K L E F

DEPARTMENT OF MECHANICAL ENGINEERING

M.TECH IN THERMAL ENGINEERING

2021-22 admitted batch course structure

First Year (First Semester):

S. No.	Course Code	Course Title	Periods			Contact Hours	Credits
			L	T	P		
1	18 ME 5109	Numerical Methods in Thermal engineering	3	1	0	4	4
2	18 ME 5110	Advanced Thermodynamics	3	1	0	4	4
3	18 ME 5111	Design of Thermal Systems	3	1	0	4	4
4	18 ME 5112	Advanced Heat and Mass Transfer	3	1	0	4	4
5		Elective – 1	3	0	0	3	3
6		Elective - 2	3	0	0	3	3
7	18 IE 5149	Seminar	0	0	4	4	2
		Total	**18**	**4**	**4**	**26**	**24**

First Year (Second Semester):

S. No.	Course Code	Course Title	Periods			Contact Hours	Credits
			L	T	P		
1	18 ME 5213	Incompressible and Compressible Flows	3	1	0	4	4
2	18 ME 5214	Computational Fluid Dynamics	3	0	2	5	4
3	18 ME5215	Refrigeration and Cryogenics	3	1	0	4	4
4	18 ME 5216	Measurements in Thermal Engineering	3	1	0	4	4
5		Elective – 3	3	0	0	3	3
6		Elective - 4	3	0	0	3	3
7	18 IE 5250	Term Paper	0	0	4	4	2
		Total	**18**	**3**	**6**	**27**	**24**

Second Year (First & Second Semester):

S.No	Course code	Course Title	Periods			Credits
			L	T	P	
1	21 IE 6150/21IE6250	Dissertation	0	0	36	18

ELECTIVE COURSES

S.No	Course code	Course Title	Periods			Credits
			L	T	P	
Elective-1						
1	18 ME 51E1	Heat Exchanger Design	3	0	0	3
2	18 ME 51E2	Convection and Two-Phase Flow	3	0	0	3
3	18 ME 51E3	Compact Heat Exchangers	3	0	0	3
Elective-2						
1	18 ME 51F1	Engine Systems and Performance	3	0	0	3
2	18 ME 51F2	IC Engine Combustion and Pollution	3	0	0	3
3	18 ME 51F3	Alternative Fuels	3	0	0	3
Elective-3						
1	18 ME 52G1	Principles of Turbo-machinery	3	0	0	3
2	18 ME 52G2	Gas Turbine Engineering	3	0	0	3
3	18 ME 52G3	Turbo-Compressors	3	0	0	3
Elective-4						
1	18 ME 52H1	Energy Conservation, Management & Audit	3	0	0	3
2	18 ME 52H2	Renewable Energy Technology	3	0	0	3
3	18 ME 52H3	Solar Energy and Wind Energy	3	0	0	3

18ME5109-NUMERICAL METHODS IN THERMAL ENGINEERING

L-T-P: 3-1-0 **Credits:4** **Pre-Reqisite:Nil**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply mathematical knowledge in Solving an algebraic or transcendental equation, linear system of equations	PO1-3, PSO1	3
CO2	Apply knowledge of differential equations in appropriate numerical method. Solving the initial boundary value problems and boundary value problems using finite	PO1-2, PSO1	2
CO3	Apply knowledge of finite element methods in selection of appropriate numerical methods to solve various types of problems	PO1-2, PSO1	2
CO4	Apply knowledge of engineering and science in consideration the minimum number of mathematical operations involved, accuracy requirements and available computational resources.	PO1-3, PSO1	2

Syllabus:

Mathermatical Description of the Physical Phenomena: Governing equations-mass, momentum, energy, species, General form of the scalar transport equation, Elliptic, parabolic and hyperbolic equations, Behavior of the scalar transport equation with respect to these equation type; **Discretization Methods:** Methods for deriving discretization equations-finite difference, finite volume and finite element method, Method for solving discretization equations, Consistency, stability and convergence; **Diffusion Equation:** 1D-2D steady diffusion, Source terms, non-linearity, Boundary conditions, interface diffusion coefficient, Under- relaxation, Solution of linear equations (preliminary), Unsteady diffusion, Explicit, Implicit and Crank-Nicolson scheme, Two dimensional conduction, Accuracy, stability and convergence revisited; **Convection and Diffusion:** Steady one-dimensional convection and diffusion, Upwind, exponential, hybrid, power, QUICK scheme,Two-dimensional convection-diffusion, Accuracy of Upwind scheme; false diffusion and dispersion, Boundary conditions; **Flow Field Calculation:** Incompressibility issues and pressure-velocity coupling, Primitive variable versusother methods, Vorticity-stream function formulation, Staggered grid, SIMPLE family of algorithms; **Numerical Methods for Radiation:** Radiation exchange in enclosures composed of diffuse gray surfaces, Finite volume method for radiation, Coupled radiation-conduction for participating media.

TEXT BOOKS:

1. Numerical heat transfer and fluid flow, S. V. Patankar, Hemisphere publishing company(1980)
2. Computational Fluid Mechanics and Heat Transfer, J. C. Anderson, D. A. Tanehil and R. H. Pletcher, Taylor & Francis publications, USA (1997)

REFERENCE BOOKS:

1. Advances in numerical heat transfer, (Eds.) W. J. Minkowycz, E. M. Sparrow, Taylor & Francis publications (1997)
2. Heat Transfer - Mathematical Modelling, Numerical Methods and InformationTechnology, (Ed.) A. Belmiloudi, InTech Publications (2011)
3. Numerical heat transfer by T. M. Shih, Hemisphere publications company (1984)
4. Numerical methods in thermal problems: Proceedings of seventh internationalconference held in Staford, USA, Volumes 1-2, (Eds.) K. Morgan (1991)
5. Computational Heat Transfer, Mathematical Modelling, A. A. Samarskii, P. N.Vabishchevich, John Wiley & Sons (1995)
6. Hand book of numerical heat transfer, W. J. Minkowycz, E. M. Sparrow, G. E. Schneider, R. H. Pletcher, Wiley publishers (2001)

