Curriculum Structure and Syllabus

for

MTech

in

Mechanical Engineering

(R-25 Regulations)

Specialization with

Thermal Engineering

A.Y 2025-26

Department of Mechanical Engineering
National Institute of Technology Andhra Pradesh
Tadepalligudem, West Godavari Dist., 534 101
Andhra Pradesh (India)

Course Structure

MTech Mechanical 2025-2026

Distribution of Total Credits:

Semester	Core Subjects	Dept. Elective	Open * Elective (MOOCs)	Humanities elective course (T/P)	Labs.	Total
I	3 (3*3 = 9)	1 (1*3 =3)	--	1 (1*2=2)	1 (1*2=2)	**16**
II	3 (3*3=9)	1 (1*3=3) + (1*2=2) Total = 5	1* (1*2 = 2)	--	1 (1*2=2)	**18**
III	Dissertation Part-A					**13**
IV	Dissertation Part-B					**13**
	Total					**60**

***Open Elective (MOOCs)**

A student can choose a 3-credit MOOC course, and it would still fulfill the requirement of a 2-credit MOOC course.

Semester-I **Course structure & scheme of instruction**

Code No.	Subject Name		L-T-P	Cr.
25ME601	Advanced Thermodynamics		3-0-0	3
25ME602	Advanced Heat & Mass Transfer		3-0-0	3
25ME603	Numerical Methods in Thermal Engineering		3-0-0	3
	Department Elective – I		3-0-0	3
	25ME604	Incompressible and Compressible Flows		
	25ME605	Heating, Ventilating, and Air-conditioning		
	25ME606	Alternate Fuels and Energy systems		
	25ME607	Measurements in Thermal Engineering		
	25ME608	Energy conservation and Management		
	25ME609	Design of Wind Turbine Systems		
25HS601	Advanced technical communication		2-0-0	2
25ME610	Thermal Engineering Laboratory		0-0-2	2
Total credits				16

Semester-II

Code No.	Subject Name		L-T-P	Cr.
25ME611	Gas Turbines and Jet Propulsion		3-0-0	3
25ME612	Computational Methods in Fluid Flow and Heat Transfer		3-0-0	3
25ME613	Advanced Prime Movers		3-0-0	3
	Department Elective – II		3-0-0	3
	25ME614	Jet and Rocket Propulsion		
	25ME615	Cryogenic Systems		
	25ME616	Conjugate Heat Transfer		
	25ME617	Dynamics and control of mechanical systems		
	Department Elective – III		2-0-0	2
	25ME618	Design and Optimization of Energy systems		
	25ME619	Multiphase flows		
	25ME620	Battery thermal management		
	25ME621	Microfluidics		
	Open elective (MOOCs) * For example, few MOOC courses are given below			
	Online code	Artificial Intelligence Search Methods for Problem Solving	2-0-0	2
	Online code	Data Science for Engineers		
	Online code	Introduction to Machine Learning (IITM)		
	Online code	Entrepreneurship Essentials		
25ME622	CFD Laboratory		0-0-2	2
Total credits				18

*In open elective apart from given subjects a student can select any other MOOC course listed in Swayam website (https://swayam.gov.in/) and the selected MOOC course must not be identical to or overlap with any course listed in the regular MTech curriculum.

Semester-III

Code No.	Subject Name	L-T-P	Total credits
25ME698	Dissertation-Part A	0-0-26	13

Semester-IV

Code No.	Subject Name	L-T-P	Total credits
25ME699	Dissertation-Part B	0-0-26	13

25ME601 Advanced Thermodynamics

SYLLABUS:

Introduction: Recapitulation of Basic thermodynamics.

Second Law Analysis: Review of entropy, Second law analysis for a control volume, Irreversibility and availability, Exergy balance equation and Exergy analysis.

Thermodynamic relations: For homogeneous phase, Maxwell relations, Relations involving enthalpy, internal energy, and entropy Equilibrium between two-phases of a pure substance Clausius- Clapeyron equation.

Review of Ideal Gas & Real Gas: Ideal gas mixtures and mixing rules, Real gas behavior, Real gas equations of state, Property relations for mixtures and Psychrometry.

Introduction to combustion: Applications of combustion, Types of fuel and oxidizers, Characterization of fuel, various combustion mode, Scope of combustion. Thermodynamics of Combustion: Thermodynamics properties, Laws of thermodynamics, Stoichiometry, Thermochemistry, adiabatic temperature, Chemical Equilibrium, Chemical potential, Second law analysis of reacting systems, Chemical equilibrium, Free energies, Equilibrium flame temperature, Equilibrium products of combustion.

Chemistry of Combustion: Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics.

Physics of Combustion: Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.

Text Books/ References:

1. Moran, M. J., Shapiro, H. N., Boettner, D. D., & Bailey, M. B. (2010). Fundamentals of engineering thermodynamics. John Wiley & Sons.
2. Nag, P. K. (2013). Engineering thermodynamics. Tata McGraw-Hill Education.
3. Çengel, Y. A., & Boles, M. A. (2008). Thermodynamics: An Engineering Approach, McGraw-Hill.
4. Van Wylen, G. J., & Sonntag, R. E. (1985). Fundamentals of classical thermodynamics (No. 536 VAN).
5. Hawkins, G. A. (1986). Engineering thermodynamics: an introductory textbook. John Wiley & Sons.

25ME602 Advanced Heat & Mass Transfer

SYLLABUS:

Introduction to Heat Transfer: Modes, Conduction, Convection, Radiation-Governing Laws: Fourier's law, Newton's law of cooling, Stefan-Boltzmann law, Practical Applications, Basic recap numerical.

Steady-State Two-Dimensional Heat Conduction: Cartesian & Cylindrical coordinates, Boundary conditions and simplified analytical solutions, Introduction to Bessel's functions (brief concept only), Numerical problems (basic)

Extended Surfaces (Fins): Uniform Fins: Rectangular and Circular, Fin efficiency and effectiveness, Corrected fin-length concept (covered conceptually, no derivation), Numerical problems

Transient (Unsteady) Heat Conduction: Lumped system analysis, Semi-infinite solids, Use of Heisler charts (only for 1D cases), Comparable thermal and surface resistance (brief overview), Numerical problems

Free (Natural) Convection Laminar and turbulent flows, Grashof and Nusselt numbers, Empirical correlations for vertical/horizontal plates, Numerical problems

Forced Convection External flow: Flat plate (laminar & turbulent), Internal flow: Circular pipe – Constant wall temperature, Governing Equations (brief explanation only), Boundary Layer concepts, Prandtl number significance, Numerical problems

