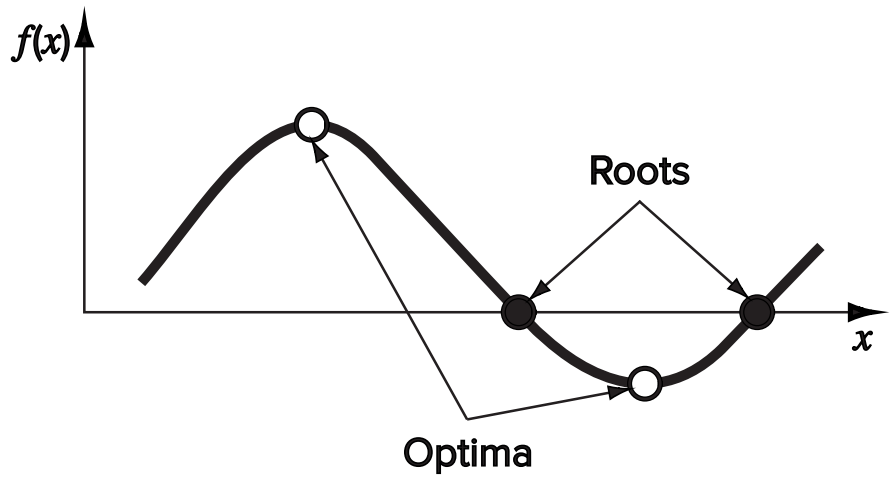
Introduction

- mathematical problems
- numerical methods
- course information

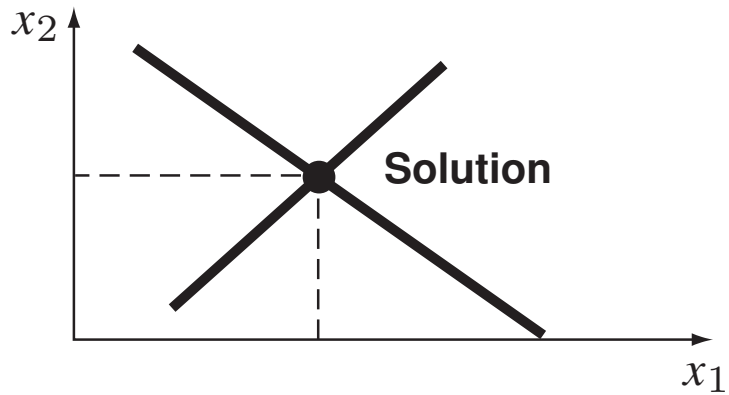
Roots and optimization

- roots: solve $f(x) = 0$ for x
- optimization: find x that minimize or maximize $f(x)$



Linear equations

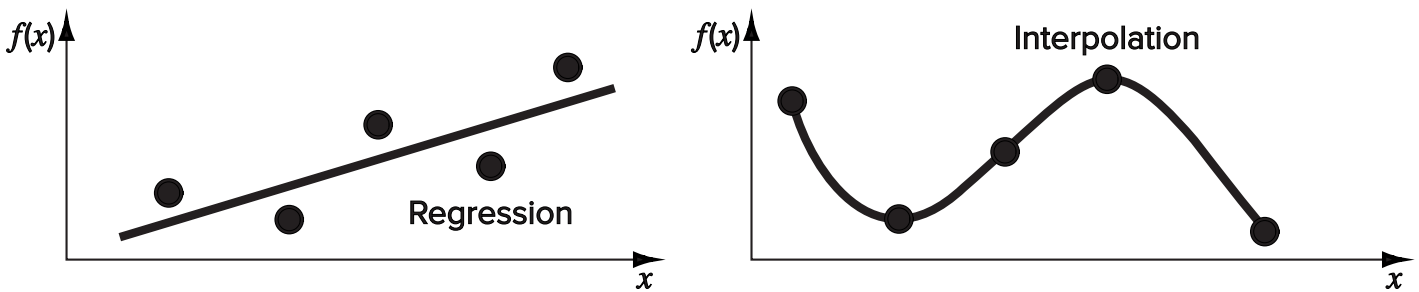
solve $Ax = b$ where A is a matrix and b is a vector



