Milwaukee School of Engineering | Introductory Physics
PHY 1110

Group Problem Set 3: Position, Velocity, Acceleration

For one dimensional motion, average velocity is a function of distance (x) and time (t). The average velocity is found by subtracting the initial distance x_i from the final distance x_f and dividing by the difference between the final time, t_f and the initial time t_i

$$v_{avg} = \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t}$$

This equation works well when the velocity is constant (when the velocity is represented well with a straight line). In this case, we know that

$$x_f = v_{avg}t + x_i$$

BUT velocity isn't always constant, and in those cases, we can still calculate the instantaneous velocity,

$$v_x = \frac{dx}{dt}$$

From finding the average velocity, we know that the change in distance with respect to the change in time of the particle is the slope of the function representing position versus time. Further, using calculus, we know that the derivative of a function gives the slope of the line tangent to the function at that point. As a consequence, the velocity found using this method is instantaneous as it is only guaranteed to correspond to that location.

Acceleration is defined as the change in velocity (v) as a function of the change in time (t). The average acceleration can be found the same way average velocity is calculated:

$$a_{x,avg} = \frac{v_{x,f} - v_x, i}{t_f - t_i} = \frac{\Delta v_x}{\Delta t}$$

Notice here that if v is constant, $v_{x,f} = v_{x,i}$, then acceleration is ZERO. In the case where velocity is changing, we can calculate the instantaneous acceleration for a direction:

$$a_{x,avg} = \frac{dv_x}{dt}$$

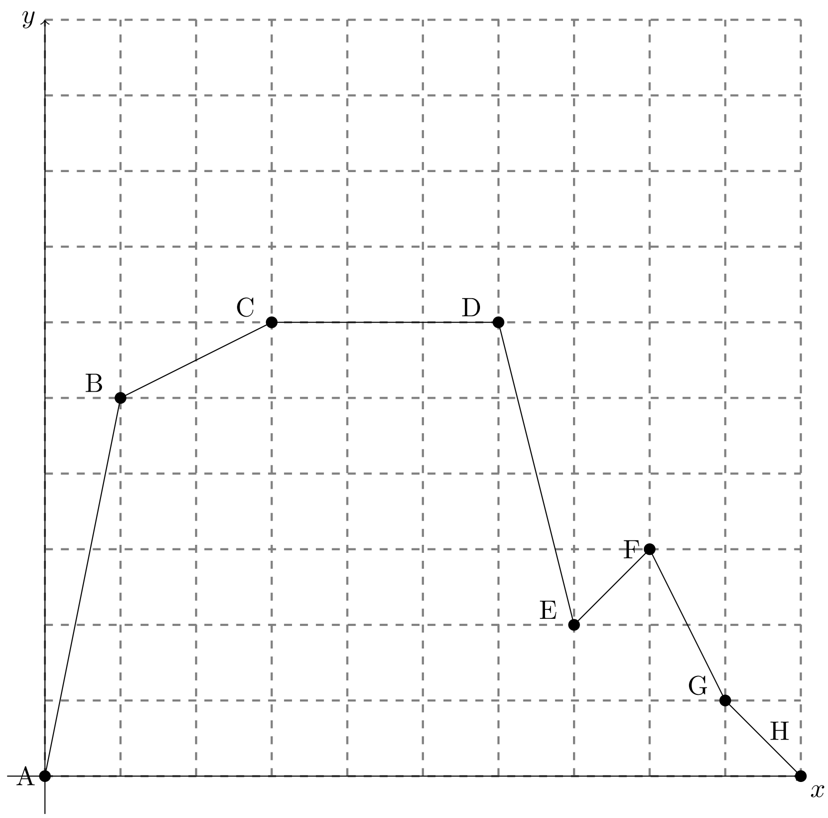
When the velocity is plotted as function of time (V/T graph), the slope of function corresponds to the acceleration.

Vector direction can say a lot about the motion of a particle. For instance, a positive slope (line points upward) corresponds to a positive velocity. A negative slope (line points downward) corresponds to deceleration. No slope (flat line) corresponds to no change either in velocity or acceleration.

1. The following velocity versus time graph represents my attempt to outrun a bear... On the graph below,

   (a) Label the axes with velocity and time, assigning your units of choice (i.e. ant steps vs. years).

   (b) State whether the acceleration is positive (+), negative (-) or has not change (0) for each section (you directly label the graph, i.e. $a = 0$).



   (c) What segment has the largest change in velocity? What is the acceleration in this region?
   (d) At what time intervals is there no change in velocity? At what intervals is there no acceleration?
   (e) In which segments do I start to slow down? Where do I start to speed up?
   (f) Construct an acceleration v. time graph to represent these changes.
   (g) Using the velocity over each interval, construct a position v. time graph.

2. A tennis ball was tracked on a tennis court during the course of a rally in a match. The motion graph represents the track of the tennis ball

   (a) At what time interval(s) is the velocity of the ball positive? At what time interval(s) is the velocity of the ball negative?

   (b) The tennis ball was volleyed back and forth at the distances 2, -3, 3, 1, and 3 meters along the $\vec{x}$, measured from the net, during the match. Draw the corresponding position versus time graph. Be sure to include labels and appropriate units.

   (c) Complete the following table and draw the corresponding velocity graph. Be sure to include the appropriate labels with the correct associated units.

   (d) Acceleration is the change in velocity divided by the change in time. Try to calculate the acceleration over the interval and plot you findings in an acceleration v. time graph. Note: without calculus your graph should look like an ugly step function. You will also have to make several assumptions in the calculation.

Time	**position**	**velocity**	**change in velocity**	**acceleration**
0 s				
1 s				
2 s				
3 s				
4 s				