18ME5110-ADVANCED THERMODYNAMICS

L-T-P: 3-1-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply thermodynamics concepts for various applications like availability analysis and thermodynamic relations	PO1-3, PSO1	3
CO2	Analyze Phase transition, types of equilibrium and stability, multi-component and multi-phase systems, equations of state. Chemical thermodynamics, combustion. Third law of thermodynamics	PO2-2, PSO1	4
CO3	alyze the basic concepts of Statistical and Irreversible thermodynamics.	PO2-1, PSO1	4
CO4	Analyze the behaviour of real gas behaviour, availability analysis, statistical and irreversible thermodynamics	PO2-1, PSO1	4

Syllabus:

Review of first and second law of thermodynamics, Maxwell equations, Joule- Thompson experiment, irreversibility and availability, exergy analysis, phase transition,types of equilibrium and stability, multi-component and multi-phase systems, equations of state, chemical thermodynamics, combustion. Third law of thermodynamics, Kinetic theory of gases- introduction, basic assumption, molecular flux, equation of state for an ideal gas, collisions with a moving wall, principle of equi-partition of energy, classical theory of specific heat capacity. Transport phenomena- intermolecular forces, The Vander Waals equation of state, collision cross section, mean free path, Statistical thermodynamics- introduction, energy states and energy levels, macro and micro-scales, thermodynamic probability, Bose-Einstein, Fermi-Dirac, Maxwell-Boltzmann statistics, distribution function, partition energy, statistical interpretation of entropy, application of statistics to gases-mono-atomic ideal gas.

TEXT BOOKS:

1. Advanced Engineering Thermodynamics, A. Bejan, Wiley and sons, (2006)
2. Thermodynamics, J. P. Holman, McGraw-Hill Inc., (1998)

REFERENCE BOOKS:

1. Advanced Thermodynamics for Engineers, Kenneth Wark, McGraw-Hill
2. Thermodynamics, Kinetic theory, and Statistical thermodynamics, F. W. Sears,and G. L. Salinger, Narosa Publishing House (1998)
3. Fundamentals of Engineering thermodynamics, M. J. Moron, and H. N. Shapiro,John Wiley& Sons
4. Heat and thermodynamics, M. W. Zemansky, and R. H. Dittman, Mc_Graw HillInternational (2007)

18ME5111-DESIGN OF THERMAL SYSTEMS

L-T-P: 3-1-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the modelling concepts to the design of thermal systems	PO1-3, PSO1-3	3
CO2	Analyse the design of thermal systems by considering its economic viability	PO2-2, PSO1-3	4

CO3	alyse about the problem formulation for optimization and its search methods and understanding Lagrange multiplier	PO2-3, PSO1-3	4
CO4	Examine about Geometric, linear and dynamic Programming and modeling of thermal equipment	PO4-1, PSO1-3	5

Syllabus:

Modeling of Thermal Systems: types of models, mathematical modeling, curve fitting, linear algebraic systems, numerical model for a system, system simulation, methods for numerical simulation; Acceptable Design of a Thermal System: initial design, design strategies, design of systems from different application areas, additional considerations for large practical systems; Economic Considerations: calculation of interest, worth of money as a function of time, series of payments, raising capital, taxes, economic factor in design, application to thermal systems; Problem Formulation for Optimization: optimization methods, optimization of thermal systems, practical aspects in optimal design, Lagrange multipliers, optimization of constrained and unconstrained problems, applicability to thermal systems; search methods: single-variable problem, multivariable constrained optimization, examples of thermal systems; geometric, linear, and dynamic programming and other methods for optimization, knowledge-based design and additional considerations, professional ethics. Optimization, Objective function formulation, Constraint equations, Mathematical formulation, Calculus method, Dynamic programming, Geometric programming, linear programming methods, solution procedures. Equation fitting, Empirical equation, best fit method, method of least squares. Modeling of thermal equipments such as turbines, compressors, pumps, heat exchangers, evaporators and condensers

TEXT BOOKS:

1. W.F. Stoecker, Design of Thermal Systems - McGraw-Hill
2. Y. Jaluria, Design and Optimization of Thermal Systems –CRC Press

REFERENCE BOOKS:

1. Bejan, G. Tsatsaronis, M.J. Moran, Thermal Design and Optimization – Wiley.
2. R. F. Boehm, Developments in the Design of Thermal Systems – CambridgeUniversity Press.
3. N.V. Suryanarayana, Design & Simulation of Thermal Systems – MGH.

18ME5112-ADVANCED HEAT AND MASS TRANSFER

L-T-P: 3-1-0 **Credits: 4** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the fundamentals of heat transfer concepts to different surfaces-fins, pipe flows etc.	PO1-3, PSO1-3	3
CO2	Apply numerical methods to solve heat transfer problems	PO1-3, PSO1-3	3
CO3	alyse the heat transfer through phase change processes	PO2-3, PSO1-3	4
CO4	Apply the combined heat nd mass transfer concepts to different mechanisms in engine applications	PO1-1, PSO1-3	3

Syllabus:

Introduction - review of heat transfer Fundamentals - transient conduction and extended surface Heat Transfer, Unsteady heat conduction. Lumped capacity model, awareness of one-dimensional unsteady results (charts; Biot and Fourier numbers), Brief review of Steady Laminar and Turbulent Heat Transfer in External and Internal Flows - Heat Transfer at High Speeds - Unsteady Laminar and Turbulent Forced Convection in Ducts and on Plates - Convection with body forces, Boundary layers and internal flows. Awareness of these configurations, some knowledge of internal flow energy balances, Convection correlations. Finding heat transfer coefficients from Reynolds numbers and Rayleigh numbers, Heat Exchangers. Typical configurations andepsilon-NTU analysis, phase-change heat transfer. General awareness of processes of condensation and boiling in a pure substance, some use of correlations, Quenching of metals, Leidenfrost problem, heat transfer of sprays, jets and films, Radiation basics - Radiation in Enclosures - Gas Radiation - Diffusion and Convective Mass Transfer - Combined Heat and Mass Transfer from Plates and in Pipes.