Thermal Radiation: Radiation fundamentals: Black, Gray, White, Transparent bodies, Emission laws: Wien's and Stefan-Boltzmann law (Planck and Rayleigh-Jeans excluded), Emissivity and its types, View factors and Hottel's crossed-string method, Numerical problems

Mass Transfer Fick's law of diffusion, Equimolar counter-diffusion, Mass transfer coefficient and analogy with heat transfer, Isothermal evaporation (conceptual), Numerical problems

Textbooks/ References:

1. Kakaç, S., Yener, Y., & Naveira-Cotta, C. P. (2018). Heat conduction. CRC Press.
2. Kays, W. M. (2012). Convective heat and mass transfer. Tata McGraw-Hill Education.
3. Howell, J. R., Menguc, M. P., & Siegel, R. (2015). Thermal radiation heat transfer. CRC press.
4. Cengel, Y. (2014). Heat and mass transfer: fundamentals and applications. McGraw-Hill Higher Education.
5. Sachdeva, R. C. (2009). Fundamentals of engineering heat and mass transfer. New Age Science.
6. Holman, J. P. (2002). Heat Transfer-Si Units-Sie. Tata McGraw-Hill Education.

25ME603 NUMERICAL METHODS IN THERMAL ENGINEERING

SYLLABUS:

Solution of Linear Algebraic Equations: Gaussian elimination, LU decomposition, Pivoting strategies, Operation Count, Matrix inversion, Special cases, Tridiagonal and block tridiagonal systems, Well-conditioned and ill conditioned system, Matrix and Vector norms, Condition Number and its implications.

Solution of Non-linear Algebraic Equations: Bisection, Newton-Raphson and Secant method, System of non-linear equations, Basics of finite difference method.

Discretization of spatial and time derivatives using Taylor's series, Truncation error and the order of discretization, Fourier (von Neumann) stability analysis.

Solution of Ordinary Differential Equations, Initial Value problems, Euler explicit and implicit methods, Runge-Kutta method, Predictor-Corrector methods, Boundary value problem, shooting method, Finite difference method applied to pin fin heat dissipation, Stiff problems, Meaning of stiffness, Further insights into stiffness by the application of Euler explicit and implicit method to a stiff problem, Solution of stiff problem, Example – Chemical kinetics.

Solution of Elliptic Partial Differential Equations, Physical problems governed by elliptic PDE's, Five-point and nine-point discretization of Poisson's equation, Iterative methods, Point Iterative methods – Jacobi, Gauss-Seidel, and SOR, Detailed theory of the convergence of iterative methods, Global Iterative methods – Steepest Descent and Conjugate Gradient.

Classification of PDEs and characteristics of a PDE, Solution of Parabolic Partial Differential Equations, Physical problems governed by parabolic PDE's Operator splitting and ADI methods.

Assignments on the topics should be given to solve using computer code.

Text Books/ References:

1. Cheney, E. W., & Kincaid, D. R. (2012). Numerical mathematics and computing. Cengage Learning.
2. Gerald, C. F., & Wheatley, P. O. (2013). Applied Numerical Analysis. Seventh.
3. Isaacson, E., & Keller, H. B. (2012). Analysis of numerical methods. Courier Corporation.
4. Smith, G. D. (1985). Numerical solution of partial differential equations: finite difference methods. Oxford university press.
5. Golub, G. H., & Van Loan, C. F. (2012). Matrix computations (Vol. 3). JHU press.
6. Press, W. H., Flannery, B. P., Teukolsky, S. A., & Vetterling, W. T. (1989). Numerical recipes.

Department Elective I

25ME604 INCOMPRESSIBLE AND COMPRESSIBLE FLOWS

SYLLABUS:

Introduction: Introduction to Fluid Mechanics-Properties of Fluids, Fluid Statics: Fluid Statics, Fundamental Equations-Applications of Fundamental Equations, Relative Motion of Liquids.

Kinematics of Fluids: Kinematics of Fluids- Review of basics-Velocity potential, Stream function and Vorticity. Theory of Stress and Rate of Strain: General theory of Stress and Rate of Strain Fundamental Equations – Integral Form-Fundamental Equations – Integral form-Reynolds Transport Theorem-Applications of the Integral Form of Equations-Numerical.
Fundamental Equations in Differential Form: Fundamental: Equations in Differential Form-One-dimensional Inviscid Incompressible Flow-Euler's Equation and Bernoulli's Equation-Applications of the Bernoulli's Equations-Numerical.

Two and three – dimensional Inviscid Incompressible Flow: Two and Three – dimensional Inviscid Incompressible Flow-Laminar Flow- Flow between Parallel Flat Plates-Steady Flows in Pipes-Applications of Laminar Flow-Numericals.

The Laminar Boundary layer: The Laminar Boundary layer – Prandtl's Boundary Layer Equations-The Boundary layer along a Flat Plate-Solution to the Boundary Layer Equations-Momentum Integral Equation-Separation of Boundary Layer and Control-Numericals.

Turbulent Flow: Introduction to Turbulent Flow – Modified N-S Equations-Semi - empirical Theories-Turbulent Boundary Layer-Numericals.

Dimensional Analysis: Flow over a bluff body – Lift and Drag-Dimensional Analysis and Similitude.

Introduction to Compressible Flow: Introduction to Compressible Flow – review of Fundamentals-Stagnation Properties – Relations and Tables-Numericals.

Wave Motion: Wave Motion-Propagation of Motion in Compressible Fluids-Mach number and Mach Cone-Numericals.

Isentropic Flow: Isentropic Flow Relations-Flow through Nozzles and Diffusers-Isentropic Flow Relations and Tables-Numericals.

Flow across Normal Shock and Oblique Shock: Basic Equations Normal Shock – Prandtl-Meyer Equation, Oblique Shock-Property variation – Relations and Tables-Numericals.

Flow through a constant area duct with Friction: Flow through a constant area duct with Friction-Fanno Line, Fanno Flow -Variation of Properties – Relations and Tables-Numericals. Flow through a constant area duct with Heat Transfer-Flow through a constant area duct with Heat Transfer-Rayleigh Line, Rayleigh Flow – Variation of Properties – Relations and Tables-Numericals.

Text Books/ References:

1. Yuan, S. W. (1970). Foundations of fluid mechanics. Prentice-Hall.
2. Yahya, S. M. (2010). Fundamentals of Compressible Flow: With Aircraft and Rocket Propulsion. New Age Science.
3. Schlichting, H., & Gersten, K. (2016). Boundary-layer theory. Springer.
4. White, F. M., & Corfield, I. (2006). Viscous fluid flow (Vol. 3, pp. 433-434). New York: McGraw-Hill.

Department Elective I

25ME605 HEATING, VENTILATING, AND AIR-CONDITIONING

SYLLABUS:

Introduction - Purpose, applications, definition, and components of air conditioning - Need and methods of ventilation - Course outline.

