**Applications of Differentiation** Calculus of a Single Variable X. Du

- **Related rates**
  - Differentiate with respect to *time* using Chain Rule.
  - Common examples:
    - Pouring water into various geometric shapes
    - Changing angles of elevation of moving objects
- One-dimensional motion of an object
  - Let $x(t)$ be a **position function** of an object with respect to time $t$.
    - Velocity $v(t) = x'(t)$
    - Acceleration $a(t) = x''(t)$
- **Optimization** in a single variable
  - Function of one variable (ex: optimize $y = f(x)$ )
  - Function of two variables given one constraint
    - Ex: optimize $f(x, y)$ with $y = g(x)$ or $g(x, y) = k$ )
    - Plug constraint into function.
  - At the maximum, the derivative must be 0 or undefined (usually 0).
  - Take the derivative. Set equal to 0. Solve.
  - Applications:
    - Economics - optimizing revenue or profit
    - Geometry - optimize with the constraint of a curve or shape
- **L'Hôpital's Rule**
  - Let $f(x)$ and $g(x)$ be differentiable on ($a$, $b$) containing $c$, except possibly at $c$ itself. Assume that $g(x) \neq 0$ for all $x$ in ($a$, $b$), except possibly at $c$ itself. If $\lim_{x \to c} \frac{f(x)}{g(x)}$ yields an indeterminate form, then $\lim_{x \to c} \frac{f(x)}{g(x)} = \lim_{x \to c} \frac{f'(x)}{g'(x)}$ .
  - It may be necessary to apply L'Hôpital's Rule many times to obtain desired result.
- Rate of flow of a fluid through a surface as a function of time
- Rate of change in:
  - Fluid (fluid dynamics)
  - Heat (heat transfer)
  - Mass (mass transfer)
  - etc
- Mathematical modeling