MATH 162
Mathematical Models and Computational Science

Course Description
Introduction to mathematical and computational modeling using high-level computer programming languages such as C++. Implementation of parallel algorithms for solving linear systems, systems of differential equations and running stochastic simulations on high performance CPU and GPU computer clusters.

Prerequisites
MATH 031 with a grade of C- or better, MATH 135A with a grade of C- or better; or equivalent; or consent of instructor.

Textbooks
Mathematics for Modeling and Scientific Computing (2016) by Goudon

Introduction to Mathematical Biology (Modeling, Analysis, and Simulations) (2016) by Ching-Shan Chou and Avner Friedman
eBook ISBN: 978-3-319-29638-8
Hardcover ISBN: 978-3-319-29636-4

Introduction to Parallel Computing by A. Grama, A. Gupta, G. Karypis, V. Kumar
ISBN-0-201-64865-2

Professional CUDA C Programming by J. Cheng, M. Grossman, T. McKercher
ISBN-978-1-118-73932-7

References
Iterative Methods for Linear and Nonlinear Equations (1995) by C.T. Kelley

Introduction to High Performance Scientific Computing (2019) by David L. Chopp

Numerical Recipes in C: The Art of Scientific Computing (2nd edition) by W. Press, S. Teukolsky, W. Vetterling, B. Flannery

Suggested Lecture Schedule

Week #	Topic(s)
1	Intro to C/C++ programming: pointer, dynamic theory allocation, class, template, etc. Discussion/Lab – Practice how to define scalar/vector variables, mathematical functions in C/C++, implement basic calculations
2, 3	Parallel computing, MPI basics Discussion/Lab – Practice parallel algorithms such as matrix multiplication, fast Fourier transform

4, 5	Parallel algorithms for implementing direct and iterative methods for solving system of linear equations Discussion/Lab – Solve linear systems using iterative or non-iterative methods
6, 7	Computing on GPUs Discussion/Lab – Solve ordinary differential equation systems using Euler method or Runge Kutta methods
8	OpenMP basics Discussion/Lab – Solve partial differential equations e.g. reaction-diffusion equations in CPU with information obtained from GPU
9	Monte Carlo and stochastic simulations (simple examples) Discussion/Lab – Implement cell deformation or cell division using subcellular element method
10	Final presentations