

SCHOOL OF MECHANICAL ENGINEERING

M.Tech Applied Computational Fluid Dynamics

Curriculum & Syllabi (2022-2023 batch onwards)



VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

• Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- **World class Education**: Excellence in education, grounded in ethics and critical thinking, for improvement of life.
- **Cutting edge Research**: An innovation ecosystem to extend knowledge and solve critical problems.
- **Impactful People**: Happy, accountable, caring and effective workforce and students.
- **Rewarding Co-creations**: Active collaboration with national & international industries & universities for productivity and economic development.
- **Service to Society**: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

• To be a leader in imparting world class education in Mechanical Engineering, leading to nurturing of scientists and technologists of highest caliber who would engage in sustainable development of the globe.

MISSION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To create and maintain an environment fostering excellence in instruction & learning, Research and Innovation in Mechanical Engineering and Allied Disciplines.
- To equip students with the required knowledge and skills to engage seamlessly in higher educational and employment sectors ensuring that societal demands are met.



M.Tech Applied Computational Fluid Dynamics

PROGRAMME OUTCOMES (POs)

PO_01: Having an ability to apply mathematics and science in engineering applications.

PO_02: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints, including public health, safety, culture, society and environment.

PO_03: Having an ability to design and conduct experiments, as well as to analyse and interpret data, and synthesis of information.

PO_04: Having an ability to use techniques, skills, resources and modern engineering and IT tools necessary for engineering practice.

PO_05: Having problem solving ability- to assess social issues (societal, health, safety, legal and cultural) and engineering problems.

PO_06: Having adaptive thinking and adaptability in relation to environmental context and sustainable development.

PO_07: Having a clear understanding of professional and ethical responsibility.

PO_08: Having a good cognitive load management skills related to project management and finance.



M.Tech Applied Computational Fluid Dynamics

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Automotive Engineering) programme, graduates will be able to

- **PSO_1:** Compute, Design, Model, Simulate and Analyse various fluid flow and heat transfer problems using numerical techniques for applications in Aerospace, Automotive, Biomedical, Chemical, Environmental and Energy Engineering.
- **PSO_2:** Adopt a multidisciplinary approach to solve real-world industrial problems involving Mass, Momentum and Energy transport processes.
- **PSO_3:** Independently carry out research / investigation to solve practical problems and write / present a substantial technical report/dissertation.



M.Tech Applied Computational Fluid Dynamics

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

- 1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.
- 2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.
- 3. Graduates will function in their profession with social awareness and responsibility.
- 4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.
- 5. Graduates will be successful in pursuing higher studies in engineering or management.
- 6. Graduates will pursue career paths in teaching or research.

Agenda Item 66/8

To consider and approve the new academic programme, curriculum and course contents for Master of Technology in Applied Computational Fluid Dynamics

ANNEXURE – 4

Proceedings of the 66th Academic Council (16.06.2022)

Master of Technology in Applied Computational Fluid Dynamics School of Mechanical Engineering

| Programme Credit Structure | Credits | Discipline Elective Courses | 12 |
|--|--|--|----------------------|
| Discipline Core Courses Skill Enhancement Courses Discipline Elective Courses | 24 05 12 | MCFD601L Computational Aerodynamics MCFD602L Chemically Reacting Flows - Combustion | 3 0 0 3 2 0 0 2 |
| Open Elective Courses Project/Internship | 03 | MCFD602P Chemically Reacting Flows - Combustion Lab | 0 0 2 1 |
| Total Graded Credit Requirement | 70 | MCFD603L Fluid Structure Interaction MCFD604L Experimental methods for Fluid | 3 0 0 3 2 0 0 2 |
| Discipline Core Courses | 24 L T P C | Flow MCFD604P Experimental methods for Fluid | 0 0 2 1 |
| MCFD501L Transport Phenomena MCFD502L Advanced Fluid Dynamics | 3 0 0 3 3 0 0 3 | MCFD605L Multiphase flows MCFD606L Finite Element Analysis of Solids | 3 0 0 3 3 0 0 3 |
| MCFD503L Advanced Heat Transfer MCFD504L Numerical Methods for Partial Differential Equations | 3003 | and Fluids MCFD607L High Performance Computing MCED607P High Performance Computing | 2002 |
| MCFD504P Numerical Methods for Partial Differential Equations Lab | 0 0 2 1 | Lab | 30021 |
| MCFD505P Computational Fluid Dynamics Lab | 0 0 4 2 | vironmental and Atmospheric Flows | 5005 |
| MCFD506L Numerical Solution of the Navier-Stokes equations | 3003 | MCFD609L Modeling and Simulation of En- ergy Systems | 3 0 0 3 |
| MCFD506P Numerical Solution of the Navier-Stokes equations Lab | 0 0 2 1 | | |
| MCFD507P Advanced Computational Fluid Dynamics Lab | 0 0 4 2 | Open Elective Courses | 03 |
| MCFD508L Turbulence Modelling | 3003 | Engineering Disciplines Social Sciences | |
| Skill Enhancement Courses | 05 | Project and Internship | 26 |
| MENG501P Technical Report Writing MSTS501P Qualitative Skills Practice MSTS502P Quantitative Skills Practice | $\begin{array}{ccccccc} 0 & 0 & 4 & 2 \\ 0 & 0 & 3 & 1.5 \\ 0 & 0 & 3 & 1.5 \end{array}$ | MCFD696JStudy Oriented ProjectMCFD697JDesign ProjectMCFD698JInternship I/ Dissertation IMCFD699JInternship II/ Dissertation II | 02 02 10 12 |

Master of Technology in Applied Computational Fluid Dynamics

Short Syllabus

Discipline Core courses

MCFD501L Transport Phenomena (3-0-0-3)

Tensor analysis - differential operations, integral theorems; Mechanisms of momentum, energy and mass transport- transport properties; Equations of change- isothermal systems, non-isothermal systems, multicomponent systems; Friction factors – internal flow, external flow, steady-state and unsteady-state; Newtonian and non-Newtonian models; Turbulent Flow - temperature distribution; Mass diffusion - heterogeneous and homogeneous chemical reaction; Time-dependent mass diffusion- Equation and solution.

MCFD502L Advanced Fluid Dynamics (3-0-0-3)

Overview of Fluid Dynamics - Lagrangian and Eulerian approaches; Governing Equations of Fluid Flow - Reynolds transport theorem, NS Equations for viscous flow; Potential Flow Theory - Pressure distribution over stationery, rotating cylinders, Conformal transformation, flow over flat plate, cylinder, spherical body and airfoils; Boundary layer Theories - von Karmann Momentum integral equation, Flow separation and recirculation; Turbulent flows - Eddy Viscosity concepts, Laws of the Wall and free shear flows; Compressible Flow - nozzles and diffusers, normal and oblique shock waves; Flow measurement devices - intrusive and non-intrusive techniques.

MCFD503L Advanced Heat Transfer (3-0-0-3)

Governing Laws of heat transfer- heat conduction, convection, thermal radiation; Generalized heat conduction equations for anisotropic inhomogeneous mediums- steady state, unsteady state, analytical and numerical methods; Transient conduction- analytical and numerical methods; Convective heat transfer in external flows- analytical and numerical methods; Notural convection- Combined forced and free convection; Radiation- Radiative Transfer Equation, Radiative properties of surfaces.

MCFD504L Numerical Methods for Partial Differential Equations (3-0-0-3)

Partial Differential Equations- PDE Definition, Elliptic, parabolic, and hyperbolic equations; Interpolation Methods - Operators, Lagrange's methods, Newton's fundamental interpolation, Interpolation by iteration; Solution Techniques for Elliptic equations - Finite difference discretization, Direct and Iterative methods; Parabolic Equations- Initial Boundary Value problems, Consistency, Stability, Convergence, Forward-Time Centered Space, Backward-Time Centered Space, Crank Nicolson, Alternating Direction Implicit; Hyperbolic Equations -Solution properties: Domain of Dependence, Finite difference discretization schemes, Dispersion and Dissipation behaviour; The Finite Element Method- Generalization of the finite element concepts, Basic equations and solution procedure.

MCFD504P Numerical Methods for Partial Differential Equations Lab (0-0-2-1)

Code development for 2D Elliptic equation using Jacobi, Gauss-Seidel and SOR methods; 1D parabolic (Heat equation) using the FTCS method; 2D parabolic equation; 1D advection equation, using the Upwind scheme; 1D convection-diffusion equation, using the FTCS scheme and the upwind scheme; 1D convection-diffusion equation, using finite volume method to implement the FTCS scheme and the upwind scheme; 1D convection-diffusion equation, using finite volume method to implement the FTCS scheme and the upwind scheme; 1D convection-diffusion equation, using finite volume method to implement QUICK scheme; 1D finite element Poisson equation using Conjugate gradient method; Lid-driven cavity problem using vorticity-stream function formulation; Sod's shock tube problem using any two upwind schemes.

MCFD505P Computational Fluid Dynamics Lab (0-0-4-2)

2D/3D geometry creation; Structured mesh generation; Unstructured mesh generation; Simulation of Laminar and turbulent flow; Computational analysis of Shock wave and boundary layer interaction; Simulation of Two-phase flow- VOF model; Numerical analysis of Wake formation behind tandem cylinders; Simulation of blood flow; Computational analysis of tube-in-tube heat exchanger; Simulation of melting of an ice block.

MCFD506L Numerical Solution of the Navier-Stokes Equations (3-0-0-3)

Navier-Stokes equations variants and related mathematical models - Vorticity-stream function equations, Velocity-pressure formulation; Solution algorithms for NS equations - Operator splitting, projection; FVM for Convection-Diffusion Equations - Steady one and multi-dimensional equations; Flux limiter functions; Finite volume steady incompressible Navier-Stokes flow Solver - Pressure correction based incompressible steady flow solvers - staggered grid, NS equations spatial discretization, SIMPLE, SIMPLER, SIMPLEC algorithm and PISO algorithm; Unsteady incompressible NS flow Solver - Explicit, Crank–Nicolson and implicit scheme; Finite volume Implementation of different Boundary conditions; Complex geometries - Body-fitted, Cartesian vs. Curvilinear grids, Structured and Unstructured grids, Spatial discretization, pressure–velocity coupling and face velocity interpolation in unstructured meshes.

MCFD506P Numerical Solution of the Navier-Stokes Equations Lab (0-0-2-1)

Finite difference codes on structured Cartesian grids – For incompressible NS equations in Vorticity/stream function, Velocity/Vorticity, and Velocity/pressure formulations, staggered and collocated grids; Finite volume codes on structured Cartesian grids – For incompressible NS equations in Velocity/pressure formulations, staggered grids; Solution algorithms for incompressible NS equations in Velocity/pressure formulations - Operator splitting, Projection, and Pressure-correction based (SIMPLE, SIMPLEC).

MCFD507P Advanced Computational Fluid Dynamics Lab (0-0-4-2)

3D geometry creation using ICEM CFD; Computational analysis of Jet surface interaction; Supersonic flow over a bump; Simulation of shell and tube heat exchanger; Computational investigation of a hydraulic jump; Analysis of a moving strip in an air stream; Simulation of a blower using multiple reference frames model; Simulation of Species transport and gaseous combustion; Simulation of a porous media; use of user defined function for ANSYS.

MCFD508L Turbulence Modelling (3-0-0-3)

Background of Turbulence Flows - Origin of turbulence, irregularity, three dimensional motions; Statistical Description of Turbulence - Kolmogorov hypothesis, scales of turbulence, energy cascading; Turbulent Transport of Moment and Heat - Reynolds decomposition technique, turbulent stresses, Reynolds' analogy, dynamics of turbulence; Turbulence Modelling - eddy viscosity hypothesis, near-wall treatment; Free Shear Flows - Mixing Layer, wakes and Jets; Wall-Bounded Flows - Channel and pipe flows, Reynolds stresses, turbulent boundary layer equations; Advanced Turbulence Modelling Techniques - Large Eddy simulation (LES), Direct Numerical Simulation (DNS), Detached Eddy Simulation (DES) models.

Discipline Elective courses

MCFD601L Computational Aerodynamics (3-0-0-3)

Aerodynamics/Gas dynamics Concepts - Wing Aerodynamics, Compressibility effects, Transonic Aerodynamics, shock, and expansion waves; Governing equations of compressible flows – Integral conservative form; Numerical Schemes for Euler Equations; Spatial discretization- Structured and unstructured Finite Volume Schemes, Discretization of the Convective Fluxes, Discretization of the Viscous Fluxes; Temporal Discretization-Explicit and implicit Time stepping, Multistage Schemes; Turbulence Modeling Approaches for compressible flow- Favre Averaging, one and two-equation models; Boundary Conditions.

MCFD602L Chemically Reacting Flows - Combustion (2-0-0-2)

Combustion and thermochemistry - flame types; Chemical Kinetics- Elementary reaction rates, Some important chemical mechanisms; Conservation Equations for reacting flows; Laminar flames - premixed flames, diffusion flames; Droplet evaporation and burning - Simple model for droplet evaporation, Simple model of droplet burning; Turbulent flames - Structure of turbulent premixed flames, Turbulent nonpremixed flames; Burning of solids, Simulations using different combustion models.

MCFD603L Fluid Structure Interaction (3-0-0-3)

Governing Equations of Fluid and Structural Mechanics - Continuum Mechanics, Material Laws, Linear Stokes, steady and unsteady Equations, Flow Problems on Moving Domains; Coupled Fluid Structure Interactions (FSI) – Interface Regularity and Boundary Conditions, FSI in ALE and Fully Eulerian Formulation; Discretization techniques for FSI equations - Time Discretization using Shifted Crank-Nicolson, Fractional-step θ method, and Galerkin Methods, Discretization of Interface and moving Interfaces; ALE Formulation –Discretization and Linearization; Finite Elements for FSI in ALE Formulation – Inf-Sup stable FE-Spaces, Stabilised Finite elements; Fully Eulerian Formulation - Interface Capturing and Initial Point Set Method, Fully Eulerian Framework; Linear Solvers for FSI - Partitioned Solvers, Direct Solution of Linear Systems, Krylov Space Solvers, GMRES Multigrid Iteration.

MCFD604L Experimental methods for Fluid Flow (2-0-0-2)

Measurements - Error Estimates, Uncertainty Analysis; Pressure measurements – static and total pressure measurements; Measurements of Temperature, Heat flux and Species Concentrations; Flow Rate measurements; Velocity measurements- Pressure-based Velocity Measurements, Particle-based techniques, Density-based Techniques;

Measurements of Force and Moment; Linking experiments with CFD-verification and validation.

MCFD605L Multiphase flows (3-0-0-3)

Overview of Multiphase flow - Flow patterns and regimes, conservation equations for multiphase flows; Liquid - Gas Two Phase Flows - Separated flow instabilities, Pressure drop models; Particle motion - Single particle motion, Flow around a sphere, Grain's size and concentration effect on free flow drag; Bubble/Droplets dynamics - Rayleigh-Plesset equation, Bubble growth and collapse; Euler-Lagrangian Model - particle tracking and trajectory, Force balance; Euler-Euler Model - Liquid-liquid / liquid-solid mixing, Complex multiphase flows with turbulence; Boiling and Condensation - Flow boiling in mini and micro channels, Film boiling, Condensation.

MCFD606L Finite Element Analysis of Solids and Fluids (3-0-0-3)

Introduction to approximation methods - Direct formulation, Minimum total potential energy formulation, weighted residual formulation, variational approach; Higher order and isoparametric elements - polynomial form of interpolation functions, lagrangian interpolation, Higher order one dimensional elements; Application to solid mechanics- one dimensional analysis and multi-dimensional problems - trusses, beams, plates, shells, plane stress and plane strain problems; Application to fluid mechanics- isothermal and non-isothermal problems; Application to steady state heat conduction; Application to transient heat conduction analysis.

MCFD607L High Performance Computing (2-0-0-2)

Moore's law and saturation, Multi-core and multi-node computers, accelerators, Amdahl's law, introduction to Linux; Professional code development practices – editors, compilers, IDEs, unit and integration testing, scripting languages, environment modules, run code on HPC; Parallelization in modern computers – pipelining, memory hierarchy and latency, Compiler flags based optimization; Analysis tools and Optimization – Debugging, profiling, and instrumenting the code, interoperability; Shared Memory Architecture – data dependencies and resolution, Directive driven optimization, task based vs data parallelization, reduction, synchronization, atomic operations, performance enhancement comparison; Distributed Memory Architecture – Message Passing Interface, blocking vs non-blocking communication, debugging, instrumenting, and performance enhancement; Hybrid Computing – GPU Architecture, Nvidia and CUDA, CUDA kernels and memory management.

MCFD608L Numerical Simulation of Environmental and Atmospheric Flows (3-0-0-3)

Overview-Anthropogenic climate change and environmental flows, Solar variability, orbital mechanics, greenhouse gases, Scales of motion, atmospheric and oceanic circulation; Fundamentals of Atmospheric Processes-Equations of motion in Cartesian coordinates; Energy Climate Dynamics-Potential Temperature, States of stability, Stratification and diffusion problems, Parcel Concepts; Thermodynamical Processes-Thermodynamic principles; Boundary Layer Processes-Expanded continuity equations, Cloud-fog physics, Boundary layer physics; Shallow Water model theory-Shallow Water equations; Numerical methods in Boundary layer Processes including large scale flows-Mass conservation equation implementation, Boundary conditions, Introduction of zonal jets and currents, Large scale perturbations and geostrophic equilibrium.

MCFD609L Modeling and Simulation of Energy Systems (3-0-0-3)

Overview of Energy Systems - Workable and Optimum Energy systems, Equation fitting; System Simulation - Sequential and simultaneous calculations; Optimization - Unconstrained and constrained optimization, Sensitivity Coefficients, Search Methods; Thermal System Analysis - Geometric programming, Linear Programming, Simplex algorithm; Modelling of Thermodynamic properties - Regression analysis, Internal energy and entropy, pressuretemperature relationship; Design of Heat Exchangers - parallel flow, counter flow; Simulation and optimization of thermal devices - thermal power plant components, Solar collector, Wind turbine Simulation and optimization of thermal power plant components, Solar collector, Wind turbine, hydraulic turbine and draft tubes, Gas turbine and compressors.

Skill Enhancement Courses

MENG501P Technical Report Writing (0-0-4-2)

Basics of Technical Communication–Process of communication, Levels of communication; Vocabulary and Editing - Word usage, Punctuation and Proofreading; Advanced Grammar - Shifts: Voice, Tense, Person and Number - Clarity: Pronoun reference, Misplace and unclear modifiers; Elements of Technical writing - Eliminating unnecessary words - Sentence clarity and combining; The Art of condensation; Technical Reports - Formats of reports and Prewriting; Data Visualization; Systematization of Information; Research and Analyses; Structure of Reports; Writing the Report; Writing scientific abstracts; Supplementary Texts; Presenting Technical Reports.

MSTS501P Qualitative Skills Practice (0-0-3-1.5)

Business Etiquette: Social and Cultural Etiquette; Writing Company Blogs; Internal Communications and Planning: Writing press release and meeting notes; Time management skills - Prioritization, Procrastination, Scheduling, Multitasking; Presentation skills – Preparing presentation; Organizing materials; Maintaining and preparing visual aids; Dealing with questions; Quantitative Ability -L1 – Number properties; Averages; Progressions;Percentages; Ratios; Reasoning Ability-L1 – Analytical Reasoning - Data Arrangement, Blood Relations,Ordering/ranking/grouping, Puzzle test, Selection Decision table; Verbal Ability-L1 – Vocabulary Building.

MSTS502P Quantitative Skills Practice (0-0-3-1.5)

Resume skills – Resume Template; Use of power verbs; Types of resume; Customizing resume; Interview skills – Types of interview; Techniques to face remote interviews and Mock Interview; Emotional Intelligence - L1 – Transactional Analysis; Brain storming; Psychometric Analysis; SWOT analysis; Quantitative Ability-L3 – Permutation-Combinations; Probability; Geometryand mensuration; Trigonometry; Logarithms; Functions; Quadratic Equations; Set Theory; Reasoning ability-L3 – Logical reasoning; Data Analysis and Interpretation - Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, DataInterpretation; Verbal Ability-L3 – Comprehension and Critical reasoning.

Open Electives

MFRE501L Français Fonctionnel (3-0-0-3)

Saluer, Se présenter, Etablir des contacts. Compétences en lecture - consulter un dictionnaire, appliquer des stratégies de lecture, lire pour comprendre - Présenter quelqu'un, Chercher un(e) correspondant(e), Demander des nouvelles d'une personne.Situer un objet ou un lieu, Poser des questions-Comprendre et traduire un texte court, et indiquer le chemin.- Trouver les questions, Répondre aux questions générales en français, Écouter des vidéos (site internet, YouTube) qui aident à améliorer leur prononciation/ vocabulaire et leurs compétences orales- Comment écrire un passagedévelopper des compétences rédactionnelles. Discussion de groupe (donnez un sujet et demandez aux élèves de partager leurs idées)-Comment écrire un dialogue-Invited Talk: Native speakers.

MGER501L Deutsch für Anfänger (3-0-0-3)

Die erste Begegnung - Einleitung, Begrüssungs formen, Länder und Sprachen; Hobbys und Berufe - Über Hobbyssprechen, Wochentage, Jahreszeiten, und Monatenennen; Alltag und Familie - Über die Familiesprechen, eineWohnungbeschreiben, Situations gespräche-Korrespondenz - Leseverständnis, Mindmapmachen, Korrespondenz- Briefe, Postkarten, E-Mail; Aufsatzschreiben - Meine Universität, Das Essen, mein Freund odermeine Freundin, Übersetzungen - Trainierung den Sprachfähigkeiten

| Course Code | Course Title | | L | Т | Ρ | С | | | | |
|---|---|--|------------------------|----------------------|------------------------|--------------------|--|--|--|--|
| MCFD501L | Transport Phenomena | a 3 0 0 | | | | | | | | |
| Pre-requisite | NIL | Syllabus versio | | | | | | | | |
| | | | | 1.0 | | | | | | |
| 1 To teach | es the basic concents of transport phenome | na similarities o | f the | | /ern | ina | | | | |
| equations of mass, momentum, and heat transfer 2. To illustrate the common mathematical structure of transport problems. 3. To formulate appropriate differential equations to obtain velocity, temperature, and concentration profiles of transport processes. | | | | | | | | | | |
| Course Outcome | | | | | | | | | | |
| | s | a abla ta | | | | | | | | |
| 1. Understar energy 2 Relate sin | Upon successful completion of the course the students will be able to Understand the transport properties of molecular transfer of mass, momentum and energy | | | | | | | | | |
| 3. Solve one 4. Apply Na mass tran 5. Analyse ir | -dimensional steady state momentum, hea vier-Stokes equation to examine the prot sfer. ndustrial transport problems with appropria | at and mass transfolders related to | fer p fluid s an | roble hea d bo | ems. at, a und | and ary | | | | |
| Conditions | · | | | | | | | | | |
| Module:1 Mec | nanisms of Momentum, Energy and | | | 7 | hou | Jrs | | | | |
| Coordinate syste Vector and tens transport - level o pressure and terr | ms and its rotation of axes- Vector and or integral theorems. momentum transpo of analysis - molecular transport properties perature. | l tensor differenti ort, energy trans s of gases and lic | al o port quids | pera and s - e | ition I ma ffect | s - ass t of | | | | |
| Module:2 Equa | itions of Change | | | 6 | hou | Jrs | | | | |
| Equations of cha | nge for isothermal systems - equations of | change for non-is | othe | rmal | | | | | | |
| Systems - equation | ons of change for multicomponent systems | | | 6 | ho | ire | | | | |
| Bala | nces for Isothermal Flow Systems | | | Ŭ | not | 115 | | | | |
| Friction factors fo the viscous loss, problems. | r flow in tubes, Friction factors for flow arou Use of the macroscopic balances for stead | und a bluff body, I ly-state and unste | Estin ady- | natio state | n of e | | | | | |
| Module:4 Tran | sport phenomena in polymeric | | | 5 | hou | Jrs | | | | |
| Behaviour of poly | meric liquids, non-Newtonian viscosity and | the generalized | New | tonia | n | | | | | |
| models, Elasticity | and the linear viscoelastic models, nonline | ear viscoelastic m | odel | s | | | | | | |
| Module:5 Tem Flow | perature distributions in Turbulent s | | | 7 | hou | Jrs | | | | |
| Time-averaged e | quations of change for incompressible non | -isothermal flow, t | he ti | me- | | | | | | |
| averaged temper and jets. | ature profile near a wall, temperature distri | bution for turbuler | nt flo | w in | tube |)S | | | | |
| Module:6 Con Flow | centration Distributions in Laminar s | | | 6 | hou | Jrs | | | | |
| Shell mass balan with a heterogene film-gas absorptio | ces, boundary conditions; Diffusion throug eous and a homogeneous chemical reactio on - solid dissolution. | h a stagnant gas f n; Diffusion into a | ilm; falli | Diffu ng lie | ısior quid | 1 | | | | |

| Independent Variables Time-dependent diffusion; Steady-state transport in binary boundary layers; Steady-state boundary layer theory for flow around objects; Boundary layer mass transport with complex interfacial motion Module:8 Contemporary Issues 2 hou Total Lecture hours: 45 hou |
|---|
| Time-dependent diffusion; Steady-state transport in binary boundary layers; Steady-state boundary layer theory for flow around objects; Boundary layer mass transport with complex interfacial motion Module:8 Contemporary Issues 2 hou Total Lecture hours: 45 hou Text Book(s) Foundary layer house |
| boundary layer theory for flow around objects; Boundary layer mass transport with complexinterfacial motion Module:8 Contemporary Issues 2 hou Total Lecture hours: 45 hou Text Book(s) Contemporary Issues 45 hou |
| interfacial motion Module:8 Contemporary Issues 2 hou Total Lecture hours: 45 hou Text Book(s) |
| Module:8 Contemporary Issues 2 hou Image: State of the state of th |
| Total Lecture hours: 45 hou Text Book(s) |
| Total Lecture hours: 45 hou Text Book(s) |
| Total Lecture hours: 45 hou Text Book(s) |
| Text Book(s) |
| |
| 1. Bird R. B., Stewart W. E., Lightfoot E. N., Transport Phenomena, 2012, Second Editio |
| John |
| Wiley & Sons Inc., Wiley Student Edition, India. |
| Reference Books |
| 1 Geankoplis C.J., Transport Processes and Separation Process Principles, 2018, Fifth |
| Edition, Pearson Education India. |
| 2. Plawsky Joel L, Transport Phenomena fundamentals, 2020, Fourth Edition., CRC Pres |
| USA. |
| 3. William M. Dean, Analysis of Transport Phenomena, 2013, Second Edition, Oxford |
| University Press, India. |
| Mode of Evaluation: Continuous assessment test, written assignment, Quiz and Final |
| assessment test |
| Recommended by Board of Studies 27-05-2022 |
| Approved by Academic Council No. 66 Date 16-06-2022 |

