# Chapter 1

# Introduction

## 1.1 February 2, 2005

Handouts: Syllabus, Heat conduction

Circulate signup sheet: name, username, course (if not 3)

- Introductions: me, Randy, TA Wanida Pongsaksawad.
- What is covered: review stuff on general overview. Lots of complexity: structure formation, some process engineering, cost modeling.
- Necessary for all classes of materials, draws on wide range of examples:
  - Polymers: synthesis, injection molding, extrusion, membranes
  - Bio: drug delivery, anisotropic diffusion, blood flow
  - Ceramics: glass ceramics, powder separation, drying, sintering
  - Electronic: crystal growth, CVD, diffusion processing
  - Metals: smelting, refining, casting, heat treatment
- Why 3.044 is important: processing-(structure)-properties-performance. We do low-cost, high-quality processing, low environment overhead, which is one of the two important aspects of this triad/tetrahedron.

  Sponsors of our work care about two things: low-cost high-quality processes and high performance. They don't care about structure. Andy Groves, chairman of Intel, could care less about the electronic structure of titanium silicide-titanium aluminide diffusion barriers in aluminum interconnects, he wants cheap high-quality processes that result in high performance. Closer to home, parents' eyes glaze over at talk of "Kinetics of eta phase precipitation in nickel superalloys," but not at "Avoiding catastrophic failure of jet engine turbine blades in service." Structure provides an important way to model the relationship between processing and properties, without which a black box, not a science.

Randy New sections on engineering economics: cost modeling, material and process selection, market size. Life cycle analysis. Intro to stuff in new Fall course.

**Mechanics**

- Discuss grading: HW points and collab, double-session tests, mixed final.
- Little project: suggest on note cards any time.
- Get test conflict dates, aim for Weds. March 9–11 and April 20–22.

- Make sure everyone has a recitation.
- Schedule office hours.
- Discuss travel: out 2/14, David Dussault covering, tradition of having previous TA give a lecture.

**Required math**

- Vector arithmetic (dot product, cross product, outer product)
- Vector calculus (gradient, divergence, curl)
- Solving homogeneous linear ordinary differential equations, e.g.

$$y'' = k, \quad \text{or} \quad y'' - ky = 0 \tag{1.1}$$

- What partial differential equations look like, e.g.

$$\nabla^2 C = 0 \tag{1.2}$$

- The error function and derivatives:

$$\text{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-\xi^2} d\xi \tag{1.3}$$

$$\frac{d}{dx}\text{erf}(x) = \frac{d}{dx}\frac{2}{\sqrt{\pi}} \int_0^x e^{-\xi^2} d\xi = \frac{2}{\sqrt{\pi}} e^{-x^2} \tag{1.4}$$

- The substantial derivative: the time derivative in a moving frame.

$$\frac{D}{Dt} = \frac{\partial}{\partial t} + \vec{u} \cdot \nabla \tag{1.5}$$

  Kind of like moving vector $x(t), y(t), z(t)$:

$$\left.\frac{dC}{dx}\right|_{(x,y,z)} = \frac{\partial C}{\partial t} + \frac{\partial C}{\partial x}\frac{\partial x}{\partial t} + \frac{\partial C}{\partial y}\frac{\partial y}{\partial t} + \frac{\partial C}{\partial z}\frac{\partial z}{\partial t}. \tag{1.6}$$

**Previous feedback**

- Prof. Powell is cool, lectures are great, double tests are neat!
- Too much busy algebra on problem sets. Okay, will cut quite a bit, some computer.
- Textbook is awful. It covers things in the wrong order, and is hard to read. Changing to set of texts, better readings. Hopefully will cover all material without problems.
- Too much online. But taking it off would only hurt those without Bibles. Sorry, won't do.
- Prof. Powell lets "dumb" questions slow things down. No dumb questions. Very often correct mistakes or omissions, ten others have the same question. If anything, MIT juniors and seniors need to be much more vocal! (Last mid-term evaluation, dreadful lecture...)