MATH 484: Course Outline and Overview

Prologue:

Physical Modeling
Biological and Chemical as subsets
Different characteristic length and time scales-
Quantum Mechanics; Classical Mechanics (Particles); Statistical Mechanics; Continuum Mechanics; Classical Mechanics (Macroscopic); General Relativity

PDEs**:** Often, three main varieties (actually many more) –
Waves (Hyperbolic), Diffusion (Parabolic), Multi-dimeinsional Steady states (Elliptic)

Modules:

1. Crystal Precipitation & Oswald Ripening (Chapter 1 – Friedmann)

Read 1.1-1.3, 1.8-1.10, 1.13
HW: 1.8.1, 1.8.3, 1.10.2, 1.10.3, 1.10.4, 1.13.1, 1.13.2

Day 1: Modeling overview – assumptions, parameters, unknowns
Physical process and model

Day 2: Crystals of single size: Steady states – how many; computation

Day 3: Crystals of multiple sizes – dissolution, reduction to single size case

2. In-host Disease dynamics and HIV modeling (A Biomathematical Approach to HIV and AIDS, Chapter 10 from Mathematical Biology: An Introduction with Maple and Matlab - Shonkwiler and Herod)
HW: Handout Problem #2, and 3 of my own problems – local stability analysis and antiretroviral therapy

Day 1: Biological process
Basic HIV model - progression within a host; big factors – Latency and Mutation

Day 2: Simulation of basic model + stability Analysis (Hartman-Grobman Thm; Routh-Hurwitz Thm)

Day 3: Viral mutation model – analysis & computation

3. Air Quality Control: Diffusion and Finite Difference Methods (Chapter 2 – Friedmann)

HW: 2.4.1, 2.4.2, 2.4.4, 2.5.2, 2.6.1
2.7.2, 2.7.5, 2.7.6, 2.8.3, Stencil for Lax-Wendroff and accuracy

Day 1: Physical process – advection; Method of characteristics & examples

Day 2: Introduction to Finite Difference Methods – write method and code for advection

Day 3: Additional details – add diffusion, spatial dependent velocity, general (2D) advection

Day 4: Stability analysis of FDM + Consistency implies

4. Aggregation of Slime Mold Amebae (What is Applied Mathematics? – Ch1 of Lin & Segal)

HW: Lin and Segal Problems 2 and 3, FTBS (and Diffusion) for aggregation

Day 1: Biological background & formulation of model
Uniform steady states & beginning of stability analysis

Day 2: Finish stability analysis
Computational approximation with FDM

5. Electron Beam Lithography: Scattering, Kernels, and Inverse Problems (Chapter 3 – Friedmann)

HW: 3.3.3, 3.5.1, Fourier series computation, Fejer series computation

Day 1: Formulation of model & Direct vs Inverse Problem
Equivalence of scattering kernel and solution to heat equation
Forward problem – code

Day 2: Finish Forward problem
Inverse Problem – separation of variables
Inverse Problem – Fourier approximation & code

Day 3: Finish coding Fourier approximation
Fejer sums & renormalization of Fourier approximation
Code Fejer sums and solve Inverse Problem

6. Development of Color Film Negative: Implicit Finite Difference Methods (Chapter 4)

HW: 5.7.3 or 4.6.1 (Implicit)

Day 1: Formulation of Model – Nonlinear Reaction-Diffusion model
Implicit FDM for Diffusion equation
Solving Linear System via LU factorization or backslash operator

Day 2: Stability Analysis – unconditional stability!
Code method

OPTIONAL

7. Catalytic Converter – Variational & Control problems (Chapter 5 – Freidmann)

HW: 5.7.3, 5.8.1

FINAL PROJECT
Proposal - Due in early March
Progress Report – Due in early April
Presentation – During last two weeks of class
Final Report – Due early May (finals week)