Online M. Tech. in Computational Mechanics

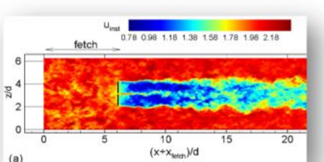
Department of Mechanical and Aerospace Engineering
Indian Institute of Technology, Hyderabad

Highlights

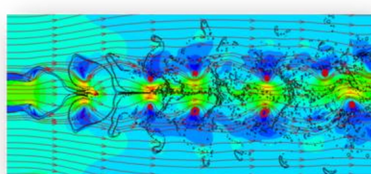
- **Industry-oriented learning.** Courses tailored for industry-working professionals.
- **Immense learning.** Hands-on learning with several state-of-the-art theory and lab courses to benefit their professional career.
- **Breadth.** Cover a broad range of topics on computational methods ranging from FEM, CFD, Optimization, Additive Manufacturing.
- **Immersive learning.** Live interactive sessions coupled with self-paced learning.
- **No GATE score required.** Selection based on an interview where the academic and professional background will be assessed.
- **Earn master's degree without leaving your job.** Learn while you earn, with the flexibility to complete the program between 2-4 years.
- **Learn from our expert faculty** from the Department of Mechanical and Aerospace Engineering, IIT Hyderabad.
- **Networking**. Opportunity to create a meaningful network with diverse professionals.

Program

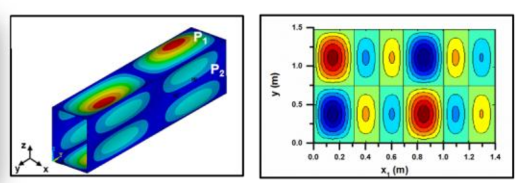
The online M. Tech. in Computational Mechanics is a unique program offered by the Department of Mechanical and Aerospace Engineering, started in August 2021, that will train students to solve multidisciplinary problems related to mechanical systems using computational techniques



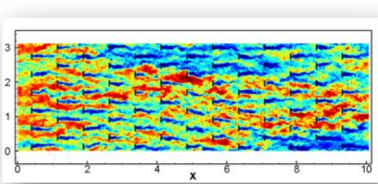
Large-eddy simulation of a multi-rotor wind turbine



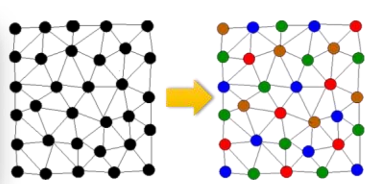
Computation of sprays and atomization



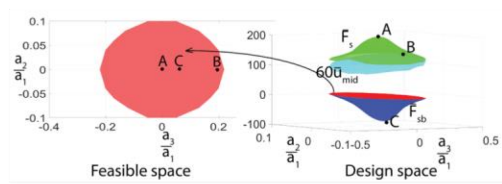
Duct and Equivalent Plate Mode Shapes



Turbine wakes simulation in large wind farms



CFD Solver Parallelization on CPU/GPU architectures



Design space and optimal profiles of bistable arches

. Computational tools are ubiquitous in mechanical, aerospace and allied industries and form an integral part of the engineering design process today. Training in advanced computational techniques will greatly broaden the spectrum of opportunities available to graduates.

The program combines elements of numerical methods and scientific computing with fundamental principles in solid mechanics, fluid mechanics, design and vibrations. Courses covering fundamentals of numerical analysis will be complemented with hands-on training using wide-ranging examples drawn from various domains of engineering. The program will benefit industry professionals looking to build expertise in the area looking to address technological challenges in industries in the automotive, oil and natural gas, renewable energy, defense and manufacturing sectors.

Eligibility

- B. E./B. Tech. with first class (60%) in Mechanical, Aerospace, Civil or Chemical engineering or other equivalent degrees
- Should be currently working in industry with a minimum of 2 years of industry experience after B. Tech.

The selection will be based on the candidates' background along with performance in a written test and/or interview, which will be conducted online between April-May 2024.

Duration and Structure

Option 1: M. Tech. (CM) with thesis - up to 4 years.

