Chapter 2: Kinematics in One Dimension

Essential Concepts and Summary
Displacement

- Displacement is a vector pointing from an object's initial position to its final position, and has a magnitude equal to the shortest distance between the points.

- SI Unit: meter
Speed and Velocity

- Average velocity is the change in displacement over change in time.
- Average speed is change in distance over change in time.
- Velocity has direction, speed doesn't.

\[ \vec{v} = \frac{\Delta \vec{x}}{\Delta t} \]

\[ \vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t} \]
Acceleration

Average acceleration is the change in velocity over a change in time.

\[ \vec{a} = \frac{\Delta \vec{v}}{\Delta t} \]

\[ \vec{a} = \lim_{{\Delta t \to 0}} \frac{\Delta \vec{v}}{\Delta t} \]
Kinematics for Constant Acceleration

These set of four equations apply when an object moves with constant acceleration along a straight line:

\[ v = v_0 + at \]
\[ x = \frac{1}{2} (v_0 + v) t \]
\[ x = v_0 t + \frac{1}{2} at^2 \]
\[ v^2 = v_0^2 + 2ax \]
Derivation

\begin{align*}
x &= \frac{1}{2} (v_0 + v)t \\
v &= v_0 + at \\
t &= \frac{(v - v_0)}{a} \\
x &= \frac{1}{2} (v + v_0) \frac{(v - v_0)}{a} \\
2ax &= v^2 - v_0^2 \\
v^2 &= v_0^2 + 2ax
\end{align*}
Freely Falling Bodies

- Idealized motion, where air resistance is neglected and acceleration is nearly constant, is referred to as free-fall.
- Acceleration due to gravity on earth, $g$, is $9.80 \text{ m/s}^2$
- Kinematics equations are the same but $a = g$
Graphical Analysis

- Slope of position vs. time plot is velocity
- Slope of velocity vs. time plot is acceleration
- The area underneath a velocity vs. time plot is distance
Summary of Equations

\[ \Delta x = \vec{x} - \vec{x}_0 \]

\[ \vec{v} = \frac{\Delta x}{\Delta t} \]

\[ \vec{v} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \]

\[ \vec{a} = \frac{\Delta \vec{v}}{\Delta t} \]

\[ \vec{a} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t} \]

\[ \vec{v} = \vec{v}_0 + \vec{a}t \]

\[ x = \frac{1}{2} (\vec{v}_0 + \vec{v})t \]

\[ x = \vec{v}_0 t + \frac{1}{2} \vec{a}t^2 \]

\[ \vec{v}^2 = \vec{v}_0^2 + 2\vec{a}\vec{x} \]