Course Announcement: Math 6790 Spring 2012

Case Studies in Computational Engineering and Science

The course consists of 4 segments — 4 case studies, taught by 4 instructors. The goal is to show active research. Each segment defines a scientific or engineering problem, describes how it is formulated as a mathematical problem, and shows how computations have been used to attack that problem and give new insight into the original scientific/engineering problem.

1. Chaos, predictability, and the butterfly effect: Applications to numerical weather forecasting

Prof. Thomas Reichler, Atmospheric Sciences, thomas.reichler@utah.edu.

Predicting how atmospheric winds will evolve represents an interesting and challenging problem. This class will discuss techniques that are commonly used to solve such a problem, including numerical solutions of partial differential equations using finite differencing. During the first half of the course we will use such techniques to explore the predictability properties of the famous 3-equation Lorenz system. Later, we will explore how these concepts can be applied to the problem of weather prediction. In the main class project, each student is expected to program a simple but insightful atmospheric forecast model that is based on the solution of one simple equation.

2. Lagrangian modeling of particle transport

Prof. William Johnson, Geology & Geophysics, william.johnson@utah.edu.

Predicting pathogen and other particle transport in the subsurface (how far should septic systems be from drinking water wells?)

Answering a practical question by Lagrangian modeling of particle transport in porous media. Involving simulation of particle trajectories based on force and torque balances of physico-chemical processes of diffusion, fluid drag, gravity, and DLVO (Derjaguin, Landau, Verwey, and Overbeek) forces in simple representative flow fields in porous media.

3. Mathematics and Materials

Prof. Yekaterina Epshteyn, Mathematics, epshteyn@math.utah.edu.

We will start this course by first discussing numerical and mathematical tools used to study problems in Material Sciences. Modeling and analysis of polycrystalline materials will be of particular interest in this course. Most technologically useful materials are polycrystalline microstructures composed of a myriad of small monocrystalline grains separated by grain boundaries. Grain boundaries are dynamic, driven by an interfacial energy that forces some grains to shrink and disappear, others to grow. The result is a general coarsening process of a large metastable network that is a rich subject of research for mathematicians and materials scientists.

Different approaches to the problem, as well as the recent progress and open questions in the area will be presented as a part of this module.

4. Computational Modeling in Biological Fluid Dynamics

Prof. Aaron Fogelson, Mathematics, fogelson@math.utah.edu.

In this case study we will look at how fluid dynamic problems arise in biological systems. What is noteworthy about biofluid problems that distinguishes them from many engineering fluid dynamics problems is that large deformations of the objects 'containing' (blood vessel, heart) or 'contained' (cells) in the fluid are common. The motion of the fluid and these deformable objects must be solved for simultaneously. We will discuss and use computational methods for attacking such problems.

If you have questions about the course, contact *Prof. Alexander Balk, Mathematics*, balk@math.utah.edu, JWB 304, 801-581-7512. For questions about a particular segment, contact the instructor, teaching that segment.

Tuesday, Thursday, 2-3:20 pm, HEB 2002