TEXT BOOKS:

1. Heat transfer, A. Bejan, John Wiley & Sons (1993)
2. Advanced Heat and Mass Transfer, A. Faghri, Y. Zhang, J. Howell, GlobalDigital Press (2010)

REFERENCE BOOKS:

1. A Heat Transfer Text Book, J. H. Lienhard iv, and J. H. Lienhard V, Phlogiston Press(2008)
2. Heat and Mass Transfer, H. D. Baehr, and K. Stephan, Springer-Verlag (1998)
3. Heat transfer, F. M. White, Addision-Wesley (1984)
4. Basic heat and mass transfer, K. C. Rolle, Prentice-Hall (2000)
5. Heat Transfer – A practical approach, Y. A. Cengel, Tata McGraw-Hill (2002)

18ME51E1-HEAT EXCHANGER DESIGN

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply heat transfer and fluid flow principles to understand the thermos-hydraulic fundamentals of heat exchangers	PO1-3, PSO1-3	3
CO2	Apply LMTD and ε-NTU methods for the design of different types of shell and tube heat exchangers	PO1-3, PSO1-3	3
CO3	ply different methods in the design of shell and tube heat exchangers	PO1-3, PSO1-3	3
CO4	Design of Compact heat exchangers and study of fouling control techniques	PO3-1, PSO1-3	5

Syllabus:

Heat Exchangers-Introduction, C1assfication, and Selection. Heat Exchanger Thermo- Hydraulic Fundamentals. Heat Exchanger Design. Compact Heat Exchangers. Shell and Tube Heat Exchanger Design. Regenerators. Plate Heat Exchangers and Spiral Plate Heat Exchangers. Heat-Transfer Augmentation. Fouling; Flow-Induced Vibration of Shell and Tube Heat Exchangers. Mechanical Design of Shell and Tube Heat Exchangers. Corrosion; Material Selection and Fabrication. Quality Control and Quality Assurance and Nondestructive Testing. Heat Exchanger Fabrication.

TEXT BOOKS

1. Heat Exchanges: Selection, Design and Construction, E. A. Saunders, LongmanScientific and Technical (1988)
2. Fundamentals of Heat Exchanger Design, Ramesh K. Shah, Dusan P. Sekulic,Wiley (2002)

REFERENCES

1. Heat Transfer, J. P. Holman, McGraw Hill, New York (1989)
2. Process Heat Transfer, CRC Press, G.F. Hewitt, G.L. Shires, T.R. Bott (1994)
3. Fluid Dynamics and Heat Transfer, J.G. Knudsen and D.L. Katz, McGraw Hill,New York (1958)
4. Heat Exchanger Design Handbook, K. Thulukkanam, CRC Press (2013)
5. Heat Exchangers: Selection, Rating and Thermal Design, S. Kakaç and H. Liu, CRCPress (2002)
6. Fluid Mechanics and Transfer Processes, Cambridge University Press, J. M. Kay,and R. M. Nedderman (1985)
7. Heat exchanger design handbook, Hemisphere publishing corp., (1981)

18ME51E2-CONVECTION AND TWO-PHASE FLOW

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL.**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the knowledge of fluid mechanics and heat transfer to understand the two-phase flow phenomena	PO1-3, PSO1-3	3
CO2	Apply the first order and second order differential equations technique to problems involving two-phase flow	PO1-3, PSO1-3	3
CO3	alyse the convection heat transfer problems with solutions involving partial differential equations	PO2-3, PSO1-3	4
CO4	Synthesize the complex engineering problems by applying the fundamentals of heat transfer and fluid flow	PO4-1, PSO1-3	5

Syllabus:

Introduction to two-phase flow and heat transfer technology, Liquid-vapor phase change phenomena, Interfacial tension, Wetting phenomenon, Contact angles, Transport effects, Dynamic behavior of interfaces, Phase stability and nucleation, Two- phase flow fundamentals, Flow patterns and map representation, Development of homogeneous, separated flow and drift flux models, Flooding mechanisms, Boiling Fundamentals, Homogeneous and heterogeneous nucleation, Pool boiling and convective flow boiling, Heat transfer and CFH mechanisms, Enhancement techniques, Condensation fundamentals, External and internal condensation, Film condensation theory, Drop-wise condensation theory, Enhancement techniques, Application of two- phase flow and heat transfer, Electronics thermal management, Latent heat storage devices, Gravity assisted thermo-siphons/Vapor chambers, Theory and operation of Conventional heat pipes, Micro heat pipes, Pulsating heat pipes, Capillary pumpedloops/ Loop heat pipes, Micro two-phase heat exchangers, Static and dynamic instabilities, micro-scale boiling and condensation, atomistic nucleation models.