Psychrometry - Evolution of air properties and psychrometric chart - Basic processes such as sensible heating/cooling, humidification/dehumidification and their combinations, steam and adiabatic humidification, adiabatic mixing, etc. - Bypass factor and Sensible heat ratio.

Summer and Winter AC - Simple summer AC process, Room sensible heat factor, Coil sensible heat factor, ADP - Precision AC - Winter AC.

Human Comfort - Heat transfer from body, convection, radiation, conduction, evaporation, clothing resistance, activity level - Concept of human comfort - Thermal response - comfort factors - Environmental indices - Indoor air quality.

AC Equipments - Filters, types, efficiency - Fans basic equations, parallel and series configurations - Air washer, adiabatic, heated and cooled - Cooling tower, enthalpy potential, types, tower efficiency, NTU and characteristics, sizing and off design performance - Cooling and dehumidifying coil, dry and wet, sizing, performance.

Heat Transfer - Heat transfer in wall and roof, sol-air temperature, insulation, cooling load temperature difference - Fenestration, types of glass, sun shade, shading coefficient, maximum radiation, cooling load factor.

Cooling Load Estimation - Design conditions, outdoor, indoor - External load, wall, roof, glass - Internal load, occupancy, lighting, equipment's - Ventilation, air quantity, loads - Load estimation methods.

Heating load estimation - Vapour transfer in wall, vapour barrier, load estimation basics.

Air Distribution - Ducts, types, fittings, air flow, friction chart, methods of sizing, balancing.

Air Diffusion - Isothermal jet, throw, drop, types of outlets, ADPI, outlet/inlet selection.

Basics of Ventilation - Need, threshold limits of contaminants, estimation of ventilation rates, decay equation, air flow round buildings.

Methods of Ventilation - Natural, wind effect, stack effect, combined effect - Mechanical, forced, exhaust, combined - Displacement ventilation

Industrial Ventilation - Steel plants, car parks, plant rooms, mines, etc.

Ventilation System Design - Exhaust ducts, filters, blowers, hoods, chimney, etc.

Text Books/ References:

1. Handbook-Fundamentals, A. S. H. R. A. E. (2009). American society of Heating. Refrigerating and Air-Conditioning Engineers.
2. Kuehn, T. H., Ramsey, J. W., & Threlkeld, J. L. (1998) Thermal environmental engineering.
3. Clements-Croome, D., & Roberts, B. M. (1975). Airconditioning and ventilation of buildings (Vol. 10). Pergamon.
4. Stoecker, W. F., & Jones, J. W. (1982). Refrigeration and air conditioning, Mc GrawHill Book Co, New York.
5. Arora, C. P. (2003). Refrigeration and Air Conditioning. 9th reprint. Tata-McGraw-Hill, New Delhi,

Department Elective I

25ME606 ALTERNATE FUELS AND ENERGY SYSTEMS

SYLLABUS:

Introduction: Estimation of petroleum reserve – Need for alternate fuels – Availability and properties of alternate fuels, ASTM standards

Alcohols: General Use of Alcohols – Properties as Engine fuel – Gasolene and alcohol blends – Performance in SI Engine – Methanol and Gasolene blend – Combustion Characterstics in engine – emission characteristics

Vegetable oils: Soyabeen Oil, Jatropha, Pongamia, Rice bran, Mahuaetc as alternate fuel and their properties, Esterification of oils

Natural Gas, LPG: Availability of CNG, properties, modification required to use in engines – performance and emission characterstics of CNG using LPG in SI & CI engines.

Hydrogen: Hydrogen production, storage systems-reformers, Hydrogen as an alternative fuel.

Fuel Cell vehicles: Fuel cells: Introduction-Fuel cell characteristics, Thermodynamics of fuel cells-Fuel cell types: emphasis on PEM fuel cell.

Alternate Fuels: Need for Alternate fuels, Desirable Characteristics of good Alternate Fuel-Liquid and Gaseous fuels for SI and CI Engines, Kerosene, LPG, Alcohols, Bio-fuels, Natural gas, Hydrogen and use of these fuels in engines.

Electric and Solar powered vehicles: Layout of an electric vehicle – advantage and limitations- specificatios –system component – electronic control system – High energy and power density batteries – Hybrid vehicle – solar powered vehicles

Automobile emissions & its control: Need for emission control -Classification/ categories of emissions -Major pollutants - control of emissions – Evaluating vehicle emissions – EURO I,II,III,IV standards – Indian standards

Text Books/ References:

1. Richard, L. (1997). Alternative Fuels Guidebook Properties, Storage, Dispensing and Vehicle Facility Modifications. Society of Automotive Engineers (SAE), 1-721.

2. Norbeck, J. M., Heffel, J. W., Durbin, T. D., Tabbara, B., Bowden, J. M., & Montano, M. C. (1996). Hydrogen fuel for surface transportation (Vol. 160).

3. Wakefield, E. H. (1998). History of the Electric Automobile-Hybrid Electric Vehicles (Vol. 187)

4. Pundir, B. P. (2007). Engine emissions: pollutant formation and advances in control technology. Alpha Science International, Limited.

5. S.C. Bhatia (2007) Air Pollution and its Control, Atlantic Publications,

6. Halderman, J. D., & Linder, J. (2011). Automotive fuel and emissions control systems. Pearson Higher Ed.

Department Elective I

25ME607 MEASUREMENTS IN THERMAL ENGINEERING

SYLLABUS:

Basics of Measurements: Introduction, General measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction.

Analysis of experimental data: Causes and types of errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Statistical analysis of Experimental data.

Sensing Devices: Transducers-LVDT, Capacitive, piezoelectric, photoelectric, photovoltaic, Ionization, Photoconductive, Hall-effect transducers, etc.

Pressure measurement: Different pressure measurement instruments and their comparison, Transient response of pressure transducers, dead-weight tester, low-pressure measurement.

Thermometry: Overview of thermometry, temperature measurement by mechanical, electrical and radiation effects. Pyrometer, Thermocouple compensation, effect of heat transfer.

Flow Measurement: Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, flow measurement by drag effects, pressure probes, other methods.

Thermal and transport property measurement: Measurement of thermal conductivity, diffusivity, viscosity, humidity, gas composition, pH, heat flux, calorimetry, etc.

Nuclear, thermal radiation measurement: Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc. Other measurements: Basics in measurement of torque, strain.

Air-Pollution: Air-Pollution standards, general air-sampling techniques, opacity measurement, sulphur dioxide measurement, particulate sampling technique, combustion products measurement.

Advanced topics: Issues in measuring thermos physical properties of micro and Nano fluids.