- Total 48 Credits (Course Credits: 24 + Thesis Credits: 24)
- Courses can be done over up to three years.
- Thesis will be done in the final year (maximum 4th year) after course work.

Option 2: Executive M. Tech. (CM) without thesis - up to 3 years.

- Total 24 Course Credits.
- Courses can be done over up to three years.

Thesis:

- Students will do their project in their own industry.
- The project can be started only after coursework worth 24 credits is completed.

- During the project, each candidate will have a guide from IITH and may have another from his/her industry.

Format

- Online live and self-paced sessions will be conducted.
- Classes will be separate from regular courses.
- Classes will be held in the evening and at weekends based on faculty availability.
- Examinations will be conducted online.
- Students will do their project in their own industry. The project can be started only after coursework worth 24 credits is completed. During the project, each candidate will have a guide from IITH and may have another from his/her industry.
- Opportunity to meet experts and experience IITH campus during campus visits.

Curriculum

Semester	Course	Credit	Course Title
Semester 1/3/5 (Total 13 credits)			
Odd	ME5139	3	Finite Element Method
Odd	ME5339	3	Computational Fluid Dynamics
Odd	ME5899	2	Structural Optimization
Odd	ME5769	1.5	Applied Solid Mechanics
Odd	ME5779	1.5	Applied Fluid Mechanics
Odd	ME5909	2	Additive Manufacturing Technology
Semester 2/4/6 (Total 11 credits)			
Even	ME5789	3	Computational Dynamics and Vibrations
Even	ME5819	3	Advanced Computational Fluid Dynamics
Even	ME5799	3	Topics in Computational Mechanics
Even	ME5429	1	FEM Lab
Even	ME5449	1	CFD Lab
Semester 3/5/7 (Total 12 credits in any one semester)			
Odd	ME6005	12	Project
Semester 4/6/8 (Total 12 credits in any one semester)			
Even	ME6505	12	Project

Total: 48 Credits

Fee Details

Category	Fee Details
Non-government organizations	• Semester Fee of Rs. 15,000/- per semester* • Rs 20,000/- per course credit • Rs 5,000/- per thesis credit
Governmental Organization & IITH alumni	• Semester Fee of Rs. 15,000/- per semester* • Rs 10,000/- per course credit • Rs 5,000/- per thesis credit

* Semester fee must be paid throughout the program until the program requirements are completed.

More Details

Contact Us:

Course coordinator:	Dr. Sai Sidhardh (ocm@mae.iith.ac.in)
Head, Mechanical and Aerospace Engineering, IIT Hyderabad:	Prof. Ashok Kumar Pandey (head@mae.iith.ac.in)

Course Descriptions

ME 5139 - Finite Element Methods

Theory and implementation of finite element methods for solving boundary value problems in solid mechanics. Mathematical foundations (Calculus of Variation), review of energy theorems, theory and implementation of 1D, 2D, and 3D elasticity problems. Introduction to FEM softwares.

References

1. R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt, “Concepts and Applications of Finite Element Analysis”, Wiley, 2001.
2. O. C. Zienkiewicz and R. L. Taylor, J. Z. Zhu, “The Finite Element Method: Its Basis and Fundamentals”, Butterworth-Heinemann, 2013.
3. A. F. Bower, “Applied Mechanics of Solids”, Online Resource: http://solidmechanics.org/, CRC Press, Taylor & Francis, 2010.
4. R. J. Boulbes, “Troubleshooting Finite-Element Modeling with Abaqus”, Springer, 2020.

ME 5339 - Computational Fluid Dynamics

Introduction to numerical solutions of PDEs; importance of CFD; various methods; Taylor Series; Finite-difference of first, second and third derivatives; Order of accuracy; finite-differences on non-uniform grids; time-stepping; explicit and implicit time-stepping of 1D unsteady heat conduction equation; Boundary and Initial conditions; tri-diagonal solver; Explicit and Implicit schemes for 2D unsteady heat conduction equation; Gauss-Seidel method; Convergence; iterative vs direct methods; Types of PDEs, and their IC and BCs; the well-posed problem; Methods of Elliptic PDE; False-transient method; Hyperbolic PDEs; 1st order wave equation: characteristics; Methods: Lax, McCormack etc; modified equation; dissipative and dispersive errors; systems of hyperbolic equations; diagonalization; Finite-volume method; Convection-Diffusion equation; Convective schemes: Upwind, 2nd upwind, Quick, etc; Vorticity-stream function formulation: Explicit, Implicit and Semi-Implicit schemes; coupled temperature equation; segregated and coupled solution methods; SMAC method for Navier-Stokes equations.

