Chapter 2: Motion Along A Single Line

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General

Quantities

$$
\begin{aligned}
x &= \text{position} \\
\Delta x &= \text{displacement} \\
t &= \text{time} \\
\Delta t &= \text{change in time} \\
v_{\text{avg}} &= \text{average velocity} \\
v &= \text{instantaneous velocity} \\
s_{\text{avg}} &= \text{average speed} \\
a_{\text{avg}} &= \text{average acceleration} \\
a &= \text{instantaneous acceleration} \\
g &= \text{magnitude of free-fall acceleration}
\end{aligned}
$$

Constants

$$g = 9.8 \text{ m/s}^2$$

1 Position, Displacement, and Average Velocity

Displacement

$$\Delta x = x_2 - x_1 \tag{1}$$

Average Velocity

$$v_{\text{avg}} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1} \tag{2}$$

Average Speed

$$s_{\text{avg}} = \frac{\text{total distance}}{\Delta t} \tag{3}$$

2 Instantaneous Velocity and Speed

Instantaneous Velocity

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt} \tag{4}$$

3 Acceleration

Average Acceleration

$$a_{\text{avg}} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1} \tag{5}$$

Instantaneous Acceleration

$$a = \frac{dv}{dt} \tag{6}$$

$$a = \frac{dv}{dt} = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2} \tag{7}$$

4 Constant Acceleration

$$v = v_0 + at \tag{8}$$

$$x - x_0 = v_0 t + \frac{1}{2}at^2 \tag{9}$$

$$v^2 = v_0^2 + 2a\left(x - x_0\right) \tag{10}$$

$$x - x_0 = \frac{1}{2}\left(v_0 + v\right)t \tag{11}$$

$$x - x_0 = vt - \frac{1}{2}at^2 \tag{12}$$

5 Free-fall Acceleration

The free-fall acceleration near Earth's surface is $a = -g = -9.8\ \text{m/s}^2$, and the *magnitude* of the acceleration is $g = 9.8\ \text{m/s}^2$. Do not substitute $-9.8\ \text{m/s}^2$ for g.

6 Graphical Integration In Motion Analysis

Integrating Acceleration

$$v_1 - v_0 = \int_{t_0}^{t_1} a\, dt \tag{13}$$

Integrating Velocity

$$x_1 - x_0 = \int_{t_0}^{t_1} v\, dt \tag{14}$$