Course Syllabus: Intro to Mathematical Modeling - AMCS 332

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	AMCS 332
Course Title	Intro to Mathematical Modeling
Academic Semester	Spring
Academic Year	2018/2019
Semester Start Date	01/27/2019
Semester End Date	05/23/2019
Class Schedule (Days & Time)	01:00 PM - 02:30 PM | Mon Wed

Instructor(s)

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Teaching Assistant(s)

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Course Information

Comprehensive Course Description	Modelling of systems from the real world stands at the beginning of Mathematics. Mathematical theories like analysis have been developed mainly as tools to model problems from Physics. The first principlles form Physics are the basis of our modelling approach. Real systems are distinguished by their enormous complexity and variability. That is why mathematical modelling and computational simulation of those systems is difficult, in particular thinking of detailed models which are based on first principles. The difficulties start with geometric modelling which needs to extract basic structures from highly complex and variable phenotypes, on the other hand also has to take the statistic variability into account. Moreover, the models of the processes running on these geometries are not yet well established, since these are equally complex and often couple many scales in space and time. Thus, simulating such systems always means to put the whole frame to test, from modelling to the numerical methods and software tools used for simulation. These need to be advanced in connection with validating simulation results by comparing them to experiments. To treat problems of this complexity, novel mathematical models, methods and software tools are necessary. In recent years, such models, numerical methods and tools have been developed, allowing to attack these problems. As paradigms for the process of modelling and simulation we present our approach to problems like the computation of eigenmodes of lakes, to modelling the diffusion of xenobiotics through human skin and to signal processing in neurons. Questions like geometric reconstruction of cell anatomies from microscopic data are treated as well.
Course Description from Program Guide	An introduction to mathematical modeling through a combination of practical problemsolving experience and applied mathematics techniques, including dimensional analysis, non-dimensionalization, asymptotic expansions, perturbation analysis, boundary layers, computing and other topics.
Goals and Objectives	The students are introduced to the basic techniques of mathematical modelling. The goal of the course is to enable them to setup PDE based models for problems from Science and Technology.
Required Knowledge	Basic mathematics is required. Knowledge in analysis, functional analysis, PDE and numerics is useful.
Reference Texts	A script will be available during the course.
Method of evaluation	**67.00**% - Final exam **33.00**% - Active participation
Nature of the assignments	Acrtive participation
Course Policies	as usual
Additional Information	

Tentative Course Schedule *(Time, topic/emphasis & resources)*		
Week	**Lectures**	**Topic**
1	Mon 01/28/2019 Wed 01/30/2019	1. Modelling and Simulation 1.1 Introduction 1.2 Partial differential equations of 2nd order
2	Mon 02/04/2019 Wed 02/06/2019	1.3 Discretisation 1.3.1 Morphology discretisation 1.3.2 Time discretization
3	Mon 02/11/2019 Wed 02/13/2019	1.3.3 Space discretization by finite differences 1.3.4 Finite volumes
4	Mon 02/18/2019 Wed 02/20/2019	1.4 Solvers
5	Mon 02/25/2019 Wed 02/27/2019	2. Modeling Biological Barrier Membranes 2.1 Introduction
6	Mon 03/04/2019 Wed 03/06/2019	2.2 Permeation of xenobiotics through human skin 2.2.1 The brick and mortar model 2.2.2 Characterization of membranes by lag time
7	Mon 03/11/2019 Wed 03/13/2019	2.2.3 The cuboid model
8	Mon 03/18/2019 Wed 03/20/2019	2.2.4 The tetrakaidekahedra model
9	Mon 03/25/2019 Wed 03/27/2019	Spring Break
10	Mon 04/01/2019 Wed 04/03/2019	3. Modeling Signal Processing in Neurons 3.1 Introduction
11	Mon 04/08/2019 Wed 04/10/2019	3.2 Reconstruction of Morphology from microscope data 3.2.1 The inertia-based diffusion filter, 3.2.2 The Neuron Reconstruction Algorithm (NeuRA)
12	Mon 04/15/2019 Wed 04/17/2019	3.3 Generation of realistic networks of neurons (NeuGen) 3.4 Classification of neuron morphologies (NeuClass)
13	Mon 04/22/2019 Wed 04/24/2019	3.5 A 3d model for passive signal transduction
14	Mon 04/29/2019 Wed 05/01/2019	3.6 The HodgkinHuxley model 3.7 A 3d model for active signal processing
15	Mon 05/06/2019 Wed 05/08/2019	Eigenmodes of Lakes 4.1 Introduction and history 4.2 The model 4.2.1 The geometry 4.2.2 Shallow water equations
16	Mon 05/13/2019 Wed 05/15/2019	4.3 Numerics 4.4 Results
17	Mon 05/20/2019 Wed 05/22/2019	Final Exam Week

Note

The instructor reserves the right to make changes to this syllabus as necessary.