TEXT BOOKS

1. Liquid Vapor Phase Change Phenomena, Van P. Carey, Taylor & Francis
2. Boundary layer theory, H. Schlichting, Springer (2002)

REFERENCES

1. Heat Transfer - Incropera and Dewitt, John Wiley and Sons
2. One Dimensional Two-Phase Flow, G. B. Wallis, McGraw Hill (1969)
3. Heat transfer, McGraw Hill book, C. Gebhart (1961)
4. Convective Boiling And Condensation by Collier John (Oxford EngineeringScience)
5. Two-phase Flow and Heat Transfer - P. B. Whalley (Oxford Engineering Science)
6. Heat Transfer Characteristics in Boiling and Condensation by Karl Stephan(Springer)
7. Heat Pipe Technology and Applications by J. P. Peterson (John Wiley & Sons)

18ME51E3-COMPACT HEAT EXCHANGERS

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the principles of heat transfer principles to study the compact heat exchangers	PO1-3, PSO1-3	3
CO2	Analyze the compact heat exchanger by using basic heat exchanger analysis theory	PO2-3, PSO1-3	4
CO3	ply the principles of heat transfer to analyze the performance of compact recuperators	PO1-3, PSO1-3	3

CO4	Analyze the performance of plate heat exchanger, heat pipe heat exchanger and understand the application of compact heat exchanger in multiphase flow applications	PO2-3, PSO1-3	4

Syllabus:

Classification of heat exchangers - compactness - heat transfer correlation for laminar and turbulent flow through channels, fins their geometries and efficiently. Applications and selection of compact heat exchangers. Basic heat exchangers theory related to compact heat exchangers - Definition of important HX parameters - ε NTU, F - LMTD, P-NTU, P-θ and combination charts. Coupling of heat exchangers, effect of longitudinal conduction in compact heat exchangers, effects of variable property and heat transfer coefficient, core pressure drop and velocity distribution in compact heat exchangers. Contraction and expansion pressure loss. Compact recuperators - Advantages and disadvantages of plates fin and tube fin heat exchangers - fin configuration, heat transfer and pressure drop data in finned heat exchangers, importance of laminar flow in finned recuperators and entry length effect. Plate and frame heat exchangers - Advantages of PHE, Plate geometry and flow configurations, effectiveness and pressuredrop in PHE, Fouling in PHE. Thermal regenerations - working principle of periodic flow and rotary regenerators, transient temperature profile, Hausen's chart, optimization of thermal storage. Heat Pipe Heat Exchangers - Working principles, Wick types, various operating limits of heat pipes, pressure gradient and heat transfer requirements in heat pipe heat exchangers. Use of compact heat exchangers in multiphase applications.

TEXT BOOKS:

1. Heat Exchangers Selection, Rating and Thermal design, Sadik Kakac, HongtanLiu,CRC Press (2002)
2. Heat Exchanger Design, P Arthur. Frass, John Wiley & Sons (1988)

REFERENCE BOOKS:

1. Heat Exchangers, Theory and Practice, Taborek.T, Hewitt.G.F and Afgan.N,McGraw-Hill Book Co. (1980)
2. Fundamentals of Heat Exchanger Design, Ramesh K. Shah, Dusan P. Sekulic,Wiley (2002)
3. Process Heat Transfer, Hewitt.G.F, Shires.G.L, Bott.T.R, CRC Press (1994)

18ME51F1-ENGINE SYSTEMS AND PERFORMANCE

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Understand the construction and operation of various IC Engines	PO-1	3
CO2	Analyze the role of fuel in engine combustion, and understand the basic combustion chamber design	PO2-2, PSO1-3	4
CO3	Analyze the effect of turbo charging on the performance of the IC engine	PO2-3, PSO1-3	4
CO4	Analyse the effect of various design parameters on the perfromance and emssions of IC engine	PO2-2, PSO1-3	4

Syllabus:

Working principle; Constructional details; Classification and application of different types of I.C. Engines; Wankel and other rotary engines; Operation of the Stirling engine; Mixture preparation systems for SI and CI engines; Combustion chambers; Ignition, lubrication and cooling systems; Speed governing systems; Intake and exhaust systems; Supercharging methods; Turbocharger matching; Aero-thermodynamics of compressors and turbines; Engine Testing and performance; Effects of engine design and operating parameters on performance and emissions

TEXT BOOKS

1. John B Heywood, Internal Combustion Engine Fundamentals, Tata McGraw-Hill (1988)
2. Elements of gas turbine technology, J. D. Mattingly, Tata McGrawHill (2005)

REFERENCE BOOKS:

1. Ganesan V, Internal Combustion Engines , Third Edition, Tata Mcgraw-Hill ,2007
2. Gas turbine theory, Cohen, Rogers, Saravanamutto, Pearson education (2001)
3. Patterson D.J. and Henein N.A, ―Emissions from combustion engines and theircontrol‖ Ann Arbor Science publishers Inc, USA, 1978
4. Gupta H.N, ―Fundamentals of Internal Combustion Engines‖ ,Prentice Hall ofIndia, 2006
5. Ultrich Adler ,‖ Automotive Electric / Electronic Systems, Published by RobertBosh, GmbH,1995.

18ME51F2-IC ENGINE COMBUSTION AND POLLUTION

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Analyze the role of fuel in engine combustion, and understand the basic combustion process in SI and CI engine	PO2-2, PSO1-3	4
CO2	Analyze the combustion process in engines and understand the working of various instrumentation used in IC engines	PO2-2, PSO1-3	4
CO3	Analyze the effect of various pollution control techniques to reduce engine emissions	PO2-3, PSO1-3	4
CO4	Analyze the perfromance of various instruments used in the measurement and control of pollution and emissions	PO2-2, PSO1-3	4

Syllabus:

Role of fuel in engine combustion, selection of fuels, Basic combustion processes for SI and CI engines - Factors affecting combustion in these engines - Combustion chambers - Instrumentation to study the combustion process in engines. Pollution formation in SI and CI engines - Factors affecting emissions - Control measures for evaporative emissions - Thermal reactors and catalytic converters - Engine modifications to reduce emissions - Instrumentation to measure pollutants - Emission standards and testing.

