Math 617 Introduction to Industrial Mathematics
Fall Semester, 2008

The variety of mathematical methods used in industry covers the whole spectrum of mathematics. Given the limited time to develop valuable methodologies and discuss in some detail case studies in this new course, the methodologies and case studies focused on *partial differential equation models*. In fact, to avoid getting bogged down in physics, the concentration was on mass and heat transfer problems. The structure of the course was: (i) a mini-course in continuum mechanics; (ii) a development of a number of industrial case studies; (iii) a team project and presentation. For the background continuum mechanics, gave lectures on dimensional analysis and scaling, conservation principles and constitutive relations. After that we plunged into some case studies, drawn mostly from Mathematical Problems in Industry workshops. The topics we discussed and developed at least initial models for were:

- Drilling holes with a laser to determine the speed of the drilling
- Continuous casting of steel: feasibility of a method to manufacture thin steel sheets
- Factory fires: determining what thickness of sawdust layer on hot fiberboard presses might initiate spontaneous ignition
- Desaltation plants: reverse osmosis and the problem of salt build-up on the semi-permeable membranes
- Development of bread crust in the commercial process of baking bread
- Cooking of cereal grain: following temperature and moisture fronts to get proper consistency of the cooked product
- Optimization of furrow width for conserving water in an irrigation problem
- Operation of automotive catalytic converters in warm-up phase: an optimization approach
- Heat and current flow in a thermistor: estimating the temperature switch point
- Modeling the electric railroad pantograph

Each case study involves starting with stating a general (physical) problem and a specific question, giving some general background, and then developing an initial mathematical model to address the question. Most of the case study problems involve some transformation or approximation technique that is introduced, and then applied to a simpler problem or two so that participants can become a bit more familiar with the technique. Then we returned to the original industrial model. So the learning objectives include:

1. learn some of the types of questions that arise in industry;
2. learn some mathematical modeling principles;
3. learn some analytical techniques for attacking linear and nonlinear ordinary and partial differential equations beyond Math 225 and Math 404 material;
4. learn that there are interesting and challenging problems from industry.

We also rely mostly on classical analysis rather than develop numerical approaches. For that it is necessary to have, as prerequisites, a background in Math 225 and 404, and some familiarity with a high level programming language. Course grade is derived from homework exercises and a semester project. Teams are formed and presented with a list of potential projects, though teams can propose other topics for study. What is required is developing a model, being precise about assumptions, and solving it in some way to explain a certain question. A written report is required along with the team giving an oral presentation of their project to the class.

The course is part of a departmental track in industrial mathematics, but is open to other students.