Design of Experiments: Basic ideas of designing experiments, Experimental design protocols with some examples and DAS.

Text Books/ References:

1. Beckwith, T. G., Marangoni, R. D., & Lienhard, J. H. (2009). Mechanical measurements. Pearson.
2. Doebelin, E. O., & Manik, D. N. (2007). Measurement systems: application and design.
3. Holman, J. P., & Gajda, W. J. (2001). Experimental methods for engineers (Vol. 2). New York: McGraw-Hill.

Department Elective I

25ME608 ENERGY CONSERVATION AND MANAGEMENT

SYLLABUS:

Energy Scenario: Classification of Energy, Indian energy scenario, Sectorial energy consumption (domestic, industrial, and other sectors), energy needs of growing economy, energy intensity, long term energy scenario, energy pricing, energy security, energy conservation and its importance, energy strategy for the future. Energy Conservation Act 2001 and related policies: Energy conservation Act 2001 and its features, notifications under the Act, Schemes of Bureau of Energy Efficiency (BEE) including Designated consumers, State Designated Agencies, Electricity Act 2003, Integrated energy policy, National action plan on climate change, ECBC code for Building Construction.

Financial Management and Energy Monitoring and Targeting: Investment-need, appraisal and criteria, financial analysis techniques simple payback period, return on investment, net present value, internal rate of return, cash flows, risk and sensitivity analysis; financing options, energy performance contracts and role of Energy Service Companies (ESCOs).

Energy Monitoring and Targeting: Defining monitoring & targeting, elements of monitoring & targeting, data and information-analysis, techniques – energy consumption, production, cumulative sum of differences (CUSUM). Energy Management Information Systems (EMIS).

Energy Efficiency in Thermal Utilities and systems: Boilers: Types, combustion in boilers, performances evaluation, analysis of losses, feed water treatment, blow down, energy conservation opportunities. Boiler efficiency calculation, evaporation ratio and efficiency for coal, oil and gas. Soot blowing and soot deposit reduction, reasons for boiler tube failures, start up, shut down and preservation, Thermic fluid heaters, super critical boilers.

Steam System: Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system, identifying opportunities for energy savings. Steam utilization, Performance assessment more details, installation, thermo-compressor, steam pipe insulation, condensate pumping, steam dryers.

Furnaces: Classification, general fuel economy measures in furnaces, excess air, heat distribution, temperature control, draft control, waste heat recovery. Forging furnace heat balance, Cupola, non-ferrous melting, Induction furnace, performance evaluation of a furnace, hot air generators.

Insulation and Refractories: Insulation-types and application, economic thickness of insulation, heat savings and application criteria, Refractory-types, selection and application of refractories, heat loss. Cold insulation.

Heat Exchangers: Types, networking, pinch analysis, multiple effect evaporators, condensers, distillation column, etc.

Waste Heat Recovery: Classification, advantages and applications, commercially viable waste heat recovery devices, saving potential.

Cogeneration: Definition, need, application, advantages, classification, saving potentials. Heat balance, steam turbine efficiency, tri-generation, micro turbine.

CASE STUDY: Energy Audit at NIT Andhra Pradesh Campus, Indian Railways – Electrification and LED Lighting, Delhi Metro – Energy Conservation and Regenerative Braking, Rural Electrification – Smart Microgrid in Bihar

Text Books/ References:

1. Fardo, S. W., Patrick, D. R., Richardson, R. E., & Fardo, B. W. (2015). Energy conservation guidebook. Lulu Press, Inc.
2. Thumann, A., & Younger, W. J. (2008). Handbook of energy audits. The Fairmont Press, Inc.
3. Bureau of Energy Efficiency Reference book: No.1, 2, 3 4.
4. Doty, S., & Turner, W. C. (2004). Energy management handbook. Crc Press.
5. Wilson, E., & Gerard, D. (2007). Carbon capture and sequestration: integrating technology, monitoring, regulation.
6. Kreider, J. F., Curtiss, P. S., & Rabl, A. (2009). Heating and cooling of buildings: design for efficiency. CRC Press.

Departmental Elective I

25ME609 DESIGN OF WIND TURBINE SYSTEMS

SYLLABUS:

General Introduction to Wind Turbines, classification & status. Thermodynamic analysis and Betz theory. Fluid dynamic analysis of wind source and classification of sources.

2-D aerodynamics of wind turbine & blade.

3-D aerodynamics of blade.

Aerodynamics of rotor wakes and selection of number of blades & speed.

Analysis of rotor design and selection of capacity.

Design of horizontal axis wind turbines.

Design of vertical axis wind turbines.

Controls for wind turbines.

Auxiliary systems.

Special designs for micro wind turbines.

Text Books/ References:

1. Hansen, M. O. L. (2008). Aerodynamics of Wind Turbine second edition Earthscan. London, UK.
2. Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi (2010) Wind Energy Handbook, John Wiley and Sons.
3. Abbott, I. H., & Von Doenhoff, A. E. (1959). Theory of Wing Sections Dover Publications Inc.

25HS601 ADVANCED TECHNICAL COMMUNICATION

Course Objectives:

· To gain foundational understanding of science communication
· To critically analyze and communicate scientific ideas
· To conceptualize and refine a research topic using scientific process

<u>SYLLABUS</u>

Module 1
Key characteristics of scientific writing- types of documents (journal articles, conference papers, reports, theses) IMRAD structure in detail (Introduction, Methods, Results, Discussion)-abstract- drafting titles

Module 2
Scientific language- (clarity, brevity, precision)-common errors and how to fix them (grammar, style, tone)-organizing and synthesizing information-literature review and referencing-citation styles- using reference managers

Module 3
Research paper writing and its constituents-research publication and ethics

Module 4
Writing proposals (grants, research, project)- presenting research

References:

1. Bagla, Pallava, and V. V. Binoy, editors. Bridging the Communication Gap in Science and Technology: Lessons from India. Springer Nature, 2017
2. Dean, Cornelia. Am I Making Myself Clear? A Scientist's Guide to Talking to the Public. Harvard University Press, 2009.
3. Gastel, Barbara, and Robert A. Day. How to Write and Publish a Scientific Paper. 8th ed., Cambridge University Press, 2016.

25ME610 THERMAL ENGINEERING LABORATORY

SYLLABUS:

Pin-Fin Apparatus: Determination of temperature distribution, efficiency and effectiveness of the fin working in forced convection environment.

Natural Convection Apparatus: Determination of experimental and empirical values of convection heat transfer coefficient from a Vertical Heated Cylinder losing heat to quiescent air.

Forced Convection Apparatus: Determination of theoretical, experimental and empirical values of convection heat transfer coefficient for internal forced convection through a circular GI pipe.

