**Modeling**

**Instructor:** Bengt Fornberg  
Office hours: To be announced.  
e-mail: fornberg@colorado.edu

**Lectures:** MWF 11.00 - 11.50 am in ECCR 131

**Text book:** A preliminary book manuscript is posted on the class web page.

**Assignments:** Assignments will be posted on the class web page.

**Final exam:** Thursday, December 17, 4:30- 7:00 pm (time to be used for final projects that have not been presented earlier)

**Final grade:** About (or just over) half of the final score will come from the Final Project; other factors are earlier assignments (presentations), and in-class quizzes. Course attendance, if low, can also be a factor. See section “Course Grading” below.

**Course motivation:**

The 'life-blood' of all parts of applied mathematics is applications. In spite of that, both analytical and numerical techniques are traditionally taught in very 'encyclopedic' fashions (and as two entirely separate subjects). Key techniques are often enumerated in manners which are better suited for reference works than for first introductions. In contrast, this course will be centered on examples of how one carries through all the steps: problem -> mathematical formulation -> theoretical analysis -> numerical solution. The goals of the course include

- provide illustrating examples of major modeling tasks of current significance,
- convey practical approaches of how to approach problems not originally stated in mathematical form, and
- introduce a number of key techniques from analysis and numerics (only at the points where these are needed).

We will discuss topics only according to what we need to have available in order to resolve specific issues, as they arise in a handful of primary modeling problems. These problems have been selected in such a way that, between them, they involve (and can serve as a first introduction to) a broad range of interconnected analytical and numerical methods. The presently planned topics are (unlikely all will be covered):

- Tomographic image reconstruction - e.g. as applied for medical diagnosis,
• Freak ocean waves - isolated giant waves, which frequently severely damage or sink large ships in certain parts of the oceans,
• GPS - Global Positioning System; satellite-based system for accurate navigation,
• Seismic forward modeling - a key procedure in exploring for oil and gas,
• Automated facial recognition from images,
• Multi-dimensional data display/modeling through use of radial basis functions - novel, revolutionary approach to extract much more information out of complex data sets than previously possible.

The course, in its present form, was first taught in the fall of 96. Its motivation comes from several recent studies of 'industrial needs', for example as expressed in SIAM Report on Mathematics in Industry. This report lists as most significant traits for non-academic mathematicians:

• skill in formulating, modeling and solving problems from diverse and changing areas
• interest in, knowledge of, and flexibility across applications,
• knowledge of and experience with computation,
• communication skills (spoken and written), and
• adeptness at working with colleagues (teamwork).

Many references on mathematical modeling and information on classes taught, books published and projects carried out in this area can be found by searching on 'Mathematical Modeling' on the web.

**Course grading:**

This is a type of course that is well suited for Pass/Fail grading. However, that can cannot be used as default, and grades will need to be assigned (apart from for students who, on an individual basis, request P/F early in the semester).

The following is a general outline of how grades will be assigned. More details (and possible changes) will be discussed in class as the semester progresses.

<table>
<thead>
<tr>
<th>Project 1:</th>
<th>Individual presentation</th>
<th>15 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 2:</td>
<td>Team presentation</td>
<td>15 points</td>
</tr>
<tr>
<td>In-class mini-exams (likely of multiple choice type)</td>
<td>20 points</td>
<td></td>
</tr>
<tr>
<td>Final Project:</td>
<td></td>
<td>50 points</td>
</tr>
</tbody>
</table>

Regarding the final project, a number of factors will be considered, such as:
- Project plan; Originality of topic; Proportion of own novelties vs. materials from the literature;
- Programming effort; Overall effort; Clarity of presentation; Presentation 'style' / enthusiasm.

Even if ultimately unsuccessful, a strong effort with explorations into unknown territory will be ranked higher than a successful one that follows well-trodden paths.

While some general project feedback will be given in class, all students are strongly encouraged to discuss their individual standing during office hours.