1 Kinematics of Straight Line Motion

Describing Motion

The **position** of an object is given by the vector $\vec{r} = (x, y, z)$. We can denote a particular *component* of $\vec{r}$ as s; that is, s stands for x, y, or z depending on the situation.

The **velocity** of an object is the *derivative* of the position with respect to time; it tells you have much the position changes with time:

$$\vec{v} = \frac{d\vec{r}}{dt} = \left(\frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt}\right)$$

We can write one component of the velocity vector as

$$v_s = \frac{ds}{dt}$$

The **acceleration** of an object is the derivative of the velocity with respect to time; it tells you have much the velocity changes with time:

$$\vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2}$$

We can write one component of the acceleration vector as

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

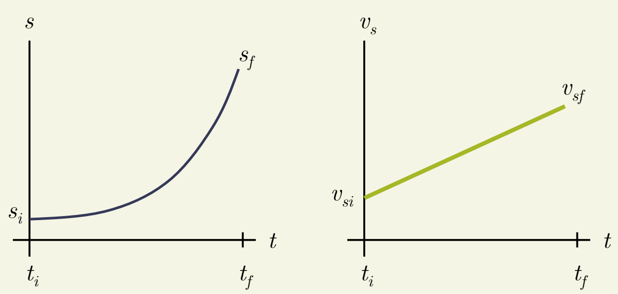
Model: Constant Acceleration

If an object in moving in a straight line with approximately constant acceleration, we can model it as having *constant acceleration.*

Position: $s_f = s_i + v_{i_s}\Delta t + \frac{1}{2}a_s\Delta t^2$

Velocity: $v_{f_s} = v_{i_s} + a_s\Delta t$

No time: $v_{f_s}^2 = v_{i_s}^2 + 2a_s\Delta s$



Motion on an Inclined Plane

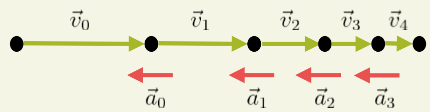
An object *sliding* (without friction) down an incline has a constant acceleration

$$a_s = \pm g\sin\theta$$

where the plus or minus sign depends on the direction of the ramp.

Motion Diagrams

A *motion diagram* shows a moving object simplified as a series of equally-spaced-in-time positions. Use five or six dots to indicate the positions when you're making one, and include the velocity and acceleration vectors.



Example: motion diagram for a car slowing down.

The Particle Model

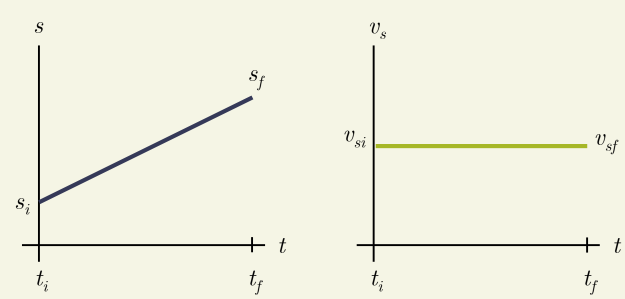
A *model* in physics is a simplified picture of reality that still captures the essence of the situation. We can model an object as a **particle** if its size and shape don't affect its motion. This model treats the object as though all of its mass is concentrated at a single point. In diagrams, we use a *dot* to represent a particle.

Model: Constant Velocity

If an object in moving in a straight line at approximately constant speed, we can model it as having *constant velocity.*

Position: $s_f = s_i + v_s\Delta t$

Velocity: $v_{s_f} = v_{s_i}$



Free Fall

An object falling under the influence of *gravity* only is said to be in *free fall.* We can model the motion of the object as being in constant acceleration with

$$\vec{a}_{\text{free fall}} = (g, \text{vertically downward}),$$

where the *magnitude* g of this free fall acceleration has the value

$$g = 9.80\ \text{m/s}^2.$$

Note that, since g is a magnitude of a vector, it is a *positive* value.