Abel's apparatus: Determination of flash and fire points of a given oil sample.

Redwood Viscometer No. 1: Determination of kinematic and absolute viscosities of an oil sample given

Distillation apparatus: Determination of distillation characteristic of a given sample of gasoline.

Two-Stage Reciprocating Air-Compressor: Determination of volumetric efficiency of the compressor as a function of receiver pressure.

IC Engines: Valve and Port Timing Diagrams on 4-stroke and 2-stroke IC Engines. Valve Timing Diagrams on 4-stroke CI Engine.

Single-Cylinder Kirloskar CI Diesel Engine: Constant Speed Performance Test on Single-Cylinder Kirloskar CI Diesel Engine.

Single-Cylinder Kirloskar CI Diesel Engine: Motoring Test on Single-Cylinder Kirloskar CI Diesel Engine.

Single-Cylinder Kirloskar CI Diesel Engine: Retardation Test on Single-Cylinder Kirloskar CI Diesel Engine.

Thermocouple calibration:

Text Books/ References:

1. Ozisik, M. N. (1985). Heat transfer: a basic approach.
2. Incropera, F. P., Lavine, A. S., Bergman, T. L., & DeWitt, D. P. (2007). Fundamentals of heat and mass transfer. Wiley.
3. Holman, J. P. (2002). Heat Transfer-Si Units-Sie. Tata McGraw-Hill Education.
4. Ganesan, V., Fundamentals of IC Engines, Tata McGraw Hill, 2003.

25ME611 GAS TURBINES AND JET PROPULSION

SYLLABUS:

Introduction: Classification of Turbomachines, Applications of Gas Turbines, Assumptions for Air-Standard Cycles, Simple Brayton Cycle, Heat Exchange Cycle, Inter-cooling and Reheating Cycle, Comparison of Various Cycles.

Ideal Shaft Power Cycles and their Analysis: Assumptions for Air-Standard Cycles, Simple Brayton Cycle, Heat Exchange Cycle, Inter-cooling and Reheating Cycle, Comparison of Various Cycles.
Real Cycles and their Analysis: Methods of Accounting for Component Losses, Isentropic and Polytropic Efficiencies, Transmission and Combustion Efficiencies, Comparative Performance of Practical Cycles, Combined Cycles and Cogeneration Schemes.

Jet Propulsion Cycles and their Analysis: Criteria of Performance, Simple Turbojet Engine, Simple Turbofan Engine, Simple Turboprop Engine, Turbo-shaft Engine, Thrust Augmentation Techniques
Fundamentals of Rotating Machines: General Fluid Dynamic Analysis, Euler's Energy Equation, Components of Energy Transfer, Impulse and Reaction Machines.
Centrifugal Compressors: Construction and Principle of Operation, Elementary Theory and Velocity Triangles, Factors Effecting Stage Pressure Ratio, The Diffuser, The Compressibility Effects, Pre-rotation and Slip Factor, Surging and Choking, Performance Characteristics.

Flow Through Cascades: Cascade of Blades, Axial Compressor Cascades, Lift and Drag Forces, Cascade Efficiency, Cascade Tunnel.

Axial Flow Compressors: Construction and Principle of Operation, Elementary Theory and Velocity Triangles, Factors Effecting Stage Pressure Ratio, Degree of Reaction, Work done factor, Three-Dimensional Flow, Design Process, Blade Design, Stage Performance, Compressibility Effects, Off-Design Performance.

Combustion System: Operational Requirements, Classification of Combustion Chambers, Factors Effecting Combustion Chamber Design, The Combustion Process, Flame Stabilization, Combustion Chamber Performance, Some Practical Problems Gas Turbine Emissions.

Axial and Radial Flow Turbines: Construction and Operation, Vortex Theory, Estimation of Stage Performance, Overall Turbine Performance, Turbine Blade Cooling, the Radial Flow Turbine. Off-Design Performance: Off-Design Performance of Single Shaft Gas Turbine, Off-Design Performance of Free Turbine Engine, Off-Design Performance of the Jet Engine, Methods of Displacing the Equilibrium Running Line.

Text Books/ References:

1. Saravanamuttoo, H. I., Rogers, G. F. C., & Cohen, H. (2001). Gas turbine theory. Pearson Education.
2. Hall, C., & Dixon, S. L. (2013). Fluid mechanics and thermodynamics of turbomachinery. Butterworth-Heinemann.
3. Flack, R. D. (2005). Fundamentals of jet propulsion with applications (Vol. 17). Cambridge University Press.
4. Ganesan, V. (2010). Gas Turbines 3E. Tata McGraw-Hill Education.
5. Yahya, S. M. (1987). Turbines compressors and fans. Tata McGraw-Hill Education.
6. Lefebvre, A. H., & Ballal, D. R. (2010). Gas turbine combustion: alternative fuels and emissions. CRC press.

25ME612 COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER

SYLLABUS:

Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods.

Governing equations of fluid dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, the momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.

Mathematical behavior of partial differential equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.

Basic aspects of discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points.

Grids with appropriate transformation: General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.

Parabolic partial differential equations: Finite difference formulations, Explicit methods – FTCS, Richardson and DuFort-Frankel methods, Implicit methods – Laasonen, Crank-Nicolson and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization.

Stability analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, artificial dissipation and dispersion.

Elliptic equations: Finite difference formulation, solution algorithms: Jacobi-iteration method, a Gauss-Siedel iteration method, point- and line-successive over-relaxation methods, and alternative direction implicit methods.

Hyperbolic equations: Explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes, tvd formulations, entropy condition, first-order and second-order tvd schemes.

Scalar representation of navier-stokes equations: Equations of fluid motion, numerical algorithms: FTCS explicit, FTBCS explicit, Dufort-Frankel explicit, Maccormack explicit and implicit, BTCS and BTBCs implicit algorithms, applications.

Grid generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation.

Finite volume method for unstructured grids: Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetra hedral Elements, 2-D Heat conduction with Triangular Elements.

Numerical solution of quasi one-dimensional nozzle flow: Subsonic-Supersonic isentropic flow, Governing equations for Quasi 1-D flow, Non-dimensionalizing the equations, MacCormack technique of discretization, Stability condition, Boundary conditions, Solution for shock flows.

Text Books/ References:

1. Anderson, J. D., & Wendt, J. (1995). Computational fluid dynamics (Vol. 206). New York: McGraw-Hill.
2. Hoffmann, K. A., & Chiang, S. T. (2000). Computational fluid dynamics volume I. Engineering Education System.
3. Chung, T. J. (2010). Computational fluid dynamics. Cambridge university press.
4. Anderson, D., Tannehill, J. C., & Pletcher, R. H. (2016). Computational fluid mechanics and heat transfer. CRC Press.
5. Versteeg, H. K., & Malalasekera, W. (2007). An introduction to computational fluid dynamics: the finite volume method. Pearson education.

