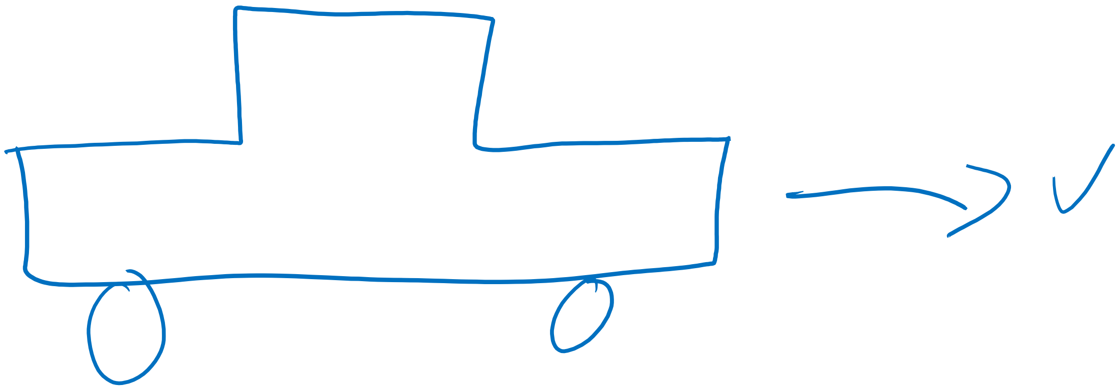
Chapter 2: Kinematics in 1D

- Uniform motion (skip)
- Connections between r(t), v(t), a(t)
  - Or s(t), $v_s(t)$, $a_s(t)$
- Instantaneous vs average velocity (and acceleration)
- Constant acceleration, free-fall
- Non-constant acceleration



$s(t)$

where is $s = 0$?
when is $t = 0$?