| Course Code | Course Title | | L | Τ | Ρ | С | | | |
|---|--|----------|----------|----------------|--------------|------------|--|--|--|
| MCFD502L | Advanced Fluid Dynamics | | 3 | 0 | 0 | 3 | | | |
| Pre-requisite | NIL | Sy | /llab | us v | ersi | on | | | |
| | | | | 1.0 | | | | | |
| Course Objective | es iundomentals of fluid machanics and reverning as | untinga | for | | | <u></u> | | | |
| time engineering applications | | | | | | | | | |
| 2. To provide in-depth knowledge of potential flow and boundary layers. | | | | | | | | | |
| 3. To understand complex phenomena underlying turbulent and compressible flows. | | | | | | | | | |
| 4. To familiarize students with experimental techniques related to fluid mechanics. | | | | | | | | | |
| | | | | | | | | | |
| Lipon completion | e the course the students will be able to | | | | | | | | |
| opon completion | | | | | | | | | |
| 1. Deduce go | overning equations for particular flow fields with app | ications | 5. | | | | | | |
| 2. Analyse p | otential flows and execute concept of conformal | transfor | mati | on fe | or fl | ow | | | |
| over bodie | S. | flow | م الم | ++ | | far | | | |
| 3. Apply bou | ndary layer concepts for real huids for solving huid | now ar | ia ne | รลเ เ | rans | ler | | | |
| 4. Analyse tu | Irbulent flows through various techniques for wall t | ounded | and | free | e she | ear | | | |
| flows. | ç i | | | | | | | | |
| 5. Examine o | compressible flows through various systems involvin | g shock | wav | 'es. | | | | | |
| 6. Apply vari | ous intrusive and non-intrusive techniques to n | easure | flow | / an | d fl | uid | | | |
| properties. | | | | | | | | | |
| Module:1 Over | view of fluid motion | | | 5 | hou | Jrs | | | |
| Introduction- New | tonian and non-Newtonian fluids. Description of flu | id motic | n – | Lagr | ang | ian | | | |
| and Eulerian app | proaches. Motion of fluid element translation, rot | ation ar | าd d | eforr | nati | on; | | | |
| vorticity and strain | n-rate tensors; Streamlines, Path lines, Streak lines | and Tin | ne lin | es, S | Strea | am | | | |
| vorticity | ocity Potential Functions, Rotational and Irroration | al nows | ; - C | Ircuia | atior | 1 – | | | |
| | | | | | | | | | |
| Module:2 Gove | erning Equations of Fluid Flow | differen | tial | <u>8</u> | hou | <u>Jrs</u> | | | |
| forms – equation | n incorem. Three dimensional continuity equation - | aineerir | illai a | ina i nolic | nieg atio | jrai ne | | | |
| Derivation of Nav | rier-Stokes Equations for viscous compressible flo | vs – Ex | act | solut | ions | to | | | |
| certain simple ca | ses: Coutte flow - Hagen Poisoulle flow - flow k | etween | two | con | cen | tric | | | |
| rotating cylinders. | - | | | | | | | | |
| Module:3 Pote | ntial Flow Theory | | | 5 | hou | Jrs | | | |
| Pressure distribut | ion over stationery and rotating cylinders in a unifo | m flow | - Ma | gnus | s eff | ect | | | |
| - Kutta – Zhukov | sky theorem. Complex potential functions. Confe | rmal tra | ansfo | orma | tion | to | | | |
| analyze flow ove | r a flat plate, cylinder, spherical body and airfoil | s. Thin | airfo | oil th | eory | / – | | | |
| generalized airfoll | theory for campered and flapped airfolis. | | | | | | | | |
| Module:4 Bour | ndary layer Theory | | | 7 | hou | Jrs | | | |
| Boundary Layer | thickness - laminar and turbulent boundary layer | formula | ition, | go\ | /ern | ing | | | |
| equations, order- | or-magnitude analysis, von Karmann Momenium | ntegrai | equ | ation | 1. FI | ow | | | |
| Separation and re | | | | | | | | | |
| Module:5 Turb | ulent Flow | | <u> </u> | 7 | hou | Jrs | | | |
| Introduction to Th | eory of Hydrodynamic Stability, factors affecting tr | ansition | and | its o | conti | rol. | | | |
| distribution Laws | of the wall and free shear flows | pis, ur | ivers | bal V | 100 | лгу | | | |
| alstribution, Laws | | | | | | | | | |

| Мо | dule:6 | Compressible Flow | | | | 6 hours | | | |
|------|--|-----------------------------|-------------------|----------|--------|-------------------------------|--|--|--|
| One | e dimen | sional compressible fluid f | low – flow throug | h varia | able | area passage – nozzles and | | | |
| diff | users, fu | indamentals of supersonic | cs – normal and c | oblique | e sho | ock waves and calculation of | | | |
| flov | flow and fluid properties over solid bodies - flat plate, wedge and diamond. | | | | | | | | |
| Мо | dule:7 | Experimental Techniqu | les | | | 5 hours | | | |
| Intr | oductior | : Design of fluid flow ex | periments; unce | rtainty | / ana | alysis - types of error; flow | | | |
| me | measurement - hot wire and hot film anemometers; flow visualization techniques - Laser - | | | | | | | | |
| Dop | opler a | nemometry (LDA) and | Particle Image | Velo | cime | try (PIV), pressure and | | | |
| tem | perature | e measurements, methods | s of measuring tu | rbuler | ice. | | | | |
| Мо | dule:8 | Contemporary issues | | | | 2 hours | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | - | Total Lecture ho | urs: | | 45 hours | | | |
| Ŧ | | | | | | | | | |
| Iex | | S) | | <u> </u> | | | | | |
| 1. | Muralic | Inar, Gautam Biswas, Adv | anced engineerin | ng tiulo | d me | chanics, 2015, 3rd Edition, | | | |
| 2 | Maite | Publications. | | unatio | | th Edition 2021 | | | |
| Z. | vvnile, | | | ucalic | л, э | | | | |
| rei | | DOUKS | hokroborty Intro | ductic | n to | Eluid Machanias and Eluid | | | |
| ١. | Machin | e 2017 McCraw Hill | makiaborty, mito | aucii | | Fluid Mechanics and Fluid | | | |
| 2 | Kundu | Pijush K Ira M Cohen : | and David R. Dow | vlina | Eluio | mechanics Academic | | | |
| ۷. | press, | 2015. | | viirig. | i iuiu | meenames. Academic | | | |
| 3 | Schlich | ting, H and K. Gersten. B | oundary Layer Th | neory. | Spri | nger, 2017 | | | |
| Mo | de of Ev | aluation: CAT, written ass | ignment, Quiz an | d FAT | Γ | | | | |
| Red | commen | ded by Board of Studies | 27-05-2022 | | | | | | |
| Арр | proved b | y Academic Council | No. 66 | Date | | 16-06-2022 | | | |
| | | | | | | | | | |

| Course Code | Course Title | | | L | Т | Ρ | С |
|-----------------------------|---|----------------|--------|--------|--------------|--------|------------------|
| MCFD503L | Advanced Heat Transfer | | | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | | Sy | llab | us v | ersi | on |
| | | | | | 1.0 | | |
| Course Objecti | Ves t knowledge of soversing lowe of different modes | ofboot | tran | ofor | | | |
| 2 To form | late and reduce mass momentum and energy | | serva | sier. | eai | latic | ns |
| situation | allv. | <i>yy</i> 0011 | | | сq | June | 115 |
| 3. To obtai | n the exact and approximate solutions of externa | I and ir | ntern | al he | eat t | rans | fer |
| equation | S. | | | | | | |
| 4. To deter | mine radiative heat flux between the two surfa | ces wit | th pa | artici | patir | ng/no | on- |
| participa | ling mealums. | | | | | | |
| Course Outcor | 16 | | | | | | |
| Upon successfu | completion of the course the students will be able | e to | | | | | |
| 1. Formula | e governing equations for real time problems. | | | | | | |
| 2. Solve pr | blems of steady state heat conduction. | | | | | | |
| 3. Analyze | problems of transient heat conduction. | | | | | | |
| 4. Solve for 5. Solve pa | ced convective heat transfer problems | | | | | | |
| 6. Solve ra | diative heat transfer problems. | | | | | | |
| | | | | | | | |
| Module:1 Gov | verning laws of Heat Transfer | | | | 5 | hοι | ırs |
| A review of hea | t conduction, convection, thermal radiation, and | viscous | flow | ; the | e dei | rivati | on |
| of mass, mom | entum, and energy equation in dimensional ar | nd non- | -dime | ensio | nal | forn | ns. |
| various non-dim | ensional numbers in near transfer. | | | | | | |
| Module:2 Ste | ady State Conduction | | | | 6 | hοι | ırs |
| Derivation of th | ree-dimensional heat conduction equations for a | anisotro | pic i | nhor | noge | enec | us |
| mediums, conc | uctive tensor. Steady state conduction in isc | otropic | and | nor | noge | enec | us |
| | | | | | | | |
| Module:3 Tra | nsient Conduction | <u> </u> | | | 6 | hοι | irs |
| Transient condu | ction: Recapitulation of transient conduction for s | simple s | syste | ms. | Ana | lysis | of |
| and numerical | onduction with complex boundary conditions. So | nution r | netne | Jus | - an | aiyu | car |
| | <u> </u> | | | | | | |
| Module:4 Ext | ernal Forced Convection | | • | | 6 | hou | ırs |
| Convective hea | t transfer in external flows and their solution h | nethods | s: An | alog | y be | etwe | en |
| equations Simil | arity solution techniques. Momentum and energy | intears | al me | thod | inu Is ar | nd th | gy eir |
| applications in f | ow over flat plates with low and high Prandtl num | per app | roxin | natio | ns. | | |
| Modulo 5 Inte | real Foread Convertion | | | | 7 | hai | |
| Convective hear | transfer in internal flows and solution methods: | Flow th | roug | h ch | 1 anna | | <u>irs</u> nd |
| circular pipes. | Fully developed forced convection in ducts with | th cons | stant | hea | at flu | ix a | nd |
| constant wall te | mperature boundary conditions, Forced convecti | on in th | ne th | erma | al er | ntrar | ice |
| region of ducts, | Heat transfer in combined entrance region, Integr | al meth | nod fo | or int | erna | al flo | ws |
| with different wa | Il boundary conditions. | | | | | | |
| Module:6 Nat | ural Convection | | | | 7 | hοι | ırs |
| Introduction to | natural convection; Boussinesq approximation a | nd sca | le ar | nalys | sis; I | Natu | ral |
| convection from | a vertical plate using similarity and integral solu | ution, N | atura | al co | nveo | ction | in |
| enciosed space | s. Complined forced and free convection. | | | | | | |

| Module:7 Radiation | | | 6 hours | | | |
|---|----------------------------------|-------------|-------------------------------|--|--|--|
| Laws of Radiation, Intensity of Radiation, Irradiation, Radiosity, Radiative properties of surfaces, Radiation exchange between surfaces, View Factor, Radiation exchange in a black enclosure, Radiative heat transfer in participating media (Gas Radiation), Radiative Transfer Equation. Radiant exchange between surfaces; Radiative heat transfer in non-participating media. | | | | | | |
| Module:8 Contemporary Issues | | | 2 hours | | | |
| | | | | | | |
| | Total Lecture be | | 15 hours | | | |
| | | urs. | 45 110015 | | | |
| Taxt Book(a) | | | | | | |
| 1 Vunue & Congol and Afabin J Ch | noior Hoot and M | Trong | for: Fundamentals and | | | |
| Applications 5 th edition McGra | Majar,⊓eat anu Ma w-Hill 2015 | 155 110115 | | | | |
| Reference Books | W Thii, 2010. | | | | | |
| 1 J P Holman and Souvik Bhattach | narvva. Heat Trar | sfer. 10 tl | n edition. McGraw-Hill. 2016. | | | |
| 2. F P Incropera, D P Dewitt, T L E | Bergman, and A S | Lavine, I | ncropera's Principles of Heat | | | |
| and Mass Transfer, Wiley, 2018. | 5 / | , | | | | |
| 3. D W Hahn, and M N Ozisik, Hea | t Conduction, Joh | n Wiley 8 | Sons, 3rd Edition, 2012. | | | |
| 4. V S Arpaci, Conduction Heat Tra | ansfer, Addison-W | /esley, Re | eading, MA, 1966. | | | |
| 5. M F Modest, Radiative Heat Tra | nsfer, Academic I | Press, 3rd | Edition, 2013. | | | |
| 6. Kays, W.M. and Crawford W., Co | onvective Heat ar | nd Mass T | ransfer, McGraw Hill , 2004 | | | |
| Mode of Evaluation: Continuous asse | essment test, writ | ten assigr | nment, Quiz and Final | | | |
| assessment test | | | | | | |
| Recommended by Board of Studies | 27-05-2022 | | | | | |
| Approved by Academic Council | No. 66 | Date | 16-06-2022 | | | |

| Course Code | Course Title | | L I. | TF |) C | | | |
|---|--|-------------|-------|-------|------------|--|--|--|
| MCFD504L | Numerical Methods for Partial Differential Equati | ons 🗧 | 3 (| 0 0 |) 3 | | | |
| Pre-requisite | NIL | Sylla | bus | ver | sion | | | |
| | | | 1.0 | 0 | | | | |
| Course Objectiv | es | | | | | | | |
| 1.To develop | a conceptual understanding of numerical methods | commor | nly | used | d for | | | |
| solving pa | rtial differential equations | | | | | | | |
| 2.To impart working knowledge of numerical methods including experience in | | | | | | | | |
| implementi | ng them for model problems drawn from fluid flow | and h | eat | trar | nsfer | | | |
| applications | | | | | | | | |
| 3.To develop a foundation for theoretical techniques to analyze the behavior of the | | | | | | | | |
| numerical | methods | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Course Outcom | 9 | | | | | | | |
| Upon successful | completion of this course students will be able to | | | | | | | |
| 1. Demonstr | ate the understanding of numerical methods common | nly used | t to | r so | lving | | | |
| partial diff | erential equations. | | | | | | | |
| 2. Apply diffe | erent interpolation methods to compute parameters ne | eded as | s th | e pa | irt of | | | |
| | simulation and presentation of results | | | | | | | |
| 3. Develop 1 | at and iterative techniques to solve system of equations | | 15 | | | | | |
| 4. Apply ulle | the consistency of a finite differences scheme and | , dofino | tho | cto | hility | | | |
| | the consistency of a limite differences scheme and | denne | uie | รเล | Dility | | | |
| 6 Apply diffe | erent boundary conditions and linearization techniques | | | | | | | |
| 7 Apply the | finite element method for the solution of PDEs | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Module:1 Part | al Differential Equations | | | 6 h | ours | | | |
| PDE Definition – | Linear, Semi-linear, Quasi-linear, fully non-linear - So | me mod | el e | qua | tions | | | |
| Applications, | Limiting Cases –The existence of characteristics | and the | eir | phy | sical | | | |
| interpretation. E | lliptic, parabolic, and hyperbolic partial differenti | al equa | atio | ns. | The | | | |
| convection-diffusion | on equation. Initial Values and Boundary Conditions- | numeric | al c | once | erns. | | | |
| Machine arithmet | ic and related matters relevant to computations. | | | | | | | |
| Module:2 Inter | polation Methods | | | 6 h | ours | | | |
| Operators -finite | differences, average, differential, etc., their inter-relation | ations. D | Diffe | renc | e of | | | |
| polynomials. Di | fference equation. Interpolation. Lagrange's meth | iods, e | error | te | rms. | | | |
| Uniqueness of | interpolating polynomial. Newton's fundamental inte | rpolatio | n. | Forw | /ard, | | | |
| backward, and | central difference interpolations. Interpolation by | y iterat | ion. | S | pline | | | |
| interpolation, co | mparison with Newton's interpolation. Hermite's inte | erpolatio | n. | Biva | riate | | | |
| interpolation, Lag | range, and Newton's methods. Inverse interpolation. | | | | | | | |
| Module:3 Solu | tion Mechanisms for linear systems – Elliptic | | | 6 ho | ours | | | |
| equa | ations | | | | | | | |
| Finite difference | discretization – Lagrangian interpolation, Taylor's seri | es, trun | cati | on e | rror, | | | |
| Application to P | oisson equation in one and two dimensions – Solu | tion me | tho | ds-D | rect | | | |
| methods: Gauss | -Jourdan elimination, Lower-Upper decomposition, Th | iomas a | algo | rithm | 1 for | | | |
| tridiagonal syster | ns. Iterative methods: Jacobi Gauss-Seidel, Successi | ve Over | -Re | laxa | tion, | | | |
| Successive Line | Uver-Relaxation, Steepest descent, Conjugate gra | aient. C | on\ | /erge | ence | | | |
| analysis for itera | uve methods. Solution of algebraic system. Solution | method | IS TO | ר פו | iiptic | | | |
| equations. | | | | | | | | |
| Module:4 Solu | ition Techniques for Parabolic Partial | | | 6 ho | ours | | | |
| Diff | erential Equations | | | | - | | | |
| Finite difference | discretization of spatial derivatives - Parabolic equation | ı in its s | emi | -disc | crete | | | |

| ioni – Matrix Ionidiation, Initial Boundary Valde problems – solution properties – | | | | | |
|--|--|--|--|--|--|
| Consistency, Stability, Convergence. Solution methods for the Parabolic Differential | | | | | |
| equations (1D & 2D): Forward-Time Centered Space (FTCS), Backward-Time Centered | | | | | |
| Space (BICS), Crank Nicolson, Alternating Direction Implicit (ADI). Newmann Boundary | | | | | |
| conditions- Over relaxation – Under relaxation. Multigrid Techniques. | | | | | |
| Module:5 Solution for Hyperbolic Partial Differential /nours | | | | | |
| Solution properties. Domain of Dependence Ceneral solution _Time and spatial Finite | | | | | |
| difference discretization schemes - Forward time central difference Forward time unwind | | | | | |
| Lax-Wendroff Beam and Warming Predictor/Corrector Algorithm Semi-discrete form | | | | | |
| Method of lines: Consistency Stability Analysis Convergence Truncation Error Lax | | | | | |
| Equivalence theorem. CFL condition. Fourier stability Analysis. Von Stability Criterion. | | | | | |
| Absolute Stability Diagrams. Dispersion and Dissipation behaviour: Application- wave | | | | | |
| equations, Runge–Kutta Methods. | | | | | |
| Module:6 The Finite Volume Method 6hours | | | | | |
| Finite volume discretization – conservation methods Finite Volume Method (1D) Finite | | | | | |
| Volume Method (2D): computational cells cell averages Cartesian grids orthogonal non- | | | | | |
| Cartesian grids non-orthogonal meshes | | | | | |
| Module:7 The Finite Element Method 6hours | | | | | |
| Generalization of the finite element concepts. Basic equations and solution procedure: Direct | | | | | |
| method, Galerkin-weighted residual, variational approaches. The Finite Element Method | | | | | |
| (1D): Discretization of the domain, Derivation of element matrices and vectors, Assembly of | | | | | |
| element matrices and vectors and derivation of system equations | | | | | |
| cionicia matrices and vectore and derivation of eyetem equatione | | | | | |
| Module:8 Contemporary Issues 2hours | | | | | |
| Module:8 Contemporary Issues 2hours | | | | | |
| Module:8 Contemporary Issues 2hours | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Text Book(s) 5000000000000000000000000000000000000 | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Text Book(s) 1. Sandip Mazumder, Numerical Methods for Partial Differential Equations, Finite | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Text Book(s) 1. Sandip Mazumder, Numerical Methods for Partial Differential Equations, Finite Difference and Finite Volume Methods, Academic Press, 2016, ISBN: 978-0-12-040204.4 | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Text Book(s) 45hours 1. Sandip Mazumder, Numerical Methods for Partial Differential Equations, Finite Difference and Finite Volume Methods, Academic Press, 2016, ISBN: 978-0-12-849894-1. 2. Haffman Lea D, and Steven Frenkel, Numerical Methods for Partial Methods, for Partial Difference and Finite Volume Methods, Academic Press, 2016, ISBN: 978-0-12-849894-1. | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Text Book(s) 1. Sandip Mazumder, Numerical Methods for Partial Differential Equations, Finite Difference and Finite Volume Methods, Academic Press, 2016, ISBN: 978-0-12-849894-1. 2 Hoffman, Joe D., and Steven Frankel. Numerical Methods for Engineers and Scientists CPC press, 2001, ISBN: 078-0-82, 470443-8 | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Image: Second Colspan="2">Image: Second Colspan="2">Image: Second Colspan="2">Addition Colspan="2">Second Colspan="2">Second Colspan="2">Second Colspan="2">Second Colspan="2">Second Colspan="2">Second Colspan="2">Second Colspan="2">Contemporary Issues Total Lecture hours: 45hours Text Book(s) 1. Sandip Mazumder, Numerical Methods for Partial Differential Equations, Finite Difference and Finite Volume Methods, Academic Press, 2016, ISBN: 978-0-12-849894-1. 2 Hoffman, Joe D., and Steven Frankel. Numerical Methods for Engineers and Scientists. CRC press, 2001, ISBN 978-0-82-470443-8 Reference Books | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Intervalue of the tector and derivation of system equations Text Book(s) 1. Sandip Mazumder, Numerical Methods for Partial Differential Equations, Finite Difference and Finite Volume Methods, Academic Press, 2016, ISBN: 978-0-12-849894-1. 2 Hoffman, Joe D., and Steven Frankel. Numerical Methods for Engineers and Scientists. CRC press, 2001, ISBN 978-0-82-470443-8 Reference Books 1 Morton K W. & Mayers D E Numerical Solution of Partial Differential Equations (2nd) | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Intervalue of the vector of the vec | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Image: Second Colspan="2">Image: Second Colspan="2">Afshours Text Book(s) 1. Sandip Mazumder, Numerical Methods for Partial Differential Equations, Finite Difference and Finite Volume Methods, Academic Press, 2016, ISBN: 978-0-12-849894-1. 2 Hoffman, Joe D., and Steven Frankel. Numerical Methods for Engineers and Scientists. CRC press, 2001, ISBN 978-0-82-470443-8 Reference Books 1. Morton, K. W., & Mayers, D. F. Numerical Solution of Partial Differential Equations (2nd Ed.). Cambridge University Press, 2005. 2. Pinder, George F. Numerical methods for solving partial differential equations: a | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Text Book(s) 1. Sandip Mazumder, Numerical Methods for Partial Differential Equations, Finite Difference and Finite Volume Methods, Academic Press, 2016, ISBN: 978-0-12-849894-1. 2 Hoffman, Joe D., and Steven Frankel. Numerical Methods for Engineers and Scientists. CRC press, 2001, ISBN 978-0-82-470443-8 Reference Books 1. Morton, K. W., & Mayers, D. F. Numerical Solution of Partial Differential Equations (2nd Ed.). Cambridge University Press, 2005. 2. Pinder, George F. Numerical methods for solving partial differential equations: a comprehensive introduction for scientists and engineers. John Wiley & Sons, 2018. | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Text Book(s) 1. Sandip Mazumder, Numerical Methods for Partial Differential Equations, Finite Difference and Finite Volume Methods, Academic Press, 2016, ISBN: 978-0-12-849894-1. 2 Hoffman, Joe D., and Steven Frankel. Numerical Methods for Engineers and Scientists. CRC press, 2001, ISBN 978-0-82-470443-8 Reference Books 1. Morton, K. W., & Mayers, D. F. Numerical Solution of Partial Differential Equations (2nd Ed.). Cambridge University Press, 2005. 2. Pinder, George F. Numerical methods for solving partial differential equations: a comprehensive introduction for scientists and engineers. John Wiley & Sons, 2018. | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Text Book(s) 1. Sandip Mazumder, Numerical Methods for Partial Differential Equations, Finite Difference and Finite Volume Methods, Academic Press, 2016, ISBN: 978-0-12-849894-1. 2 Hoffman, Joe D., and Steven Frankel. Numerical Methods for Engineers and Scientists. CRC press, 2001, ISBN 978-0-82-470443-8 Reference Books 1. Morton, K. W., & Mayers, D. F. Numerical Solution of Partial Differential Equations (2nd Ed.). Cambridge University Press, 2005. 2. Pinder, George F. Numerical methods for solving partial differential equations: a comprehensive introduction for scientists and engineers. John Wiley & Sons, 2018. Mode of Evaluation: CAT , written assignment , Quiz , FAT | | | | | |
| Module:8 Contemporary Issues 2hours Total Lecture hours: 45hours Text Book(s) 1. Sandip Mazumder, Numerical Methods for Partial Differential Equations, Finite Difference and Finite Volume Methods, Academic Press, 2016, ISBN: 978-0-12-849894-1. 2 Hoffman, Joe D., and Steven Frankel. Numerical Methods for Engineers and Scientists. CRC press, 2001, ISBN 978-0-82-470443-8 Reference Books 1. Morton, K. W., & Mayers, D. F. Numerical Solution of Partial Differential Equations (2nd Ed.). Cambridge University Press, 2005. 2. Pinder, George F. Numerical methods for solving partial differential equations: a comprehensive introduction for scientists and engineers. John Wiley & Sons, 2018. Mode of Evaluation: CAT , written assignment , Quiz , FAT Recommended by Board of Studies 27-05-2022 | | | | | |