25ME613 ADVANCED PRIME MOVERS

SYLLABUS:

Basics of IC engines: -Classification **of** Prime Movers; IC Engines as Prime Movers; Concept of charge, power cycles-Otto, Miller and Atkinson cycles, comparison.

SI and CI engines combustion concepts: Normal and abnormal combustion, factors for Good Combustion, performance improvement methods-super charging and turbo charging.

Pollutant emissions from IC Engines: Introduction to clean air, Pollutants from SI and CI Engines, Emission control strategies, Emission norms-EURO and Bharat stage norms.

Batteries: lead-acid battery, cell discharge and charge operation, construction, advantages of lead- acid battery-Battery parameters: battery capacity, discharge rate, state of charge, state of discharge, depth of discharge, technical characteristics-Ragone plots. Batteries of future- Graphene Batteries, SSB, Sodium-Ion (Na-ion) Batteries etc.

Electric vehicles: Introduction: Limitations of IC Engines as prime mover, History of EVs, EV system, components of EV-DC and AC electric machines: Introduction and basic structure-Electric vehicle drive train-advantages and limitations, Permanent magnet and switched reluctance motors-EV motor sizing: Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability.

Hybrid vehicles: classification**,** Configurations of hybrids, advantages and limitations-Hybrid drive trains, sizing of components Initial acceleration, rated vehicle velocity, Maximum velocity, and maximum gradeability:

Fuel Cell vehicles: Fuel cells: Introduction-Fuel cell characteristics, Thermodynamics of fuel cells-Fuel cell types: emphasis on PEM fuel cell.

Text Books/ References:

1. G. Amba Prasad Rao, and T. Karthikeya Sharma (2020). Engine emission control technologies: design modifications and pollution mitigation techniques. Apple Academic Press.
1. Heywood, J. B. (1988). Internal combustion engine fundamentals.
2. Pulkrabek, W. W. (2014). Engineering fundamentals of the internal combustion engine. Upper Saddle River: Pearson Prentice Hall.
3. Leitman, S., & Brant, B. (2013). Build your own electric vehicle. McGraw-Hill Education.
4. Barbir, F. (2012). PEM fuel cells: theory and practice. Academic Press.

Departmental Elective II

25ME614 JET AND ROCKET PROPULSION

SYLLABUS:

Motion in Space: Requirement for Orbit: Motion of Bodies in space, Parameters describing motion of bodies, Newton's Laws of motion, Universal law of gravitational force, Gravitational field, Requirements of motion in space, Geosynchronous and geostationary orbits, Eccentricity and inclination of orbits, Energy and velocity requirements to reach a particular orbit, Escape velocity, Freely falling bodies, Means of providing the required velocities.

Theory of Rocket Propulsion: Illustration by example of motion of sled initially at rest, Motion of giant squid in deep seas, Rocket principle and rocket equation, Mass ratio of rocket, Desirable parameters of rocket, Rocket having small propellant mass fraction, Propulsive efficiency of rocket, Performance parameters of rocket, Staging and clustering of rockets, Classification of rockets.

Rocket nozzle and Performance: Expansion of gas from a high pressure chamber, Shape of the nozzle, Nozzle area ratio, Performance loss in conical nozzle, Flow separation in nozzles, Contour or bell nozzles, Unconventional nozzles, Mass flow rates and characteristics velocity, Thrust developed by a rocket; Thrust coefficient, Efficiencies, Specific impulse and correlation with C* and CF, General Trends.

Chemical Propellants: Small value of molecular mass and specific heat ratio, energy release during combustion of products, Criterion for choices of propellants, Solid propellants, Liquid propellants, Hybrid propellants.

Solid Propellants Rockets: Mechanism of burning and burn rate, Choice of index n for stable operation of solid propellant rockets, Propellant grain configuration, Ignition of solid propellant rockets, Pressure decay in chamber after propellant burnout, Action time and burn time, Factors influencing burn rate, Components of a solid propellant rocket.

Liquid Propellant Rockets: Propellant feed system, Thrust chamber, Performance and choice of feed system cycle, Turbo pumps, Gas requirements for draining of propellants from storage tanks, Draining under microgravity condition, Trends in development of liquid propellant rockets.

Hybrid Rockets: Working principle, Choice of fuels and oxidizer, Future of hybrid rockets.

Text Books/ References:

1. Barrere, M., Jaumotte, A., Fraeijs de Veubeke, B., & Vandenkerckhove, J. (1960). Rocket propulsion (No. OA-2). LTAS
2. Sutton, G. P., & Biblarz, O. (2001). Rocket Propulsion Elements JOHN WILEY & SONS. Inc., New York.
3. Ramamurthi, K. (2010). Rocket Propulsion. Macmillan.
4. Feodosiev, V. I., & Siniarev, G. B. (2014). Introduction to rocket technology. Academic Press.
5. Saravanamutto, H., Rogers, G., Cohen, H., & Straznicky, P. (2008). Gas Turbine Theory, 6th red.

Departmental Elective II

25ME615 CRYOGENIC SYSTEMS

SYLLABUS:

Introduction: Definition and Engineering Applications of Cryogenics, Properties of solids for cryogenic systems.

Refrigeration and Liquefaction: Simple Linde cycle, Pre-cooled Joule-Thomson cycle, dual-pressure cycle, Simon helium liquefier, classical cascade cycle, mixed-refrigerant cascade cycle.

Ultra-low-temperature refrigerators: Definition and Fundamentals regarding ultra-low-temperature refrigerators, Equipment associated with low-temperature systems, Various Advantages and Disadvantages.

Storage and Handling of Cryogenic Refrigerants: Storage and Transfer systems, Insulation, Various Types of Insulation typically employed, Poly Urethane Foams (PUFs) and Polystyrene Foams (PSFs), Vacuum Insulation, and so on.

Applications: Broad Applications of Cryogenic Refrigerants in various engineering systems

Text Books/ References:

1. Frederking, T. H., & Yuan, S. W. (2005). Cryogenics: low temperature engineering and applied sciences. Yutopian Enterprises.
2. Arora, C. P. (2000). Refrigeration and air conditioning, New Delhi.
3. Jha, A. R. (2011). Cryogenic technology and applications. Elsevier.

Departmental Elective II

25ME616 CONJUGATE HEAT TRANSFER

SYLLABUS:

Introduction: Definition of conjugate heat transfer, basics, applications in engineering practice and research.

Review of Fundamentals: Review of fundamentals of energy balance approach, view factor calculations, Algebra of view factors, Enclosure Analysis, Radiosity - irradiation methods.

