AME60714: Advanced Numerical Methods

Course logistics

AME60714: Advanced Numerical Methods, 3 units
Lecture: MW 2:20p-3:35p, 138 DeBartolo Hall

Course description

Theory and implementation of advanced numerical methods to solve and optimize linear and nonlinear partial differential equations (PDEs) with particular emphasis on hyperbolic PDEs and (compressible) computational fluid dynamics. In the first part of the course, the foundational theory of hyperbolic partial differential equations including conservation laws, characteristics, Riemann problems, and Rankine-Hugoniot jump conditions, will be discussed. These concepts will be used to construct numerical methods for approximating solutions of hyperbolic PDEs including finite volume and high-order discontinuous Galerkin methods. The second part of the course will build upon the theory and methods developed in the first part to delve into more advanced topics including Arbitrary Lagrangian-Eulerian (ALE) formulations to solve PDEs on moving domains, optimization problems constrained by partial differential equations including boundary control and shape optimization, and model reduction methods to reduce the computational cost of solving PDEs. Aspects of software design (version control, continuous integration) and verification will also be discussed, as well as advanced programming tools such as automatic and symbolic differentiation and code generation.

Learning goals

Upon successful completion of this course, students will have: (1) fundamental understanding of hyperbolic partial differential equations and their solutions, (2) familiarity with basic and advanced methods for computational fluid dynamics, (3) understanding of advanced numerical methods including PDE-constrained optimization and model reduction, (4) ability to apply and implement the methods introduced in the course to solve relevant problems that arise in research.

Prerequisites

Numerical methods (AME60611 or equivalent)

Instructor

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