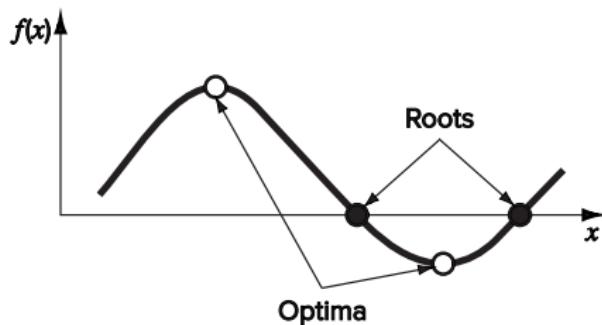


# Introduction

- mathematical problems
- numerical methods
- course information

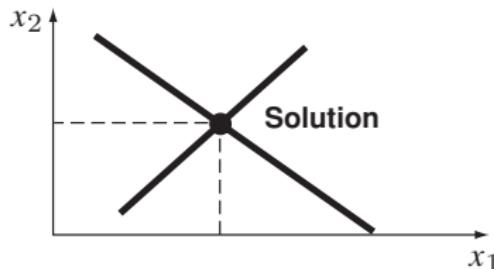
## Roots and optimization

- 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

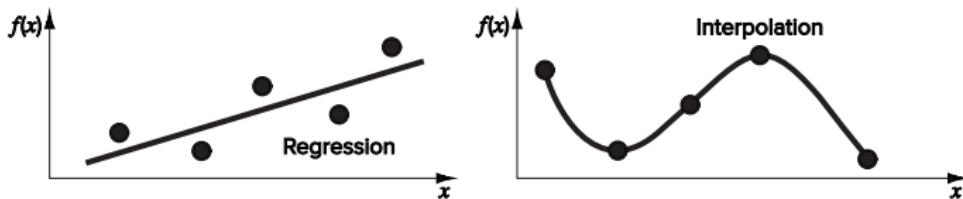


$$a_{11}x_1 + a_{12}x_2 = b_1$$

$$a_{21}x_1 + a_{22}x_2 = b_2$$

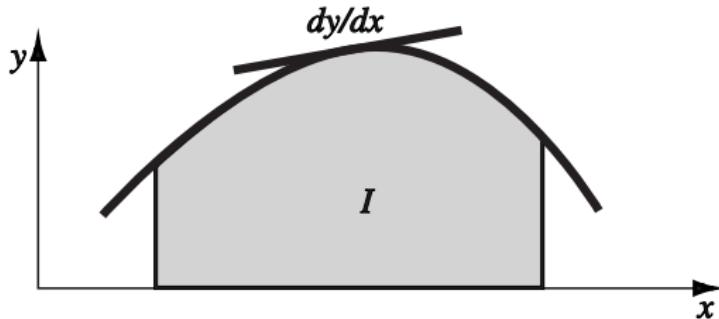
## Curve fitting: regression and interpolation

- 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  $\frac{dy}{dx}$



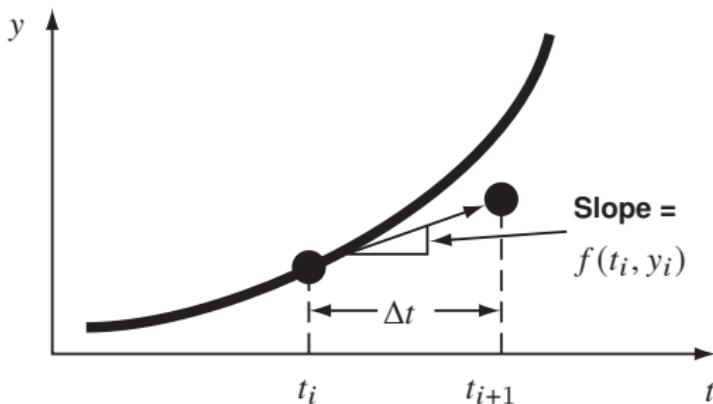
# Ordinary differential equations

given

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

solve for  $y$  as a function of  $t$

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

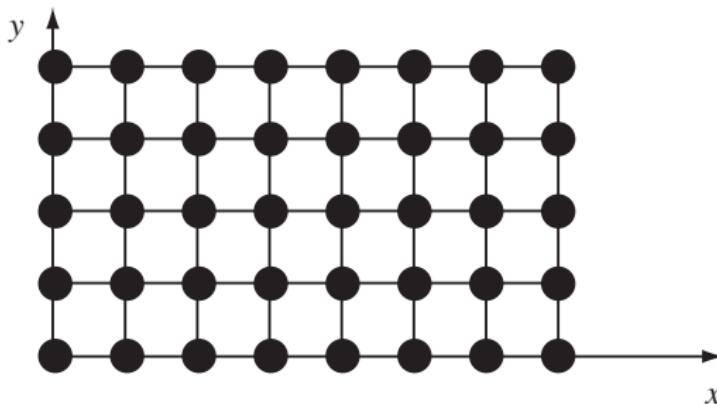


## Partial differential equations

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
- ...

# Outline

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

# 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 non-linear 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.