

General Physics I

Classnotes

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1 Summary

x = position

Δx = displacement

$$= x_f - x_i$$

\bar{v} = average velocity

$$= \frac{\Delta x}{\Delta t}$$

v = instantaneous velocity

$$= \frac{dx}{dt} = \text{slope of } x \text{ vs. } t$$

$$\text{Avg Speed} = \frac{\text{distance traveled}}{\text{time elapsed}}$$

2 Acceleration

Let \bar{a} = average acceleration

$$\bar{a} \equiv \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{\text{change in velocity}}{\text{time elapsed}}$$

Example: A car goes from 20 *mph* to 60 *mph* in 8 *s*. What is its average acceleration?

$$\begin{aligned}
 v_i &= 20 \text{ mi/h} \\
 v_f &= 60 \text{ mi/h} \\
 \Delta t &= 8 \text{ s} \\
 \bar{a} &= \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} \\
 &= \frac{60 \text{ mi/h} - 20 \text{ mi/h}}{8 \text{ s}} \\
 &= \frac{40 \text{ mi/h}}{8 \text{ s}} \\
 &= 5 \frac{\text{mi}}{\text{h} \times \text{s}}
 \end{aligned}$$

Example: Justin Bieber's Limo goes from 30 m/s to a stop in 0.10 s . What is its average acceleration?

$$\begin{aligned}
 v_i &= 30 \text{ m/s} \\
 v_f &= 0 \text{ m/s} \\
 \Delta t &= 0.10 \text{ s} \\
 \bar{a} &= \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} \\
 &= \frac{0 \text{ m/s} - 30 \text{ m/s}}{0.10 \text{ s}} \\
 &= \frac{-30 \text{ m/s}}{0.10 \text{ s}} \\
 &= -300 \frac{\text{m/s}}{\text{s}} = -300 \text{ m/s}^2
 \end{aligned}$$

($-$ means slowing)

Let

$$\begin{aligned}
 a &= \text{instantaneous acceleration} \\
 &= \lim_{\Delta t \rightarrow 0} \frac{\Delta v}{\Delta t} \\
 a &\equiv \frac{dv}{dt} = \text{rate of change of velocity} \\
 &= \text{slope of tangent line to } v \text{ vs. } t
 \end{aligned}$$

Example:

$$x = 3 \text{ m} + (17 \text{ m/s}) t + (7 \text{ m/s}^3) t^3$$

Find : a) velocity at 3 s

b) velocity at 5 s

c) average acceleration from 3 s \rightarrow 5 s

c) instantaneous acceleration at 4 s

a)

$$\begin{aligned}
 v &= \frac{dx}{dt} = 17 \text{ m/s} + (21 \text{ m/s}^3) t^2 \\
 v(3 \text{ s}) &= 17 \text{ m/s} + (21 \text{ m/s}^3) (3 \text{ s})^2 \\
 &= 17 \text{ m/s} + 189 \text{ m/s} \\
 &= 206 \text{ m/s}
 \end{aligned}$$

b)

$$\begin{aligned}
 v(5 \text{ s}) &= 17 \text{ m/s} + (21 \text{ m/s}^3) (5 \text{ s})^2 \\
 &= 17 \text{ m/s} + 525 \text{ m/s} \\
 &= 542 \text{ m/s}
 \end{aligned}$$

c)

$$\begin{aligned}
 \bar{a} &= \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{542 \text{ m/s} - 206 \text{ m/s}}{5 \text{ s} - 3 \text{ s}} \\
 &= \frac{336 \text{ m/s}}{2 \text{ s}} = 168 \text{ m/s}^2
 \end{aligned}$$

d)

$$\begin{aligned}
a &= \frac{dv}{dt} \\
&= \frac{d}{dt} [17 \text{ m/s} + (21 \text{ m/s}^3)t^2] \\
&= 0 + (42 \text{ m/s}^3)t \\
a(4 \text{ s}) &= (42 \text{ m/s}^3)(4 \text{ s}) \\
&= 168 \text{ m/s}^2
\end{aligned}$$

t_i	\rightarrow	0
t_f	\rightarrow	t
x_i	\rightarrow	x_0
x_f	\rightarrow	x
v_i	\rightarrow	v_0
v_f	\rightarrow	v

Suppose $a = \text{constant}$

$$\begin{aligned}
\bar{a} &= a \\
\frac{v - v_0}{t} &= a \\
v - v_0 &= at \\
v &= v_0 + at : v(t)
\end{aligned} \tag{1}$$

$$x = x_0 + v_0t + \frac{1}{2}at^2 : x(t) \tag{2}$$

$$x = x_0 + \frac{1}{2}(v_0 + v)t : \text{no } a \tag{3}$$

$$2a(x - x_0) = v^2 - v_0^2 : \text{no } t \tag{4}$$