Finite volume and finite difference methods: Principles and Applications of finite volume and finite difference methods, Practice of computer programs for simple problems

Two-mode heat transfer problems: Conjugate convection from different geometries without radiation, Applications in Electronics Cooling and other related appliances.

Three-mode heat transfer problems: Conjugate convection with radiation from various geometries, Applications in Electronics Cooling and other related appliances.

Conjugate mixed convection problems: Problems of the above kind as referred to Gas cooled nuclear reactors, Electronics cooling appliances, and so on.

Text Books/ References:

1. Kakaç, S., Yener, Y., & Naveira-Cotta, C. P. (2018). Heat conduction. CRC Press.
2. Kays, W. M. (2012). Convective heat and mass transfer. Tata McGraw-Hill Education.
3. Howell, J. R., Menguc, M. P., & Siegel, R. (2015). Thermal radiation heat transfer. CRC press.
4. Bergman, T. L., Incropera, F. P., DeWitt, D. P., & Lavine, A. S. (2011). Fundamentals of heat and mass transfer. John Wiley & Sons.

Departmental Elective II

25ME617 DYNAMICS AND CONTROL OF MECHANICAL SYSTEMS

SYLLABUS:

Basic Concepts: Inertial Coordinate System. Fundamental Laws of Motion. Mechanics of Particles and System of Particles. Principle of Linear and Angular Momenta. Work-energy principles.

Lagrangian Dynamics: Degrees of Freedom. Generalized Coordinates and Generalized Forces. Holonomic and Nonholonomic Constraints, Lagrange's Equation from D'Alembert's Principles. Application of Lagrange's equation for Conservative and Non-conservative Autonomous Systems with holonomic and Nonholonomic Constraints. Applications to systems with very Small Displacements and Impulsive Motion. Hamilton Principle from D'Alembert's Principle. Lagrange Equation from Hamilton's Principle.

Multi-body Dynamics: Space and Fixed body Coordinate Systems. Coordinate Transformation Matrix. Direction Cosines, Euler Angles. Euler Parameters. Finite and Infinitesimal Rotations. Time Derivatives of Transformations Matrices. Angular Velocity and Acceleration Vectors. Equations of Motion of Multi-Body System. Newton-Euler Equations. Planer Kinematic and Dynamic Analysis. Kinematic Revolute Joints. Coordinate Partitioning, Equations of Motion. Joint Reaction Forces. Simple Applications of Planer Systems.

Stability of Motion: Fundamental Concept in Stability. Autonomous Systems and Phase Plane Plots. Routh's Criteria for Stability. Liapunv's Method. Liapunov's Stability Theorems. Liapunov's Function to Determine Stability of the System.

Control System Dynamics: Open and Close Loop Systems. Block Diagrams. Transfer Functions and Characteristics Equations. Proportional Integral and Derivative Control actions and their Characteristics.

Text Books/ References:

1. Ginsberg, J. H. (1998). Advanced engineering dynamics. Cambridge University Press.
2. Meirovitch, L. (2010). Methods of analytical dynamics. Courier Corporation.
3. Canon, R. (1967). Dynamics of Physical Systems, ch. 4.

Departmental Electives III

25ME618 DESIGN AND OPTIMIZATION OF ENERGY SYSTEMS

SYLLABUS:

Introduction: Introduction to design and specifically system design. Morphology of design with a flow chart. Very brief discussion on market analysis, profit, time value of money, an example of discounted cash flow technique. Concept of workable design, practical example on workable system and optimal design.

System Simulation: Classification. Successive substitution method - examples. Newton Raphson method - one unknown - examples. Newton Raphson method - multiple unknowns - examples. Gauss Seidel method - examples. Rudiments of finite difference method for partial differential equations, with an example.

Regression and Curve Fitting: Need for regression in simulation and optimization. Concept of best fit and exact fit. Exact fit - Lagrange interpolation, Newton's divided difference - examples. Least square regression - theory, examples from linear regression with one and more unknowns - examples. Power law forms - examples. Gauss Newton method for non-linear least squares regression - examples.

Optimization: Introduction, Formulation of optimization problems – examples. Calculus techniques – Lagrange multiplier method – proof, examples. Search methods – Concept of interval of uncertainty, reduction ratio, reduction ratios of simple search techniques like exhaustive search, dichotomous search, Fibonacci search and Golden section search – numerical examples. Method of steepest ascent/ steepest descent conjugate gradient method – examples. Geometric programming – examples. Dynamic programming – examples. Linear programming – two variable problem –graphical solution. New generation optimization techniques – Genetic algorithm and simulated annealing -examples.

Text Books/ References

1. Balaji, C. (2011). Essentials of thermal system design and optimization. Ane Books Pvt.
2. Jaluria, Y. (2007). Design and optimization of thermal systems. CRC press.
3. Burmeister, L. C. (1998). Elements of thermal-fluid system design (p. 220). New Jersey: Prentice Hall.
4. Stoecker, W. F. (1980). Design of thermal systems. McGraw Hill Book Company.
5. Arora, J. S. (2004). Introduction to optimum design. Elsevier.
6. Deb, K. (2012). Optimization for engineering design: Algorithms and examples. PHI Learning Pvt. Ltd.

Departmental Electives III

25ME619 MULTIPHASE FLOWS

SYLLABUS:

Introduction & Fundamentals: Definitions: multiphase flows, terminology, industrial relevance, Flow patterns & maps: gas–liquid, liquid–liquid, gas–solid; pattern identification/classification.

Governing Principles & Models: Conservation (mass, momentum, energy) for multiple immiscible phases, Two-fluid (Eulerian–Eulerian) formulations; single-particle motion (Oseen's models), Homogeneous vs separated-flow models; slip ratio and void fraction correlations.

One-Dimensional Flow Models: Steady homogeneous flow; choking and cavitation, Steady separated-flow: application to annular and stratified flow.

Drift-Flux Model: Drift-flux theory for bubbly/slug flow, Adaptations for liquid–liquid & gas–liquid microchannel flows.

Three-Phase Flow & Contactors: Gas–solid–liquid systems in industrial contactors (bubble columns, fluidized beds, packed/trickle beds, pneumatic conveyance), Regime identification, pressure drop, holdup/volume fraction estimation techniques.

Multiphase Flow Phenomena & Modeling: Cavitation, bubble/droplet breakup, coalescence, Surface tension roles; particle dynamics in turbulence.

Experimental & Measurement Techniques: Measurement tools and techniques for phase identification, void fraction, flow regimes, Hydraulic design equations for slurry and pneumatic transport.