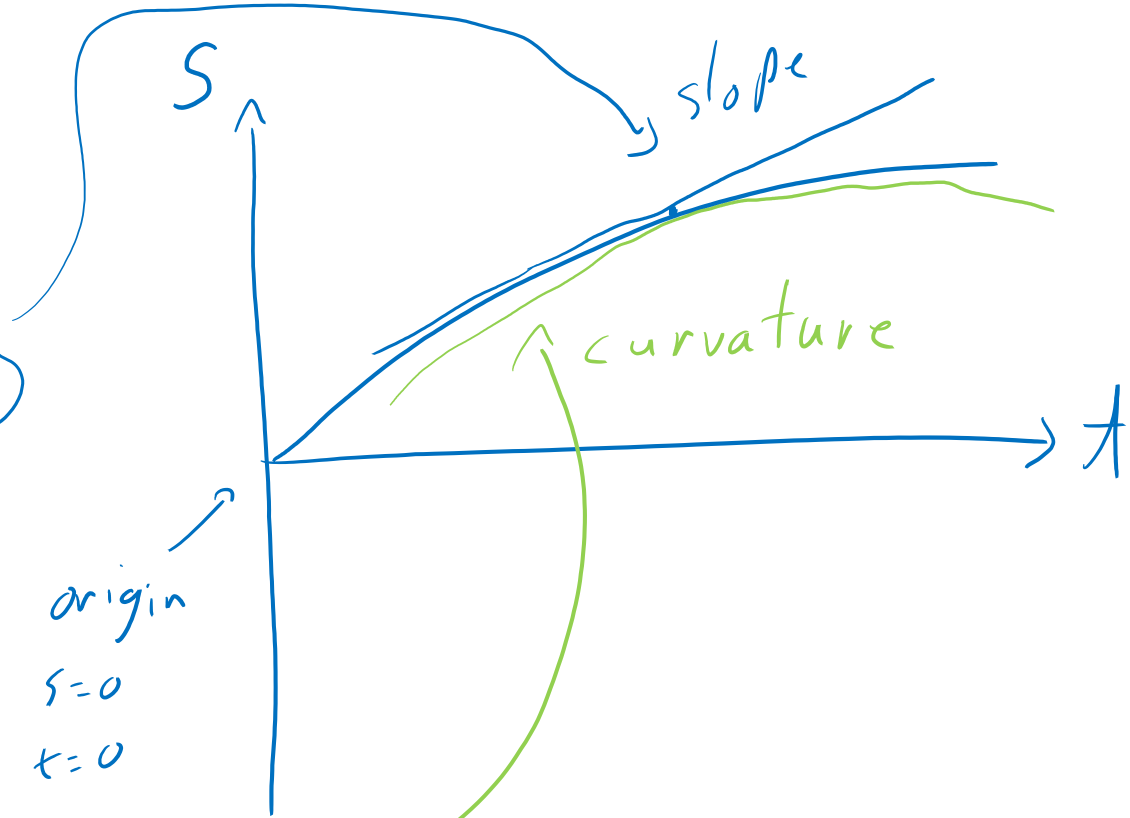
reference frame

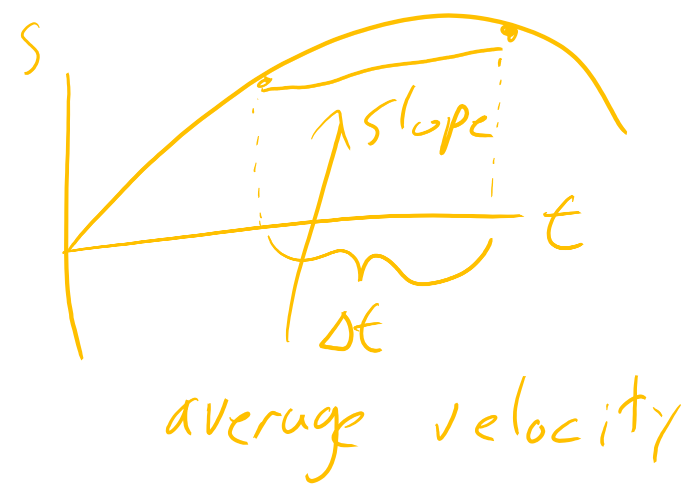
$\vec{r}(t)$ position

$\vec{v} = \dfrac{d\vec{r}}{dt}$ instantaneous velocity

$\vec{a} = \dfrac{d\vec{v}}{dt}$ acceleration

$= \dfrac{d^2\vec{r}}{dt^2}$





$$s_f = s_i + v_{s,i}t + \frac{1}{2}a_s t^2 \;\; ☆$$

$$v_s = \frac{ds}{dt} = 0 + v_{s,i} + \underbrace{\frac{1}{2}a_s(2t)}$$

$$v_{s,f} = v_{s,i} + a_s t$$

$$a_s = \frac{dv_s}{dt} = 0 + a_s$$

$$a_s \longrightarrow v_{s,f} = v_{s,i} + \int_{t_i}^{t_f} a_s \, dt$$

a constant

$$\frac{1}{2}a_s t^2$$

$$\boxed{s_f} = s_i + \int_{t_i}^{t_f} v_s \, dt = \boxed{s_i} + \boxed{\int_{t_i}^{t_f}\left(\int_{t_i}^{t'} a_s \, dt\right) dt'} \;\; \boxed{+ v_{s,i} t}$$

Summary

General Principles

Kinematics describes motion in terms of position, velocity, and acceleration.

General kinematic relationships are given **mathematically** by:

Instantaneous velocity $v_s = ds/dt =$ slope of position graph

Instantaneous acceleration $a_s = dv_s/dt =$ slope of velocity graph

Final position $$s_f = s_i + \int_{t_i}^{t_f} v_s\,dt = s_i + \begin{cases}\text{area under the velocity} \\ \text{curve from } t_i \text{ to } t_f\end{cases}$$