| Course Code Course Title L T F | | | | | | Ρ | С | | | |
|--------------------------------|--|--|--------------------|----------------------|---------------------------|----------------|--------------|------|----------|------------|
| MCF | D504P | Numerical Methods for Partial Differential Equations 0 0 2 | | | | | 2 | 1 | | |
| | | | Lab | | | | | | | |
| Pre- | requisite | NIL | | | | Syllabus versi | | | | |
| | | | | | | 1.0 | | | | |
| Cou | rse Objective | es | | | | <u> </u> | | | | |
| | 1. Io enable | e the students to dev | velop nume | erical c | odes by a | applyin | g t | heo | oreti | cal. |
| | 2 To teach | the students to extend | the numer | ised for | solving PD | res. | חס | Ee | to t | the |
| | solution of | fluid flow and heat trans | sfer problem | s | | nouei | ΓD | _3 | 10 1 | .ne. |
| | | | | 0. | | | | | | |
| Cou | rse Outcome |) | | | | | | | | |
| Upo | n successful o | completion of this course | e students wi | ill be al | ole to. | | | | | |
| | 1. Develop nu | umerical codes using FD | M for solving | g mode | l partial diff | erentia | l eq | uat | tions | 3. |
| | 2. Develop nu | umerical codes using FE | M for solving | g mode | l partial diffe | erentia | l eq | uat | ions | ; . |
| | | - | | | | | | | | |
| Indi | cative Experi | iments | | | <i></i> | | | | | |
| 1. | Write a prog | gram to solve a 2D Ell | liptic (Poisso | on equ | ation) using | g Jaco | bl, | Ga | | - |
| 2 | Seidel and S | rom to colvo a 1D parab | lo Dinchiel C | | hann bound | ETCS | nait mot | | 5 1 | |
| 2. | Write a prog | ram to solve a 1D parab | olic (Heat et | ruation |) using the $\frac{1}{2}$ | FTCS | me | tho | r Y | |
| <u> </u> | Write a prog | ram to solve a 1D adve | ection equat | tion us | ing the Un | wind s | che | me | u the | <u>د</u> |
| <u></u> т. | Lax-Friedric | hs scheme and the Lax- | Wendroff scl | heme a | and check th | ne uns | table | e F | TCS | , } |
| | scheme | | | | | | | | | |
| 5. | Write the co | de to solve a 1D convec | tion-diffusior | n equa | tion, using t | he FT | CS s | sch | eme | <u>}</u> |
| | and the upw | ind scheme | | | | | | | | |
| 6. | Write the co | ode to solve a 1D con | vection-diffu | ision _. e | quation, us | sing fir | nite | vol | ume | ; |
| | method to in | nplement the FICS sche | eme and the | upwind | scheme. | · . | •• | | | |
| 1. | vvrite the co | ode to solve a 1D con | ivection-aimu | ision e | quation, us | sing tir | nte | VOI | ume | ; |
| 8 | Write the co | npiemeni Quick scheme nde to solve 1D finite e | element Poi | sson e | a usina Ca | oniuaa | te c | ira | dien | t |
| 0. | method | | | 00011 0 | q. using O | onjuga | | Jia | | |
| 9. | Write the co | de to solve Lid-driven ca | vity using vo | orticity- | stream func | tion fo | rmu | lati | on | |
| 10. | Write the co | de to solve Sod's shock | tube problen | n using | any two up | wind s | sche | me | s | |
| | | | To | tal Lab | oratory Hou | ırs 30 |) ho | urs | | |
| Text | t Book(s) | | | | | | | | | |
| 1. | Hoffman, Jo | be D., and Steven Fra | ankel. Nume | erical | methods fo | or eng | inee | ers | anc | ł |
| | scientists. C | RC press, 2018. | | | | | | | | |
| Refe | erence Books | | | | | | | 4: - | | Over el |
| 1. | Ed Combr | V., & Mayers, D. F. Num idae University Press, 20 | erical Solutio | on of P | artial Differe | ential E | :qua | atio | ns (2 | zna |
| | | andall I Finite Differen | ore Methods | s for (| rdinary and | d Part | i al I | iff | oror | ntial |
| | Faustione [.] | Steady-State and Time-F |)enendent ¤ | Prohlem | s Philadali | nhia E | οΔ· (| Sor | cietv | for |
| | Industrial an | d Applied Mathematics | 2007 ISRNI | | 98716290 | orna, r | Л. ч | 500 | nety | 101 |
| Mod | e of assessm | ent: Continuous assess | ment and $F\Delta$ | T | | | | | | |
| Rec | ommended by | V Board of Studies | 27-05-202 | 2 | | | | | | |
| App | roved by Acad | demic Council | No. 66 | _ Date | 16-06-20 | 22 | | | | |
| Mod | Leveque, Randall J. Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems. Philadelphia, PA: Society for Industrial and Applied Mathematics, 2007. ISBN: 9780898716290. Mode of assessment: Continuous assessment and FAT Recommended by Board of Studies 27-05-2022 | | | | | | itial for | | | |
| Abb | ioveu by Acat | | 110.00 | Dale | 10-00-20 | <u></u> | | | | |

| Course Code Course Title L | | | | | | | L | ΤI | Ρ | С |
|----------------------------|---------------------------|---------------------------|-----------------|------------|----------------|-------------|--------|--------|-------|-----|
| MCFD | 505P | Computati | onal Fluid D | vnamic | s Lab | | 0 | 0 4 | 4 | 2 |
| Pre-rec | uisite | NIL | | , | | Svl | abu | s ve | rsi | on |
| | | | | | | | 1 | .0 | - | |
| Course | Obiectiv | es | | | | | | | | |
| 1. | To impart | skills required for the c | creation of 2D |) and 3D |) aeometrie | s for fl | ow r | node | lin | a. |
| 2. | To teach | different methods of gri | id generation | for simp | ole fluid flov | v prob | lems | 5. | | 5 |
| 3. | To enable | students to apply the o | concepts of C | FD and | perform si | , mulati | ons | using | a flo | ow |
| | solvers a | nd visualize the results. | | | • | | | | • | |
| | | | | | | | | | | |
| Course | Outcome | 9 | | | | | | | | |
| Upon s | uccessful | completion of this cours | se students w | /ill be ab | le to | | | | | |
| 1. | Perform g | eometry modeling for si | imple fluid flo | w proble | ems. | | | | | |
| 2. | Develop d | ifferent types of mesh s | suited for the | accurate | e capturing | of flov | v fiel | d. | | |
| 3. | Perform 2 | D analysis to understa | and the flow | charact | eristics and | d force | es ir | nvolv | ed | in |
| | different ir | ternal and external flow | VS. | | | | | | | |
| 4. | Develop u | ser defined functions to | perform cus | tomized | simulation | s. | | | | |
| 5. | Demonstra | ate simulation-results u | sing different | post pro | ocessing to | ols. | | | | |
| | | | | | | | | | | |
| Indicat | ive Exper | iments | | | | | | | | |
| 1. 20 | D/3D geom | etry creation using Des | sign Modeler | and/or S | Space Clair | n . | | | | |
| 2. U | nstructured | d mesh generation for a | a y-section/ B | iturcatin | g Artery do | main | | | | |
| 3. St | ructured n | nesh generation for the | study of exte | ernal flov | v over a NA | CA ae | erofo | bil | | |
| 4. La | aminar and | I turbulent flow over an | aerofoil at di | fferent a | ngles of att | ack | | | | |
| 5. Si | mulation o | f incident shock wave a | and boundary | / layer in | iteraction | | | | | |
| 6. In | vestigatior | of flow patterns in oil- | water flows u | sing VO | F model | | | | | |
| 7. Pi | rediction of | f wake formation behind | d tandem cyli | nders sı | ubjected to | consta | ant h | eatfl | ux | |
| 8. Si | mulation o | f blood flow through bif | urcating arter | ry | | | | | | |
| 9. N | umerical si | tudy of tube-in-tube hea | at exchanger | with the | incorporati | ion of | user | defir | nec | t |
| in | let velocity | profiles | | <u> </u> | <u></u> | | | | | |
| 10. Tr | ansient st | udy of phase change ch | naracteristics | of an ic | e block | | | | | |
| - 15 | | | lo | otal Labo | oratory Hou | rs 60 |) hoi | Jrs | | |
| Text B | <u>ook(s)</u> | <u> </u> | | | | <u>.</u> | 1 | | | |
| 1. It | J, JIYUAN, actical apr | Guan Heng Yeoh, and | inemann 201 | IU. Com | putational | fluid d | ynai | mics: | а | |
| Refere | nce Book | | | 10. | | | | | | |
| | azek liri | Computational fluid c | lynamics: nri | incinles | and applic | ations | Bi | itterv | vor | th_ |
| | einemann | 2015 | iynamios. pri | noipieo | | auono | . Dt | | 101 | u |
| 2. Jo | hn Matsso | on. An Introduction to A | NSYS Fluent | t 2020. S | SDC Public | ations. | 202 | 20 | | |
| | | | | | | | | | | |
| 3. Ve | ersteeg, H | enk Kaarle, and Weera | tunge Malala | sekera. | An introduc | ction to |) | | | |
| CC | omputation | al fluid dynamics: the fi | nite volume r | nethod. | Pearson eo | ducatio | on, 2 | 2007. | | |
| Mode o | fassesem | ent: Continuous assess | sment and F/ | Т | | | | | | |
| Recom | mandad h | V Roard of Studies | 27_05_2022 | 11 | | | | | | |
| | ad by Acce | demic Council | No 66 | Data | 16_06 204 | 22 | | | | |
| Abbion | eu by Aca | | 110.00 | Dale | 10-00-20 | <u></u> | | | | |

| Course Code | Course Title | | LT | P | С | | | |
|--|---|----------|---------|--------|-------------|--|--|--|
| MCFD506L | Numerical Solution of the Navier-Stokes Equation | ns | 3 0 | 0 | 3 | | | |
| Pre-requisite | NIL | Sylla | | ersic | on | | | |
| Course Objectiv | 20 | L | 1.0 | | | | | |
| 1 To develo | es n a conceptual understanding of different forms of Navi | ier Stol | | nuati | ons | | | |
| and the so | blution algorithms used to solve them | | | 1440 | 0113 | | | |
| 2. To develo | bp a foundation for understanding the different finite | e volur | ne ni | umer | ical | | | |
| schemes | for structured and unstructured grids, boundary and init | tial con | dition | s, lin | ear | | | |
| algebraic and differential algebraic equations solvers | | | | | | | | |
| 3. To impart | working knowledge implementing the solution algo | rithms | and | deve | lop | | | |
| computer programs to solve benchmark incompressible fluid flow and heat transfer | | | | | | | | |
| problems | on simple and complex geometries and evaluate t | he sol | ver a | ICCUR | асу | | | |
| thorough | verification and validation | | | | | | | |
| Course Outcom | | | | | | | | |
| Lipon ou coostul | e application of this course students will be able to | | | | | | | |
| 1 Distinguis | h and apply different forms of Navier Stokes equations | | | | | | | |
| 2 Distinguis | h and apply different solution algorithms to solve | the I | Vavie | r-Sto | kes | | | |
| equation | in and apply amerent solution algorithms to solve | | avic | 0.0 | Reo | | | |
| 3. Explain th | e different finite volume schemes to discretize the conv | vection | and | diffus | sion | | | |
| terms on s | structured and unstructured grids | | | | | | | |
| 4. Develop c | omputer programs to solve steady and unsteady Navie | r Stoke | es equ | Jatio | n in | | | |
| primitive v | ariables using finite volume methods for simple and co | mplex g | geom | etries | 3 | | | |
| 5. Apply line | arization techniques, boundary conditions, direct and i | terativ | e app | roacl | hes | | | |
| for the dev | velopment of flow solvers | | .: | | | | | |
| 6. Demonstr | ate the accuracy of the developed computer prog | ram v | vitn t | norol | Jgn | | | |
| Vernication | Tand validation and generation of quality documentatio | | suits | | | | | |
| Module:1 Navi | er-Stokes equations variants and related mathemat | ical | | 6 ho | urs | | | |
| form | ulations | | | | | | | |
| Vorticity-stream f | unction formulation for two-dimensional flow - Governin | g equa | tions | , Flov | <i>w</i> in | | | |
| a rectangular cav | ity, Direct computation of a steady flow, Modified dynai | nics fo | r stea | idy fl | ow, | | | |
| unsteady flow. Ve | elocity-pressure formulation - Pressure Poisson equation | n (PPE | E), Alt | erna | tive | | | |
| systems of gove | erning equations, Boundary conditions for the pres | ssure, | Com | patib | llity | | | |
| Implementation of | f primitive variables. Implementation on a staggered | arid r | une p | adde | ure. | | | |
| arid Second-orde | er methods | gnu, i | 1011-51 | ayye | ieu | | | |
| Module:2 Solu | tion algorithms for Navier Stokes equations | | | 6 ho | urs | | | |
| Operator splitting | projection, and pressure-correction methods - Solen | oidal r | roiec | tion a | and | | | |
| the role of the pr | essure - Boundary conditions for intermediate variable | es - Ev | olutio | n of | the | | | |
| rate of expansio | n - First-order projection method - Second-order m | ethods | . Met | hods | of | | | |
| modified dynamic | cs or false transients - Artificial compressibility meth | od for | stea | dy fl | ow. | | | |
| Modified PPE - P | enalty-function formulation | | | | | | | |
| Module:3 Finit | e Volume methods for Convection-Diffusion Equation | ons | | 7 ho | urs | | | |
| Steady one-dime | nsional convection and diffusion. Central differencing so | heme | Prop | ertie | s of | | | |
| discretization sch | emes - Conservativeness - Boundedness - Transpo | prtivene | ess. | Upw | /ind | | | |
| differencing sche | me, Hybrid differencing scheme, Assessment of the | central | differ | encir | ng, | | | |
| upwind differenc | ing and hybrid differencing scheme for convection- | -diffusi | on pi | oble | ms, | | | |
| Hybrid differencir | ng scheme for multi-dimensional convection-diffusion, | Power | -law s | scher | me, | | | |
| Higher-order diffe | erencing schemes for convection-diffusion problems | - Qua | dratic | upw | /ind | | | |
| differencing sche | eme: QUICK scheme - Assessment of the QUICK | schen | ne - | Stab | ility | | | |
| problems of the | QUICK scheme and remedies- General comme | nts or | the | QUI | CK | | | |
| | | | | | | | | |

| achamaa | scheme, IVD schemes- | Generalization | of upwind-blased d | Iscretization | | | | |
|--|---|---|--|--|--|--|--|--|
| schemes- Total variation and TVD schemes- Criteria for TVD schemes- Flux limiter | | | | | | | | |
| functions- Implementation of TVD schemes- Evaluation of TVD schemes | | | | | | | | |
| Module:4 | Finite volume implementat | tion of pressure | -correction based | 6 hours | | | | |
| | incompressible Navier-Sto | kes Solver for S | Steady flows | | | | | |
| The stage | ered grid. The momentum e | equations, Disc | retization of convection | n, diffusion, | | | | |
| pressure q | adient and body force terms | , The SIMPLE a | algorithm, Assembly of | a complete | | | | |
| method, Th | e SIMPLER algorithm, The | SIMPLEC algori | thm, The PISO algorith | nm, General | | | | |
| comments | on SIMPLE, SIMPLER, SIMP | LEC and PISO, | Worked examples of | the SIMPLE | | | | |
| algorithm. | | | | | | | | |
| Module:5 | Finite volume implementat incompressible Navier-Sto | tion of pressure kes Solver for L | -correction based Jnsteady flows | 7 hours | | | | |
| Explicit sch | eme, Crank–Nicolson scheme | e, the fully implic | it scheme, Implicit met | hod for two- | | | | |
| and three- | dimensional problems, Solut | tion procedures | for unsteady flow ca | alculations - | | | | |
| Transient S | SIMPLE - The transient PIS | SO algorithm, St | eady state calculation | s using the | | | | |
| pseudo-trar | nsient approach. | | | | | | | |
| Module:6 | Finite volume Implementat | tion of Boundary | y conditions | 4 hours | | | | |
| Inlet bound | ary conditions - Outlet bound | dary conditions | Wall boundary condi | itions - The | | | | |
| constant pr | essure boundary condition - | Symmetry bour | ndary condition - Perio | dic or cyclic | | | | |
| boundary c | ondition - Potential pitfalls | | | · | | | | |
| Module:7 | Finite volume methods for | dealing with co | mplex geometries | 7 hours | | | | |
| Body-fitted | co-ordinate grids for comple | ex geometries, C | artesian vs. curvilinear | grids – an | | | | |
| example, | Curvilinear grids – difficult | ties, Block-struct | tured grids, Unstruct | tured grids, | | | | |
| Discretization | on in unstructured grids, Disci | | diffusion term, Discretiz | zation of the | | | | |
| convective | term, Treatment of source t | erms, Assembly | convective term, Treatment of source terms, Assembly of discretised equations, Example | | | | | |
| calculations with unstructured grids. Pressure-velocity coupling in unstructured meshes. | | | | | | | | |
| Staggarod | with unstructured grids, Pr | ressure-velocity | coupling in unstructur | ed meshes, | | | | |
| Staggered | with unstructured grids, Pr vs. co-located grid arrangen unstructured meshes | ressure–velocity nents, Extension | coupling in unstructure of the face velocity i | ed meshes, interpolation | | | | |
| Staggered method to u | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. | ressure–velocity nents, Extension | coupling in unstructure of the face velocity i | ed meshes, interpolation | | | | |
| Staggered method to u | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues | ressure–velocity nents, Extension | coupling in unstructure of the face velocity i | ed meshes, interpolation | | | | |
| Staggered method to u Module: 8 | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho | nents, Extension | coupling in unstructure of the face velocity i 45 hours | ed meshes, interpolation | | | | |
| Staggered method to u Module: 8 | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho | nents, Extension | coupling in unstructure of the face velocity i 45 hours | ed meshes, interpolation 2 hours | | | | |
| Text Book | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho s) | nents, Extension | coupling in unstructure of the face velocity i 45 hours | 2 hours | | | | |
| Text Book | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho s) rsteeg and W Malalasekera, A inite Volume Method, 2 nd Edit | ours: | coupling in unstructure of the face velocity i 45 hours o Computational Fluid E | Dynamics | | | | |
| Text Book 1. H K Ve - The F 1312-7 | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho s) rsteeg and W Malalasekera, A inite Volume Method, 2 nd Edit 498-3 | An Introduction to tion, Pearson Pre | coupling in unstructure of the face velocity i 45 hours o Computational Fluid E entice Hall, 2007, ISBN: | 2 hours Oynamics 978-0- | | | | |
| Text Book 1. H K Ve - The F 1312-7 2. Pozriki | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho s) rsteeg and W Malalasekera, A inite Volume Method, 2 nd Edit 498-3 | An Introduction to tical and compu | coupling in unstructure of the face velocity i 45 hours o Computational Fluid E entice Hall, 2007, ISBN: | 2 hours 2 hour | | | | |
| Text Book 1. H K Ve 1312-7 2 Pozrikie Edition | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho s) rsteeg and W Malalasekera, A inite Volume Method, 2 nd Edit 498-3 dis, C. Introduction to theore Oxford University Press, 201 | An Introduction to tion, Pearson Pre- tical and compu 1. ISBN 978-0-19 | coupling in unstructure of the face velocity i 45 hours o Computational Fluid E entice Hall, 2007, ISBN: tational fluid dynamics | Dynamics 978-0- , Second | | | | |
| Text Book 1. H K Ve - The F 1312-7 2 Pozrikie Edition Reference | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho s) rsteeg and W Malalasekera, A inite Volume Method, 2 nd Edit 498-3 dis, C. Introduction to theore Oxford University Press, 2017 Books | An Introduction to tion, Pearson Pre- tical and compu 1, ISBN 978-0-19 | coupling in unstructure of the face velocity i 45 hours o Computational Fluid E entice Hall, 2007, ISBN: tational fluid dynamics 997-5207-2 | Dynamics 978-0- , Second | | | | |
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| Text Book 1. H K Ve - The F 1312-7 2 Pozrikie Edition Reference 1. Joel H Dynam 2. Hirsch of Nun | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho s) rsteeg and W Malalasekera, A inite Volume Method, 2 nd Edit 498-3 dis, C. Introduction to theore Oxford University Press, 201 Books . Ferziger, Milovan Perić, R hics, 4 th Edition, Springer, 202 . Ch., Numerical computation herical discretization, 2 nd Edit | An Introduction to tion, Pearson Pre- tical and compu 1, ISBN 978-0-19 Robert L. Street, 21, ISBN: 978-3-3 of internal and e ion, Butterworth- | coupling in unstructure of the face velocity i 45 hours o Computational Fluid E entice Hall, 2007, ISBN: tational fluid dynamics 097-5207-2 Computational Method 3199-9691-2 external flows, Vol.1 Fu Heinemann, Elsevier, 2 | 2 hours 2 hours 2 hours 2 hours 2 hours 2 hours 3 yramics 3 978-0- 3 Second 4 ds for Fluid 1 undamentals 2007, ISBN: | | | | |
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| CalculationsStaggeredmethod to uModule: 8Text Book1.H K Ve- The F1312-72PozrikieEditionReference1.Joel HDynam2.Hirschof Nun978-0-3.Jiri BlaButtern | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho s) rsteeg and W Malalasekera, A inite Volume Method, 2 nd Edit 498-3 dis, C. Introduction to theore Oxford University Press, 2017 Books . Ferziger, Milovan Perić, R nics, 4 th Edition, Springer, 202 . Ch., Numerical computation herical discretization, 2 nd Edit 7506-6594-0. zek, Computational Fluid Dyn vorth-Heinemann, 2015, ISBN | An Introduction to tion, Pearson Pre- tical and compu 1, ISBN 978-0-19 Robert L. Street, 21, ISBN: 978-3-3 of internal and e ion, Butterworth- namics: Principles | coupling in unstructure of the face velocity in 45 hours o Computational Fluid E entice Hall, 2007, ISBN: tational fluid dynamics 097-5207-2 Computational Method 3199-9691-2 external flows, Vol.1 Fu Heinemann, Elsevier, 2 s and Applications, 3 rd E 05-1 | 2 hours 2 hours 2 hours 2 hours 2 hours 2 hours 3 yours 978-0- , Second ds for Fluid undamentals 2007, ISBN: Edition, | | | | |
| CalculationsStaggeredmethod to uModule: 8Text Book1.H K Ve- The F1312-72PozrikieEditionEditionReference1.Joel HDynamDynam2.Hirschof Nun978-0-3.Jiri BlaButternMode of Ev | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho s) rsteeg and W Malalasekera, A inite Volume Method, 2 nd Edit 498-3 dis, C. Introduction to theore Oxford University Press, 2017 Books . Ferziger, Milovan Perić, R nics, 4 th Edition, Springer, 202 Ch., Numerical computation herical discretization, 2 nd Edit 7506-6594-0. zek, Computational Fluid Dyn vorth-Heinemann, 2015, ISBN aluation: CAT , written assign | An Introduction to tion, Pearson Pre- tical and compu- 1, ISBN 978-0-19 Robert L. Street, 21, ISBN: 978-3-3 of internal and e- ion, Butterworth- namics: Principles N 978-0-0809-999 ment , Quiz , FA | coupling in unstructure of the face velocity in 45 hours o Computational Fluid E entice Hall, 2007, ISBN: tational fluid dynamics 097-5207-2 Computational Method 3199-9691-2 external flows, Vol.1 Fu Heinemann, Elsevier, 2 s and Applications, 3 rd E 05-1 | 2 hours 2 hours 2 hours 2 hours 2 hours 2 hours 3 pr8-0- 5 g78-0- 5 g78-0- 5 g78-0- 5 g78-0- 6 gr Fluid 1 ndamentals 2007, ISBN: 5 dition, | | | | |
| Calculations Staggered method to u Module: 8 Text Book(1. H K Ve - The F 1312-7 2 Pozrikie Edition Reference 1. Joel H Dynam 2. Hirsch of Nun 978-0- 3. Jiri Bla Buttern Mode of Ev Recomment | with unstructured grids, Pr vs. co-located grid arrangen instructured meshes. Contemporary issues Total Lecture ho s) rsteeg and W Malalasekera, A inite Volume Method, 2 nd Edit 498-3 dis, C. Introduction to theore Oxford University Press, 2017 Boks . Ferziger, Milovan Perić, R nics, 4 th Edition, Springer, 202 . Ch., Numerical computation nerical discretization, 2 nd Edit 7506-6594-0. zek, Computational Fluid Dyn vorth-Heinemann, 2015, ISBN aluation: CAT , written assign ded by Board of Studies | An Introduction to tion, Pearson Pre- stical and compu- 1, ISBN 978-0-19 cobert L. Street, 21, ISBN: 978-3-3 of internal and e ion, Butterworth- mamics: Principles 1 978-0-0809-999 ment , Quiz , FA | coupling in unstructure of the face velocity in 45 hours o Computational Fluid E entice Hall, 2007, ISBN: tational fluid dynamics 997-5207-2 Computational Method 3199-9691-2 external flows, Vol.1 Fu Heinemann, Elsevier, 2 s and Applications, 3 rd E 95-1 | 2 hours 2 hours 2 hours 2 hours 2 hours 2 hours 2 hours 3 for Fluid 3 for Fluid 5 for F | | | | |

| Course Code | Course Title | | L | Т | P C | ; |
|--|--|---|---------------------------------|--------------------------------|----------------------------|------------------|
| MCFD506P | Numerical Solution of the Navier-Stokes Equations Lab | | 0 | 0 | 2 1 | |
| Pre-requisite | NIL | Sylla | bus | vei | rsion | |
| October Oblighting | | | 1 | .0 | | |
| | encentual understanding and working knowledge | of Tin | ita | diffo | ronoo | |
| To develop a c and finite volur Navier Stokes formulation. To impart work drawn from fluid | conceptual understanding and working knowledge ne discretization techniques and solution algorith equations in velocity/pressure, velocity/vorticity, king knowledge of developing CFD codes for be d flow and heat transfer applications | and vo | ark | or s ity/s pro | olving tream blems | י ן ז 5 |
| | | | | | | |
| Course Outcome | | | | | | |
| Upon successful comp 1. Demonstrate th incompressible vorticity/stream | letion of this course students will be able to ne understanding of finite difference methods u Navier- Stokes equations in velocity/pressure, v function formulation | sed fo elocity | r so /vor | olvin ticity | ig the /, and | e E |
| Demonstrate the incompressible Demonstrate the incompressible Develop finite geometries by formulation on the formulation on t | Navier- Stokes equations in velocity/pressure form ne understanding of different solution algorithms Navier- Stokes equations in velocity/pressure form difference scheme to simulate benchmark pr solving the Navier -Stokes equations in vorti | nulation nulatior nulatior roblem city/stre | n or so n s fo earr | olvir olvir or s n fu | g the simple nction | 9 9 0 |
| 5. Develop finite geometries by on staggered a method | difference scheme to simulate benchmark p solving the Navier -Stokes equations in velocity/p nd collocated Cartesian grids using operating spl | roblem pressur litting a | s fo e fo ind | or s ormu proj | simple lation ection | 9 า า |
| Develop finite geometries by velocity/pressur SIMPLE, SIMP | volume scheme to simulate benchmark pr v solving the two dimensional Navier -Sta re formulation on staggered and collocated Ca LEC and projection method | oblems okes irtesiar | i fo equa gr | or s atio ids | simple ns in using | 9 1 J |
| | 4. | | | | | |
| Indicative Experimen | ts Evaluait finite difference code to compute the v | <u>alaaitu</u> | | ofilo | in a | |
| unidirection the prese velocity/p | cribed boundary conditions by solving the gov ressure formulation | condition /erning | on, eq | subj luati | ject to | ג כ ר |
| 2. Write a unidirection the preserve velocity-p | Implicit finite difference code to compute the volume the volume on a channel flow starting from the specified initial cribed boundary conditions by solving the government of the government of the solving formulation | /elocity conditi /erning | ,pr on, eq | ofile subj juati | in a ject to on in | ג כ ר |
| 3. Write a Implicit finite difference code to compute the velocity profile in a unidirectional channel flow starting from the specified initial condition and pressure gradient, subject to the prescribed boundary conditions by solving the governing equation in velocity/vorticity formulation | | | | | | ε Ε Ε |
| 4. Develop a finite-difference method based on the stream function/vorticity formulation for computing the velocity profile of steady channel flow subject to a specified flow rate. | | | | | | / a |
| 5. Develop formulatio a sliding l | a finite-difference method based on the streat on for computing the two-dimensional flow in a squ id. | am fun Jare ca | ictio vity | on/vo driv | orticity en by | / / |
| 6. Develop a | a finite-difference method based on the velocity / μ | pressur | e fo | ormu | lation | <u>ו</u> |