TEXT BOOKS:

1. Internal Combustion Engines Fundamentals- John B. Heywood, Pub.-McGrawHill, New York
2. Engineering fundamental of the I.C.Engine – Willard W. Pulkrabek Pub. PHI,India

REFERENCE BOOKS:

1. Fundamentals of I.C. Engines - P.W. Gill, J.H. Smith & Ziurys- IBH & Oxfordpub.
2. Internal Combustion Engines –V. Ganesan, Pub.-Tata McGraw-Hill.
3. Internal Combustion Engines & Air pollution- Obert E.F, Pub.-Hopper & RowPub., New York

18ME51F3-ALTERNATIVE FUELS

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	BTL
CO1	Analyse the properties of various alternative fuels to select the appropriate fuel for IC engine	PO2-3, PSO1-3	4
CO2	Analyze the various methods involved in the production of alternative fuels	PO2-3, PSO1-3	4
CO3	alyse the use of gaseous fuels for IC engines	PO2-3, PSO1-3	4
CO4	Examine the different approaches like dual fuel combustion and use of additives to improve the performance of IC engines	PO2-1, PSO1-3	1

Syllabus:

Fossil fuels and their limitations; Engine requirements; Potential alternative liquid and gaseous fuels; Methods of production; Properties, safety aspects, handling and distribution of various liquid alternative fuels like alcohols, vegetable oils, Di-methyl and Di-ethyl ether etc., their use in engines, performance and emission characteristics; Conversion of vegetable oils to their esters and effect on engine performance; Use of gaseous fuels like biogas, LPG, hydrogen, natural gas, producer gas etc. in SI/CI engines; Production, storage, distribution and safety aspects of gaseous fuels. Different approaches like dual fuel combustion and surface ignition to use alternative fuels in engines; Use of additives to improve the performance with alternative fuels; Hybrid power plants and fuel cell.

TEXT BOOKS:

1. Richard.L.Bechfold – Alternative Fuels Guide Book - SAE International Warrendale - 1997.
2. Handbook of Alternative Fuel Technologies, Sungyu Lee, CRC Press

REFERENCE BOOKS:

1. Alternative Fuels: Emissions, Economics, and Performance**,** Timothy T. Maxwell,Jesse C. Jones, SAE International (1991)
2. Nagpal - ―Power Plant Engineering‖ - Khanna Publishers – 1991
3. Maheswar Dayal - Energy Today & Tomorrow - I & B Horishr India - 1982.
4. ―Alcohols as motor fuels progress in technology‖ - Series No.19 - SAEPublication USE – 1980
5. SAE paper nos. 840367, 841333, 841334, 841156, Transactions, SAE, USA.

18ME5213-INCOMPRESSIBLE AND COMPRESSIBLE FLUID FLOWS

L-T-P : 3-1-0 **Credits: 4** **Pre-requisite: NIL**

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the laws of fluid flow for ideal and viscous fluids	PO1-2, PSO1-3	3
CO2	Analyze various solid shapes by suitable flow patterns for aerodynamic applications	PO2-1, PSO1-3	4
CO3	alyze the changes in properties of compressible flow and shock expansion	PO2-1, PSO1-3	3
CO4	Apply the concepts of ideal flow, viscous flow and boundary layer to compressible flow and shock expansion	PO1-3, PSO1-3	3

Syllabus:

Definition and properties of Fluids, Fluid as continuum, Langragian and Eulerian description, Velocity and stress field, Fluid statics, Fluid Kinematics, Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum and energy conservation equation, Couette flows, Poiseuille flows, Fully developed flows in non-circular cross-sections, Unsteady flows, Creeping flows, Revisit of fluid kinematics, Stream and Velocity potential function, Circulation, Irrotational vortex, Basic plane potential flows: Uniform stream; Source and Sink; Vortex flow, Doublet, Superposition of basic plane potential flows, Flow past a circular cylinder, Magnus effect; Kutta-Joukowski lift theorem; Concept of lift and drag, Boundary layer equations, Boundary layer thickness, Boundary layer on a flat plate, similarity solutions, Integral form of boundary layer equations, Approximate Methods, Flow separation, Entry flow into a duct, Basic concepts of thermodynamics, governing equations in various forms, concept of Mach number, one dimensional flows and normal shock wave, Rayleigh and Fanno flows, Two dimensional flows and oblique shock waves, θ-B-M relations, understanding of shock interaction and shock reflection with various graphs, Prandtl- Mayer expansion, shock-expansion theory, quasi one dimensional flows, method of characteristics and, unsteady wave motion and introduction to various experimental facilities for these speed ranges.

TEXT BOOKS:

1. Boundary layer theory, H. Schlichting, and K. Gersten, Springer (2000)
2. Elements of gas Dynamics, H. W. Liepmann & A. Roshko, Dover Publications(2002)
3. Viscous fluid flow, F. M. White, Mc-Graw Hill (2005)

REFERENCE BOOKS:

1. Introduction to Fluid Mechanics, E. J. Shaughnessy, I. M. Katz and J. P. Schaffer,Oxford University Press (2004)
2. Compressible fluid flow, M. A. Saad, Prentice Hall (1985)
3. Incompressible flow, R. L. Panton, John Wiley & Sons (2005)
4. Advanced Fluid Mechanics, Som, and Biswas, Tata McGraw Hill (2008)
5. The dynamics and thermodynamics of compressible fluid flow, Vol. 1 & 2, A. H.Shapiro, Ronald Press (1954)

18ME5214-COMPUTATIONAL FLUID DYNAMICS

L-T-P : 3-0-2 **Credits: 4** **Pre-requisite: NIL**

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply various discretization techniques for solving complex problems in the fields of fluid flow and heat transfer	PO1-3, PSO1-3	3
CO2	Develop finite volume discretized forms of the CFD eqautions	PO3-1, PSO1-3	3
CO3	mulate explicit & implicit algorithms for solving the Euler Equations & Navier Stokes Equations	PO3-1, PSO1-3	4
CO4	Apply concept of CFD to analyse flow in thermal systems	PO1-3, PSO1-3	5

