

# CEE 6513, Computational Methods in Mechanics

## Fall 2023, Georgia Institute of Technology

**Instructor:** Dr. Phanish Suryanarayana, Mason 5139A

Lectures: Mon, Wed 9:30-10:45 pm, Cherry Emerson 322

Office Hours: Mon (11:00 am - 12:00 pm), Wed (12:00 - 12:30 pm, 1:30 - 2:00 pm)

### 1 Textbook

There is no textbook for this course. However, the following references will be useful.

- *Finite Difference Methods for Ordinary and Partial Differential Equations*, R. LeVeque, SIAM, ISBN-13: 978-0898716290.
- *Mesh Free Methods: Moving Beyond the Finite Element Method*, G.R. Liu, CRC Press, ISBN-13: 978-0849312380.
- *Chebyshev and Fourier Spectral Methods*, J.P. Boyd, Dover Publications, ISBN-13: 978-0486411835.
- *Spectral Methods in MATLAB*, L.N. Trefethen, SIAM, ISBN-13: 978-0898714654.
- *Introduction to the Finite-element method*, P. Papadopoulos, Course notes. Available online.

### 2 Grading

- Homeworks - 70%
- Final Project - 30%

### 3 Objectives

- Introduce the method of weighted residuals and variational methods.
- Develop a theoretical understanding of finite-elements, finite-differences, and spectral methods. Learn how to solve ordinary and partial differential equations using these methods. Further, learn the applicability and limitations of these methods.
- Learn how to implement the above mentioned computational methods using Matlab/python/C++.

### 4 Outline

- **Partial Differential Equations**
  - Elliptic equations
  - Parabolic equations

- Hyperbolic equations
- Eigenvalue problems
- **Methods of Weighted Residuals**
  - Galerkin methods
  - Collocation methods
  - Least-squares methods
  - Composite methods
- **Variational Methods**
  - Introduction to variational principles
  - Weak forms
  - Rayleigh-Ritz method
- **Finite-element methods**
  - Finite-element approximations
  - Error estimates - rates of convergence
  - Numerical Integration - quadrature
  - Spectral finite-elements
  - $h$  and  $p$  adaptivity
- **Finite-difference methods**
  - Finite-difference approximations
  - Accuracy, stability and convergence
  - Runge-Kutta methods
  - Linear multistep methods
- **Spectral methods**
  - Differentiation matrices
  - Discrete Fourier Transform and Fast Fourier Transform
  - Smoothness and spectral accuracy
  - Polynomial interpolation and clustered grids
- **Numerical methods for linear and nonlinear systems**
  - Direct methods for linear systems
  - Iterative methods for linear systems
  - Nonlinear solvers
  - Eigensolvers
  - Symmetry: application to lattice structures
- **Machine learning**
  - Data-driven computational mechanics
- **Parallel programming**
  - MPI
  - GPU acceleration

## 5 Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit <http://www.catalog.gatech.edu/policies/honor-code/> or <http://www.catalog.gatech.edu/rules/18/>. Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations. Please note the following specific information pertaining to homeworks and project for this class.

- You are allowed to discuss homework problems with other students. However, you must write up and turn in your own solutions. Please, do not copy the solution or part of the solution from anyone else, even if you have discussed the procedure together.
- The project has to be your work alone. No form of discussion (verbal or otherwise) with anyone else is permitted.

## 6 Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or <http://disabilityservices.gatech.edu/>, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

## 7 Miscellaneous

- Regularly check Canvas for updates. All announcements and homeworks will be posted on Canvas.
- No electronic communication of any kind is allowed during lectures (i.e. No cell phones, etc).
- There will be a grader for the course: Shashikant Kumar, Mason 5139, Office hours: Tue, Thur, 12:00 - 1:00 pm.
- I might have to travel for Georgia Tech related work. In such a scenario, the lectures will be recorded and posted on Canvas.