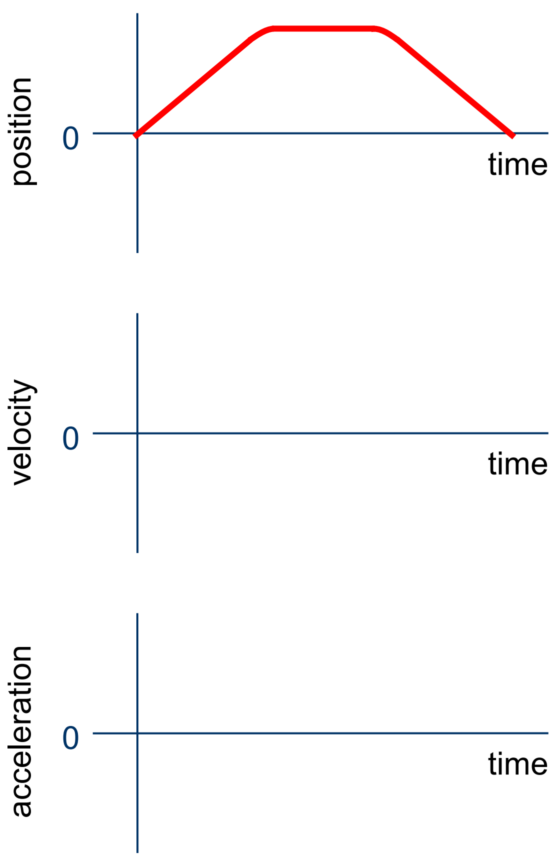
Algebraic substitution allows us to find relations not requiring t or not requiring a:

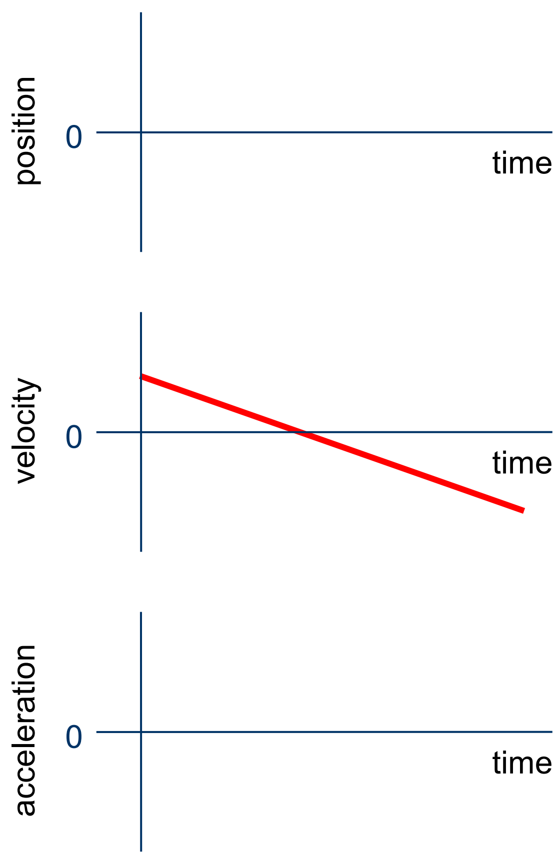
$$2a(x - x_0) = v^2 - v_0^2; \qquad x - x_0 = \frac{1}{2}(v_0 + v)t$$

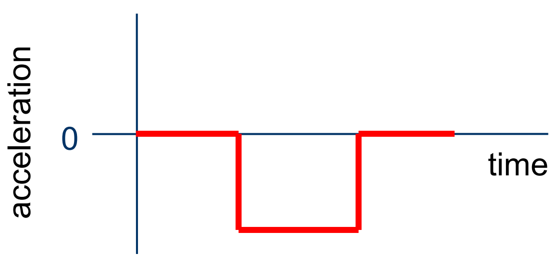
Problems

With your group, discuss how to answer the questions and write your group answer in the space provided.

1. In the following scenarios, the motion of an object is to be described in four ways: (i) in words, (ii) as a position-time graph, (iii) as a velocity-time graph, and (iv) as an acceleration-time graph. In each case, only one description is given. Construct the other three. (You may need to assume some initial conditions.) For additional fun, think of mathematical expressions that would describe the position, velocity, and acceleration.







A coconut hangs motionless from its tree, then drops with increasing downward speed until it lands on the ground, quickly coming to rest.

There is not space on this worksheet to work the rest of the questions. You will need your own scratch paper.

2. A ball starts from rest and rolls down an incline at a constant acceleration. In 5.0 s, it rolls a distance of 50.0 m down the hill.

a. What is its acceleration?

b. If the same ball rolls down the same incline with the same acceleration, but begins with an initial speed of 2.0 m/s downhill, how far down the hill will it be in 5.0 s?

c. If the ball begins with an initial speed of 2.0 m/s *uphill*, where will it be in 5.0 s? (Its acceleration is still the same as in the previous parts of the question.)

3. The human body can survive an acceleration trauma incident (sudden stop) if the magnitude of the acceleration is less than 250 m/s^2. If you are in an automobile accident with an initial speed of 30 m/s and you are stopped by an airbag that inflates from the dashboard, over what distance must you stop for you to survive the crash?

4. A student is running at her top speed of 5.0 m/s to catch a bus, which is stopped at the bus stop. When the student is still 40.0 m from the bus, it starts to pull away, moving with a constant acceleration of 0.170 m/s^2.

a. Sketch an x-t graph for both the student and the bus.

b. For how much time and for what distance must the student run to reach the bus?

c. When she reaches the bus, how fast is the bus traveling?

d. The equations you used to find the time have a second solution, corresponding to a later time for which the student and bus are again at the same place if they continue their specified motion. Explain the significance of this second solution.

e. What is the minimum speed the student must have to *just* catch the bus? (What does it mean to "just catch" the bus?)

f. If the student just catches the bus, how far does she run to catch it?