Syllabus:
Introduction: Conservation equation; mass; momentum and energy equations; convective forms of the equations and general description, Classification and Overview of Numerical Methods: Classification into various types of equation; parabolic elliptic and hyperbolic; boundary and initial conditions; over view of numerical methods, Finite Difference Technique: Finite difference methods; different means for formulating finite difference equation; Taylor series expansion, integration over element, local function method; treatment of boundary conditions; boundary layer treatment; variable property; interface and free surface treatment; accuracy of FD method, Finite Volume Technique: Finite volume methods; different types of finite volume grids; approximation of surface and volume integrals; interpolation methods; central, upwind and hybrid formulations and comparison for convection-diffusion problem, Finite Element Methods: Finite element methods; Rayleigh-Ritz, Galerkin and Least square methods; interpolation functions; one and two dimensional elements; applications, Methods of Solution: Solution of finite difference equations; iterative methods; matrix inversion methods; ADI method; operator splitting; fast Fourier transform, Time integration Methods: Single and multilevel methods; predictor-corrector methods; stability analysis; Applications to transient conduction and advection-diffusion problems, Numerical Grid Generation: Numerical grid generation; basic ideas; transformation and mapping, Navier-Stokes Equations: Explicit and implicit methods; SIMPLE type methods; fractional step methods, Turbulence modeling: Reynolds averaged Navier-Stokes equations, RANS modeling, DNS and LES.

TEXT BOOKS:

1. Numerical Computation of Internal and External Flows, C. Hirsch, Vols. I & II,John Wiley & Sons (2004)
2. An Introduction to Computational Fluid Dynamics, H. K. Versteeg & W.Malalasekera, Longman Scientific & Technical (1995)

REFERENCE BOOKS:

1. Computational Fluid Mechanics and Heat Transfer, J. C. Anderson, D. A.Tannehil and R. H. Pletcher, Taylor & Francis publications, USA (1997)
2. Fundamentals of CFD, T. K. Sengupta, Universities Press (2004)
3. Computational Fluid Dynamics, T. J. Chung, Cambridge University Press (2002)
4. Computational Methods for Fluid Dynamics, J. H. Ferziger and M. Peric,Springer (1997)
5. Computational Techniques for Fluid Dynamics, C. A. J. Fletcher, Vols. I & II,Springer-Verlag (1996)

18ME5215-REFRIGERATION AND CRYOGENICS

L-T-P : 3-1-0 **Credits: 4** **Pre-requisite: NIL**

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the concepts of thermodynamics to analyse refrigeration cycles	PO1-3, PSO1-3	3
CO2	Analyze various methods to produce low temperatures and understand the application of cryogenics in the industry	PO2-1, PSO1-3	3
CO3	alyze the properties of super conductors by various theories	PO2-1, PSO1-3	4
CO4	Analyze various methods involved in the handling of cryogenics	PO2-3, PSO1-3	5

Syllabus:

Review of Basic Thermodynamics, Properties of Cryogenic fluids, First and Second Law approaches to the study of thermodynamic cycles, Isothermal, Adiabatic and Isenthalpic processes. Production of Low Temperatures: Liquefaction systems, ideal, Cascade, Linde Hampson and Claude cycles and their derivatives; Refrigerators: Stirling, Gifford-McMahon cycles and their derivatives. Cryogenic Insulations: Foam, Fibre, powder and Multilayer. Applications of Cryogenics in Industry, Space Technology, Nuclear Technology, Biology and Medicine, Matter at low temperatures: specific heat, thermal conductivity, electrical conductivity, magnetic and mechanical properties; Review of free electron and band theory of solids: Basic properties of Superconductors; out lines of Ginzbarg Landau and Bardeen-Cooper-Schrieffer theories of superconductivity: Super-conducing tunneling phenomena; Introduction to type II superconductivity including flux flow and critical current density: High temperature superconductivity. Properties of liquid ^{4}He and ^{3}He; Production of very low temperatures by Adiabatic demagnetization, dilution refrigeration and nuclear demagnetization and their measurements.

TEXT BOOKS:

1. Refrigeration and Air conditioning, Stoecker, and Jones ()
2. Cryogenics Systems, R. F. Barron, Oxford Univesity Press (1985)
3. Cryogenics: Theory, Processes and Applications, Allyson E. Hayes, Nova SciencePub Incorporated (2010)

REFERENCE BOOKS:

1. Refrigeration and Air Conditioning, Jordan, and Priester, Prentice Hall India ()
2. A text book of Cryogenics, V. V. Kostionk, Discovery publishing house pvt. Ltd.(2003)
3. Principles of Refrigeration by Dossat. , Thomas J. Horan: Books.
4. Heating, Ventilating, Air-Conditioning and Refrigeration by Billy C. Langley,Prentice Hall
5. Haselden, G. G. (1971) *Cryogenic fundamentals* Academic Press, New York

18ME5216-MEASUREMENTS IN THERMAL ENGINEERING

L-T-P: 3-1-0 **Credits: 4** **Pre-requisite: NIL**

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply scientific and engineering methods for the measurement of field and derived quantities	PO1-3, PSO1-3	3
CO2	Analyze principles of presentation, estimation and data analysis	PO2-2, PSO1-3	4
CO3	ply various experimental measurement techniques for the measurement of field quantities with probe and non-instructive techniques	PO1-3, PSO1-3	3
CO4	Evaluate the measurement of derived quantities and analytical methods and design and conduct the experiments, as well as to organize, analyze and interpret data to produce meaningful conclusions and recommendations	PO3-1, PSO1-3	5

Syllabus:
Introduction to measurements for scientific and engineering applications - need and goal - broad category of methods for measuring field and derived quantities; Principles of measurement - parameter estimation - regression analysis - correlations - error estimation and data presentation - analysis of data; Measurement of field quantities - thermometry - heat flux measurement - measurement of force, pressure, flow rate, velocity, humidity, noise, vibration - measurement of the above by probe and non intrusive techniques; Measurement of derived quantities - torque, power, thermo- physical properties - radiation and surface properties; Analytical methods and pollution monitoring - mass spectrometry - chromatography - spectroscopy.