| | for computing the two-dimensional using the operation splitting and s | flow in a squar | re cavity driven by | y a sliding lid |
|-------------|---|---|---|---|
| | arid. | | | a concoutou |
| 7. | Develop a finite-difference method for computing the two-dimensional using the operation splitting and s grid. | based on the flow in a squa olenoidal proje | velocity /pressure re cavity driven by ection method on | e formulation y a sliding lid a staggered |
| 8. | Develop a finite-volume method ba computing the two-dimensional flow a staggered grid using the SIMPLE | ased on the vel w in a square o E algorithm | ocity /pressure fo avity driven by a | rmulation for sliding lid on |
| 9. | Develop a finite-volume method ba computing the two-dimensional na staggered grid using Projection me | ased on the vel tural convectio thod | ocity /pressure fo n flow in a squar | rmulation for e cavity on a |
| 10. | Develop a finite-volume method ba computing the two-dimensional staggered grid using the SIMPLEC | ased on the vel flow over a algorithm | ocity /pressure fo backward facing | rmulation for step on a |
| | | | 1 | |
| | | Total La | boratory Hours | 30 hours |
| Text Book(| | | <u> </u> | . Ast |
| 1. | Edition, CRC press, 2022, ISBN: 9 | Jynamics for N 78-0-367-6873 | /lechanical Engin 0-4. | eering, 1°° |
| 2. | C. Pozrikidis, Fluid Dynamics: simulation, 3 rd Edition, Springer,20 | Theory, Cor 17, ISBN 978-1 | nputation and I-4899-7990-2. | Numerical |
| Reference | Books | | | |
| 1. | H K Versteeg and W Malalasekera Dynamics - The Finite Volume Met 2007, ISBN: 978-0-1312-7498-3. | , An Introducti hod, 2 nd Editio | on to Computatio n, Pearson Prent | nal Fluid ice Hall, |
| 2. | D. G. Roychowdhury, Computation 1 st Edition, CRC press, ISBN: 978- | al Fluid Dynan 0-367-40806-0 | nics for Incompre | ssible Flows, |
| 3. | Joel H. Ferziger, Milovan Perić, R Fluid Dynamics, 4 th Edition, Spring | Robert L. Stree Jer, 2021, ISBN | t, Computational I: 978-3-3199-969 | Methods for 91-2 |
| 4. | Sreenivas Jayanthi, Computatio Scientists, 1 st Edition, Springer, 20 | nal Fluid Dy 18, ISBN 978-9 | namics for Eng 94-024-1215-4 | gineers and |
| Mode of ass | essment: Continuous assessment / | FAT / Oral exa | mination and othe | ers |
| Recommend | ded by Board of Studies | 27-05-2022 | | |
| Approved by | y Academic Council | No. 16 | Date 16-06-20 | 22 |

| Cou | rse Code | Course 1 | ïtle | LTPC | | |
|------|--|--------------------------------------|---------------------------|----------------------|--|--|
| MCF | D507P | Advanced Computational | Fluid Dynamics Lab | 0 0 4 2 | | |
| Pre- | requisite | | Syllabus version | | | |
| | | | | 1.0 | | |
| Cou | rse Obiectiv | es | | - | | |
| 1 | To impart | skills required for the advanced a | rid generation technig | ues. | | |
| | 2. To teach o | lifferent methods of simulation se | tup for fluid flow proble | ems | | |
| | To enable | the students to apply CED techni | ques for the design a | nd analysis of | | |
| | aerospace | automotive and turbo machinery | / svstems | | | |
| | dereepue | | | | | |
| Cou | rse Outcom | | | | | |
| Upo | n successful | completion of the course, students | s will be able to | | | |
| · · | I. Perform a | eometry modeling and grid generation | ation for complex fluid | flow domains. | | |
| | 2. Perform c | omputational analysis on internal | and external flows. | | | |
| 3 | 3. Analyze tł | e interaction between fluid and st | ructure. | | | |
| 4 | 1. Setup con | putational framework for the ana | ysis of reacting flows. | | | |
| 5 | 5. Perform c | omputational analysis of turboma | chines using moving r | eference frame. | | |
| 6 | Develop u | ser defined functions to perform of | sustomized simulation | S. | | |
| | | | | | | |
| Indi | cative Exper | iments | | | | |
| 1. | Grid generat | ion for 3D domain using ICEM CF | D | | | |
| 2. | Computation | al analysis of Jet surface interact | on | | | |
| 3. | Computation | al study of supersonic flow over a | 3D bump | | | |
| 4. | Computation | al analysis of shell and tube heat | exchanger | | | |
| 5. | Investigation | of a hydraulic jump using two pha | ase flow model | | | |
| 6. | Analysis of a | moving strip in an air stream usir | ng Fluid structure inter | raction | | |
| 7. | Simulation o | f a centrifugal blower using multip | le reference frames | | | |
| 8. | Simulation o | f Species transport and gaseous of | combustion using met | hane and air | | |
| | mixture. | | | | | |
| 9. | Simulation o | f a porous media in an exhaust sy | stem of an IC engine | | | |
| 10 | Creating and | l compile user defined function (U | DF) of temperature pr | ofile | | |
| _ | – • • • • | Т | otal Laboratory Hou | rs 60 hours | | |
| Text | Book(s) | | | <u> </u> | | |
| 1. | Tu, Jiyuan, | Guan Heng Yeoh, and Chaoqun | Liu. Computational | fluid dynamics: a | | |
| Defe | practical app | roach. Butterworth-Heinemann, 2 | 018. | | | |
| Refe | Plozok liri | S Computational fluid dynamica: | principles and applie | ationa Buttonwarth | | |
| 1. | Heinemann | | principles and applic | allons. Dullerworth- | | |
| 2 | Iohn Mateer | n An Introduction to ANSVS Flue | ant 2020 SDC Publics | ations 2020 | | |
| ۷. | 50mm Mat330 | | ant 2020, ODC 1 ublice | 110113, 2020 | | |
| 3. | Versteeg, Henk Kaarle, and Weeratunge Malalasekera. An introduction to | | | | | |
| | computational fluid dynamics: the finite volume method. Pearson education, 2007. | | | | | |
| | <u></u> | | | | | |
| 4 | Charles Hirs | cn, Numerical Computation of Inte | ernal and External Flo | ws: The | | |
| | Fundamentals of Computational Fluid Dynamics, Butterworth-Heinemann, 2007 | | | | | |
| Mod | Mode of assessment: Continuous assessment / Lab FAT / Viva voce | | | | | |
| Rec | ommended h | V Board of Studies | 022 | | | |
| Ann | roved by Aca | demic Council No. 66 | Date 16-06-201 |)) | | |
| | Sicu by Aca | | | -4 | | |

| Course Co | de | Course Title L T P C | | | | | | |
|---|--|---|----------|--------------|--------------------|------------|------------|--|
| MCFD508L | FD508L Turbulence Modelling | | | | 0 | 0 | 3 | |
| Pre-requis | site NIL Syllabus version | | | | | on | | |
| | 1.0 | | | | | | | |
| Course Ob | ojective | es | | | | | | |
| 1. To | provide | e a comprehensive knowledge in the field of turbu | llence | mo | dellir | ng a | ind | |
| sim | ulation. | a the physical insight and the methomatical fr | 20014 | | n | dod | to | |
| 2. 10 und | proviu Ierstan | the formulations of turbulence models and their ess | antial I | JIK imita | tion | s S | 10 | |
| 3. To | make | the students to understand the underlying com | blex r | hen | ome | non | in | |
| turb | ulent fl | ows and modelling approaches. | | | | | | |
| | | | | | | | | |
| Course Ou | itcome | | | | | | | |
| Upon succe | essful o | completion of the course, students will be able to | | | | | | |
| | | | | | | | | |
| 1. Rela | ate the | basic characteristics of turbulence in various enginee | ring a | pplic | atior | าร. | | |
| 2. Ana | lyse th | e transport of momentum and energy in turbulent flov | /S. | | | | | |
| 3. App | ly Rey | nolds decomposition principle for the analysis of turbu | ilent m | lean | flow | <i>'</i> . | | |
| 4. Ana | lyse th | e free shear and wall bounded turbulent flow characte | eristics | | | | | |
| 5. App | ly the | advanced turbulence modelling techniques in pred | cting | the | sma | ll-sc | ale | |
| fluc | tuation | S. | | | | | | |
| | | | | | | | | |
| Module:1 | Chara | acteristics of Turbulence | | | 5 | hou | Jrs | |
| Origin of t | urbuler | nce, irregularity, diffusivity, three dimensional motio | ns, di | ssip | atior | 1, W | ide | |
| spectrum, | eddy | motions and length scales, experimental tech | niques | s ir | tu | rbul | ent | |
| measureme | ents. | | | | | | | |
| Module:2 | Statis | stical Description of Turbulence | | | 7 | hou | Jrs | |
| Random n | ature | of turbulence, distribution function, probability de | isity f | unct | ion | (PD | F), | |
| moments, | correla | ations, Laylor's hypothesis, integral micro scales | hom | oge | າຍວເ | is a | and | |
| turbulence | spectra | a | e, en | ergy | Ca | Sca | ue, | |
| tarbaichioc | Special | a. | | | | | | |
| Module:3 | Turbu | lent Transport of Momentum and | | | 7 | hou | Jrs | |
| | Energ | | | | | | | |
| Reynolds d | lecomp | osition technique, turbulent stresses, vortex stretchin | j, Rey | nold | S | | | |
| equations, | mixing | length model, Reynolds' analogy, dynamics of turbule | ence. | | | <u> </u> | | |
| wodule:4 | Turb | | | | <u> </u> | nou | <u>Jrs</u> | |
| Introduction | n, eddy | -viscosity hypothesis, algebraic model, Spalart Alimai | as mo | del, | K-8 8 | and | K- | |
| ω models, | Reynol | ds-stress model, near-wall treatment. | | | ~ | | | |
| Mixing Lov | or Tur | Snear Flows | | cim | b ilorit | | urs rid | |
| Turbulence | e, Large | e scale turbulent motion – Vortex stretching. | 5, 501 | -5111 | nan | у, С | лц | |
| Module:6Wall-Bounded Turbulent Flows6 hours | | | | | | | | |
| Channel and pipe flows, Reynolds stresses, turbulent boundary layer equations, logarithmic- | | | | | | | | |
| law of walls, turbulent structures | | | | | | | | |
| Module:7 | Adva | nced Turbulence Modelling | | | 5 | hou | Jrs | |
| | Iech | niques | | | | | <u> </u> | |
| Large Eddy | Large Eddy simulation - Smagorinsky–Lilly model, Dynamic Smagorinsky–Lilly model, wall | | | | | | | |
| adopting local eddy viscosity (WALE) sub grid scale model; Direct Numerical Simulation | | | | | | | | |

| (D1 | (DNS) model. Detached Eddy Simulation (DES) model. | | | | | | | | |
|------------------|--|------------------------------|-------------------|-------------|-----------------------------|--|--|--|--|
| Мо | dule:8 | Contemporary Issues | | | 2 hours | | | | |
| | | | | | | | | | |
| | | | | T | | | | | |
| | | | Total Lecture ho | ours: | 45 hours | | | | |
| | | | | | | | | | |
| Tex | kt Book | (S) | | | | | | | |
| 1. | Pope, | S.B., 2003, Turbulent Flow | ws, Cambridge U | niversity F | Press. ISBN: 0-521-59886- | | | | |
| | 9. | | - | - | | | | | |
| 2. | Tenne | kes, H., and Lumley, J.L | , 2018, A First | Course i | n Turbulence, MIT Press, | | | | |
| | Cambr | idge, Massachusetts, USA | A. ISBN: 9780262 | 2536301. | | | | | |
| Re | ference | Books | | | | | | | |
| 1. | Wilcox | , D.C., 2006, Turbulence I | Modelling for CFL | D, DCW Ir | dustries, California, USA. | | | | |
| 2. | Ferzige | er, J.H., and Peric, M., 200 | 02, Computationa | al Methods | s for Fluid Dynamics, | | | | |
| | Spring | er. | | | | | | | |
| 3 | Sagau | , P., and Germano, M., 20 | 002, Large Eddy | Simulatio | n for Incompressible Flows, | | | | |
| Springer Verlag. | | | | | | | | | |
| Мо | de of Ev | aluation: CAT, written ass | signment, Quiz ar | nd FAT | | | | | |
| Re | commer | ded by Board of Studies | 27-05-2022 | | | | | | |
| Ap | proved b | y Academic Council | No. 66 | Date | 16-06-2022 | | | | |

| Course Code | Course Title | LTPC | | | |
|---|---|-------------------------|--|--|--|
| MCFD601L | Computational Aerodynamics | 3 0 0 3 | | | |
| Pre-requisite NIL Syllabus ver | | | | | |
| | | 1.0 | | | |
| Course Object | ves | | | | |
| 1. To dev | elop a conceptual understanding of numerical metho sible flows | ods suitable for the | | | |
| 2 To impa | SIDIE 110WS. It knowledge of spatial and temporal discretization sol | nomes applicable for | | | |
| | red finite volume framework | lemes applicable 101 | | | |
| 3 To te | ach the turbulence modelling techniques and t | oundary conditions | | | |
| impleme | tation strategies applicable for the compressible flows | Journauly contaitions | | | |
| | | | | | |
| Course Outcor | ne | | | | |
| Upon successfu | I completion of this course students will be able to | | | | |
| 1. Demons | trate the knowledge of complex flow structures of sible flows | different regimes of | | | |
| 2. Formula | te governing equations of compressible flows by cons | idering different flow | | | |
| features | involved. | | | | |
| 3. Develop | numerical algorithms for steady and unsteady Euler equ | lations. | | | |
| 4. Apply so | hemes suitable for the discretization of convective and | viscous fluxes for the | | | |
| developi | nent N-S solvers. | manahing strategies | | | |
| 5. Develop | compressible unsteady now solvers using different time | marching strategies | | | |
| 0. Select | amice | | | | |
| 7 Impleme | nt appropriate boundary condition for a chosen flow don | nain | | | |
| | in appropriate boundary condition for a chosen new den | | | | |
| Module:1 Co | nputational Aerodynamics: Aerodynamics/Gas dyr | amics 8 hours | | | |
| Co | ncepts: Overview and Preparation | | | | |
| Wing Aerodyn | amics- Wing Terminology, Prandtl's Lifting Line | Theory, Subsonic | | | |
| Compressibility | Effects, Transonic Aerodynamics- Wing Sweep. Super | sonic Aerodynamics- | | | |
| Oblique shock | vaves, shock reflections, shock/shock interactions, Prar | ndtl-Meyer expansion | | | |
| waves, under/o | ver-expanded flow. Hypersonic Aerodynamics- Importan | ce of Temperature in | | | |
| Hypersonic Flov | v, Aerodynamic Heating. | | | | |
| Module:2 Pri | nciples of Computational Gas dynamics | 4 hours | | | |
| Compressible fl | bw governing equations in integral form, conservative fi | nite volume method - | | | |
| The Euler Equa | tions, introduction to flux averaging, introduction to flux | splitting. Introduction | | | |
| to flux reconstru | ction. Artificial viscosity | 6 houro | | | |
| Flux Approach | Lev Friedriche method Lev Wondreff Methode Wa | | | | |
| Vector Splitting | Stear Warming Flux vector splitting Van Leer Flux V | ector Splitting Wave | | | |
| Approach-II: Re | construction-Evolution- Roe's First-Order Upwind Metho | id | | | |
| Module:4 Fir | ite Volume Method for compressible flow- S | natial 7 hours | | | |
| dis | cretization | | | | |
| Structured Finit | e-Volume Schemes, Geometrical Quantities of a Cont | trol Volume, General | | | |
| Discretization N | lethodologies, Discretization of the Convective Fluxes. | Discretization of the | | | |
| Convective Fluxes-Geometrical Quantities of a Control Volume, Cell-centered scheme, | | | | | |
| Median-Dual C | ell-vertex scheme, Discretization of the Convective FI | uxes-central scheme | | | |
| with artificial d | ssipation, upwind schemes, Solution reconstruction, | gradients and limiter | | | |
| functions, Discr | etization of the Viscous Fluxes. | | | | |
| Module:5 Fir | ite Volume Method for compressible flow- | 6 hours | | | |
| | nporal UISCretization | | | | |
| Explicit Time-St | epping Schemes - First-Order Lime Accuracy, Second- | Jrder Time Accuracy, | | | |
| General Form | or Backward Time Difference, Multistage Schemes (H | kunge-kutta), Hybrid | | | |

| Multi | stage | Schemes, Determination of the Maximum Time Step, Implicit Time- | Stepping | | |
|--|----------|--|-----------|--|--|
| Sche | emes | | | | |
| Mod | ule:6 | Turbulence Modelling for compressible flows | 6 hours | | |
| Turb | ulence | e Modeling Approaches- Basic Equations of Turbulence, Favre (Mass) Av | veraging, | | |
| Eddy | /, Visco | cosity Hypothesis, First-Order Closures- Spalart-Allmaras One-Equation I | Model, k- | | |
| ε-Tw | o-Equa | uation Model, Wall functions, SST Two-Equation Model | | | |
| Mod | ule:7 | Boundary Conditions and their implementations | 6 hours | | |
| Solid | wall | boundary, farfield in external flows, Inlet/Outlet boundary in international | al flows, | | |
| symr | metry, | coordinate cut and periodic boundary, interface between grid blocks | -physical | | |
| signi | ficance | es and implementation strategies for structured and unstructured domains | S. | | |
| Mod | ule:8 | Contemporary Issues | 2 hours | | |
| | | | | | |
| | | | | | |
| | | Total Lecture hours: | 45 hours | | |
| | | | | | |
| Text | Book | <(S) | | | |
| 1. (| Cummi | nings. Russell M., et al. Applied computational aerodynamics: A m | odern | | |
| e | engine | eering approach. Vol. 53. Cambridge University Press, 2015. | | | |
| 2 E | Blazek. | Generational fluid dynamics: principles and applications. Butter Action Section 2.1 Sectio | worth- | | |
| H | Heinen | mann, 2015. | | | |
| Refe | rence | e Books | | | |
| 1. | Laney | ey, Culbert B. Computational gasdynamics. Cambridge university press, 19 | 998. | | |
| 2. | Morar | an, Jack. An introduction to theoretical and computational aerodynamics | . Courier | | |
| | Corpo | oration, 2003. | | | |
| | - • | , | | | |
| Mode | e of Ev | valuation: CAT , written assignment , Quiz,FAT | | | |
| Mode | e of as | ssessment: Continuous assessment and FAT | | | |
| Recommended by Board of Studies 27-05-2022 | | | | | |
| Appr | oved b | by Academic Council No. 66 Date 16-06-2022 | | | |
| | | · · · · · · · · · · · · · · · · · · · | | | |

| Course code Course Title L T F | | | | | | С | | |
|--|--|--|---------------------------------|----------------------|---------------------------|-------------------------|--|--|
| MCFD602L Chemically Reacting Flows-Combustion | | | | | 0 | 2 | | |
| Pre-requisite NIL Sy | | | | | | ion | | |
| 1.0 | | | | | | | | |
| Course Objectiv | /es | | | | | | | |
| To introduce To impart ski between turb To enable stu To familiarize | To introduce theory and methodology to simulate reacting flows with CFD. To impart skills required for incorporating species transport and coupling the interaction between turbulence and chemistry. To enable students to perform combustion simulations using commercial CFD tools. To familiarize the students with the multi-phase spray modeling. | | | | | | | |
| | | | | | | | | |
| Course Outcom | e | | | | | | | |
| Upon completion Explain the kinds Apply the kinds Apply the kinds Perform gas for the second secon | of the course the students will be able to nowledge of different types of flames. nowledge of different turbulence-chemistry interac reacting flows. turbine engine's combustion analysis. pasic theory of Lagrangian models for spray and its injection simulation and analyse key fuel droplet charac d fuel atomization and combustion simulation within | tion m s appl cteristic a typic | nodel icatic cs. cal g | ls f on f as | or or f turb | the uel | | |
| | | | | | | | | |
| WOQUIE:1 Com | Dustion and thermochemistry | | | 3 | nou | urs | | |
| Property relation Chemical Equilib temperature. Intr | rium. Equilibrium products for combustion, and their corrests, Reactant and Product mixtures, Standard Enth rium. Equilibrium products for combustion. Determinat roduction to the physics of turbulence-chemistry inte | nalpies ion of eraction | ng ap of adiat n an | forr batic d d | atio nati fla | ns. on. me ent | | |
| Module:2 Cher | mical Kinetics | | | 5 | hoi | irs | | |
| Introduction to C | chemical Kinetics. Global versus elementary reactions | Flem | enta | rv re | act | ion | | |
| rates. Rates of re important chem hydrocarbons, M | eaction for multistep mechanisms. Analysis of reaction ical mechanisms- The H2-O2 system. CO oxid ethane combustion. Oxides of Nitrogen formation. | n mech dation. | nanis Ox | ms. idat | So | me of | | |
| Module:3 Con | servation Equations for Reacting flows | | | 4 | hou | urs | | |
| Conservation of multicomponent energy in reacting | mass in reacting flows, Species mass conservation diffusion, Conservation of momentum in reacting flo g flows. The concept of conserved scalar. | (spec ows. C | ies d onse | cont erva | inui [:] tion | ty), of | | |
| Module:4 Lam | inar flames | | | 5 | hou | urs | | |
| Laminar premixed flames. Zeldovich's analysis of flame propagation. Structure of CH4-air flame. Flame velocity and flame thickness in laminar premixed flames. Quenching, flammability, and ignition in laminar premixed flames. Flame stabilization. | | | | | | | | |
| Laminar diffusion flames. Mixing in non-reacting jets. Jet-flame physical description. Simplified model for laminar jet non-premixed flames. Laminar diffusion jet flames: flame length for circular port and slot burners. | | | | | | | | |
| Module:5 Dro | olet evaporation and burning | | <u> </u> | 4 | hou | urs | | |
| Applications. Sir Simple model of constant and dro | nple model for droplet evaporation-Gas-phase analy droplet burning- Problem setup and conservation eq plet lifetimes. | sis, Dr juation | ople s, bi | t life urnir | etim ng r | es. ate | | |
| Module:6 Turk | oulent premixed and nonpremixed flames | | | 4 | hou | urs | | |

