Chapter 1

Introduction

1.1 September 3, 2003

Handouts: syllabus, ABET, Diffusion, PS1 due Monday 9/8.
  Circulate signup sheet: name, username, year, course

- Introductions: me, Albert.

- What is covered: review stuff on general overview. Lots of complexity: from single ODE to five fully-coupled nonlinear second-order PDEs in five field variables.

- Intro to the general transport methodology: conservation and constitutive equations

$$\text{accumulation} = \text{in} - \text{out} + \text{generation} \tag{1.1}$$

  Discuss the "terms", with a flying eraser.
  Microscopic and macroscopic.

- Necessary for all classes of materials, ask how many are interested in each:

    - Polymers: synthesis, injection molding, membranes (Bo)
    - Bio: drug delivery, anisotropic diffusion, blood flow (cool)
    - Ceramics: powder synthesis, separation, drying, sintering
    - Electronic: crystal growth, CVD, diffusion
    - Metals: smelting, refining, casting, heat treatment

- Why 3.185 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.

Mechanics

- Discuss grading: HW points and collab, double-session tests, mixed final.

- Get test conflict dates, aim for Weds. 10/15–17, 11/19–21.

- Make sure everyone has a recitation.

- Schedule office hours.

- Discuss travel: three trips, none of which should impact 3.185. If one more, 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.

$$y'' = k, \quad \text{or} \quad y'' - ky = 0 \tag{1.2}$$

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

$$\nabla^2 C = 0 \tag{1.3}$$

- The error function and derivatives:

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

$$\frac{d}{dx}\text{erf}(x) = \frac{d}{dx}\frac{2}{\sqrt{\pi}} \int_0^x e^{-\xi^2} d\xi = \frac{2}{\sqrt{\pi}} e^{-x^2} \tag{1.5}$$

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

$$\frac{D}{Dt} = \frac{\partial}{\partial t} + \vec{u} \cdot \nabla \tag{1.6}$$

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

$$\left.\frac{dC}{dx}\right|_{(x,y,z)} = \frac{\partial C}{\partial t} + \frac{\partial C}{\partial x}\frac{\partial x}{\partial t} + \frac{\partial C}{\partial y}\frac{\partial y}{\partial t} + \frac{\partial C}{\partial z}\frac{\partial z}{\partial t}. \tag{1.7}$$

Previous feedback

- Prof. Powell is cool, lectures are great, double tests are neat!

- This course spent way too much time on diffusion. Okay, will cut a bit shorter this time. But non-3.01s will be lost, need to see TA or me.

- Too much busy algebra on problem sets. Okay, will cut quite a bit, some computer.

- Problem sets should be due on Friday instead of Monday, for last-minute recitation help. Poll class, incl. PS1 Mon or Weds?

- Textbook is awful. It covers things in the wrong order, and is hard to read. Changing to new textbook, better readings, but still wrong order. Also see Incropera and DeWitt, in Reading Room; old text there too.

- TLL: "muddiest part", index cards for each lecture from Friday, started last year, need more.

- 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...)