References

1. J. D Anderson, “Computational Fluid Dynamics” McGraw-Hill International Editions, Series in Mechanical Engineering, 1995.
2. J. C. Tannehill, D. A. Anderson, R. H. Pletcher, “Computational fluid mechanics and heat transfer”, Taylor and Francis, 1997.
3. T. K. Sengupta, “High accuracy computing methods”, Cambridge University Press, 2013.

4. H. K. Versteeg, W. Malalasekera, “An Introduction to computational fluid dynamics”, Pearson Education, 2008.

ME 5899 - Structural Optimization

Overview of size, shape and topology optimisation; constrained and unconstrained finite-variable optimization; KKT conditions; sufficiency conditions; analytical size optimization of bars and beams for stiffness, flexibility, strength, and stability criteria in the framework of variational calculus; gradient-based computational optimization of trusses, frames, and continuum structures; sensitivity analysis for parameter, shape, and topology variables; shape optimization; topology optimization; design parameterization for topology optimization of coupled structural problems involving multi-physics domains.

References

1. R. T. Haftka, Z. Gurdal, "Elements of Structural Optimization," Kluwer Academic Publishers, 1992.
2. M. P. Bendsoe, O. Sigmund, "Topology Optimization: Theory, Methods, and Applications," Springer, 2003.

ME 5769 - Applied Solid Mechanics

Introduction to basic solid mechanics, various strain measures and stress tensors, Balance laws, constitutive relations (commonly used energy density functions), special cases through simplification (incompressibility, plane stress and strain, hydrostatic loading, isotropy, linear elasticity), problems in Cartesian and other curvilinear coordinates.

References

1. A. F. Bower, “Applied Mechanics of Solids”, Online Resource: http://solidmechanics.org/, CRC Press, Taylor & Francis, 2010.
2. M. Saad, “Elasticity: Theory, Applications, and Numerics”, Academic Press Inc., Elsevier, 2020.
3. J. R. Barber, “Elasticity”, Springer, 2010.

ME 5779 - Applied Fluid Mechanics

Tensors; Lagrangian and Eulerian frames of reference; Derivation of continuity equation and Navier-Stokes Equations; Elliptic and parabolic equations; Analytical solutions of NS equations; Boundary-layer theory; Turbulence; RANS equations; Introduction to turbulence modelling; Non-dimensionalization and non-dimensional parameters

References

1. P. Kundu, I. Cohen, D. Dowling, "Fluid Mechanics", Academic Press, 2015.
2. H. Schlichting, K. Gersten, "Boundary Layer Theory", Springer, 2016.
3. P. Davidson, "Turbulence: An introduction for Scientists and Engineers", Oxford University Press, 2015.

ME 5209 - Additive Manufacturing

Overview of Rapid Product Development: Product Development Cycle, virtual prototyping, physical prototyping, Solid Modelling: Data formats, conversion, checking, repairing and transmission. Synergic integration technologies, Part slicing and Build Orientation, Area-filling strategies, applications and limitations of RPM. Classification of RPM processes: Sheet Lamination, Material Extrusion, Photo-polymerization, Powder Bed Fusion, Binder Jetting, Direct Energy Deposition. Popular RPM processes. Selection of rapid prototyping, tooling and manufacturing systems based on product requirements. Energy sources and their interactions with feedstock.

References

1. B. Stucker, D. Rosen, I. Gibson, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", Springer-Verlag, 2015.
2. P. K. Venuvinod, W. Ma, "Rapid Prototyping, Laser-based and Other Technologies", Springer, 2004.
3. W. M. Steen, J. Mazumder, "Laser Material Processing", Springer-Verlag, 2003.