Practical applications. Turbulent flame speed. Structure of turbulent premixed flames. Wrinkled laminar flame regime. Distributed Reaction regime. Flamelet model. Flame stabilization. Turbulent nonpremixed flames- Jet flame, Flame length, Flame radiation, Lift off and blowout

| - | | | | | | | | |
|-----|--|-------------------------------|----------------|-----------|------------------|-----------------|--|--|
| Мо | dule:7 | Burning of solids | | | | 3 hours | | |
| Pra | ctical a | pplications. Heterogeneous r | eactions. Bui | ning of c | arbon-overview, | one-film | | |
| mo | del, two | -film model, particle burning | times. Coal c | ombustic | on. | | | |
| Мо | dule:8 | Contemporary Issues | | | | 2 hours | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | Total L | ecture hours: | 30 hours | | |
| | | | | | | | | |
| Тех | t Book | (s) | | | | | | |
| 1. | Turns, | Stephen R., An Introduction | to Combusti | on: Conc | epts and Applica | ations, 2018, | | |
| | 3 rd edit | ion, McGraw-Hill Companies | s, New York, | NY, USA | | | | |
| | | · · · · · · | | - | | | | |
| 2 | Poinso | t, Thierry, and Denis Veyna | nte. Theoreti | cal and r | numerical combu | ustion, 2005, | | |
| | 2 ^{na} edi | tion, RT Edwards, Inc. | | | | | | |
| Ref | ference | Books | | | | | | |
| 1. | Lefebv | re, Arthur H., and Dilip R. I | Ballal. Gas tu | urbine co | mbustion: altern | ative fuels and | | |
| | emissi | ons. CRC press, 2010. | | | | | | |
| Mo | Mode of Evaluation: CAT, written assignment, Quiz, FAT | | | | | | | |
| | | ý 5 | , . | | | | | |
| Red | Recommended by Board of Studies 27-05-2022 | | | | | | | |
| App | proved b | y Academic Council | No. 66 | Date | 16-06-2022 | | | |
| | | - | • | | • | | | |

| Соц | irse code | | Course Tit | le | | | 1 | т | Р | С |
|---|---|---------------------------|----------------|------------|--------------|--------|-------|------|------|------|
| MCFD602P Chemically Reacting Flows - Combustion Lab 0 0 | | | | | | 0 | 2 | 1 | | |
| Pre | -requisite | NIL | ioning i lonio | | | Svl | labi | JS \ | /ers | ion |
| | | | | | | •). | 1 | 1.0 | | |
| Cou | irse Objecti | ves | | | | | | | | |
| 1. | To provide | e hands on experience | e required t | o simulat | e reacting | flows | s by | / cł | າວວຣ | sing |
| | adequate c | combustion models. | • | | 0 | | , | | | 0 |
| 2. | To enable | students to perform con | nbustion sim | ulations u | sing comm | ercial | CFE |) to | ols. | |
| 3. | To train stu | idents to carry out the n | nulti-phase s | pray mod | elling studi | es. | | | | |
| | | | | - | | | | | | |
| Cou | Irse Outcon | ne | | | | | | | | |
| Upo | n successfu | I completion of the cour | se, students | will be at | ole to | | | | | |
| 1. | Perform co | mbustion simulation of | an IC engine |). | | | | | | |
| 2. | Perform sir | nulations of flow combu | istion. | | | | | | | |
| 3. | Perform sp | ray modelling studies. | | | | | | | | |
| | | | | | | | | | | |
| | | • • • • • • | | | | | | | | |
| Indi | cative Expe | eriments | | | - ! | | | | | |
| 1. | Simulation | of compustion of Metha | | sence or | air. | | | | | |
| 2. | Simulation | of combustion in a rock | et engine's c | ombustio | n section | | | | | |
| 3. | Simulation | of gas burner with air s | wirier | | | | | | | |
| 4. | Simulation | of a Non-Premixed com | ibustion | | | | | | | |
| 5. | Spray simu | lation by using DPM mo | | | | | | | | |
| - | | | 10 | tal Labor | atory Hou | rs 3l |) no | urs | • | |
| Iex | t BOOK(S) | | | | | | - 4 : | | 005 | |
| 1. | Poinsot, I hi | erry, and Denis Veyna | nte. Theoret | ical and r | numerical c | ombu | stior | ı, 2 | 005 | , |
| Def | 2nd edition, | RI Edwards, Inc. | | | | | | | | |
| Ret | erence Boo | KS | L - | | | | | | | |
| 1. | Ansys Fluer | | | | | | | | | |
| NIOC | Mode of assessment: Continuous assessment / Lab FAT / Viva voce | | | | | | | | | |
| Rec | ommended | by Board of Studies | 27-05-2022 | D (| 40.00.000 | | | | | |
| App | roved by Ac | ademic Council | NO. 66 | Date | 16-06-202 | 22 | | | | ļ |

| Course Code Course Title L T | | | | | | | |
|--|--|---|--|--|--|--|--|
| MCFD603L | Fluid Structure Interaction | 3 0 0 3 | | | | | |
| Pre-requisite NIL Syllabu | | | | | | | |
| | | 1.0 | | | | | |
| Course Objectives | | | | | | | |
| 1. To develo Mechanic | p a conceptual understanding of governing equations of s. | fiuld and structural | | | | | |
| 2. To develo structure i | p a foundation for understanding of the coupling condition nteractions | ons involved in fluid | | | | | |
| 3. To develo | op an understanding of FEM methods to solve the gove | erning equations of | | | | | |
| 4 To impart | an understanding of linear equations solvers for FSI | | | | | | |
| | | | | | | | |
| Course Outcom | 6 | | | | | | |
| Upon successful | completion of this course students will be able to | | | | | | |
| 1. Apply the | governing equation of fluid and structural mechanics. | | | | | | |
| 2. Apply the | different coupling conditions involved in fluid structure in | teraction. | | | | | |
| 3. Formulate | the FSI governing equations in ALE and Fully Eulerian | approaches. | | | | | |
| 4. Explain t | he different finite element schemes to discretize t | he FSI governing | | | | | |
| 5. Apply line | arization techniques and linear algebraic equation solv | vers for solving FSI | | | | | |
| problems. 6. Perform n | umerical simulation of Fluid structure Interaction problem | ns. | | | | | |
| | | | | | | | |
| Module:1 Mod Mec | els : Governing Equations of Fluid and Structural hanics | 6 hours | | | | | |
| Continuum Mech | nanics - Coordinate Systems - Deformation Gradient | - Strain - Rate of | | | | | |
| Deformation and Systems, Materia The Navier-Lamé The Fluid Probler Incompressible F Problems on Mo | Strain Rate - Stress - Conservation Principles in D al Laws - Hyperelastic and Incompressible Materials, T e Equations - Steady and unsteady incompressible Navie m- Boundary and Initial Conditions-The Linear Stokes Ec Tows- Flow Problems on Moving Domains- Eulerian To ving Domains - The Arbitrary Lagrangian Eulerian (AL | ifferent Coordinate he Solid Problem - er-Lamé Equations. quations- Theory of echniques for Flow LE) Formulation for | | | | | |
| Module:2 Cou | aled Fluid Structure Interactions | 6 hours | | | | | |
| Coupling Condition | one Kinematic Dynamic and Geometric Conditions | Interface Pequilarity | | | | | |
| and Boundary Co Variational Coup Definition of the Structures in Eule | onditions - Coupled Fluid-structure Interaction - The A bling Techniques - Fluid-structure Interactions in A ALE Map - Coupled ALE Formulation - Fully Eulerian Formulation - Fully Eulerian Formulation - Fully Eulerian | dded Mass Effect - LE Coordinates - ormulation - Elastic Coordinates | | | | | |
| Module:3 Disc | retization techniques for FSI governing equations | 6 hours | | | | | |
| Time Discretization - Numerical Stability- Numerical Dissipation- Shifted Crank-Nicolson Methods- The Fractional-Step-Method -Galerkin and Discontinuous Galerkin Methods- Time Discretization of the Stokes and N-S Equations. Spatial Discretization - Interpolation with Finite Elements - Elliptic Problems - Finite Elements on Curved Domains - Saddle-Point Problems. Methods for Navier-Stokes equations- Oseen Fixed Point Linearization -Newton Iteration -Discretization of Transport Dominant Flows-Discretization of Interface-Problems - Discretization of Moving Interfaces | | | | | | | |
| Module:4 ALE | Module:4 ALE Formulation for Fluid-structure Interactions 7 hours | | | | | | |
| Time-Discretization Fluid-structure In Derivation of Sen Discretization ar Framework - Line | on for the FSI Problem in ALE-Formulation - Non-stati nteractions- Time Stepping Schemes for Fluid-stru cond Order Time Stepping Schemes - Temporal Stab nd Damping, Linearization of Fluid-structure Interac earization by Fixed Point-Iterations- Newton Linearization | onary Dynamics of octure Interactions- ility - Stable Time- ctions in the ALE n for Fluid-structure | | | | | |

| Inte Line | eractions earizatio | in ns | Arbitrary | Lagrangian | Eulerian | Formulat | tion - | Numerical | Study | on |
|--|--|--|--|--|---|---|---|--|--|---|
| Мо | dule: 5 | Fini | te Elemen | ts for Fluid- | structure I | nteractior | ns in A | LE | 6 ho | urs |
| | | For | mulation | | | | | | | |
| Fin | ite Elem | ent T | riangulatio | ns for Fluid- | structure Ir | nteractions | in AL | E Formulation | on - Inf-S | Sup |
| Sta | ble FE-S | Space | es for Flui | d-structure li | nteractions | in ALE I | Formula | ation - Stab | ilized Fi | nite |
| Ele | ments fo | or Fl | uid-structu | re Interaction | ns- Matrix | Formulat | ion of | the Linear | System | s - |
| Cor | nstruction | n of t | he ALE M | ap - Harmon | ic Extensio | n - Harmo | onic Ex | tension with | Stiffenir | ng - |
| Extension by Pseudo-Elasticity- Biharmonic Extension | | | | | | | | | | |
| Мо | dule:6 | Fully | / Eulerian | Formulation | for Fluid- | structure | Intera | ctions | 6 ho | urs |
| Eul | erian Mo | dels | for Fluid-st | ructure Intera | actions - El | astic Struc | ctures i | n Eulerian C | oordinate | es - |
| Flu | id-structı | ire In | teraction i | n Eulerian Co | oordinates- | Interface | Captu | ring and the | Initial P | oint |
| Set | Method | -Time | -Discretiza | ation of the F | ully Euleria | in Framev | vork - L | inearization | of the F | ully |
| Eul | erian Co | ordin | ates - Finit | e Elements f | or the Fully | / Eulerian | Frame | work - Nume | erical Stu | ıdy- |
| Sta | tionary S | Struct | ure Bench | mark Probler | n - Station | ary Fluid- | structu | re Interactio | n Proble | m - |
| Cor | ntact Pro | blem. | | | | | | | | |
| Мо | dule:7 | Line | ar Solvers | s for Fluid-st | ructure Int | eractions | ; | | 6 ho | urs |
| Par | titioned | Solve | rs - Direct | Solution of I | _inear Syst | ems - Co | ndition | Number Ana | alysis of | the |
| Sys | stem Mat | rices | -Krylov Sp | ace Solvers | for Fluid-st | ructure Int | eractio | ns - Multigric | Solvers | tor |
| the | Arbitrar | y La | grangian | Eulerian Forr | nulation - | GMRES | Multigr | id Iteration- | Partitio | ned |
| Mu | ltiarid Sm | Multiarid Smoother | | | | | | | | |
| Module: 8 Contemporary Issues 2 hours | | | | | | | | | | |
| Мо | dule: 8 | Cont | emporary | Issues | | | | | 2 ho | urs |
| Мо | dule: 8 | Cont | emporary | lssues Total | Lecture h | ours: | | | 2 ho 45 ho | urs urs |
| Мо | dule: 8 | Cont | emporary | r Issues Total | Lecture h | ours: | | | 2 ho 45 ho | urs urs |
| Мо Тех 1 | dule: 8 | S) | ter Fluid | r Issues Total | Lecture he | ours: | nalysis | and finite e | 2 ho 45 ho | urs urs |
| Мо Тех 1. | dule: 8 (t Book(Thomas Second | S) Editio | nter, Fluid | Total Structure Int er. 2017. ISB | Lecture ho eractions: N 978-3-31 | Durs: Models, A 9-63969-7 | nalysis | and finite e | 2 ho 45 ho elements | urs urs |
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| Course code | Course Title | | L T P C | | | |
|----------------------------------|--|------------------------------------|-------------------------|--|--|--|
| MCFD604L | Experimental methods for | fluid flow | 2 0 0 2 | | | |
| Pre-requisite | NIL | | Syllabus version | | | |
| | | | 1.0 | | | |
| Course Objective | es | | | | | |
| 1. To teach va measurements | arious measuring techniques suited | for therma | I, flow and force | | | |
| 2. To impart know | wledge on how to interpret and analyse t | he experimen | ital data and its error | | | |
| 3. To teach the v | rerification and validation methods of nur | nerical model | s in comparison with | | | |
| experimental c | lata. | | | | | |
| Course Outcome | Course Outcome | | | | | |
| Upon successful c | completion of the course the students will | be able to | | | | |
| 1. Understand t | 1. Understand the measuring techniques of temperature, heat flux and species | | | | | |
| 2. Understand the | e measuring techniques of pressure, velo | ocity, and flow | v rate. | | | |
| 3. Understand the | e measuring techniques of force. | • | | | | |
| 4. Verify and vali | date the numerical model with experimer | nts. | | | | |
| 5. Demonstrate experimental c | the knowledge of experimental flu lata and uncertainties. | id dynamics | and analyse the | | | |
| 6. Validate CFD | solvers by comparing with experimental | data | | | | |
| | | | - | | | |
| Module:1 Meas | surements | 5 NA | 5 nours | | | |
| Inermal and FI | ow Measurements, Characteristics o | f Measureme | ent Systems, Lime | | | |
| Response of Me | easurement Systems, Time-Series A | nalysis and | Signal Processing, | | | |
| Statistical Principi | es, Error Estimates, Gramer-Rao Lowe | er Bound (CR | (LB), Propagation of | | | |
| Modulo:2 Moas | ession, oncertainty Analysis, Dimensiona | al Allalysis allo | | | | |
| Manometers Me | asurement of Pressure with Wall Ta | nning - Stat | ic Tubes Pressure | | | |
| Transducers Base | ed on Elastic Strain Piezoelectric Tran | sducers Pres | sure-Sensitive Paint | | | |
| (PSP) | | | | | | |
| Module:3 Mea | surements of Temperature, Heat | | 5 hours | | | |
| flux | and Species Concentrations | | · | | | |
| Temperature Mea | asurements based on Thermal Expans | ion of Materia | als, Thermocouples, | | | |
| Resistance-Based | I Temperature Sensors, Pyrometer | Measurement | s of Temperature. | | | |
| Thermochromic L | iquid Crystals, Measurements of Suna | ce Heat Tran | sier Characteristics, | | | |
| Molecular Energy | and Spectroscopy Rayleigh Scattering | Mie Scattering | n Raman | | | |
| Scattering Light S | Scattering and Laser-Induced Fluorescen | nie Ocaterinę | J, Maman | | | |
| Module:4 Meas | surement of Flow Rates | 00 | 3 hours | | | |
| Fundamentals, Ob | ostruction Flowmeters., Rotameters, Turk | oine Flowmete | ers, Thermal Mass | | | |
| Flowmeters | | | | | | |
| Module:5 Meas | surements of Flow Velocity | | 5 hours | | | |
| Pressure-based V | elocity Measurements- Pitot-Static tube | ; Particle-base | ed techniques- Laser | | | |
| Doppler Anemom | etry/Velocimetry (LDA/LDV), Particle Ir | nage Velocim | netry (PIV), Doppler | | | |
| Global Velocimetr | y (DGV), and Laser Transit Velocimetry | (LIV); Density | /-based lechniques- | | | |
| Module:6 Mea | nieren Method, Interferometry, Optical T | omograpny. | 2 hours | | | |
| Basics Basic Ter | ms of Balance Metrology Mounting Va | riations Strain | n Gauges Wiring of | | | |
| Wheatstone Bridg | les Strain Gauge Selection Strain Cau | inacions, Sciali Ige Annlicatio | n Materiale Sindle | | | |
| Force oad Cell | s Multicomponent Load Measuremen | ige Applicatio | Balances - External | | | |
| Balances. | | | | | | |
| Module:7 Exp | erimental Synergy | | 3 hours | | | |
| | | | | | | |

Computer program verification and validation, Fundamentals of verification, Role of computational error estimation in verification testing, Fundamentals of validation, Construction of a validation experiment hierarchy, Statistical estimation of experimental error, Uncertainty quantification in computations, Validation metrics.

| IVIOQ | ule:o | Contemporary issues | | | | 2 nours |
|-------|----------|-------------------------------|----------------------------|----------------------|------------------|-----------------|
| | | | | | | |
| | | | | | | |
| | | Total | Lecture ho | urs: | | 30 hours |
| | | | | | | |
| Text | Book(| 5) | | | | |
| 1. | Taewo | oo Lee., Thermal and flow me | asurements | , 2008, 0 | CRC Press. | |
| 2. | Roach | e, P.J., Verification and | Validation | in Co | mputational | Science and |
| | Engine | eering, 1998, Hermosa publis | hers, Albuqu | Jerque, I | NM. | |
| Refe | rence | Books | | | | |
| 1. | Came | ron Tropea, Alexander L. Yai | ⁻ in, John F. F | ⁻ oss (Ed | s.) - Handbook | of Experimental |
| | Fluid N | lechanics, 2007, Springer. | | | | |
| 2. | Rober | t P. Benedict (auth.) - Funda | mentals of To | emperati | ure, Pressure, a | and Flow |
| | Measu | rements, 1984, Third Edition | , John Wiley | & Sons | | |
| | (= | | | | | |
| Mode | e of Eva | aluation: Continuous assessn | nent test, wri | itten assi | gnment, Quiz a | and Final |
| asse | essment | test | | | | |
| Poor | ommon | had by Board of Studios | 27 05 2022 |) | | |
| A | | | 21-03-2022 | | 40.00.0000 | |
| Appr | oved by | Academic Council | NO. 66 | Date | 16-06-2022 | |

| Cou | Course code Course Title L T P (| | | | | | С | | | |
|-----------|--|--|------------------|----------------------|-----------------|----------|-------|--------|-----|----------|
| MCF | D604P | Experimenta | I methods fo | or Fluid I | Flow Lab | | 0 | 0 | 2 | 1 |
| Pre- | requisite | NIL | | | | Sylla | abu | s ve | rsi | ion |
| | | | | | | | 1 | .0 | | |
| Cou | rse Objectiv | es | | | | | | | | |
| 1. | To teach measureme | various measuring nts. | techniques | suited | for therma | l, flow | / a | ind | fo | rce |
| Ζ. | orror estima | tion | interpret and | analyse | ine expen | mentai | ua | la a | nu | 115 |
| 3. | To teach the verification and validation methods of numerical models in comparison with experimental data. | | | | | | | | | |
| | 0.1 | | | | | | | | | |
| Cou | rse Outcom | 9 | | | -1- 4- | | | | | |
| Оро 1. | Perform ter standard ins | nperature, heat flux truments | and specie | s conce | entration m | easure | me | nts | us | ing |
| 2. | Carry out pr | essure, velocity, and fl | ow rate meas | suremen | ts in a given | flowfie | eld | | | |
| 3. | Perform flow | visualization using hi | gh speed ima | aging | | | | | | |
| 4. | Conduct the | experiments and anal | lyse the expe | rimental | data and ur | ncertair | nties | S. | | |
| | | | | | | | | | | |
| Indi | cative Exper | iments | | | | | | | | |
| 1. | Wind Tunne | l study of flow over an | airfoil at diffe | erent ang | les of attacl | <-Surfa | ce p | ores | sur | re |
| 2 | Measureme | nts of lift and drag ford | es of a symm | netric ae | rofoil in a lov | N SNee | d flo | אור | | |
| 3 | Smoke visu | alization of flow over a | cylinder | | | | | | | |
| 4 | Shadowgrau | oh visualization of a fla | me | | | | | | | |
| 5 | Visualization | of an under expande | d iet using So | chlieren t | echnique | | | | | |
| 6. | Measureme | nt of open flame temp | erature using | a IR the | rmal imagin | a came | era | | | |
| 7. | Measureme | nt of temperature in di | fferent mediu | ms using | thermocou | ples | | | | |
| 8. | Visualization | of flow over a bluff be | odv usina tuft | /oil flow | , | | | | | |
| 9. | Flow rate m | easurements using ve | nturi and orifi | ce meter | S | | | | | |
| 10. | Comparisor | of experimental and r | numerical res | ults of flo | w over a N | ACA00 | 12 a | airfoi | il | |
| 11. | Non-intrusiv | e velocity measureme | nts using adv | anced fl | ow diagnost | ic tech | niqu | les | | |
| | | , , | То | tal Labo | ratory Hou | rs 30 | ho | urs | | |
| Text | t Book(s) | | | | | • | | | | |
| 1. | Taewoo Lee | , Thermal and flow me | easurements, | 2008, C | RC Press. | | | | | |
| Refe | erence Book | S | | | | | | | | |
| 1. | Cameron Tro Fluid Mechai | opea, Alexander L. Ya nics, 2007, Springer. | rin, John F. I | ⁻ oss (Ed | s.) - Handb | ook of | Exp | perin | ner | ntal |
| 2. | Robert P. E | Benedict (auth.) - Fu | Indamentals | of Tem | perature, F | ressur | e, a | and | F | low |
| | <u>Measuremer</u> | ts, 1984, Third Edition | i, John Wiley | & Sons. | | | | | | <u>.</u> |
| Mod | e of assessm | ent: Continuous asse | ssment / Lab | FAT / Vi | va voce | | | | | |
| Rec | ommended b | y Board of Studies | 27-05-2022 | | | | | | | |
| Арр | roved by Aca | demic Council | No. 66 | Date | 16-06-202 | 22 | | | | |

| Course Code | Course Title | | L | Т | Ρ | С |
|--|---|--|---------------------------------|---------------------------------|---------------------------------|------------------------|
| MCFD605L | Multiphase flows | | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Sy | llab | us v | ersi | on |
| 0 011 // | | | | 1.0 | | |
| Course Objectives 1. To provide a comprehensive knowledge of various flow patterns in multiphase flows 2. To provide the physical insight and the mathematical aspects of multiphase flow pressure drop and its different model/correlations. 3. To understand the complex phenomenon underlying in multiphase flows for various industrial problems. Course Outcome Upon successful completion of this course students will be able to 1. Apply the concepts and quantitative description of multiphase flows in engineering problems. 2. Analyse the different flow patterns in liquid-gas two-phase flows and examine the flow regime maps. 3. Analyse the particles motion in multiphase flows problems. 4. Understand phenomenon of growth of bubbles and collapses. 5. Analyse the various forces acting on the fluid particles that are applied in industrial | | | | | | |
| needs. 6. Demonstrate | the knowledge of pool, flow boiling, and condensation. | | | | | |
| | | | | | | |
| Module:1 Over | view of Multiphase Flows | | | 7 | hou | irs |
| Basic definitions, Flow patterns a Lagrangian desc for single and r Boundary conditi | Importance of dimensionless numbers, Classification and regimes, Horizontal and vertical two-phase fl iption of fluid motion, Mass, momentum and energy cor nulti-phase flows, Mixture model equations, Two-flui ons in two-phase flow. | of mu lows, nserva d mc | ultiph Eu atior odel | າase leria າ equ equ | flov n a uatio atior | vs, nd ns ns, |
| Module:2 Liqu | id-Gas Two-Phase Flows | | | 8 | hou | ırs |
| Flow pattern clas Slug flow, Churr instabilities. Frict Weisbach equatio Brill, Friedel, Gas | sification, Flow regime maps for vertical and horizonta flow, Annular flow, Dispersed flow, Flow regimes lin onal pressure drop in disperse, homogenous and sep on. Pressure drop models by Lockhart-Martinelli, Barocz /bubble dynamics flows. | II flow nits, \$ aratec zy-Ch | ' - B Sepa I flov isho | ubbl arate ws, I Im, I | e flo ed fle Darc Begg | w, ow ;y– js- |
| Module:3 Part | cle Motion | | | 6 | hou | ırs |
| Single particle mo | otion, Flow around a sphere, Free flow velocity, Grain's ect on free flow drag, Schiller-Naumann drag model, Hy | size a drauli | and ic tra | ansp | ort c | of |
| solids, Particle flo | w motion. | | | | | |
| Module:4 Bub | ole/Droplets dynamics | | | 5 | hou | irs |
| Bubble shape, M and non-thermal | arangoni effects and Bjerkes forces, Rayleigh-Plesset e bubble growth and collapse. | quati | on, ⁻ | Ther | mal | |
| Module:5 Eule | r-Lagrangian Model | | | 6 | hou | ırs |
| Newton's second balance, Drag, lif Visualization of p | law for single particle's motion, Lagrangian particle trac t, buoyancy, gravitational and Brownian forces, Particle' article's trajectory. | cking, 's rela | For xati | ce on ti | me, | |
| Module:6 Eule | r-Euler Model | | | 6 | hou | ırs |
| Euler-Euler mode | el for multiphase flows, Link momentum equation for | each | pha | se, | Liqu | id- |

| liquid / liquid-solid mixing, Complex multiphase flows with turbulence, compressibility and heat transfer effects. | | | | | | |
|--|-------------------------|--|--|--|--|--|
| Module:7 Boiling and Condensation | 5 hours | | | | | |
| Horizontal surfaces – Pool boiling, Nucleate boiling, Film boiling, Critic | cal heat flux (CHF) and | | | | | |
| post CHF heat transfer in flow boiling, Flow boiling and CHF in mini and micro channels; | | | | | | |
| Vertical surfaces – Film boiling; Condensation, Choking in two-phase | flow | | | | | |
| Module:8 Contemporary Issues | 2 hours | | | | | |
| | | | | | | |
| | | | | | | |
| Total Lecture hours: | 45 hours | | | | | |
| Text Book(s) | | | | | | |
| 1. Brennen, C. (2005). Fundamentals of Multiphase Flow. Cambridg | je: Cambridge | | | | | |
| University Press. doi:10.1017/CBO9780511807169 | | | | | | |
| Reference Books | | | | | | |
| 1. Guan Heng Yeoh, Jiyuan Tu. (2019). Computational Techniques | for Multiphase | | | | | |
| Flows (Second Edition). Butterworth-Heinemann. ISBN 97800810 | JZ4539. | | | | | |
| 1 1 1 1 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 | ndensation Georgia | | | | | |
| Institute of Technology, ISBN: 9781107431638. | ndensation, ecorgia | | | | | |
| | | | | | | |
| Mode of Evaluation: CAT, written assignment, Quiz and FAT | | | | | | |
| Recommended by Board of Studies 27-05-2022 | | | | | | |
| Approved by Academic Council No. 66 Date 16-0 | 6-2022 | | | | | |

