## Announcements

- Bonus homework due Wednesday, 12/5
- Homework 13 due Wednesday, 12/5
- **Final exam: Monday, 12/10, 10:00 to 12:00, BA 057.**
  - **Practice problems posted.**
    (Solutions will be posted by Tuesday.)
  - You can also buy old finals (and solutions) from the math club. See fliers in math building.
  - Bluebooks will be provided
  - (Optional) review session Friday, 12/7, at 1:00 in CH 107
- Extra office hours this week:
  - Tuesday: 10:00 to 11:30
  - Wednesday: 10:00 to 11:30
  - Thursday: 10:00 to 11:30
  - Friday: review at 1:00

## 2nd Fundamental Theorem of Calculus

Let $f(t)$ be continuous on the interval $[a, b]$, and define the function $G$ by the integral equation

$$G(x) = \int_a^x f(t)\, dt$$

for $a \leq x \leq b$. Then $G$ is an antiderivative of $f$ on $[a, b]$.

That is,

$$G'(x) = \frac{d}{dx}\left[\int_a^x f(t)\, dt\right] = f(x)$$

## Integration by substitution

This is like the Chain Rule backwards.

Let $f, g$, and $u$ be differentiable functions of $x$ such that

$$f(x) = g(u)\frac{du}{dx}$$

Then

$$\int f(x)\,dx = \int g(u)\frac{du}{dx}\,dx = \int g(u)\,du = G(u) + C$$

where $G$ is an antiderivative of $g$.

## Substitution with definite integrals

If $f(u)$ is a continuous function of $u$ and $u(x)$ is a differentiable function of $x$, then

$$\int_a^b f[u(x)]u'(x)\,dx = \int_{u(a)}^{u(b)} f(u)\,du$$

## Substitution with definite integrals

We have two methods for evaluating a definite integral with substitution:

1. Use substitution to evaluate the indefinite integral, then evaluate the result between the original limits of integration.
2. Change the limits of integration to conform to the change of variable $u = u(x)$ by making the limits of integration $u(a)$ and $u(b)$.