Lectures: Monday and Wednesday 13:00-14:15 in CASEB30B
Office Hour: Wednesday between 15:00-16:00 or by appointment
TA: Muhammad Irfan; Room: ENG-Z20


Additional References:

Objectives: This course is designed to teach students computational methods for solving partial differential equations (PDEs). Although emphasis will be placed on fluid and heat flow equations, the methods can be applied to solve virtually any PDE or system of PDEs encountered in science and engineering.

Learning Outcomes:
Upon successful completion of this course, a diligent student will:
- understand the governing equations of fluid flow in various forms and their mathematical properties;
- understand the main numerical methods used to solve fluid flow problems, spatial and temporal discretizations;
- understand the underlying principles for analysis of numerical approximations, the concepts of accuracy, consistency, stability and convergence;
- demonstrate the knowledge and understanding of the state-of-the-art CFD methods used in engineering practice, research and development for compressible and incompressible flows;
- set up appropriate initial and boundary conditions;
- implement the numerical methods using a high level computer program, use mesh generators to produce appropriate meshes for analysis, use post-processing softwares and produce graphical representation of the numerical results;
- recognise the potential sources of numerical error and uncertainty, differentiate and quantify different numerical errors, understand the concepts of verification and validation, and be able to perform credible computational simulations;
- demonstrate the his/her acquired skills in applying commercial/open-source CFD software packages to practical engineering problems.

Topics to be covered (Tentative):
Introduction (Chapter 1 and 2) (2 Lectures)
Fluid mechanical topics and a review of PDEs
Basics of Discretization Methods (Chapter 3) (5 Lectures)
Finite differences, finite difference representation of PDEs, numerical errors, consistency, stability and convergence, Fourier or von Neumann analysis
Hyperbolic Systems of PDEs (Chapters 4 and 6) (8 Lectures)
Explicit and implicit schemes, numerical dissipation and dispersion, modern schemes for the hyperbolic equations, treatment of boundary conditions, complex geometries and finite volume formulation.

**Elliptic and Parabolic Equations** (Chapters 4, 7 and 8) (6 Lectures)
Explicit and implicit schemes for the heat equation (parabolic equations), Laplace equation (elliptic equations), iterative methods and convergence acceleration techniques.

**Numerical Methods for Navier-Stokes Equations** (Chapter 9) (5 Lectures)
Explicit MacCormack method, Beam-Warming scheme, Upwind methods, pressure correction algorithms.

**Complex Geometries** (Chapters 10) (2 Lectures)
Structured and unstructured grid systems and grid generation techniques.

**Tests:**
There will be a midterm and a final test. All homeworks and exams may require programming on a digital computer using a high-level programming language such as Fortran, C or MATLAB. Some assignments and exams may require computational modelling of complex fluid flows using the commercial or open source CFD software such as Fluent and OpenFOAM.

**Grading (Tentative):**
1) Quizzes, Homework Assignments, **Projects** 25%
2) Midterm 35%
3) Final Exam 40%

**Time commitment and ECTS credit:**

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<th>Activity</th>
<th>Number</th>
<th>Time (hrs)</th>
<th>Predicted Total Work Load (hrs)</th>
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<td>Lectures</td>
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<td>HWs/Project/Reading</td>
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<td>Lab/Tutorial</td>
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<tr>
<td>Midterm Exams</td>
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