| Course Code Course Title L T P C | | | | | |
|--|---|---|--|--|--|
| MCFD606L | Finite Element Analysis of Solids and Fluids | 3 0 0 3 | | | |
| Pre-requisite | Nil | Syllabus version | | | |
| | | 1.0 | | | |
| Course Objectiv | /es | | | | |
| 1. To provid | e students with an introduction to Finite Element Analys | sis and help them | | | |
| use this n | nethod to solve problems in solid mechanics, heat trans | fer, fluid flow and | | | |
| machine | design. | | | | |
| 2. To teach | how to convert the physical problem into an engineering | g problem through | | | |
| geometric | cal and numerical modelling capabilities. | | | | |
| 3. To introdu | uce students to various field problems and the discretize | ation of the problem. | | | |
| 4. To make | the students drive finite element equations for simple ar | nd complex | | | |
| elements | and establish the computational model of the given pro | biem. | | | |
| Course Outeers | • | | | | |
| On completion th | e o student will be able to | | | | |
| | able product data exchange techniques to convert deal | metric model into | | | |
| numerica | lable product data exchange techniques to convert geol | | | | |
| 2 Apply the | knowledge of mathematics and engineering to solve pr | oblems in structural | | | |
| fluid and | thermal engineering by approximate and numerical met | hods | | | |
| 3. Formulate | a 1D and 2D finite element equations at element and as | sembly level for | | | |
| various a | oplications | y | | | |
| 4. Apply finit | e element formulations using linear and quadratic shap | e functions to | | | |
| compute | desired results. | | | | |
| 5. Simplify a | complex engineering problem, design engineering con | nponents and solve | | | |
| real life p | roblems using commercial FEM tools or develop FE coo | des. | | | |
| | | | | | |
| Module:1 Introduction to Approximation Methods 6 hours | | | | | |
| Module:1 Intro | duction to Approximation Methods | 6 hours | | | |
| Module:1IntroBasic Steps in the | duction to Approximation Methods | 6 hours Ilation-Minimum total | | | |
| Module:1 Intro Basic Steps in the potential energy | duction to Approximation Methods ne Finite Element Method-Material models-Direct formu formulation-weighted residual formulation-variational ap | 6 hours Ilation-Minimum total pproach. | | | |
| Module:1IntroBasic Steps in the potential energyModule:2High | duction to Approximation Methods ne Finite Element Method-Material models-Direct formu- formulation-weighted residual formulation-variational ap ner Order and Isoparametric Elements | 6 hours Ilation-Minimum total oproach. 6 hours | | | |
| Module:1IntroBasic Steps in the potential energyModule:2HighPolynomial form | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic | 6 hours Ilation-Minimum total pproach. 6 hours , Simplex, Complex, | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex element | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation polation polation | 6 hours Ilation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian intert | Image: Addition to Approximation Methods The Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements The Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements The Finite Element Method-Material models-Direct formulation-variational apper Order and Isoparametric Elements The Finite Element Method-Material models-Direct formulation-variational apper Order and Isoparametric Elements The Finite Element Method Finite Elements The Finite Element Finite Element Element Finite Element Eleme | 6 hours Ilation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic and cubic functions of shape functions. | 6 hours Ilation-Minimum total pproach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D guadratic tri | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational appender Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic functions, properties of shape functions, Truss element | 6 hours Ilation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interrand their shape2D quadratic triatfunctions - linear | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic functions, properties of shape functions, Truss element angular element in natural coordinates, 2D quadrilater quadratic element | 6 hours Jation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape pent Hermite shape | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beam | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic functions, properties of shape functions, Truss element angular element in natural coordinates, 2D quadrilater, quadratic element, Shape function of beam element. | 6 hours Jation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape nent. Hermite shape | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3App | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational approximation formulation-variational approximation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic angular element in natural coordinates, 2D quadrilater, quadratic element, Shape function of beam element. Interpolation to Solid Mechanics- One | 6 hours Jation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape hent. Hermite shape 6 hours | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interrand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDim | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic angular element in natural coordinates, 2D quadrilatar, quadratic element, Shape function of beam element. lication to Solid Mechanics- One ensional Analysis | 6 hours Jation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape hent. Hermite shape 6 hours | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDimGeneric form of | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS collation, Higher order one dimensional elements- quadratic angular element in natural coordinates, 2D quadrilater, quadratic element, Shape functions of beam element. Iteration to Solid Mechanics- One ensional Analysis 1D finite element equations –Truss, Beam -1D therm | 6 hours Jation-Minimum total pproach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape nent. Hermite shape 6 hours al problem – Linear | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDimGeneric form ofelements-Quadratic | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational appropriate and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic angular element in natural coordinates, 2D quadrilater, quadratic element, Shape functions of beam elements. Interpolation to Solid Mechanics- One ensional Analysis 1D finite element equations –Truss, Beam -1D thermatic elements- Natural coordinates - Isoparametric | 6 hours Ilation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape hent. Hermite shape 6 hours 6 hours 1 al problem – Linear elements-Numerical | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDimGeneric form ofelements-Quadration. | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic functions, properties of shape functions, Truss element angular element in natural coordinates, 2D quadrilater, quadratic element, Shape function of beam element. Iication to Solid Mechanics- One ensional Analysis 1D finite element equations –Truss, Beam -1D thermatic elements- Natural coordinates - Isoparametric | 6 hours Jation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape hent. Hermite shape 6 hours hal problem – Linear elements-Numerical | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDimGeneric form ofelements-Quadration.Module:4App | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic angular element in natural coordinates, 2D quadrilater, quadratic element, Shape function of beam element. Ication to Solid Mechanics- One ensional Analysis 1D finite element equations –Truss, Beam -1D thermatic elements- Natural coordinates - Isoparametric Ication to Solid Mechanics – Multi- | 6 hours Jation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape nent. Hermite shape 6 hours nal problem – Linear elements-Numerical | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDimGeneric form ofelements-Quadration.Module:4Appdime | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS collation, Higher order one dimensional elements- quadratic angular element in natural coordinates, 2D quadrilater, quadratic element, Shape functions of beam elements. Interpolation to Solid Mechanics- One ensional Analysis 1D finite element equations –Truss, Beam -1D thermatic elements- Natural coordinates - Isoparametric Iication to Solid Mechanics – Multi-ensional Problems | 6 hours Ilation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape nent. Hermite shape 6 hours nal problem – Linear elements-Numerical 6 hours | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDimGeneric form ofelements-Quadration.Module:4AppdimeGeneric form of | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic angular element in natural coordinates, 2D quadrilater, quadratic element, Shape functions, Truss element element. Iication to Solid Mechanics- One ensional Analysis 1D finite element equations –Truss, Beam -1D thermatic elements- Natural coordinates - Isoparametric Iication to Solid Mechanics – Multi-ensional Problems 2D finite element equations - Triangular element - Residual formulation - Residual formulations - Triangular element - Residual formulations - Residual formulation - Residual formulations - Triangular element - Residual formulations - | 6 hours Jation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape hent. Hermite shape 6 hours hal problem – Linear elements-Numerical 6 hours ectangular elements- | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDimGeneric form ofelements-Quadration.Module:4AppdimeGeneric form ofAxisymmetric element | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic functions, properties of shape functions, Truss element angular element in natural coordinates, 2D quadrilater, quadratic element, Shape function of beam element. Ication to Solid Mechanics- One ensional Analysis 1D finite element equations –Truss, Beam -1D thermatic elements- Natural coordinates - Isoparametric Ication to Solid Mechanics – Multi-ensional Problems 2D finite element equations - Triangular element - Rements- Vector variable problems such as plane stress, | 6 hours Ilation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape nent. Hermite shape 6 hours al problem – Linear elements-Numerical 6 hours 6 hours | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDimGeneric form ofelements-Quadration.Module:4AppdimeGeneric form ofAxisymmetric elementsSymmetric problet | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS colation, Higher order one dimensional elements- quadratic functions, properties of shape functions, Truss element angular element in natural coordinates, 2D quadrilater, quadratic element, Shape function of beam element. lication to Solid Mechanics- One ensional Analysis 1D finite element equations –Truss, Beam -1D thermatic elements- Natural coordinates - Isoparametric lication to Solid Mechanics – Multi-ensional Problems 2D finite element equations - Triangular element - Rements- Vector variable problems such as plane stress, ems; Shell structures -Applications in structural and thermatic element - Applications in structural and thermatic element - Rements- Vector variable problems such as plane stress, ems; Shell structures -Applications in structural and thermatic element - Rements - Vector variable problems such as plane stress, ems; Shell structures -Applications in structural and thermatic element - Rements - Vector variable problems such as plane stress, ems; Shell structures -Applications in structural and thermatic element - Rements - Vector variable problems such as plane stress, ems; Shell structures -Applications in structural and thermatic element - Rements - Vector variable problems such as plane stress, ems; Shell structures -Applications in structural and thermatic element - Rements - Vector variable problems such as plane stress, ems; Shell structures -Applications in structural and thermatic element - Rements - Vector variable | 6 hours Ilation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape nent. Hermite shape 6 hours al problem – Linear elements-Numerical 6 hours ectangular elements- plane strain and axi- mal problems. | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDimGeneric form ofelements-QuadraticIntegration.Module:4AppdimeGeneric form ofAxisymmetric elementssymmetric probleModule:5FluiDiagration | duction to Approximation Methods ne Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic functions, properties of shape functions, Truss element angular element in natural coordinates, 2D quadrilater, quadratic element, Shape function of beam element. lication to Solid Mechanics- One ensional Analysis 1D finite element equations –Truss, Beam -1D thermatic elements- Natural coordinates - Isoparametric lication to Solid Mechanics – Multi-ensional Problems 2D finite element equations - Triangular element - Resensional Problems 2D finite element equations - Triangular element - Resensional Problems and Mechanical Applications in structural and thermatic of the structures - Applications in structural and thermatic of the structures - Applications in structural and thermatic of the structures - Applications | 6 hours Jation-Minimum total proach. 6 hours , Simplex, Complex, ynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape nent. Hermite shape 6 hours al problem – Linear elements-Numerical 6 hours ectangular elements- plane strain and axi- mal problems. 7 hours | | | |
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| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDimGeneric form ofelements-QuadraticIntegration.Module:4AppdimeGeneric form ofAxisymmetric elessymmetric probletModule:5FluiDiscrete and sermass conservatiobenchmark flower | duction to Approximation Methods he Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS colation, Higher order one dimensional elements- quadratic functions, properties of shape functions, Truss element angular element in natural coordinates, 2D quadrilater, quadratic element, Shape function of beam element. Iication to Solid Mechanics- One ensional Analysis 1D finite element equations –Truss, Beam -1D thermatic elements- Natural coordinates - Isoparametric Iication to Solid Mechanics – Multi-ensional Problems 2D finite element equations - Triangular element - Resensional Analysis 2D finite element equations - Triangular element - Resensional Problems 2D finite element equations - Triangular element - Resensional Problems 2D finite element equations - Triangular element - Resensional Problems 2D finite element equations - Triangular element - Resensional Problems 2D finite element equations - Triangular element - Resensional Problems 2D finite element equations - Triangular element - Resensional Problems 2D finite element equations - Triangular element - Resensional Problems | 6 hours Jation-Minimum total proach. 6 hours , Simplex, Complex, lynomials in terms of T element. dratic, Cubic element t, Shape functions of teral element shape nent. Hermite shape 6 hours 6 hours al problem – Linear elements-Numerical 6 hours ectangular elements- plane strain and axi- mal problems. 7 hours ty method - Discrete ems; Non-isothermal | | | |
| Module:1IntroBasic Steps in thepotential energyModule:2HighPolynomial formMultiplex elementglobal coordinateLagrangian interand their shape2D quadratic triatfunctions – lineatfunction of beamModule:3AppDimGeneric form ofelements-QuadraticIntegration.Module:4AppdimeGeneric form ofAxisymmetric probletModule:5FluiDiscrete and sermass conservatiobenchmark flow | duction to Approximation Methods he Finite Element Method-Material models-Direct formulation-weighted residual formulation-variational apper Order and Isoparametric Elements of interpolation functions- linear, quadratic and cubic ts, Convergence requirements, Linear interpolation poles and local coordinates of bar, triangular elements, CS polation, Higher order one dimensional elements- quadratic functions, properties of shape functions, Truss element angular element in natural coordinates, 2D quadrilater, quadratic element, Shape function of beam element. Iication to Solid Mechanics- One ensional Analysis 1D finite element equations – Truss, Beam -1D thermatic elements- Natural coordinates - Isoparametric Iication to Solid Mechanics – Multi-ensional Problems 2D finite element equations - Triangular element - Rements- Vector variable problems such as plane stress, ems; Shell structures -Applications in structural and thermatic of the functions in structural and thermatic on and energy conservation; Isothermal fluid flow problems problem; | 6 hours Jation-Minimum total proach. 6 hours , Simplex, Complex, ynomials in terms of T element. T element. T element shape functions of teral element shape 6 hours 6 hours al problem – Linear elements-Numerical 6 hours ectangular elements- plane strain and axi- mal problems. 7 hours ty method - Discrete ems; Non-isothermal | | | |

| Мо | dule:6 | Steady State Heat Co | nduction with | th | | 6 hours |
|--------------|------------|------------------------------|------------------|-------------|------------|--------------------------|
| | | Applications | | | | |
| Hea | at Tran | sfer through Plane and | Composite wa | alls- Rad | dial Heat | t Flow in a cylinder- |
| Coi | nductior | and Convections Systems | s; Two-dimensi | ional plan | e problei | ms- Three dimensional |
| and | l axisym | imetric problems- Finite ele | ment solution | to conveo | ction-diff | usion equation. |
| Мо | dule:7 | Transient Heat Condu | ction Analy | sis with | | 6 hours |
| Applications | | | | | | |
| Lur | nped H | eat Capacity System- Nu | merical Solution | on- Tran | sient gov | verning equations and |
| bοι | undary a | and initial conditions -The | Galerkin me | thod -On | e-dimen | sional Transient State |
| Pro | blem - | Multi-dimensional Transi | ent Heat Cor | nduction | - Phase | Change Problems— |
| Sol | idificatio | on and Melting. | | | | 3 |
| Мо | dule:8 | Contemporary Issues | | | | 2 hours |
| | | • • | | | | |
| | | | | | | |
| | | | Total | Lecture | hours: | 45 hours |
| | | | | | | |
| Tex | rt Book | (s) | | | | |
| 1 | Rao S | S Finite Elements Metho | d in Engineerir | na 5th Ea | dition Els | sevier 2010 |
| 2 | Ronald | W Lewis P Nithiyaarasu | and K N Seeth | haramu F | undame | ntals of Finite Element |
| - | Metho | d for Heat and Fluid Flow | John Wiley & s | ons 2004 | 4 | |
| Ret | ference | Books | | , | | |
| 1 | J N Re | ddy Introduction to Finite | Element Met | hod Mc(| Graw -Hil | Il International Edition |
| •• | 2019 | | | nou, mot | | |
| 2 | Tiruna | thi R. Chandrunatla and As | hok D. Belugu | ndu Intro | duction t | to Finite Elements in |
| ~ | Engine | ering 4th Edition Prentice | Hall 2011 | nau, muc | | |
| 3 | Seshu | P Finite Flement Analysis | Prentice Hall | l of India | 2013 | |
| 4 | Saeed | Moaveni Einite Element A | nalvsis Theor | v and An | olication | with ANSYS Pearson |
| • | Fifth E | dition. 2021 | | y ana / ipi | phoadon | |
| Mo | de of F | aluation: CAT written assi | anment Quiz | FAT | | |
| | | | | , | | |
| Ree | commer | nded by Board of Studies | 27-05-2022 | | | |
| App | proved b | y Academic Council | No. 66 | Date | 16-06-2 | 2022 |

| Course code | Course Title | | L | Т | Ρ | С |
|--|--|---------------------------|-------------------|-------|--------------|-----------|
| MCFD607L | High Performance Computing | | 2 | 0 | 0 | 2 |
| Pre-requisite | NIL | S | Sylla | bus | vers | ion |
| | | | 1 | .0 | | |
| Course Objectives | | | | | | |
| 1. I o develop ur | nderstanding of programming best practices, pro | oductivi | ty to | ols a | nd lii | nux |
| 2 To improve th | lenn in general. De knowledge on working of modern computers | and pr | ara | n ov | ocuti | ion |
| 2. To improve in program effici | ency and ontimization procedures | anu pro | Jyrai | | ecui | UII, |
| 3 To familiarize | e our students with debugging performance | evalua | tion | tech | nniau | les |
| profiling and | l instrumentation to identify bottlenecks | and | oppo | rtuni | ties | of |
| parallelization in programs. | | | | | | |
| 4. To impart basic knowledge of OpenMP in the context of shared memory architecture. | | | | | | |
| 5. To demonstra | te the basics of MPI in the context of distributed | l memo | ry ar | chite | cture | э. |
| 6. To familiarize | with GPGPU device architecture and accelerate | ed code | e usir | ng Cl | JDA | |
| | | | | | | |
| Course Outcome | | | | | | |
| Upon successful com | ipletion of the course the students will be able to | | | +- | مام | |
| 2 Analyze time | profile benchmark and optimize serial codes | progra | | ig io | ois. | |
| 2. Analyze une, 3. Demonstrate | ability to use documentation system, debuggin | a syste | m h | blin | eveti | ≥m |
| version contro | ability to use decamentation system, debuggin of system profiler program analyzer etc | g 39310 | лп, к | unu | Syst | <i></i> , |
| 4. Understand p | arallelizing mechanisms in modern computer ar | nd be al | ble to | o use | e cac | he. |
| data-locality, | branch-prediction, virtual memory etc and shall | be abl | e to | explo | oit th | iem |
| to write better | performing programs. | | | • | | |
| Develop paral | lel program on a shared memory architecture us | sing Op | enM | Ρ. | | |
| 6. Write parallel | program for a distributed memory architecture u | ising M | PI. | | | |
| 7. Use GPGPU | to accelerate program performance using SIMD | archite | cture |). | | |
| | C and Linux Environment | | | | 1 60 | |
| History of computing | and computers. Moore's law and saturation | Multice | no n | atur | <u>+ 110</u> | the |
| computers and super | -computers Amdahl's law ton500 org Challen | aina nr | hler | ns th | at n | eed |
| high-performance He | ow to get Linux? Linux on a USB stick dual b | oot sve | stem | Bas | sic li | nux |
| literacy - Is. cp. mv. c | cd. mkdir. cut. curl. indirection. tee. pipe. top. h | ead. tai | l. are | ep. s | ed. s | ssh. |
| scp, .bashrc, .bash p | profile, .bash history. | , | <i>,</i> , | 1, | , | , |
| Module:2 Pro | ofessional Code Development Practices | | | (| 6 ho | urs |
| Editors: vim, emacs, | compilers: gcc, g++, gfortran, nvcc, debugging: | gdb, d | dd, I | DEs: | ecli | pse |
| (,netbeans, Visual S | tudio), version control system: git (,svn), build | systen | n: m | ake, | cma | ıke, |
| documentaion : dox | ygen (,sphinx), scripting: shell scripting, awl | k script | ting, | usir | ng H | PC |
| machine: PBS scripts | s, job scheduling, environment modules, best p | ractices | for | repro | oduc | ible |
| Modulo:3 Mo | dorn Computors and Program Ontimization | | | | 1 ho | ure |
| Clock cycle Memory | types (Pegisters 11 cache 12 cache 13 ca | che P | <u> </u> | 991 | | |
| intranet internet) an | id its significance in latency virtual memory na | adina r | ineli | nina | bra | nch |
| prediction architectu | re based optimization | , P | npen | inig, | bru | |
| Compiler Flags: inlin | ing, loop-unrolling, data-contiguity, improving l | latencv | bv d | lata | loca | litv. |
| gdb- debugging the | code, .gdbinit, preprocessor directives, Appro | priate s | selec | tion | of d | ata |
| structures and algorit | hms, timing and profiling: time, gprof. | | | | | |
| Module:4 An | alysis Tools and Optimization of Serial Code | • | | 4 | 4 ho | urs |
| Instrumentation of t | he code: google-tools, scorep, TAU, Use o | f Libra | ries | - L/ | APA | CK, |
| SCALAPACK, netlib, | Benchmarking and its importance, Interoperate | oility be | twee | n lar | ngua | ges |
| C-Fortran, creating lik | prary: sharing developed features without sharin | n <mark>g full c</mark> e | ode. | | | |
| Module:5 Sha | ared Memory Architecture (Open MP) | | | | 4 ho | urs |

| most compliers lack the implementation, data dependancies: flow dependency, an dependency, output dependency, Granularity of parallelism; fine vs coarse, Synchronizatio | аι, | | | | | | |
|---|---|--|--|--|--|--|--|
| dependency, output dependency, Granularity of parallelism; fine vs coarse, Synchronizatio | most compliers lack the implementation, data dependencies: flow dependency, anti- | | | | | | |
| dependency, output dependency, Granularity of parallelism: fine vs coarse, Synchronization, | | | | | | | |
| Atomic operations,omp_set_num_threads, omp_get_num_threads, omp_get_max_threads, | | | | | | | |
| omp_get_wtime, omp_get_wtick, omp_set_nested, OMP parallel, parallel loop, parallel | | | | | | | |
| sections for, private, firstprivate, lastprivate, reduction, schedule, collapse, ordered, nowa | ait, | | | | | | |
| OMP section, single, master, critical, task, barrier, taskwait, flush, cancel, cancellation point, | | | | | | | |
| Accelerator off-loading (simd, declare simd, loop simd, target data, declare target, target | | | | | | | |
| update, teams, distribute simd, distribute parallel), Debugging, Profiling and selection | of | | | | | | |
| code to be parallelized. Performance evaluation: speedup, latency. | | | | | | | |
| Module:6 Distributed Memory Architecture (MPI) 3 hou | rs | | | | | | |
| Open MPI library and how to build it. basic MPI - Message Passing Interface prograr | m, | | | | | | |
| Blocking and non-blocking communication, Importance of minimizing communicatio | n, | | | | | | |
| MPI_Init, MPI_Finalize, MPI_Comm_rank, MPI_Comm_size, MPI_COMM_WORLD, | | | | | | | |
| MPI_Get_processor_name, MPI_Send, MPI_Recv, MPI_Bcast,MPI_Reduce,MPI_Allreduc | е | | | | | | |
| Module:7 Hybrid Computing 3 hou | rs | | | | | | |
| GPU architecture, SIMD instruction, NVidia and CUDA, (OpenCL - much broad | er | | | | | | |
| applicability but complex), thread, block, grid, warp concepts, Nsight IDE, GPU kernels ar | nd | | | | | | |
| best code local data shared data global data data transfers synchronization narallel | | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall | lel | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns | lel | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns Module:8 Contemporary Issues 2 hou | lel rs | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns Module:8 Contemporary Issues 2 hou | lel rs | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns Module:8 Contemporary Issues 2 hou | iel rs | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns Module:8 Contemporary Issues 2 hou Total Lecture hours 30 hou | rs | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns Module:8 Contemporary Issues 2 hou Total Lecture hours 30 hou Text Book(s) | rs | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns Module:8 Contemporary Issues 2 hou Total Lecture hours 30 hou Text Book(s) 1. George Hager, Gerhard Wellein - Introduction to High Performance Computing for | rs rs | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns Module:8 Contemporary Issues 2 hou Total Lecture hours 30 hou Text Book(s) 1. George Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. | rs | | | | | | |
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| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns Module:8 Contemporary Issues 2 hou Total Lecture hours 30 hou Text Book(s) 1. George Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General- Purpose GPU Programming 1st Edition. | rs | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns Module:8 Contemporary Issues 2 hou Total Lecture hours 30 hou Text Book(s) 1. George Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General- Purpose GPU Programming 1st Edition. Mode of Evaluation: Continuous assessment test, Programming assignments, Quiz and | rs | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns Module:8 Contemporary Issues 2 hou Total Lecture hours 30 hou Text Book(s) 1. George Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General- Purpose GPU Programming 1st Edition. Mode of Evaluation: Continuous assessment test, Programming assignments, Quiz and Final assessment test | rs | | | | | | |
| host code, local data, shared data, global data, data transfers, synchronization, parall algorithms and design patterns Module:8 Contemporary Issues 2 hou Total Lecture hours 30 hou Text Book(s) 1. George Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General- Purpose GPU Programming 1st Edition. Mode of Evaluation: Continuous assessment test, Programming assignments, Quiz and Final assessment test Recommended by Board of Studies 27-05-2022 | rs | | | | | | |

| MCFD607P High Performance Computing Lab 0 0 1 1 Pre-requisite NIL Syllabus version 1.0 Course Objectives 1.0 0 1.0 Course Objectives 1.0 0 1.0 Course Objectives 1.0 Course Objectives 1.0 Course outcome 0 1.0 Course Outcome 0 0.0 0.0 Upon successful completion of the course, students will be able to 1. Analyze time, profile, benchmark and optimize serial codes. 2. Analyze time, profile, benchmark and optimize serial codes. 2. 0.0 | Course code | | Course Tit | le | | | L | Т | Ρ | С |
|--|-------------------------------|------------------------------------|----------------|----------------------|--------------------|----------|----------|-------------|-------|------|
| Pre-requisite NL Syllabus version 1.0 1.0 Course Objectives 1.0 2. To develop understanding of programming best practices, productivity tools and linux operating system in general. 1. To develop understanding of modern computers and program execution, program efficiency and optimization procedures. 3. To teach parallel code development using OpenMP, MPI and GPGPU. Course Outcome Upon successful completion of the course, students will be able to 1. Analyze time, profile, benchmark and optimize serial codes. 2. Apply parallelizing mechanisms in modern computer and be able to use cache, data-locality, branch-prediction, virtual memory architecture using OpenMP. 4. Write parallel program on a shared memory architecture using OpenMP. 4. Write parallel program for a distributed memory architecture using MPI. Indicative Experiments 1. Setup linux development environment. Install compiler, eclipse, doxygen, graphviz, gnuplot, gft, gdb, cmake, nvida-nsight, metis, open MPI, TAU. 2. Write a complete program for 1D Heat Diffusion problem using Finite Difference Method with unit test cases. demonstrate build system and git version control 3. Using gdb debug and fix issues in provided programs. 4. Time and profile provided serial codes and identify the bottlenecks – opportunities of parallelization. 5. For a given Poisson's equation program, experiment with optimization fla | MCFD607P | High Perf | ormance Co | mputing | Lab | | 0 | 0 | 2 | 1 |
| 1.0 Course Objectives 1. To develop understanding of programming best practices, productivity tools and linux operating system in general. 2. To impart knowledge on working of modern computers and program execution, program efficiency and optimization procedures. 3. To teach parallel code development using OpenMP, MPI and GPGPU. Course Outcome Upon successful completion of the course, students will be able to 1. Analyze time, profile, benchmark and optimize serial codes. 2. Apply parallelizing mechanisms in modern computer and be able to use cache, data-locality, branch-prediction, virtual memory to write better performing programs. 3. Develop parallel program on a shared memory architecture using OpenMP. 4. Write parallel program for a distributed memory architecture using MPI. Indicative Experiments 1. Setup linux development environment. Install compiler, eclipse, doxygen, graphviz, gnuplot, git, gdb, cmake, nvidia-nsight, metis, open MPI, TAU. 2. Write a complete program for 1D Heat Diffusion problem using Finite Difference Method with unit test cases. demonstrate build system and git version control 3. Using gdb debug and fix issues in provided programs. 4. Time and profile provided serial codes and identify the bottlenecks – opportunities of parallelization. 5. For a given Poisson's equation program, experiment with optimization flags. Compare timings of different solver algorithms. (Jacobi, GS, GS-SOR, ADI). Profile these codes. </th <th>Pre-requisite</th> <th>NIL</th> <th></th> <th></th> <th></th> <th>Syl</th> <th>llabu</th> <th>IS V</th> <th>ers</th> <th>ion</th> | Pre-requisite | NIL | | | | Syl | llabu | IS V | ers | ion |
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| timings of different solver algorithms. (Jacobi, GS, GS-SOR, ADI). Profile these codes. For a given unsteady LDC problem, time and instrument the code and analyse it with scorep /TAU. Parallelize a SIMPLE program using OpenMP. Compare timing and compute speedup. Instrument and Analyze the code. Improve data locality using METIS graph-partitioning library. Compare performance of a given Unstructured FE code. Compute mesh-partition using METIS and implement MPI parallelization. Compare performance. Convert the IO operations in a given program to use binary read-write to improve IO performance. Comment on the improvement. Total Laboratory Hours 30 hours Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General-Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce | 5. For a giver | Poisson's equation pro | ogram, exper | iment wit | h optimizati | ion flag | gs. C | Com | pare | е |
| 6. For a given unsteady LDC problem, time and instrument the code and analyse it with scorep /TAU. 7. Parallelize a SIMPLE program using OpenMP. Compare timing and compute speedup. Instrument and Analyze the code. 8. Improve data locality using METIS graph-partitioning library. Compare performance of a given Unstructured FE code. 9. Compute mesh-partition using METIS and implement MPI parallelization. Compare performance. 10 Convert the IO operations in a given program to use binary read-write to improve IO performance. Comment on the improvement. Total Laboratory Hours 30 hours Text Book(s) 1. Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General-Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies 27-05-2022 | | lifferent solver algorithm | ns. (Jacobi, C | <u> SS, GS-S</u> | <u>OR, ADI). I</u> | -rofile | thes | <u>se c</u> | ode | S. |
| 7. Parallelize a SIMPLE program using OpenMP. Compare timing and compute speedup. Instrument and Analyze the code. 8. Improve data locality using METIS graph-partitioning library. Compare performance of a given Unstructured FE code. 9. Compute mesh-partition using METIS and implement MPI parallelization. Compare performance. 10 Convert the IO operations in a given program to use binary read-write to improve IO performance. Comment on the improvement. Total Laboratory Hours 30 hours Text Book(s) 1. Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General-Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies 27-05-2022 | 6. For a giver scorep /TA | Unsteady LDC problem | n, time and in | strument | the code a | and an | alyse | e it v | with | |
| Instrument and Analyze the code. 8. Improve data locality using METIS graph-partitioning library. Compare performance of a given Unstructured FE code. 9. Compute mesh-partition using METIS and implement MPI parallelization. Compare performance. 10 Convert the IO operations in a given program to use binary read-write to improve IO performance. Comment on the improvement. Total Laboratory Hours 30 hours Text Book(s) 1. Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General-Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies | 7. Parallelize | a SIMPLE program usir | ng OpenMP. | Compare | e timing and | l comp | oute | spe | edu | p. |
| 8. Improve data locality using METIS graph-partitioning library. Compare performance of a given Unstructured FE code. 9. Compute mesh-partition using METIS and implement MPI parallelization. Compare performance. 10 Convert the IO operations in a given program to use binary read-write to improve IO performance. Comment on the improvement. Total Laboratory Hours 30 hours Text Book(s) 1. Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General-Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies 27-05-2022 | Instrument | and Analyze the code. | | | | | | | | |
| 9. Compute mesh-partition using METIS and implement MPI parallelization. Compare performance. 10 Convert the IO operations in a given program to use binary read-write to improve IO performance. Comment on the improvement. 30 hours Text Book(s) 1. Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General-Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce | 8. Improve da | ita locality using METIS | graph-partiti | oning libr | ary. Compa | are pe | rtorn | nan | ce c | of a |
| 9. Compute mesh-partition using METRS and implement MPT parallelization. Compare performance. 10 Convert the IO operations in a given program to use binary read-write to improve IO performance. Comment on the improvement. Total Laboratory Hours 30 hours Text Book(s) 1. Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General-Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies 27-05-2022 | given Unst | ructured FE code. | TIC and impl | | | ation | Con | | | |
| 10 Convert the IO operations in a given program to use binary read-write to improve IO performance. Comment on the improvement. Total Laboratory Hours 30 hours Text Book(s) 1. Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General-Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies | berforman | nesh-paruluon using ME | no anu impi | | | auon. | Cou | npa | е | |
| Total Laboratory Hours 30 hours Text Book(s) 1. Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General-Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies | 10 Convert the | - IO operations in a give | en program to | use hin: | arv read-wr | ite to i | mpro | nve | 10 | |
| Total Laboratory Hours 30 hours Text Book(s) 30 hours 1. Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General-Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies 27-05-2022 | performance | ce Comment on the imp | provement | | ary roud wi | | mpr | 000 | 10 | |
| Text Book(s) 1. Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General- Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies 27-05-2022 | | | То | tal Labo | ratorv Hou | rs 30 | 0 ho | urs | | |
| Georg Hager, Gerhard Wellein - Introduction to High Performance Computing for Scientists and Engineers, CRC Press, Taylor & Francis Group, 2010. Reference Books Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General- Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies 27-05-2022 | Text Book(s) | | | | | _ | | | | |
| Reference Books 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General- Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies 27-05-2022 | 1. Georg Hag | er, Gerhard Wellein - | Introduction | to High Francis (| Performan | ce Co | mpu | iting | foi | r |
| 1. Jason Sanders, Edward Kandrot - CUDA by Example: An Introduction to General- Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies 27-05-2022 | Reference Boo | | 33, Taylor & | | <u>Jioup, 2010</u> | J. | | | | |
| Purpose GPU Programming 1st Edition. Mode of assessment: Continuous assessment / Lab FAT / Viva voce Recommended by Board of Studies 27-05-2022 | 1. Jason San | ders. Edward Kandrot | - CUDA by | Example | e: An Intro | oductio | on tr |) G | ene | ral- |
| Mode of assessment: Continuous assessment / Lab FAT / Viva voce | Purpose GF | PU Programming 1st Ed | lition. | Example | . <i>,</i> | | | . 0 | 5110 | |
| Recommended by Board of Studies 27-05-2022 | Mode of assess | ment: Continuous asse | ssment / Lab | FAT / Vi | va voce | | | | | |
| LI VO LVLL | Recommended | by Board of Studies | 27-05-2022 | | | | | | | |
| Approved by Academic Council No. 66 Date 16-06-2022 | Approved by Ac | ademic Council | No. 66 | Date | 16-06-202 | 22 | | | | |