$$a_{11}x_1 + a_{12}x_2 = b_1$$
$$a_{21}x_1 + a_{22}x_2 = b_2$$

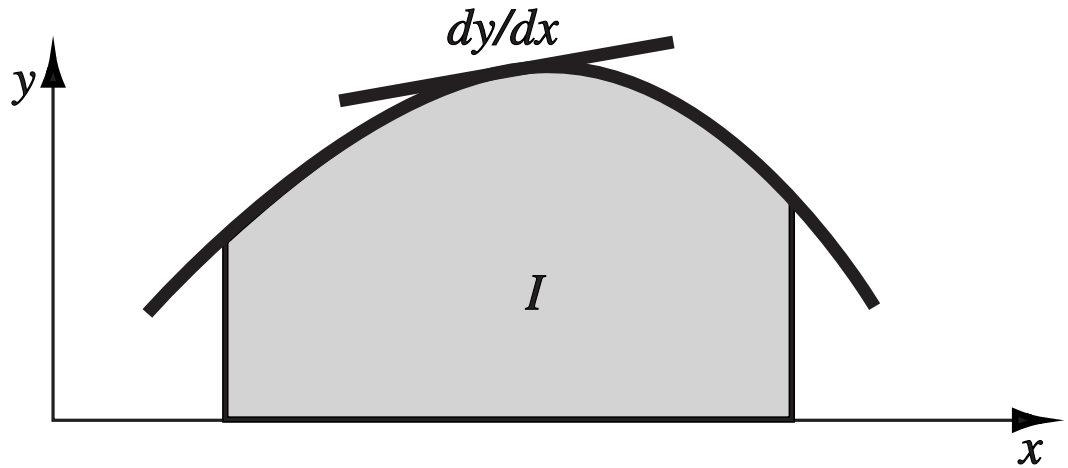
Curve fitting: regression and interpolation

- regression: find $f(x)$ that 'best' fit a given points
- interpolation: find $f(x)$ that exactly passes through given points



Integration and differentiation

- integration: find area under the curve $I = \int_a^b f(x)dx$
- differentiation: find slope of curve $\frac{dy}{dx}$



