The Hong Kong University of Science and Technology

UG Course Syllabus

Introduction to Aerospace Computational Fluid Dynamics (CFD)

MECH 3740

3 credits

Pre-requisite: MECH 3640

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Course Description:

This course introduces students to numerical methods for modelling and analyzing fluid flows in aerospace engineering. The course combines theoretical foundations with practical applications, emphasizing both conceptual understanding and computational implementation of modern CFD techniques. The course content progresses from the fundamental governing equations of fluid motion through discretization and solution methods for partial differential equations. Students will learn about practical numerical implementation strategies, while developing expertise in setting up, running, and validating CFD simulations and following best practices. Additional emphasis is placed on data pre-processing and post-processing, flow visualization, and physical interpretation. Through hands-on training sessions, students will simulate and analyze canonical flows relevant to aerospace engineering. These practical cases connect theoretical concepts to real workflows while building end-to-end computational expertise.

Intended Learning Outcomes (ILOs):

By the end of this course, students should be able to:

1. Explain the fundamental principles of CFD, including the governing equations, discretization methods, and boundary conditions.
2. Construct and validate CFD models by selecting appropriate numerical schemes and meshing strategies.
3. Perform CFD simulations using state-of-the-art software.
4. Analyze and interpret CFD data through visualization and quantitative methods to extract meaningful flow physics.

Assessment:

Assessment Task	Contribution to Overall Course grade (%)
Lab 1	50%
Lab 2	50%

Required Texts and Materials:

Computational Methods for Fluid Dynamics (Ferziger, Peric, Street) and *Fundamentals of Aerodynamics* (John Anderson).

AI Policy:

The use of generative artificial intelligence (AI) is permitted.

Course Outline:

1. Introduction + Review of Fluid Dynamics
   - Conservation laws
   - Governing equations: derivation, analysis and physical interpretation
   - OpenFOAM
2. Numerical Methods in CFD
   - Finite difference method
   - Finite volume method
   - Spatial and temporal discretization
   - Numerical accuracy and stability
3. Meshing
   - Structured vs. unstructured grids
   - Grid refinement and convergence
4. Turbulence Modeling
   - Reynolds-Averaged Navier−Stokes (RANS) equations: closure problem
   - Selecting a turbulence model
5. Advanced Topics
   - Immersed boundary methods
   - High-order numerical schemes
   - CFD for supersonic flows