| Course Co | de | Course Title | | L | Т | Ρ | С |
|---|---|---|-------------------|----------------|------------------|----------------|-------------|
| MCFD608L | - | Numerical Simulation of Environmental and Atmospheric Flows | | 3 | 0 | 0 | 3 |
| Pre-requis | ite | NIL | Sy | llab | us v | ersi | on |
| | | | | | 1.0 | | |
| Course Ob | ojective | es | | | | | |
| 2. To e 3. To e | representation of the governing equations of Environmental and Atmospheric Flows. 2. To enable students to understand cutting edge global issues in a warming planet. 3. To help students learn research trends through a research component within the remit of environmental and atmospheric flows. | | | | | | |
| Course Ou | itcome | | | | | | |
| Upon comp 1. Pos atm 2. Unc 3. Inte 4. Der insig cha | Course Outcome Upon completion of the course the students will be able to Possess knowledge of heat and mass transfer applications in environmental and atmospheric flows. Understand the principles of environmental and atmospheric flows. Interpret energy climate data pools sourced globally and write research papers. Demonstrate how atmospheric processes are linked to the dynamics and gain an insightful understanding of the physico-chemical processes leading to climate change | | | | | | |
| Modulo:1 | Over | viow | | | 5 | hou | |
| woulde. I | Over | view | | | 5 | not | 112 |
| Overview of mechanics, volcanic an | of fund , green d soil a | amental physical processes that shape climate. So house gases, Scales of motion, atmospheric and oc aerosols. | lar va eanic | ariab circu | ility, ilatic | orb on, a | ital ind |
| Module:2 | Fund | amentals of Atmospheric Processes | | | 5 | hou | Jrs |
| N-S equation The <i>f</i> -plan | ons. Co le, the j | priolis force. Rossby number. Equations of motion in C β -plane. Geostrophic flows. Vorticity and potential vor | artesi ticity. | an c | oord | linat | es. |
| Module:3 | Energ | gy Climate Dynamics | | | 6 | hou | Jrs |
| Hydrostatic and diffusi Simulation | balano on pro technic | ce. Derivation of the Potential Temperature. States of oblems. Parcel Concepts. Thermal wind equation. ques in large-scale flows. | stabili Gene | ty. S ral | trati Circ | ficat ulati | ion on. |
| Module:4 | Therr | modynamical Processes | | | 8 | hou | Jrs |
| Principles of Thermodyn motions. M | of Ener namic E oist an | gy, Entropy and Enthalpy. The First and Second law Energy Equations. Vertical structure and change of d Pseudo-adiabatic processes. | of Th state | erm due | odyr to | iami verti | cs. cal |
| Module:5 | Boun | dary Layer Processes | | | 5 | hοι | ırs |
| Expanded the momen | continu Itum eq | uity equations. Cloud-fog physics. Boundary layer ph quation in urban boundary layer. | ysics. | Арр | licat | ions | of |
| Module:6 | Shall | ow Water model theory | | | 7 | hou | ırs |
| Approximat approximat | tions to ions. P | N-S equations: Shallow Water (SW) equations, Bous otential vorticity and conservation properties. | ssines | q an | d Ar | nelas | stic |
| Module:7 | Nume | erical methods in Boundary layer Processes ding large scale flows | | | 7 | hou | ırs |
| Coriolis ac | celerat | ion configuration. Mass conservation equation imple | menta | ation | . Bo | und | ary |
| conditions. | Introdu | uction of zonal jets and currents. Large scale perturba | tions a | and g | geos | trop | hic |

| equ | equilibrium. | | | | | | |
|-----|-----------------|--|--------------------------------------|-------------------------|---|---------------|--|
| Мо | dule:8 | Contemporary issues | | | 2 | hours | |
| | | | | | | | |
| | | | | | | | |
| | | | Total Le | ecture ho | urs: 45 | hours | |
| Tex | ktbook(| S) | | | | | |
| 1. | Fundar | mentals of Atmospheric M idge University Press, U k | odelling. Mark Ja | cobson. 2 548659 IS | nd Edition (2005). Publ BN-13: 978-05215486 | lisher: 56 | |
| | Cumbi | | (. 10BN 10. 0021) | | BIT 10: 010 002 10 100 | | |
| 2. | Ocean | Modelling for Beginner | rs. Jochen Kär | npf. 1 st E | dition (2009). Publis | sher: | |
| Det | Spring | er, Berlin, Heidelberg. ISB | SIN 978-3-642-008 | 519-1 | | | |
| Re | rerence | BOOKS | | | | | |
| 1. | Geoph New Y | ysical Fluid Dynamics. Jo ork. ISBN 978-0-387-9638 | seph Pedlosky. 2 38-4 | 2 nd Edition | (1987). Publisher: Sp | oringer, | |
| 2. | Introdu | ction to Geophysical Flu | id Dynamics, Ph | ysical and | Numerical Aspects. | Benoit | |
| | Cushm Massa | an-Roisin & Jean-Marie E chusetts. Hardcover ISBN | Beckers (2011). F I: 978012088759 | Publisher: . D | Academic Press, Cam | ıbridge, | |
| 3. | Compt (2002) | Itational Methods in Enviro | onmental Fluid M | echanics. | Kolditz Olaf. 1 st Editio | n | |
| 4 | Atmos | ohere Ocean and Climat | e Dynamics Johr | n Marshall | and Alan Plumb 1 st F | dition | |
| | (2007) | Elsevier Academic Press | s. USA. ISBN-10: | 01255869 | 014 ISBN-13: 978- | annon | |
| | 0125586917 | | | | | | |
| Мо | de of Ev | aluation: CAT, written ass | signment, Quiz ar | nd FAT | | | |
| Re | commer | ded by Board of Studies | 27-05-2022 | | | | |
| Ар | proved b | y Academic Council | No. 66 | Date | 16-06-2022 | | |

| Course Code Course Title L T | | | | | |
|------------------------------|--|------------------------|--|--|--|
| MCFD609L | Modeling and Simulation of Energy System | s 3003 | | | |
| Pre-requisite | NIL | Syllabus version | | | |
| - | | 1.0 | | | |
| Course Objectiv | /es | | | | |
| 1. To impart kn | owledge on various energy conversion technologies. | | | | |
| 2. To apply the | dynamic, linear and geometric programming for solvir | ng problems related to | | | |
| energy syste | ms. | | | | |
| 3. To provide | the mathematical aspects and optimization of va | rious thermodynamic | | | |
| systems. | | | | | |
| | | | | | |
| Course Outcom | • | | | | |
| | completion of this course students will be able to | | | | |
| 1 Analyse the | various parameters for optimization in workable system | ne | | | |
| 2 Apply the ma | thematical concents to carry out the system simulation | 1 5 . | | | |
| 3 Ontimize ene | ray systems and their related components | 1. | | | |
| 4 Understand t | he relations between thermodynamic properties involv | ed in energy systems | | | |
| 5 Develop mat | nematical models for various energy systems and com | inonents | | | |
| | | | | | |
| Module:1 Ove | rview of Energy Systems | 6 hours | | | |
| Overview of vari | ous technologies and energy conversion. Workable a | nd Optimum systems. | | | |
| Economics of | Energy Systems. Polynomial representations. La | grange interpolation. | | | |
| Exponential Forr | ns, Equation fitting. | 551 , | | | |
| | | | | | |
| Module:2 Sys | tem Simulation | 4 hours | | | |
| Classes of simul | ation, Sequential and simultaneous calculations, Succ | essive substation, | | | |
| Taylor's series a | nd Newton Raphson methods. | 7 hours | | | |
| Mothematical ra | neccontation of optimization problems. Optimization | riouis | | | |
| | presentation of optimization problems, optimization | Coofficients Soarch | | | |
| Methods Dich | stomous search Eibonacci search Lattice search Lini | variate search | | | |
| Module:4 The | rmal System Analysis | | | | |
| Pattern and Ch | aracteristics of Dynamic programming solutions A | narently constrained | | | |
| problems Geor | petric programming. Mechanics of Solutions for one | independent variable | | | |
| Linear Program | ming Mathematical statement and Geometric Vi | sualization of Linear | | | |
| programming pro | blem. Simplex algorithm. | | | | |
| Module:5 Mo | deling of Thermodynamic Properties | 6 hours | | | |
| Need for ma | thematical Modeling, Linear and non-linear F | Regression analysis, | | | |
| Thermodynamic | properties, Internal energy and entropy, pressure-ter | nperature relationship | | | |
| at saturated con | ditions, Maxwell relations. | · · | | | |
| Module:6 Des | gn of Heat Exchangers | 6 hours | | | |
| Design of Heat | exchangers - parallel flow, counter flow, Evaporat | ors and Condensers, | | | |
| Effectiveness, N | TU, Pressure drop and Pumping power. | | | | |
| Module:7 Nur | nerical analysis of thermodynamic | 7 hours | | | |
| sys | tems | | | | |
| Simulation and | optimization of thermal power plant components, | Solar collector, Wind | | | |
| turbine, hydrauli | turbine and draft tubes, Gas turbine and compressor | S. | | | |
| Module:8 Cor | temporary Issues | 2 hours | | | |
| ļ, | | - | | | |
| | Total Lecture hours: | 45 hours | | | |
| | | | | | |
| | | | | | |
| 1. W.F. Stoeck | er, Design of Thermal Systems, 4" Edition, McGraw-F | HIII BOOK Company, | | | |

| | 2003, ISBN 9780072373431 | | | | | | | |
|---|---|--------------|-----------|---------|--|--|--|--|
| 2. | Y, Jaluria, Design and Optimization of Thermal Systems, 2 nd Edition, McGraw Hill, | | | | | | | |
| | 2007 | | - | | | | | |
| Ref | erence Books | | | | | | | |
| 1. | Hoseyn Sayyaadi, Modeling, Assessment, and Optimization of Energy Systems, | | | | | | | |
| | Academic Press, 2021, ISBN 978-0 | 0-12-816656- | 7. | | | | | |
| Мо | de of Evaluation: CAT / written assig | nment / Quiz | / FAT / F | Project | | | | |
| | - | | | - | | | | |
| Mode of assessment: Continuous assessment / FAT / Oral examination and others | | | | | | | | |
| Ree | Recommended by Board of Studies 27-05-2022 | | | | | | | |
| Арр | Approved by Academic Council No. 66 Date 16-06-2022 | | | | | | | |

| Cou | se code | Course Title | L | Т | Ρ | С |
|--------------|-----------------|---|---------|------------|------------|-------|
| MEN | G501P | G501P Technical Report Writing | | | | 2 |
| Pre-I | e-requisite Nil | | | | s ver | sion |
| | - | | | 1 | .0 | |
| Cou | se Objectiv | es | | | | |
| 1.To | develop writi | ng skills for preparing technical reports. | | | | |
| 2. To | analyze and | evaluate general and complex technical information. | | | | |
| 3. To | enable profi | ciency in drafting and presenting reports. | | | | |
| | | | | | | |
| Сош | se Outcome | 3 | | | | |
| | e end of the | course the student will be able to | | | | |
| 1 Co | nstruct error | free sentences using appropriate grammar vocabulary | and s | tvle | | |
| $2 \Delta r$ | nly the adva | nced rules of grammar for proofreading reports | | | | |
| 2. Ap | orprot inform | ation and concents in proparing reports. | | | | |
| | | ation and concepts in preparing reports. | | | | |
| 4. De | emonstrate th | le structure and function of technical reports. | | | | |
| 5. Im | prove the ab | ility of presenting technical reports. | | | | |
| | | | | | | |
| Indic | ative Experi | ments | | | | |
| | Basics of T | echnical Communication | | | | |
| 1. | General and | d Technical communication, | | | | |
| | Process of a | communication, Levels of communication | | | | |
| | Vocabulary | /& Editing | | | | |
| 2. | Word usage | e: confusing words, Phrasal verbs | | | | |
| | Punctuation | and Proof reading | | | | |
| 2 | Advanced | Grammar - Tongo Dereon Number | | | | |
| 3. | Shifts: Voice | e, Tense, Person, Number | | | | |
| | Clarity. Pror | f Technical writing | | | | |
| 1 | Developing | n reclinical writing paragraphs. Eliminating uppecessary words. Avoiding (| olichó | e and | l elar | ha |
| 4. | Sentence cl | arity and combining | | s and | i siai | iy |
| | The Art of | condensation | | | | |
| 5 | Steps to eff | ective precis writing | | | | |
| 0. | Paraphrasir | a and summarizing | | | | |
| 6. | Technical F | Reports: Meaning, Objectives, Characteristics and Cate | eaorie | s | | |
| _ | Formats of | reports and Prewriting: purpose, audience, sources of | of info | - rmati | on. | |
| 7. | organizing t | he material | | | . , | |
| _ | Data Visua | lization | | | | |
| 8. | Interpreting | Data - Graphs - Tables - Charts - Imagery - Info grap | ohics | | | |
| 0 | Systematiz | ation of Information: Preparing Questionnaire | | | | |
| 9. | Techniques | to Converge Objective-Oriented data in Diverse Techn | ical R | epor | ts | |
| 10 | Research a | nd Analyses: Writing introduction and literature review | , Refe | erend | e sty | /les, |
| 10. | Synchronize | e Technical Details from Magazines, Articles and e-cont | tent | | - | |
| | Structure of | of Reports | | | | |
| 11 | Title – Prefa | ace – Acknowledgement - Abstract/Summary – Introduc | ction - | Mat | erials | s and |
| | Methods – I | Results – Discussion - Conclusion - Suggestions/Reco | mmen | datio | ons | |
| 12 | Writing the | Report: First draft, Revising, | | | | |
| 12. | Thesis state | ement, Developing unity and coherence | | | | |
| 13 | Writing sci | entific abstracts: Parts of the abstract, Revising the ab | ostrac | t | | |
| 10. | Avoiding Pla | agiarism, Best practices for writers | | | | |
| 14 | Supplemen | itary Texts | | | | |
| | Appendix – | Index – Glossary – References – Bibliography - Notes | | | | |
| 15 | Presentatio | on | | | | |

| | Due sentine Teshnisel Deneute | | | | | | |
|------|--|----------------|-----------|---------------|-----------------|--|--|
| | Presenting Technical Reports | | | | | | |
| | Planning, creating anddigital pres | entation of re | eports | | | | |
| | | Tota | al Labora | tory hours : | 60 hours | | |
| Text | Book(s) | | | | | | |
| 1. | Raman, Meenakshi and Sangeeta Sharma, (2015).Technical Communication: Principles and Practice, Third edition, Oxford University Press, New Delhi. | | | | | | |
| Refe | erence Books | | | | | | |
| 1. | Aruna, Koneru, (2020). Englis Education, Noida. | h Language | Skills f | or Engineers | . McGraw Hill | | |
| 2. | Rizvi,M. Ashraf (2018)Effective Hill Education, Chennai. | Technical Co | ommunica | ation Second | Edition. McGraw | | |
| 3. | Kumar, Sanjay and Pushpalatha, (2018). English Language and Communication Skills for Engineers, Oxford University Press. | | | | | | |
| 4. | Elizabeth Tebeaux and Sam Dragga, (2020).The Essentials of Technical Communication, Fifth Edition, Oxford University Press. | | | | | | |
| Mode | e of Evaluation : Continuous Asses | ssment Tests, | Quizzes | , Assignment, | Final | | |
| Asse | Assessment Test | | | | | | |
| Reco | ommended by Board of Studies | 19-05-2022 | | | | | |
| Appr | oved by Academic Council | No. 66 | Date | 16-06-2022 | | | |
| | · · · · · | | 1 | | | | |

| Course Co | de | Course Title | L | Т | Ρ | С | |
|----------------|---|---|----------|--------------|-------|---------|--|
| MSTS501P | | Qualitative Skills Practice | 0 | 0 | 3 | 1.5 | |
| Pre-requisi | te | Nil | Sylla | abus | s ver | sion | |
| | | | | 1. | .0 | | |
| Course Obj | jective | | | | | | |
| 1. IO | develo | p the quantitative ability for solving basic level problems | s. | | | | |
| 2. 10 | improv | e the verbal and professional communication skills. | | | | | |
| | 4 | | | | | | |
| At the end | tcome | course, the student will be able to | | | | | |
| | | incontract analytical skills | | | | | |
| | | ppropriate analytical skills. | | | | | |
| 2. 30 | ve proi | beins pertaining to quantitative and reasoning ability. | | | | | |
| J. Lea | | ter vocabulary for workplace communication. | | | | | |
| 4. Dei | nonsu | ate appropriate benavior in an organized environment. | | | | | |
| | Busir | ness Etiquette: Social and Cultural Etiquette; Writing | a | | | | |
| Module:1 | Com | pany Blogs; Internal Communications and Planning | : | | 9 ho | ours | |
| | Writi | ng press release and meeting notes | | | | | |
| Value, Man | ners- | Netiquette, Customs, Language, Tradition, Building a | blog | , De | velo | ping | |
| brand mess | age, F | AQs', Assessing Competition, Open and objective Cor | nmur | nicat | ion, | Two | |
| way dialogu | ue, Un | derstanding the audience, Identifying, Gathering Infor | matic | n,. / | Analy | ysis, | |
| Determining | , Sele | cting plan, Progress check, Types of planning, Write | eas | shor | t, ca | tchy | |
| headline, G | et to th | ne Point –summarize your subject in the first paragrap | h., B | ody- | - Ma | ke it | |
| relevant to y | our au | idience. | | | | | |
| Module:2 | Time | management skills | | | 3 ho | ours | |
| Prioritizatior | ı, Proc | rastination, Scheduling, Multitasking, Monitoring, Worki | ng un | der | pres | sure | |
| and adherin | g to de | eadlines | | | | | |
| | Prese | entation skills – Preparing presentation; Organizing | | | | | |
| Module:3 | mate | rials; Maintaining and preparing visual aids; Dealing | J | | 7 ho | ours | |
| | with | questions | <u>.</u> | | | | |
| Tu lips to | prepar | e PowerPoint presentation, Outlining the content, Pas | sing | the | Elev | ator | |
| Test, Blue | sky ini | inking, introduction, body and conclusion, Use of Fo | nt, C | ise antii | or Co | DIOF, | |
| Sudionco | Docian | of postors. Sotting out the ground rules. Dealing | lU Ga | intor | ale | your | |
| Staving in c | ontrol | of the questions. Handling difficult questions | | IIICI | Tupu | 0115, | |
| | | titative Ability 1.1. Number properties: Averages: | | | | | |
| Module:4 | Prog | ressions: Percentages: Ratios | | - | 11 ho | ours | |
| Number of | factors | , Factorials, Remainder Theorem, Unit digit position, | Tens | digi | t pos | sition, | |
| Averages, \ | Weight | ed Average, Arithmetic Progression, Geometric Prog | ressi | on, | Harr | nonic | |
| Progression | rogression, increase and Decrease or Successive increase, Types of ratios and | | | | | | |
| proportions. | | | | | | | |
| Module:5 | Reas | oning Ability - L1 – Analytical Reasoning | | | 8 ho | ours | |
| Data Arrang | gement | (Linear and circular & Cross Variable Relationship), Blo | ood R | elat | ions, | | |
| Ordering / ra | anking | / grouping, Puzzle test, Selection Decision table. | | | | | |
| Module:6 | Verba | al Ability -L1 – Vocabulary Building | | | 7 ho | ours | |

Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies.