TEXT BOOKS:

1. Measurement in fluid mechanics, S. Tauvulorais, Cambridge University Press(2009)
2. Experiments and Uncertainty Analysis for Engineers, H.W. Coleman and W.G.Steele Jr., Wiley & Sons, New York, (1989)
3. Fundamentals of temperature, pressure and flow measurement, R. P. Benedict,John Wiley and Sons (2003)

REFERENCE BOOKS:

1. Fluid mechanics and measurements, R. J. Goldstein, Taylor & Francis (1996)
2. Hand book of experimental fluid mechanics, C. Tropea, Y. Alexander, J. F. Foss,Springer (2007)
3. The measurement of turbulent fluctuations, Smolyakov, and Tkachenko,Springer-Verlag (1983)
4. Thermal and flow measurements, T. W. Lee, CRC Press (2008)

18ME52G1-PRINCIPLES OF TURBO MACHINERY

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL**

CO#	Course Outcome	PO/PSO	BTL
CO1	Analyse the design principles of turbomachinery to improve and optimize its performance	PO2-3, PSO1-3	4
CO2	sign and analyse the performance of Turbo machines for engineering applications	PO3-2, PSO1-3	5
CO3	alyze the energy transfer process in Turbomachines and governing equations of various forms.	PO2-3, PSO1-3	4
CO4	Design various Turbomachines for power plant and aircraft applications	PO3-1, PSO1-3	5

Syllabus:

Classification - Specific work - Representation of specific work in T-s and h-s diagrams - Internal and external losses - Euler's equation of turbo-machinery - Ideal and actual velocity triangles - Slip and its estimation - Impulse and reaction type machines -Degree of reaction - Effect of outlet blade angle on blade shape - Model laws, specific speed and shape number - Special features of hydro, steam and gas turbines - Performance characteristics of turbo-machines - Cavitation, Surge and Stall - Thin aerofoil theory - Cascade mechanics. Use of CFD for Turbo-machinery analysis and design.

TEXT BOOKS:

1. Fundamentals of Turbomachinery by William W. Peng, John Wiley & Sons
2. Principles of turbomachinery, D. G. Shepherd, Macmilan, 1969

REFERENCE BOOKS:

1. Ahmed F. El-Sayed; Aircraft Propulsion and Gas Turbine Engines; CRC press,2008.
2. Turbine, Compressors and Fans by S.M.Yahya, TMH
3. Hydraulic and Compressible Flow Turbomachines by A.T.Sayers, Mc-Graw Hill
4. Principles of Turbomachinery by Seppo A. Korpella, John Wiley & Sons
5. Nicholas Cumpsty, Compressor Aerodynamics, 2004, Kreiger Publications, USA.
6. Elements of gastubine technology, J. D. Mattingly, Tata McGrawHill (2005)

18ME52G2-GAS TURBINE ENGINEERING

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL**

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the concepts of air standard cycle to analyse the performance of ideal and actual gas turbine cycles	PO1-3, PSO1-3	3
CO2	ply gas turbine theory to jet propulsion and understand fabrication techniques of components	PO1-2, PSO1-3	3
CO3	alyze the Performance of compressors and combustion chambers.	PO2-3, PSO1-3	4
CO4	Analyze the Performance of gas turbine and cogeneration systems.	PO2-1, PSO1-3	4

Syllabus:

Thermodynamics of gas turbines: Cycle analysis; Gas Turbine Components: compressor, combustor, heat exchangers, turbine - description: analytical considerations, performance; Matching of compressor and turbine: cooling of turbine blades. Compressor and turbine impeller construction, blade fixing details, sealing;Material selection for components, Protective coating for hot turbine parts, Components fabrication techniques, Gas turbine turbocharger, gas turbine power generation, turbo expander, gas turbine application, Closed cycle gas turbines, Co-generation - Introduction, Thermodynamics of co-generation, Criteria for component performance, Some practical schemes.

TEXT BOOKS:

1. Elements of gas turbine technology, J. D. Mattingly, Tata McGrawHill (2005)
2. Gas turbine theory, Cohen, Rogers, Saravanamutto, Pearson education (2001)

REFERENCE BOOKS:

1. Ahmed F. El-Sayed; Aircraft Propulsion and Gas Turbine Engines; CRC press,2008.
2. Turbine, Compressors and Fans by S.M.Yahya, TMH

18ME52G3-TURBO COMPRESSORS

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL**

CO#	Course Outcome	PO/PSO	BTL
CO1	Apply the concepts of thermodynamics to analyse compression and expansion processes	PO1-3, PSO1-3	3
CO2	alyse the performance of compressors and centrifugal blowers	PO1-2, PSO1-3	3
CO3	alyze the performance of turbines	PO2-3, PSO1-3	4
CO4	Analyze the Performance of compressors, centrifugal blowers and fans.	PO2-1, PSO1-3	4

Syllabus:

Thermodynamics of fluid flow and thermodynamic analysis of compression and expansion processes: Sonic velocity and Mach number; Classification of fluid flow based on Mach number; Stagnation and static properties and their relations; Compression process – Overall isentropic efficiency of compression; Stage efficiency; Comparison and relation between overall efficiency and stage efficiency; Polytropic efficiency; Preheat factor; Expansion Process – Overall isentropic efficiency for a turbine; Stage efficiency for a turbine; Comparison and relation between stage efficiency and overall efficiency for expansion process; polytropic efficiency of expansion; Reheat factor for expansion process. Axial flow compressors, propellers, centrifugal compressors. Equations of motion in axial and radial turbomachines. Operation and performance of compressors. Compressor cascades and loss correlations. Compressor instrumentation and testing. Supersonic compressors. Special aspects. Future trends.