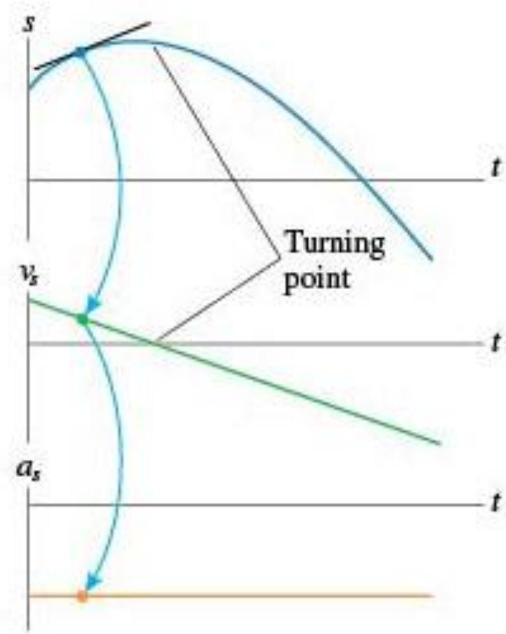
Final velocity $$v_{fs} = v_{is} + \int_{t_i}^{t_f} a_s\,dt = v_{is} + \begin{cases}\text{area under the acceleration} \\ \text{curve from } t_i \text{ to } t_f\end{cases}$$

Summary

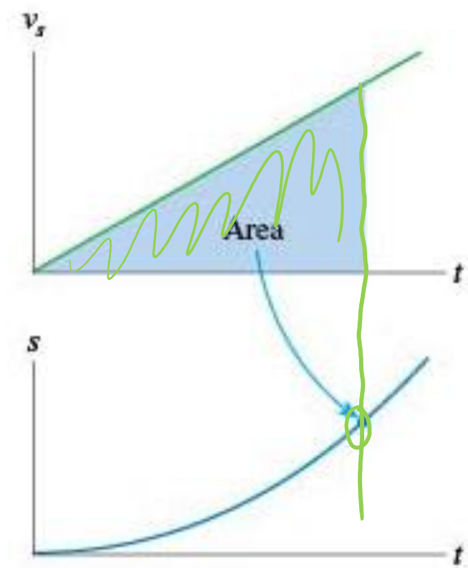
Important Concepts

Position, velocity, and acceleration are related graphically.

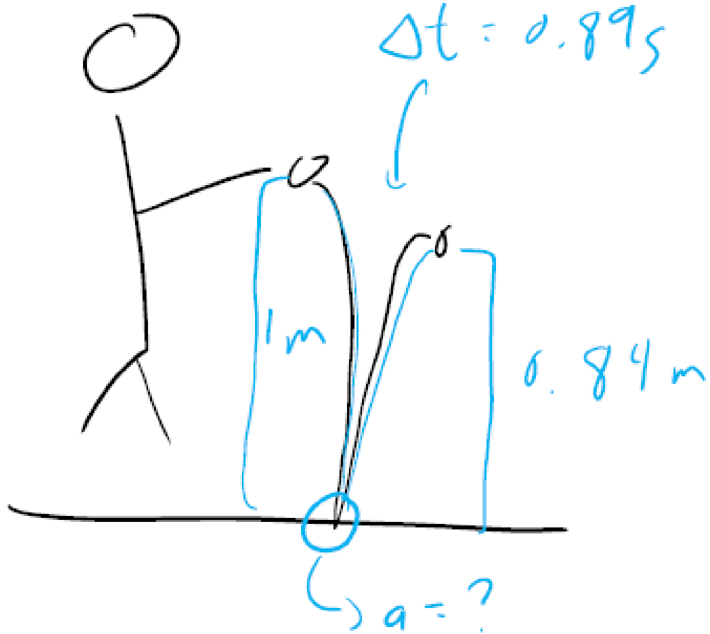
- The slope of the position-versus-time graph is the value on the velocity graph.
- The slope of the velocity graph is the value on the acceleration graph.
- s is a maximum or minimum at a turning point, and $v_s = 0$.

