1.4: In Summary

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1. To describe the motion of an object in one dimension we treat it as a mathematical point, and consider its *position coordinate*, x (often shortened to just the *position*), as a function of time: $x(t)$.
2. Numerically, the position coordinate is the distance to a chosen origin, with a positive or negative sign depending on which side of the origin the point is. For every problem, when we introduce a coordinate axis we need to specify a positive direction. Starting from the origin in that direction, the position coordinate is positive and increasing, whereas going from the origin in the opposite direction (negative direction) it becomes increasingly negative.
3. The displacement of an object over a time interval from an initial time t_i to a final time t_f is the quantity $\Delta x = x_f - x_i$, where x_f is the position of the object at the final time (or, the final position), and x_i the position at the initial time (or initial position).
4. The average velocity of an object over the time interval from t_i to t_f is defined as $v_{av} = \Delta x/\Delta t$, where $\Delta t = t_f - t_i$.
5. The *instantaneous velocity* (often just called the *velocity*) of an object at the time t is the limit value of the quantity $\Delta x/\Delta t$, calculated for successively shorter time intervals Δt, all with the same initial time $t_i = t$. This is, mathematically, the definition of the derivative of the function $x(t)$ at the time t, which we express as $v = dx/dt$.
6. Graphically, the instantaneous velocity of the object at the time t is the slope of the tangent line to the x-vs-t graph at the time t .
7. The instantaneous velocity of an object is a positive or negative quantity depending on whether the object, at that instant, is moving in the positive or the negative direction.
8. For an object moving with constant velocity v, the position function is given by [Equation (1.2.10)]:

$$x(t) = x_i + v(t - t_i)$$

   where t_i is an arbitrarily chosen initial time and x_i the position at that time. This can also be written in the form given by Equation (1.2.9). The argument (t) on the left-hand side of Equation (1.2.10) is optional, and t_i is often set equal to zero, giving just $x = x_i + vt$. This, however, is not quite as generally applicable as the result Equation (1.2.9) or Equation (1.2.10).

9. For an object moving with changing velocity, the total displacement in between times t_i and t_f is equal to the total area under the v-vs-t curve in between those times; areas below the horizontal (t) axis must be treated as negative.
10. In two or more dimensions one introduces, for every point in space, a *position vector* whose components are just the Cartesian coordinates of that point; then the displacement vector is defined as $\Delta\vec{r} = \vec{r}_f - \vec{r}_i$, the average velocity vector is $\vec{v}_{av} = \Delta\vec{r}/\Delta t$, and the instantaneous velocity vector is the limit of this as Δt goes to zero. Vectors are added by adding their components separately; to multiply a vector by an ordinary number, or *scalar*, we just multiply each component by that number.
11. When tracking the motion of an object, “P”, in two different reference frames, A and B, the position vectors are related by $\vec{r}_{AP} = \vec{r}_{AB} + \vec{r}_{BP}$, and likewise the velocity vectors: $\vec{v}_{AP} = \vec{v}_{AB} + \vec{v}_{BP}$. Here, the first subscript tells you in which reference frame you are measuring, and the second subscript what it is that you are looking at; $\vec{r}_{AB}$ is the position vector of the origin of frame B as seen in frame A, and $\vec{v}_{AB}$ its velocity.

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