| | Total Lecture hours: 45 hours | | | | | | |
|-------------|--|--|--|--|--|--|--|
| Ref | erence Books | | | | | | |
| 1. | Kerry Patterson, Joseph Grenny, Ron McMillan and Al Switzler, (2017).2 nd Edition, Crucial Conversations: Tools for Talking when Stakesare High .McGraw-Hill Contemporary, Bangalore. | | | | | | |
| 2. | Dale Carnegie,(2016).How to Win Friends and Influence People. Gallery Books, New York. | | | | | | |
| 3. | Scott Peck. M, (2003). Road Less Travelled. Bantam Press, New York City. | | | | | | |
| 4. | SMART, (2018). Place Mentor, 1 st edition. Oxford University Press, Chennai. | | | | | | |
| 5. | FACE, (2016). Aptipedia Aptitude Encyclopedia. Wiley publications, Delhi. | | | | | | |
| 6. | ETHNUS, (2013). Aptimithra. McGraw – Hill Education Pvt .Ltd, Bangalore. | | | | | | |
| Web | osites: | | | | | | |
| 1. | www.chalkstreet.com | | | | | | |
| 2. | www.skillsyouneed.com | | | | | | |
| 3. | www.mindtools.com | | | | | | |
| 4. | www.thebalance.com | | | | | | |
| 5. | www.eguru.ooo | | | | | | |
| Moc Test | Node of Evaluation: Continuous Assessment Tests, Quizzes, Assignment, Final Assessment | | | | | | |
| Rec | ommended by Board of Studies 19-05-2022 | | | | | | |
| Арр | Approved by Academic Council No.66 Date 16-06-2022 | | | | | | |

| Course Co | de | Course Title | L | Т | Ρ | С | |
|---|--|--|----------------------|------------|---------|----------|--|
| MSTS502P | 02P Quantitative Skills Practice 0 0 | | | 0 | 3 | 1.5 | |
| Pre-requisi | te | Nil | Syllabus version | | | | |
| | | | | 1.0 | | | |
| Course Obj | jective | s: | | | | | |
| 1. To | develo | p the students' advanced problem solving skills. | | | | | |
| 2. 10 | enhan | ce critical thinking and innovative skills. | | | | | |
| | | | | | | | |
| Course Out | tcome | | | | | | |
| At th | e end | of the course, the student will be able to | | | | | |
| 1. Crea | ate pos | itive impression during official conversations and inte | ervie | ws. | | | |
| 2. Dem | ionstra | te comprehending skills of various texts. | | | | | |
| 3. Impr | ove ac | vanced level thinking ability in general aptitude. | | | | | |
| 4. Deve | elop er | notional stability to tackle difficult circumstances. | | | | | |
| | | | | | | | |
| Modulo:1 | Resu | me skills - Resume Template; Use of power | verb | os; | 21 | oure | |
| wodule. I | Туре | s of resume; Customizing resume | | | 21 | iours | |
| Structure of | a star | dard resume, Content, color, font, Introduction to P | ower | verb | s and | Write | |
| up, Quiz c | on typ | es of resume, Frequent mistakes in customizi | ng r | esun | ne, La | ayout- | |
| Understand | ing diff | erent company's requirement, Digitizing career portf | olio. | - | | | |
| Module:2 | Inter remo | view skills – Types of interview; Techniques to fa ote interviews and Mock Interview | ace | | 3 ł | iours | |
| Structured | and u | nstructured interview orientation. Closed question | ns a | and | hypoth | etical | |
| questions. I | ntervie | evers' perspective. Questions to ask/not ask during | no c nan | inter | view. V | Video | |
| interview, R | ecorde | ed feedback, Phone interview preparation, Tips to c | ustor | mize | prepa | ration | |
| for personal | intervi | ew, Practice rounds. | | | | | |
| | Emot | ional Intelligence - L1 – Transactional Analysis: | Brair | n | | | |
| Module:3 | storn | ning; Psychometric Analysis; SWOT analysis | | - | 12 ł | ours | |
| Introduction | , Con | tracting, ego states, Life positions, Individual E | Srains | storm | ning, C | Group | |
| Brainstormir | ng, St | epladder Technique, Brain writing, Crawford's S | lip w | riting | appr | oach, | |
| Reverse bra | ainstorr | ning, Star bursting, Charlette procedure ,Round rob | in bra | ainsto | orming | , Skill | |
| Test, Persoi | nality T | est, More than one answer, Unique ways, SWOT ar | nalys | is. | | | |
| | | | | | | | |
| Module:4 | Quai Prob Loga | ntitative Ability - L3–Permutation - Combin ability; Geometry and menstruation; Trigono arithms; Functions; Quadratic Equations; Set The | atior met eory | ns; ry; | 14 H | ours | |
| Counting, G | Groupin | g, Linear Arrangement, Circular Arrangements, Co | onditi | onal | Proba | ıbility, | |
| Independen | t and | Dependent Events, Properties of Polygon, 2D & | 3D | Figur | res, Ar | ea & | |
| Volumes, H | eights | and distances, Simple trigonometric functions, Intro | ductio | on to | logari | thms, | |
| Basic rules | asic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding | | | | | | |
| Quadratic E | quatio | ns, Rules & probabilities of Quadratic Equations, Ba | ISIC C | once | epts of | Venn | |
| uagram. | - | | | <u> </u> | | | |
| Module:5 Reasoning ability - L3 – Logical reasoning; Data Analysis and Interpretation | | | | | 7 ł | ours | |

| Syllo | ogisms, | Binary logic, Sequentia | al output tra | cing, Crypto ar | ithmetic, Data Suffi | ciency, Data | | |
|------------|--|--|------------------------------|---------------------------------|--|----------------------|--|--|
| me | pretatio | n-Auvanceu, interpreta | alion lables, | pie charts & b | | | | |
| Мос | lule:6 | Verbal Ability - L3 – reasoning | Comprehe | nsion and Cr | itical | 7 hours | | |
| Rea | ding co | mprehension, Para Jur | nbles, Critic | al Reasoning (| a) Premise and Co | nclusion, | | |
| (b) A | Assump | tion & Inference, (c) St | rengthening | & Weakening | an Argument. | | | |
| | | | | | | | | |
| | | | | Tota | I Lecture hours: | 45 hours | | |
| Ref | erence | Books | | | | | | |
| 1. | Michae and U | el Farra and JIST Edito se an Effective Resum | ors,(2011).Q e in Just On | uick Resume & e Day. Jist Wo | & Cover Letter Bool orks, Saint Paul, Mir | k: Write Inesota. | | |
| 2. | Flage Thinki | Daniel E, (2003).The ng. Pearson, London. | e Art of Qu | iestioning: An | Introduction to C | Critical | | |
| 3. | David Pengu | Allen, (2015).Getting T in Books, New York C | hings done: ty. | The Art of Str | ess-Free productivi | ty. | | |
| 4. | SMAR | T, (2018). Place Mento | or 1 st edition | . Oxford Unive | rsity Press, Chenna | ai. | | |
| 5. | FACE | , (2016).Aptipedia Aptil | ude Encyclo | opedia. Wileyp | ublications, Delhi. | | | |
| 6. | ETHN | US, (2013).Aptimithra. | McGraw-Hi | I Education P | rt Ltd, Bangalore. | | | |
| Web | osites: | | | | | | | |
| 1. | www.c | halkstreet.com | | | | | | |
| 2. | www.s | killsyouneed.com | | | | | | |
| 3. | www.r | nindtools.com | | | | | | |
| 4. | www.thebalance.com | | | | | | | |
| 5. | <u>www.</u> e | eguru.ooo | | | | | | |
| Mod Ass | le of Eva essmen | aluation: Continuous As t Test | ssessment 7 | ests, Quizzes | , Assignment, Final | | | |
| Rec | ommen | ded by Board of Studie | s19-05- 202 | 22 | | | | |
| Арр | Approved by Academic Council No.66 Date 16-06-2022 | | | | | | | |

| Course code | Course Title | L T P C | | | | |
|------------------------|---|--------------------------|--|--|--|--|
| MFRE501L | Français Fonctionnel | 3 0 0 3 | | | | |
| Pre-requisite | NIL | Syllabus version | | | | |
| | | 1.0 | | | | |
| Course Objective | S | | | | | |
| 1. Demonstra | e competence in reading, writing, and speaking ba | sic French, including | | | | |
| knowledge | of vocabulary (related to profession, emotion | s, food, workplace, | | | | |
| sports/hob | ies, classroom and family). | | | | | |
| 2. Achieve p | ficiency in French culture oriented view point. | | | | | |
| Course Outcome | | | | | | |
| At the end | of the course, the student will be able to | | | | | |
| 1. Remembe | the daily life communicative situations via personal | pronouns, emphatic | | | | |
| pronouns, | alutations, negations, interrogations etc. | | | | | |
| 2. Create co | nmunicative skill effectively in French language vi | a regular / irregular | | | | |
| verbs. | | | | | | |
| 3. Demonstra | e comprehension of the spoken / written language | in translating simple | | | | |
| sentences | | | | | | |
| 4. Understan | and demonstrate the comprehension of some par | ticular new range of | | | | |
| unseen wr | ten materials. | | | | | |
| 5. Demonstra | e a clear understanding of the French culture th | rough the language | | | | |
| studied. | | | | | | |
| Salue | , Se présenter, Établir des contacts. Compéten | ces | | | | |
| Module:1 en le | cture - consulter un dictionnaire, appliquer | des 9 hours | | | | |
| strate | gles de lecture, lire pour comprendre. | | | | | |
| Les nombres car | inaux- Les 7 jours de la semaine-Les 12 mois de | l'annee- La date-Les | | | | |
| salsons-Les Pron | ms personnels sujets-Les Pronoms Toniques- La co | njugaison des verbes | | | | |
| reguliers- er / - ir / | re verbes (Le present)- La conjugaison des verbes in | reguliers- avoir /etre / | | | | |
| | vouloir /pouvoir etc. | | | | | |
| Savoir-Taire pour. | saluer, et se presenter – epeler en trançais – comi | nuniquer en classe - | | | | |
| | es pour comprendre un texte en trançais. | t(a) | | | | |
| Module:2 | iter queiqu'un, chercher un(e) correspondant | (e), 7 hours | | | | |
| | s verbes Pronominaux (s'anneler/ s'amuser/ se pro | mener)_ La Négation_ | | | | |
| L'interrogation ave | r 'Est-re que ou sans Est-re que'- Rénondez négativ | /ement | | | | |
| Module:3 Situe | un objet ou un lieu. Poser des questions | 6 hours | | | | |
| Les articles (défi | i/ indéfini). Les prénositions (à/en/au/aux/sur/dan | s/avec etc)- L'article | | | | |
| contracté- L'heure | La Nationalité du Pays-Les professions- L'adjectif | (La Couleur l'adiectif | | | | |
| nossessif l'adie | tif démonstratif l'adjectif interrogatif (quel | | | | | |
| l'interrogation | vec Comment/ Combien / Où etc Propor | ns relatifs simples | | | | |
| (qui/que/dont/où) | | | | | | |
| Com | rendre et traduire un texte court Demander | et l | | | | |
| Module:4 india | er le chemin. | 5 hours | | | | |
| La traduction sim | e d'un texte/ dialogue :(français-anglais / anglais –fi | ancais) | | | | |
| Trouv | er les questions. Répondre aux questions généra | ales | | | | |
| en fr | nçais, Écouter des vidéos (site internet, YouTu | ibe) | | | | |
| qui a | dent à améliorer leur prononciation/ vocabulair | e et 6 nours | | | | |
| leurs | leurs compétences orales | | | | | |
| L'article Partitif (c | / de la / de l'/ des) -Faites une phrase avec les mo | ts donnés- Mettez les | | | | |
| phrases en ordre, | masculin/féminin ; singulier/pluriel- Associez les phra | ases- les adverbes de | | | | |
| temps (ensuite/hie | /puis) | | | | | |
| Com | ent écrire un passage - développer des | | | | | |
| Module:6 ompé | ences rédactionnelles. Discussion de groupe | 5 hours | | | | |
| (donr | ez un sujet et demandez aux élèves de partager | | | | | |

| | | leurs idées) | | | | | | |
|------|--|-------------------------------|------------------|-----------|-------------|------------------|--|--|
| Déc | Décrivez La Famille -La Maison -L'université -Les Loisirs-La Vie quotidienne- La ville natale- | | | | | | | |
| Un p | personna | age célèbre | | | | | | |
| Мос | lule:7 | Comment écrire un dialog | ue | | | 5 hours | | |
| Dial | ogue | | | | | | | |
| a) F | Réserver | · un billet de train | | | | | | |
| b) E | ntre deu | ix amis qui se rencontrent au | u café | | | | | |
| c) P | armi les | membres de la famille | | | | | | |
| d) E | ntre le p | atient et le médecin | | | | | | |
| e) E | ntre le p | professeur et l'étudiant(e) | | | | | | |
| Moc | lule:8 | Contemporary Topics | | | | 2 hours | | |
| | | I | | | | | | |
| | | | Tot | al Lectu | re hours: | 45 hours | | |
| Text | t Book(s | 5) | | | | | | |
| | Adoma | nia 1, Méthode de franç | ais, CelineHiml | ber, Cori | na Brillant | , Sophie Erlich. | | |
| 1. | Publish | ner HACHETTE, February 20 | 016. | | | | | |
| 2. | Encha | nté 1 !, Méthode de français, | , Rachana Saga | r Private | Limited, Ja | n 2017. | | |
| Refe | erence I | Books | T | | | | | |
| 4 | Le fra | nçais pour vous 1, Métho | de de français | , VinodS | ikri, Anna | Gabriel Koshy, | | |
| 1. | Prozopublishing, Jan 2019. | | | | | | | |
| 2. | Accuei | I 1, Méthode de français, Ra | ichana Sagar Pr | ivate Lim | ited, Janua | ary 2016 | | |
| 3 | Apprer | ons le français 1 Méthode | e de français, M | lahitha R | anjit & Mo | nica Singh, Jan | | |
| J. | ^{3.} 2019 | | | | | | | |
| Mod | Modeof Evaluation : Continuous Assessment Tests, Quizzes, Assignment, Final | | | | | | | |
| Asse | Assessment Test | | | | | | | |
| Rec | Recommended by Board of Studies 19-05-2022 | | | | | | | |
| Арр | roved by | Academic Council | No. 66 | Date | 16-06-202 | 22 | | |

| Course code | Course Title | | L | Т | Ρ | С | | |
|---|--|--------|------------|-------|---------------|---------------|--|--|
| MGER501L | Deutsch für Anfänger | | 3 | 0 | 0 | 3 | | |
| Pre-requisite | NIL | | Sv | llab | us ve | rsion | | |
| | | | | 1 | .0 | | | |
| Course Objective | Course Objectives | | | | | | | |
| 1. Demonstrat | te competency in reading, writing and speaking in I | Basic | Ge | erma | n. | | | |
| 2. Achieve pro | oficiency in German culture oriented view point. | | | | | | | |
| 3. Develop ba | sic vocabulary in the technical field. | | | | | | | |
| Course Outcome | | | | | | | | |
| At the end of the co | ourse, the student will be able to | | | | | | | |
| 1. Communica | ate in German language in their daily life communic | cative | sit | uati | ons. | | | |
| 2 Apply the G | German language skill in writing corresponding lefte | ers F- | -Ma | ailse | tc | | | |
| 3 Create the | talent of translating passages from English-Germ | an ar | nd v | vice | versa | and | | |
| to | | anan | | | 10100 | ana | | |
| frame simp | le dialogues based on given situations. | | | | | | | |
| 4. Understand | and demonstrate the comprehension of some p | articu | ılar | ne | <i>N</i> rand | ne of | | |
| unseen | | | | | | <u>j</u> e e. | | |
| written mate | erials | | | | | | | |
| 5 Develop a c | general understanding of German culture and socie | etv | | | | | | |
| Module:1 Die e | erste Begegnung | J.J. | | | 6 1 | ours | | |
| Einleituna, Bearü | issungs formen. Länder und Sprachen. Alp | habe | t. | Buc | hstab | ieren. | | |
| Personalpronomen | 2 Zahlen (1-100), Telefonnummer und E-Mail Add | resse | -, enei | nnei | n W-fr | aden. | | |
| Aussagesätze Nor | men – Singular und Plural und Artikel | | | | | agen, | | |
| Lernziel: | | | | | | | | |
| Verständnisvon De | eutsch, Genus- Artikelwörter | | | | | | | |
| Module:2 Hobb | bys und Berufe | | | | 6 ł | nours | | |
| Über Hobbysspre | chen, Wochentage, Jahreszeiten, und Monatene | nnen | i. L | Jhrz | eitens | agen, | | |
| über Arbeit, Beru | ife und Arbeitszeitensprechen. Zahlen (Hunder | tbisei | ine | Mi | llion) | Aritel | | |
| (bestimmter, unbe | stimmter), Plural der Substantive, Konjugation de | er Ve | rbe | n (r | egeĺm | lässig | | |
| , Junregelmässig), Ja | a-/Nein- Frage, Imperativmit Sie. | | | `` | 0 | U | | |
| Lernziel : | - · · | | | | | | | |
| Sätzeschreiben, ül | berHobbyserzählen, über Berufesprechenusw. | | | | | | | |
| Module:3 Allta | g und Familie | | | | 7 ł | nours | | |
| Über die Families | prechen, eineWohnungbeschreiben, Tagesablaut | fschre | eibe | en, | Mahlz | eiten, | | |
| Lebensmittel, Get | ränke Possessivpronomen, Negation, Kasus- | Akku | lsa | titv | und | Dativ | | |
| (bestimmter, ur | nbestimmterArtikel), trennnbareverben, Mod | lalver | ber | ٦, | Adje | ektive, | | |
| Präpositionen | | | | | | | | |
| Lernziel : | | | | | | | | |
| Sätzemit Modalv | verben, Verwendung von Artikel, über F | amili | esp | orec | hen, | eine | | |
| Wohnungbeschreit | pen. | | | | | | | |
| Module:4 Situa | itions gespräche | | | | 6 ł | nours | | |
| Dialoge: | | | | | | | | |
| a) Gespräche mit | t Familienmitgliedern, am Bahnhof, | | | | | | | |
| b) Gespräche be | im Einkaufen, in einem Supermarkt, in einer Buch | handl | lun | g | | | | |
| c) Gespräche in | einem Hotel/ in einem Restaurant, Treffen im Cáfe | e, Ter | mir | ı be | im Arz | t. | | |
| Module:5 Korre | espondenz | | | | 6 ł | nours | | |
| Leseverständnis, N | /lindmapmachen, Korrespondenz- Briefe, Postkart | en, E· | -Ma | ail | | | | |
| Lernziel : | | | | | | | | |
| Wortschatzbildung | und aktiverSprachgebrauch | | - | | | | | |
| Module:6 Aufsatzschreiben 6 hours | | | | | | | | |
| Aufsätze : | | | _ | | · - | | | |
| Meine Universität, | Das Essen, mein Freund odermeine Freundin, m | eine l | ⊦ar | nilie | , eınF | est in | | |
| Deutschlandusw. | | | | | ~ · | | | |
| woaule:/ Uber | setzungen | | | | 6 1 | iours | | |
| Ubersetzungen : ([| Deutsch – Englisch / Englisch –Deutsch) | | | | | | | |
| Lernziel : | | | | | | | | |

| Grammatik – Wortschatz – Übung | | | | | | | | | |
|--|--|-----------------------------|--------------|-----------|-----------------|----------------|------|--|--|
| Modu | ule:8 | Trainierung den Sprach | fähigkeiten | | | 2 hou | urs | | |
| | | | | | | | | | |
| | | | | Total L | ecture hours: | 45 hou | urs | | |
| Text | Text Book(s) | | | | | | | | |
| 4 | Netzw | erk A1, Stefanie Dengler, I | Paul Rusch, | Helen So | chmitz, Tanja S | ieber, Ernst K | lett | | |
| 1. | Sprac | hen GmbH, Stuttgart, 2017 | | | | | | | |
| Refe | rence E | Books | | | | | | | |
| 1 | Studio | d A1 Deutsch als Frer | ndsprache, | Hermani | n Funk, Christ | ina Kuhn, Si | ilke | | |
| 1. | ^{1.} Demme: Heuber Verlag, Muenchen, 2012. | | | | | | | | |
| 2. | Lagune ,Hartmut Aufderstrasse, Jutta Müller, Thomas Storz, Muenchen, 2012 | | | | | | | | |
| 3. | Deutsche SprachlehrefürAusländer, Heinz Griesbach, Dora Schulz, 2011, Berlin | | | | | | | | |
| 4 | Theme | en Aktuell 1, Hartmurt Aufd | erstrasse, H | eiko Bocl | k, MechthildGer | des, Jutta Mü | ller | | |
| | und H | elmut Müller, 2010, Muenc | hen. | | | | | | |
| | <u>www.c</u> | <u>loethe.de</u> | | | | | | | |
| | wirtschaftsdeutsch.de | | | | | | | | |
| | hueber.de, klett-sprachen.de | | | | | | | | |
| www.deutschtraning.org | | | | | | | | | |
| Mode of Evaluation : Continuous Assessment Tests, Quizzes, Assignment, Final | | | | | | | | | |
| Asse | Assessment Test | | | | | | | | |
| Reco | mmend | ed by Board of Studies | 19-05-2022 | 2 | | | | | |
| Appro | Approved by Academic Council No.66 Date 16-06-2022 | | | | | | | | |

| MCFD696J Study Oriented Project 02 Pre-requisite NIL Syllabus version Course Objectives: 1.0 1. The student will be able to analyse and interpret published literature for information pertaining to niche areas. Scrutinize technical literature and arrive at conclusions. 3. Use insight and creativity for a better understanding of the domain of interest. Course Outcome: 1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains. Examine technical literature, resolve ambiguity, and develop conclusions. 3. Synthesize knowledge and use insight and creativity to better understand the domain of interest. International 4. Publish the findings in the peer reviewed journals / National / International Conferences. Conferences Module Content (Project duration: One semester) This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty. Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science | Course Code | Co | urse Title | | | L | Т | Ρ | С | |
|--|--|-----------------------------|---------------|-------------|--------------|--------|--------|--------|------|--|
| Pre-requisite NIL Syllabus version Course Objectives: 1.0 1. The student will be able to analyse and interpret published literature for information pertaining to niche areas. 2. 2. Scrutinize technical literature and arrive at conclusions. 3. 3. Use insight and creativity for a better understanding of the domain of interest. 5 Course Outcome: 1. 1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains. 5 2. Examine technical literature, resolve ambiguity, and develop conclusions. 3. 3. Synthesize knowledge and use insight and creativity to better understand the domain of interest. 4. 4. Publish the findings in the peer reviewed journals / National / International Conferences. 1. Module Content (Project duration: One semester) This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty. 1. Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science | MCFD696J | Study O | riented Pro | oject | | | | | 02 | |
| 1.0 Course Objectives: 1. The student will be able to analyse and interpret published literature for information pertaining to niche areas. 2. Scrutinize technical literature and arrive at conclusions. 3. Use insight and creativity for a better understanding of the domain of interest. Course Outcome: 1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains. 2. Examine technical literature, resolve ambiguity, and develop conclusions. 3. Synthesize knowledge and use insight and creativity to better understand the domain of interest. 4. Publish the findings in the peer reviewed journals / National / International Conferences. Module Content (Project duration: One semester) This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty. Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science | Pre-requisite | NIL | | | | Syll | abus | vers | ion | |
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| and project reviews – Presentation in the National / International Conference on Science | student has registered. Assessment on the project – Report to be submitted, presentation | | | | | | | | | |
| | | | | | | | | | | |
| Engineering Technology. | | | | | | | | | | |
| Recommended by Board of Studies 27-05-2022 | Recommended by | / Board of Studies | 27-05-202 | 2 | | | | | | |
| Approved by Academic Council No. 66 Date 16-06-2022 | Approved by Acad | demic Council | No. 66 | Date | 16-06-20 |)22 | | | | |

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|---|--|--|---|----------------------------|--------------------------|-----------------------|---------------------|--|--|
| Course Code | Course Title | | | L | Т | Р | С | | |
| MCFD697J | Design | Project | | | | | 02 | | |
| Pre-requisite | NIL | NIL | | | Syllabus version | | | | |
| | | | | 1.0 | | | | | |
| Course Objectives: | | | | | | | | | |
| 1. Students will be able to design a prototype or process or experiments. | | | | | | | | | |
| 2. Describe a | 2. Describe and demonstrate the techniques and skills necessary for the project. | | | | | | | | |
| 3. Acquire kr | nowledge and better unders | tanding of design | systems. | | | | | | |
| Course Outcome | 9. | | | | | | | | |
| Develop n prototype Utilize the Synthesize improve de Publish th Conference | Develop new skills and demonstrate the ability to upgrade a prototype to a design prototype or working model or process or experiments. Utilize the techniques, skills, and modern tools necessary for the project. Synthesize knowledge and use insight and creativity to better understand and improve design systems. Publish the findings in the peer reviewed journals / National / International Conferences. | | | | | | | | |
| Module Content (Project durat | | | | tion: One semester) | | | | | |
| Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototype or working models related to an engineering product or a process. | | | | | | | | | |
| Mode of Evalua student has regis and project revie Engineering Tech Recommended by Approved by Acad | tion: Evaluation involves tered. Assessment on the ws – Presentation in the N nology. y Board of Studies 2 demic Council N | periodic reviews project – Report lational / Internat 7-05-2022 | by the fac to be subr ional Confe | ulty w mitted erence | rith w , pres e on | hom senta Scier | the tion nce, | | |

| | <u> </u> | | | | | | | |
|--|---|--|---|--|---------------------------------------|--|-------------|------|
| Course Code | | Course Title | | | L | Т | Ρ | С |
| MCFD698J | Inter | nship I/ Dissertation I | | | | | 10 | |
| Pre-requisite | NIL | • | | | Syll | abus | vers | ion |
| • | | | | | - | 1.0 |) | |
| Course Objectiv | 'es: | | | | | | | |
| To provide suffici | ient hands-on learn | ing experience r | elated to | the desigr | n, dev | elopn | nent : | and |
| analysis of suitab | le product / process | s so as to enhand | ce the tec | hnical skil | ll sets | in the | e cho | sen |
| field and also to g | give research orienta | ation. | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Course Outcom | e: | | | | | | | |
| Considerative deeper instruction The capalities The capalities The capalities A conscion Publication added advisor | ably more in-depth k sight into current res pility to use a holistic prmulate and deal w usness of the ethica ns in the peer review vantage. | nowledge of the search and develoc view to critically ith complex issue al aspects of rese wed journals / Int | major sub opment w v, indepen es. earch and ernational | ject/field o ork. dently and developm Conferer | of stuc d crea ent wo nces w | ly, inc tively ork. <i>i</i> ill be | ludin an | g |
| Module Content | | (F | Project du | iration: o | ne se | mest | er) | |
| 1. Dissertatio analysis, data, soft | Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities. | | | | | | n & s of | |
| 2. Dissertation | on should be individ | ual work. | | | | | | |
| Carried out inside or outside the university, in any relevant industry or research institution. | | | | | | arch | | |
| 4. Publications in the peer reviewed journals / International Conferences will be an added advantage. | | | | | | | an | |
| | | | | | | | | |
| Mode of Evalua presentation, proj | ition: Assessment ject reviews and Fin | on the project al Oral Viva Exa | - Disserta mination. | ition repo | rt to | be sı | ıbmit | ted, |
| Recommended b | Recommended by Board of Studies 27-05-2022 | | | | | | | |
| Approved by Aca | Date | 16-06-20 |)22 | | | | | |

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|--|---|-------------------|-------------|-------------|-------------|---------|------|---------------------------|
| Course Code | se Code Course Title | | | | L | Т | Ρ | С |
| MCFD699J | MCFD699J Internship II/ Dissertation II | | | | | | | 12 |
| Pre-requisite | NIL | | | | Syllabus ve | | | ion |
| | | | | | 1.0 |) | | |
| Course Objectives: | | | | | | | | |
| To provide sufficient hands-on learning experience related to the design, development and | | | | | | | | |
| analysis of suitable product / process so as to enhance the technical skill sets in the chosen | | | | | | | | |
| field. | | | | | | | | |
| | | | | | | | | |
| Course Outcome |): completion of this cour | ree etudente u | ill ha ahla | to | | | | |
| | | rse sludenis w | | | | | | :41. |
| 1. Formulate | specific problem s | statements to | r III-defin | ed real | lite p | robiei | ms \ | Nith |
| reasonable | e assumptions and co | instraints. | | . | | | | |
| 2. Perform lit | erature search and / c | or patent searc | h in the ai | rea of inte | rest. | | | |
| 3. Conduct e results. | Conduct experiments / Design and Analysis / solution iterations and document the results. | | | | | | | |
| 4. Perform e | 4. Perform error analysis / benchmarking / costing. | | | | | | | |
| 5. Synthesize | e the results and arrive | e at scientific c | onclusion | s / produc | cts / so | olutior | ı. | |
| 6. Document | the results in the forn | n of technical r | eport / pre | esentation | | | | |
| Module Content | | | (Proj | ect durat | ion: o | ne se | mes | ter) |
| Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities. Dissertation should be individual work. Carried out inside or outside the university, in any relevant industry or research institution. Publications in the peer reviewed journals / International Conferences will be an | | | | | | | | n & s of arch an |
| added advantage. | | | | | | | | |
| Mode of Evaluation: Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination. | | | | | | | | |
| Recommended by | y Board of Studies | 27-05-2022 | | | | | | |
| Approved by Academic Council No. 66 Date 16-06-2022 | | | | | | | | |