General Physics I
Classnotes

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1 Summary

$$
\begin{aligned}
x &= \text{position} \\
\Delta x &= \text{displacement} \\
&= x_f - x_i \\
\bar{v} &= \text{average velocity} \\
&= \frac{\Delta x}{\Delta t} \\
v &= \text{instantaneous velocity} \\
&= \frac{dx}{dt} = \text{slope of x vs. t} \\
\text{Avg Speed} &= \frac{\text{distance traveled}}{\text{time elapsed}}
\end{aligned}
$$

2 Acceleration

$$
\begin{aligned}
\text{Let} \qquad \bar{a} &= \qquad \text{average acceleration} \\
\bar{a} &\equiv \qquad \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{\text{change in velocity}}{\text{time elapsed}}
\end{aligned}
$$

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

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

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

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

($-$ means slowing)

Let

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

Example:

$$\begin{aligned} x &= 3\ m + (17\ m/s)\, t + \left(7\ m/s^3\right) t^3 \\ Find &: \text{a) velocity at } 3\ s \\ &\quad \text{b) velocity at } 5\ s \\ &\quad \text{c) average acceleration from } 3\ s \to 5\ s \\ &\quad \text{c) instantaneous acceleration at } 4\ s \end{aligned}$$

a)

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

b)

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

c)

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

d)

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

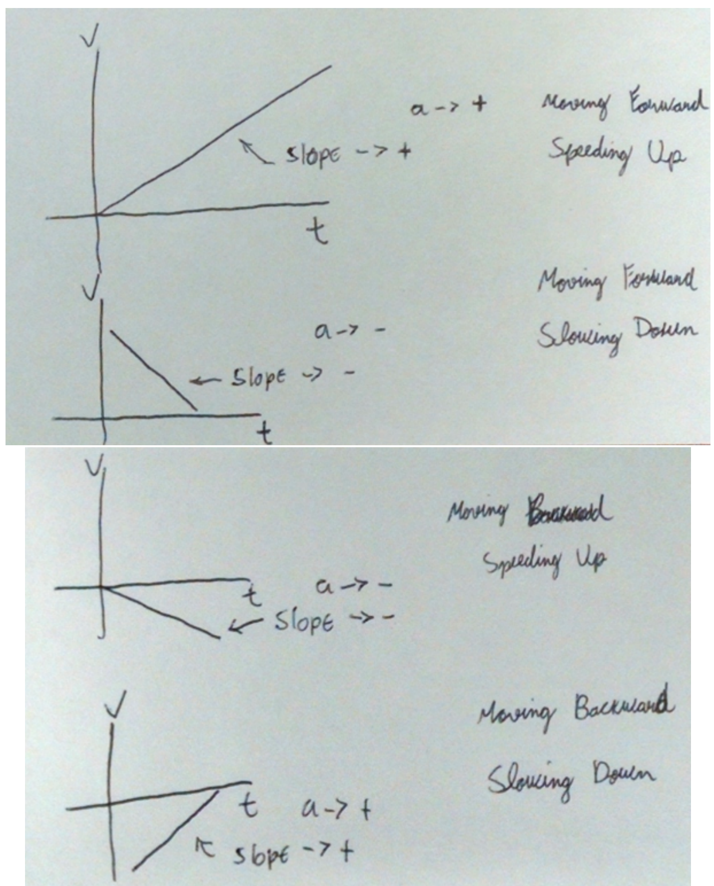

Figure 1: Graphics of Acceleration

$$
\begin{array}{lll}
t_i & \rightarrow & 0 \\
t_f & \rightarrow & t \\
x_i & \rightarrow & x_0 \\
x_f & \rightarrow & x \\
v_i & \rightarrow & v_0 \\
v_f & \rightarrow & v
\end{array}
$$

Suppose $a =$ constant

$$
\begin{aligned}
\bar{a} &= a \\
\frac{v - v_0}{t} &= a \\
v - v_0 &= at \\
v &= v_0 + at : v(t) && (1) \\
x &= x_0 + v_0 t + \frac{1}{2}at^2 : x(t) && (2) \\
x &= x_0 + \frac{1}{2}(v_0 + v)t : \text{no } a && (3) \\
2a(x - x_0) &= v^2 - v_0^2 : \text{no } t && (4)
\end{aligned}
$$