Today’s lesson has two types of application problems.

1) Applications of higher derivatives

- This is the same type of problem that you encountered in [Applications Intro](#ApplicationsIntro) and [These Applications](#TheseApplications).
- As in those lessons, there are some key principles to keep in mind. However, for this lesson there is an additional principle (in bold below), involving the second derivative.
  1. Functions measure stuff.
  2. Derivatives measure how fast that stuff changes.
  3. **The second derivative measures the rate of change of the first derivative.**
  4. All of these measurements depend on an input location.

- You must also recognize what information is given and/or asked for. There are three standard things you must recall from previous applications, and one new thing (in bold).
  1. Function data.
  2. Rate of change data.
  3. **rate of change of the rate of change data.**
  4. Location data.

- You also have to know the appropriate uses of each kind of data.

Physics Vocabulary

- **Velocity** is the rate of change of an object’s position (such as height).
- **Acceleration** is the rate of change of velocity.

- This vocabulary is primarily used when talking about an object’s position and should not be used for other rate of change data (such as rate of change of temperature, rate of change of population, etc).
2) Initial Value Problems

- An Initial Value Problem, or IVP, is a situation where you are given:
  1. The derivative of a function, $f'$, and
  2. One piece of data from the original function, usually, $f(0)$, but sometimes $f$ evaluated at some other point.

You are then asked to find the formula for $f$.

- **Example:** Given $f'(t) = 2t + \sin t$, and $f(0) = 4$, find a formula for $f(t)$.

  **Solution:**
  
  Guess antiderivative, with $+C$:
  
  $$f(t) = t^2 - \cos t + C$$

  Plug in initial value:
  
  $$f(0) = 0^2 - \cos(0) + C = 4$$

  Solve for $C$:
  
  $$0 - 1 + C = 4$$
  
  $$C = 5$$

  Final answer:
  
  $$f(t) = t^2 - \cos t + 5$$

- These problems get more interesting if you start with the **second derivative**, instead of the first derivative. Here is a [Khan Academy example](#).

- IVP problems can and will be combined with the first type of application problems.