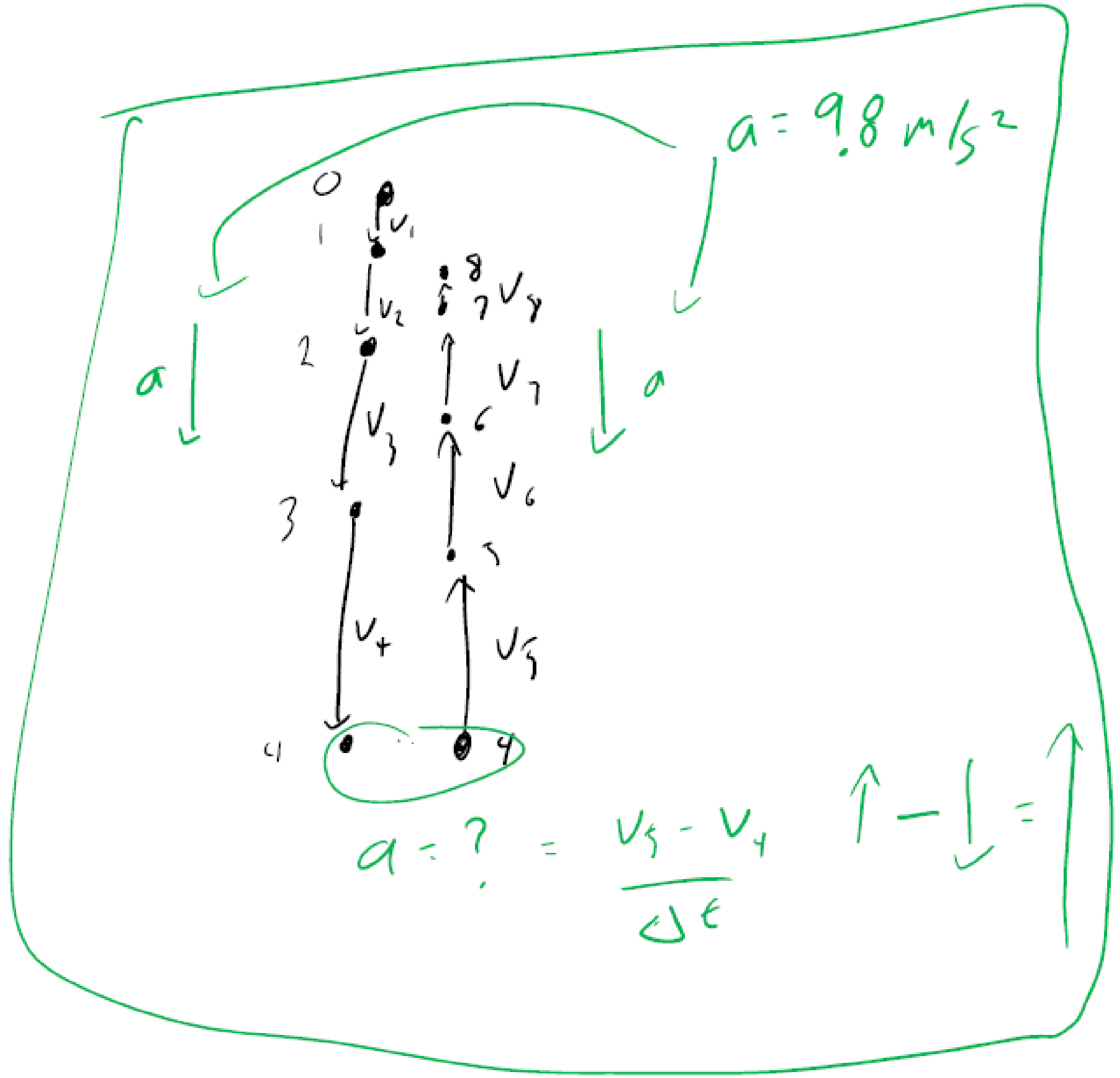


- Displacement is the area under the velocity curve.



You drop a ball from a height of 1.00 m. It bounces up to a height of 0.84 m after 0.89 s. What was the average acceleration of the ball when it was touching the ground?





You drop a ball from a height of 1.00 m. It bounces up to a height of 0.84 m after 0.89 s. What was the average acceleration of the ball when it was touching the ground?