

MECH 434/534 Computer-Based Modeling and Simulation

What is this course about ?

This is an introductory course in physics-based modeling and simulation and it is unique in a way that it has not been adopted from any other course. From one point of view, this is a course in applied physics and mechanics. From another point of view, the course teaches numerical methods and graphical simulation techniques for interactive 3D simulation. *In a nutshell, this course builds up the necessary knowledge and practical skills to develop graphical and numerical solutions to physics-based problems.* Students spent several hours in the computer laboratory where they get hands-on experience in computer programming, numerical computing, and graphics programming in front of a computer. In addition, the web-site of the course contains links to several resources for students to extend their knowledge through self-learning. The course contains 4 layers of teaching: (note: If time permits, we additionally discuss the probabilistic simulation techniques):

- 1) **C/C++ Programming:** This is the base layer. While the aim of the course is not to teach a programming language, it is necessary to develop computer programs using C/C++ language in the course. For this reason, we review the basic concepts of C/C++ language and the object oriented programming.
- 2) **Numerical Computing:** This layer teaches students how to solve physics-based problems using numerical methods. Students will learn the basic methods of numerical computing in the course, but mainly use “Numerical Recipes” in their homework and project assignments. Numerical Recipes is a well-known and online numerical computing library which contains several subroutines written in C/C++/Fortran languages.
- 3) **Graphical Simulation:** This layer teaches students how to use computer graphics for interactive simulation and visualization of the numerical solutions (Note that this layer does not aim to teach “computer graphics”). We mainly discuss the basic concepts of 3D computer graphics such as 3D transformations, shape modeling, and discrete event scheduling and handling. Students will use “Open Inventor” graphics toolkit in their homework and project assignments. Open Inventor is a well-known and freeware graphics library (built on top of Open GL) which contains several classes written in C++ language.
- 4) **Physics-based Modeling:** This layer teaches students how to model the physics of motion using the fundamental concepts mechanics and dynamics. Typically, the models of physical systems covered in the course are highly complex and it is almost impossible to obtain their analytical solutions. Students develop models to simulate the behavior of these systems. We mainly focus on the three areas of physics-based modeling (a project assignment is given to students for each area):
 - **Physics of Rigid Body Dynamics and Contact**
 - **Physics of Particle Systems and Constraint Handling**
 - **Physics of Elastic Objects and Deformation**