Text Books/ References:

1.NPTEL Lectures on Multiphase Flow by Prof. S. Pushpa Vanam (IIT-Madras) and Prof. T. Sundararajan (IIT-Madras)

2 Multiphase Flow in Process Industries. Author: Chung Fang

3 Multiphase Flow Handbook Editor**:** Clayton T. Crowe (2nd Edition)

4 An Introduction to Multiphase Flow, G.F. Hewitt

Departmental Electives III

25ME620 BATTERY THERMAL MANAGEMENT

SYLLABUS:

Battery Fundamentals & Heat Generation: Overview: cell types (Li-ion, Li-polymer), configurations, parameters, Sources of heat: internal resistance, charge/discharge dynamics, auxiliary losses

Thermal Management Needs & Objectives: Impact of temperature on performance, safety, ageing, thermal runaway, Targets: optimal range, uniformity, cooling response

Cooling Strategies & Heat Transfer Modes: Passive - heat sinks, fins, phase change materials (PCM), Active - air-cooling, liquid cooling loops, heat pipes, Emerging- immersion cooling

System Design & Modelling Techniques: Analytical/empirical heat transfer correlations – conduction, convection, Simplified modeling (1D/0D thermal circuits), COMSOL/ANSYS basic usage

Case studies: Chevrolet Volt PCM design, Tesla Model-S cooling, battery packs in drones

Instrumentation & Measurement: Sensors: thermistors, RTDs, micro-thermocouples, Data acquisition basics; Arduino-based prototype controllers, Monitoring for temperature uniformity and safety controls

Mini-Project / Case Study: Design and simulate (theory or basic CFD) a BTMS for a specified application (e.g., EV battery module or drone pack), Emphasis on system sizing, heat generation calculation, cooling method selection

Text Books/ References:

1. Battery Systems Engineering: Christopher D. Rahn & Chao-Yang Wang
2. Thermal Management of Electric Vehicle Battery Systems Ibrahim Dincer, Halil S. Hamut, and Marcelo A. Rosen
3. Design of Battery Thermal Management Systems Prashant N. Kumta & Shriram Santhanagopalan (NREL)
4. Thermal Design and Thermal Behaviour of Lithium-Ion Battery CellsJoeri Van Mierlo et al. (VUB)
5. Electric Vehicle Battery Systems, Sandeep Dhameja

Departmental Electives III

25ME621 MICROFLUIDICS

SYLLABUS

Fundamentals of Microscale Fluid Dynamics: Low Reynolds number behavior, surface tension, capillarity, scaling laws, Differences between micro- and macroscale flow physics.

Microfabrication Techniques (Overview): Photolithography, etching (wet & dry), soft-lithography (PDMS), bonding, Comparative advantages & limitations.

Design of Basic Microfluidic Components: Microchannels (straight, serpentine), mixers (passive, lamination), valves & pumps.

Droplet Microfluidics and Interfacial Dynamics: Droplet generation (T-junction, flow-focusing), breakup/coalescence, Interfacial tension, surfactant effects.

Measurement & Experimental Techniques: Flow visualization, particle tracking, pressure measurement, μPIV basics.

Mini-Project or Case Study: Design + simulate (using basic tools or conceptual analysis) a microfluidic device (e.g. mixer or droplet generator).

Text Books/ References:

1. Fundamentals and Applications of Microfluidics, Nam-Trung Nguyen & Steven T. Wereley
2. Introduction to Microfluidics, Patrick Tabeling
3. The Physics of Microdroplets, Jean Berthier
4. BioMEMS and Biomedical Nanotechnology: Microfluidics, Mauro Ferrari, Albert Lee, et al.

Open elective (MOOCs)

Online course

*In open elective apart from given subjects a student can select any other MOOC course listed in Swayam website (https://swayam.gov.in/) and the selected MOOC course must not be identical to or overlap with any course listed in the regular MTech curriculum.

The following courses are given for sample only

Course code (Depends on the course that a student selects)	**Course name**	**SYLLABUS and source**
Online code	**Artificial Intelligence: Concepts & Techniques**	Prof. V. Susheela Devi NPTEL
Online code	**Artificial Intelligence Search Methods for Problem Solving**	Prof. Deepak Khemani NPTEL
Online code	**Data Science for Engineers**	Dr. Regaswamy NPTEL
Online code	**Introduction to Machine Learning (IITM)**	Prof. Balaraman Ravindran NPTEL
Online code	**Entrepreneurship Essentials**	Dr Meeta Nihalani NPTEL

25ME622 CFD LABORATORY

SYLLABUS:

1. Solution of 1D heat conduction problem using TDMA and LU decomposition.
2. Solution of 2D parabolic equations.
   (a) Explicit
   (b) Implicit (ADI)
3. Grid generation (rectangular and circular).
4. Introduction to ANSYS FLUENT
   ANSYS FLUENT 1 (Laminar pipe Flow).
   ANSYS FLUENT 2 (Turbulent Pipe Flow).
   ANSYS FLUENT 3 (2D circular Cylinder).
   ANSYS FLUENT 4 (2D airfoil).
   ANSYS FLUENT 5 (Driven Cavity).
5. 1D Steady-State Heat Conduction
   Objective: Solve $\frac{d^2T}{dx^2} = 0$ in a rod
   Method: Finite Difference Method (FDM) – Central Difference
   Tool: MATLAB or Python (NumPy/Matplotlib)
   Concepts: Discretization, boundary conditions, matrix solvers
6. 1D Unsteady Heat Conduction
   Objective: Solve $\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2}$
   Method: Explicit and Crank–Nicolson schemes
   Tool: Python (Matplotlib for animation)
   Concepts: Stability (Fourier number), transient simulations
7. 2D Steady Heat Conduction (Laplace Equation)
   Objective: Solve Laplace equation on a square plate
   Method: FDM using Gauss-Seidel iteration
   Tool: MATLAB (contour plot) or Python (seaborn, matplotlib)
   Concepts: Iterative solvers, visualization

Text Books/ References:

1. Versteeg, H. K. and Malalasekera, W. (2010). An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd Edition, Pearson.
2. Tannehill, J. C., Anderson, D. A. and Pletcher, R. H. (2002) Computational Fluid Mechanics and Heat Transfer, McGraw Hill.
3. Blazek, J., (2006) Computational Fluid Dynamics: Principles and Applications, 2nd Edition, Elsevier Science & Technology.
4. Chung, T. J. (2003) Computational Fluid Dynamics, Cambridge University Press.
5. CFD Python (Barba's Course): https://github.com/barbagroup/CFDPython
6. Numerical Heat Transfer by Suhas Patankar
7. An Introduction to Computational Fluid Dynamics – Versteeg & Malalasekera
8. NPTEL Courses: Computational Fluid Dynamics (by IIT-K or IIT-B)