ME 5789 - Computational Dynamics and Vibrations

Governing equation and Generalized method: Newton's method, Virtual work principle, Euler-Lagrange method. Newton Raphson method, Runge kutta method, numerical tolerances and its control. Basics of linear vibration: 1 DOF linear vibration equation under free, forced and arbitrary forcing, Extension to MDOF system, Methods to solve linear equations. Basics of nonlinear vibration: 1 DOF nonlinear equation, Method to solve the equation: Perturbation methods.

References:

1. D. Greenwood, "Principle of Dynamics", Pearson, 1987.
2. L. Meirovitch, "Fundamental of Vibrations", Waveland Press Inc., 2010.
3. A. H. Nayfeh, D. T. Mook, "Nonlinear Oscillations", Wiley, 1995.
4. W. T. Thomson, "Theory of Vibrations With Applications", Pearson, 1997.

ME 5819- Advanced Computational Fluid Dynamics

Finite-volume method; pressure problem for incompressible Navier-Stokes equations; Pressure-velocity decoupling; Staggered and collocated grids; semi-explicit (SMAC) method on staggered grids; Convective schemes; Implicit SIMPLE method; higher-order accuracy implementations; Non-orthogonal grids: problems with staggered grids; collocated grid; implementation of semi-explicit and implicit schemes on rectangular collocated grids; generalization to collocated non-rectangular hexahedral grids; Boundary conditions and their implementation; adaptation of schemes to tetrahedral grids, general hybrid grids; advanced linear equations solvers; algebraic multigrid methods.

References

1. J. C. Tannehill, D. A. Anderson and R. H. Pletcher, " Computational fluid mechanics and heat transfer", Taylor and Francis, 1997.
2. J. Ferziger, M. Peric, R. Street, "Computational Methods for Fluid Dynamics", Springer, 2020.
3. H. K. Versteeg and W. Malalasekera, "An Introduction to computational fluid dynamics", Pearson Education, 2008.
4. T. K. Sengupta, "Fundamentals of Computational Fluid Dynamics", University Press, 2004.

ME 5799 – Topics in Computational Mechanics

A collection of modules (equivalent to 0.5 or 1 credit each) focusing on specialized multidisciplinary topics like Impact Mechanics, Fluid-Structure Interaction, Parallel Computing.

ME 5429 - FEM Lab

Finite element methods for solving boundary value problems in solid mechanics. Introduction, Spatial Modelling, Geometric discretization, Element Library, Material Modelling, Loading and Boundary Conditions, Constraints, Surface/Interfaces modelling, Step and job handling and Post-processing. FEA Implementation and Visualization of 1D Problems, Truss Problem, Beam bending, Plane and axisymmetric Problems and 3D problems. Various analysis such as, Static, Transient, Harmonic, Modal, Dynamics and Multi Physics (Thermomechanical, etc).

References

1. R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt, "Concepts and Applications of Finite Element Analysis", Wiley, 2001.
2. O. C. Zienkiewicz and R. L. Taylor, J. Z. Zhu, "The Finite Element Method: Its Basis and Fundamentals", Butterworth-Heinemann, 2013.
3. A. F. Bower, "Applied Mechanics of Solids", Online Resource: http://solidmechanics.org/, CRC Press, Taylor & Francis, 2010.
4. R. J. Boulbes, "Troubleshooting Finite-Element Modeling with Abaqus", Springer, 2020.

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ME 5449 - CFD Lab

Introduction and concepts of finite volume methods, Integral form of Navier-Stokes equations. Concepts of pressure and density-based solvers. Introduction to Ansys Workbench, basics of Design Modeler, Structured and unstructured meshing, Ansys fluent setup, solution and post processing. Laminar and turbulent viscous incompressible flow problems (2D and 3D Analysis). Compressible flow problems, Combustion modelling. Introduction to OpenFOAM solver.

References

1. Ansys Fluent documentation: Tutorial and Theory guide
2. H. K. Versteeg, W. Malalasekera, “An Introduction to computational fluid dynamics”, Pearson Education, 2008.
3. OpenFOAM Tutorial and User Guides, https://cfd.direct/openfoam/documentation/