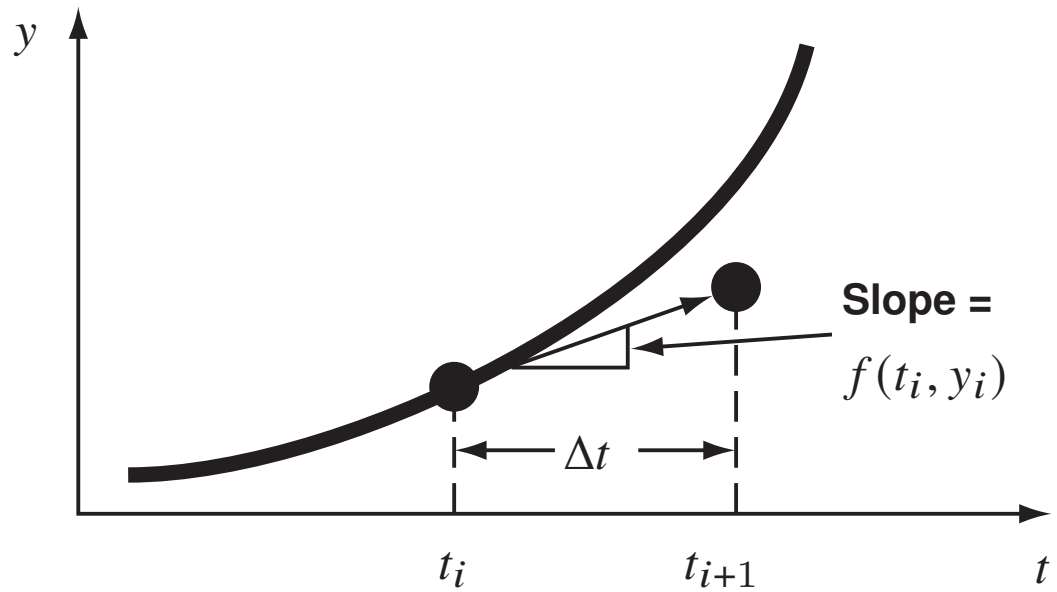
Ordinary differential equations

given

$$\frac{dy}{dt} = f(t, y)$$

solve for y as a function of t

$$y_{i+1} = y_i + f(t_i, y_i)\Delta t$$

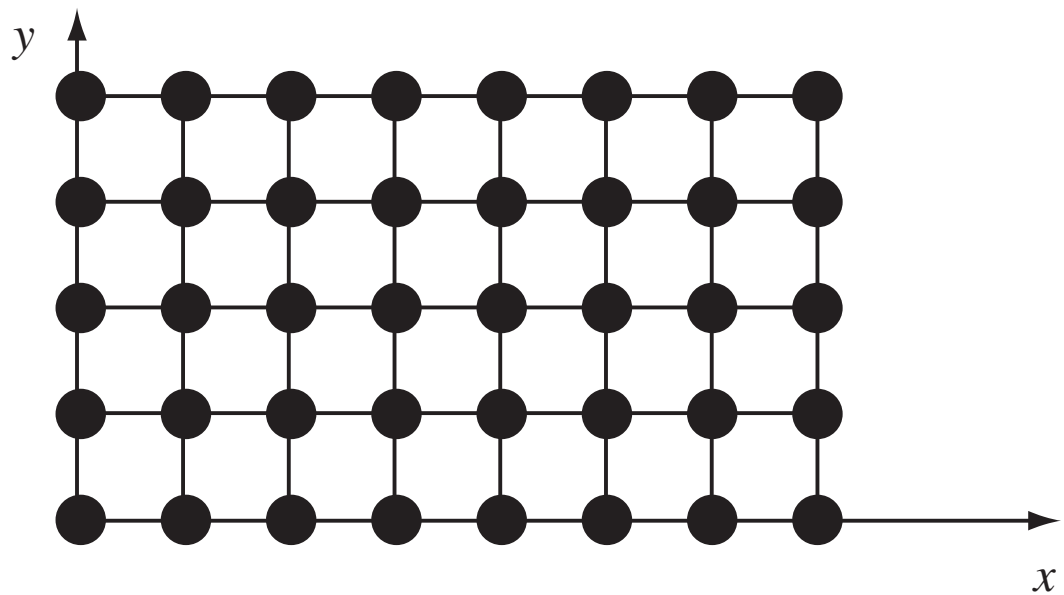


Partial differential equations

given

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = f(x, y)$$

solve for u as function of x, y



Outline

- mathematical problems
- **numerical methods**
- course information

Numerical methods

Numerical methods: techniques used to obtain approximate solutions to mathematical problems via arithmetic operations

- used when analytical solutions are difficult or impossible
  - most mathematical problems cannot be solved exactly
- widely applied in engineering and sciences
- often use an iterative algorithm that ultimately converges to a solution

Numerical errors: numerical computing involves the presence of errors

- results of computations are approximate
- goal: ensure the resulting error is tolerably small

Problem solving process

- mathematical models formulated to explain observed phenomena
- develop algorithms for efficient, accurate, and reliable solutions
- implement algorithm in computer to simulate/solve physical process numerically
- interpret and validate the computed results

Problem solving environment

high-level languages for numerical computing:

- MATLAB
- Julia
- Python
- R
- ...

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Course information

Textbook

S. C. Chapra and R. P. Canale. *Numerical Methods for Engineers* (8th edition). McGraw Hill, 2021.

Reference

S. C. Chapra. *Applied Numerical Methods with MATLAB for Engineers and Scientists* (5th edition). McGraw Hill, 2023.

Grading

- homework (5%)
- quizzes (15%)
- two midterm exams (40%)
- final exam (40%)

(see syllabus on Moodle for detailed information)

Course topics

- numerical errors
- roots of nonlinear equations
- numerical solution of linear and nonlinear system of equations
- least squares regression
- interpolation
- numerical integration
- numerical differentiation
- ordinary differential equations
- boundary-value problems

References and further readings

- S. C. Chapra and R. P. Canale. *Numerical Methods for Engineers* (8th edition). McGraw Hill, 2021.
- S. C. Chapra. *Applied Numerical Methods with MATLAB for Engineers and Scientists* (5th edition). McGraw Hill, 2023.