Chapter N5: Motion from Forces

N5.2: The Reverse Kinematic Chain

As we say in the last chapter, velocity is the time derivative of position. And acceleration is the time derivative of velocity:

$$v(t) = \frac{dx(t)}{dt} \text{ and } a(t) = \frac{dv(t)}{dt} \,. \tag{1}$$

This tells us how to go from position $x(t)$ to acceleration $a(t)$. And Netwon's second law ($\vec{F} = m\vec{a}$) lets us figure out what force caused the motion.

This chapter is about "working backwards." Given a force, we can figure out an object's acceleration. We can then take anti-derivatives to go from acceleration to velocity, and velocity to position.

N5.3: Graphical Derivatives

Examples:

1. A physics textbook falls straight down at a constant acceleration of 10 m/s^2. Sketch it's acceleration, velocity, and position as a function of time.

2. I drop a TAB mug off a 50 meter cliff. How long does it take to get to the ground?

Practice:

1. A skydiver jumps out of an airplane. She falls toward the earth, and eventually reaches a constant velocity. For each of the following, sketch a free body diagram and net-force diagram:
   (a) The instant after she jumps out of the plane.
   (b) She's been falling for a little while, but hasn't reached her terminal velocity yet.
   (c) She's falling at her terminal velocity.

2. Make a sketch of the sky diver's y, v, and a vs. t.

3. A net force of 100 Newtons is applied to a 25 kg crate of tofu for 3 seconds. Sketch the acceleration, velocity, and position of the box.

4. Starting at 1 AM, green toxic sludge is being released into a lake at a rate of 4 kg per hour. From 2AM to 4AM, the rate of release increases by 2 kg per hour each hour. At 4AM the sludge stops being released. Using graphs, figure out the total mass of sludge released into the lake.