1

# Math 211

Lecture #1

Introduction

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2

## Welcome to Math 211

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3

## Ordinary Differential Equations with Linear Algebra

- Applications & modeling.
  - ◇ Mechanics, electric circuits, population genetics epidemiology, pollution, pharmacology, personal finance, etc.
- Analytic solutions.
- Numerical solutions.
- Qualitative analysis.
  - ◇ Properties of solutions without knowing what they are.

4

## Math 211 Web Page

Official source of information about the course.
http://www.owlnet.rice.edu/~math211/ .

5

## What Is a Derivative?

- The rate of change of a function.
- The slope of the tangent line to the graph of a function.
- The best linear approximation to the function.
- The limit of difference quotients.
- Rules and tables that allow computation.

6

## What Is an Integral?

- The area under the graph of a function.
- An anti-derivative.
- Rules and tables for computing.

7

## Differential Equations

$$y' = f(t, y) \qquad y' = 2ty$$

- $t$ is the *independent variable*.
- $y$ is the *unknown function*.
- This equation is of order 1.

8

## Equations and Solutions

$$y' = f(t, y) \qquad y' = 2ty$$

A solution is a function y(t), defined for t in an interval, which is differentiable at each point and satisfies

$$y'(t) = f(t, y(t))$$

for every point $t$ in the interval.

- Example $y'(t) = 2ty(t)$.

9

## Example: $y' = 2ty$

Claim: $y(t) = e^{t^2}$ is a solution.

- Verify by substitution.
  - ◇ Left hand side: $y'(t) = 2te^{t^2}$
  - ◇ Right hand side: $2ty(t) = 2te^{t^2}$
- Therefore $y' = 2ty$.
- Verification by substitution is always available.

10

## Types of Solutions

For the equation $y' = 2ty$

- $y(t) = \frac{1}{2}e^{t^2}$ is a solution. It is a *particular solution.*
- $y(t) = Ce^{t^2}$ is a solution for any constant $C$. This is a *general solution.*

General solutions contain arbitrary constants.
Particular solutions do not.

11

## Initial Value Problem

A differential equation & an initial condition.

- Example: $y' = -2ty$ and $y(0) = 4$.
- General solution: $y(t) = Ce^{-t^2}$.
- Plug in the initial condition:

$$y(0) = 4,$$
$$Ce^0 = 4,$$
$$C = 4$$

Solution to the IVP: $y(t) = 4e^{-t^2}$.

12

## Normal Form of an Equation

$$y' = f(t, y)$$

Example: $(1 + t^2)y' + y^2 = t^3$

- Solve for $y'$ to put into normal form:

$$y' = \frac{t^3 - y^2}{1 + t^2}$$