TEXT BOOKS:

1. Hydraulic and Compressible Flow Turbomachines by A.T.Sayers, Mc-Graw Hill
2. Aerodynamics of turbines and compressors, (Ed.) W. R. Hawthorne, Vol. 10,Princeton university press, 1964

REFERENCE BOOKS:

1. Turbine, Compressors and Fans by S.M.Yahya, TMH
2. Theory of turbo machinery, G.T. Csandy, McGrawHill, 1964
3. J H Horlock, Axial Flow Turbines, Butterworths, 1965, UK.

18ME52H1-ENERGY CONSERVATION, MANAGEMENT AND AUDIT

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL**

CO#	Course Outcome	PO/PSO	BTL
CO1	Analyse the present energy scenario and understand the need of energy conservation	PO2-1, PSO1-3	4
CO2	ply various instruments in energy audit	PO1-2, PSO1-3	3
CO3	ply various measures of energy conservation and financial implications for various thermal utilities.	PO1-3, PSO1-3	3
CO4	audit the power plants, the various measures for energy conservation and financial implications for various thermal utilities.	PO1-2, PSO1-3	4

Syllabus:

Energy Scenario - Basics of Energy and its various forms - Energy Management and - Audit - Material and Energy Balance - Energy Action Planning - Financial Management –Project Management - Energy Monitoring and Targeting - Global Environmental Concerns. Energy Efficiency in Thermal Utilities - Fuels and Combustion – Boilers - Steam System - Furnaces - Insulation and Refractory - FBC Boilers - Cogeneration - Waste heat recovery. Energy Efficiency in Electrical Utilities - Electrical Systems - Electric Motors - Compressed Air System - HVAC and Refrigeration System - Fans and Blowers - Pumps and Pumping System - Cooling Tower - Lighting System - Diesel Generating System - Energy Efficient Technologies in Electrical Systems. Energy Performance Assessment for Equipment and Utility systems – Boilers – Furnaces - Cogeneration, Turbines (Gas, Steam) - Heat Exchangers - Electric Motors and Variable Speed Drives - Fans and Blowers - Water Pumps – Compressors. HVAC Systems - Lighting Systems - Performing Financial Analysis - Applications of Non - Conventional and Renewable Energy Sources - Waste Minimization and Resource Conservation

TEXT BOOKS

1. CB Smith, Enegy Management Principles, Pergamon Press, NewYork, 1981
2. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management & Case study, Hemisphere, Washington, 1980

REFERENCES:

1. Trivedi, PR, Jolka KR, Energy Managemnent, Commonwealth Publication,NewDelhi, 1997
2. Witte, Larry C, Industrial Energy Management & Utilization, HemispherePublishers, Washington,1988
3. Diamant, RME, Total Energy, Pergamon, Oxford, 1970.
4. Guide book for National Certification Examination for Energy Managers andEnergy Auditors, Bureau of energy efficiencies, 2005.

18ME52H2-RENEWABLE ENERGY TECHNOLOGY

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL**

CO#	Course Outcome	PO/PSO	BTL
CO1	Undesrstand concept of various forms of Non-renewable and renewable energy	PO1-1, PSO1-3	4
CO2	tline division aspects and utilization of renewable energy sources for both• domestics and industrial applications	PO1-1, PSO1-3	3
CO3	dy the environmental and cost economics of using renewable energy sources compared to fossil fuels	PO1-1, PSO1-3	3
CO4	derstand the commercial energy and renewable energy sources. Know the working principle of various energy systems	PO1-1, PSO1-3	4

Syllabus:

Sources: Renewable Energy Sources in India - Potential sites, availability. Solar Energy: Measurement and collection, flat plate collectors, concentrating collectors, solar ponds, photovoltaic conversion, Thermal energy storage. Ocean Energy: Principles of OTEC; wave energy, tidal energy, energy conversion systems. Wind Energy: Principle, potential and status; Wind Characteristics; National Wind Atlas; Theory of wind turbine blades; Types of wind turbines and their characteristics. Biofuels: Sources and potential, properties and characterization; Biogas generation through aerobic and anaerobic digestion; Thermochemical methods of biofuel utilization: Combustion and gasification; Status of biofuel technology. Geothermal Energy-Nature, types and utilization. Applications: Applications of renewable energy sources - Typical examples.

TEXT BOOKS

1. Renewable Energy Resources, Twidell & Wier, CRC Press
2. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, OxfordUniversity Press, U.K., 1996.

REFERENCE BOOKS:

1. L.L. Freris, Wind Energy Conversion systems, Prentice Hall, UK, 1990
2. Renewable energy resources - Tiwari and Ghosal - Narosa.
3. Renewable Energy Technologies - Ramesh & Kumar - Narosa
4. Non-Conventional Energy Systems / K Mittal /Wheeler
5. Renewable energy sources and emerging technologies by D.P.Kothari,K.C.Singhal, P.H.I
6. Non-Conventional EnergySources - G.D.Rai, KhannaPublishers

18ME52H3-SOLAR ENERGY AND WIND ENERGY

L-T-P : 3-0-0 **Credits: 3** **Pre-requisite: NIL**

CO#	Course Outcome	PO/PSO	BTL
CO1	›ose to Solar energy and its applications, wind energy and its applications, alternate energy sources	PO1-1, PSO1-3	4
CO2	monstrate the importance of renewable energy source and various applications of solar and wind systems	PO1-1, PSO1-3	3
CO3	the preliminary analysis related to wind energy systems and design of solar PV and solar thermal systems	PO1-1, PSO1-3	3
CO4	›ntify the power electronic converters for solar PV and wind energy systems	PO1-1, PSO1-3	4

Syllabus:

Solar Radiation: Availability - Measurement and Estimation - Isotropic and an Isotropic Models – Introduction to Solar Collectors (Liquid Flat - Plate Collector, Air Heater and Concentrating Collector) and Thermal Storage - Steady State Transient Analysis - Solar Pond - Solar Refrigeration. **Modeling of Solar Thermal Systems And Simulations In Process Design:** Design of Active Systems by f-chart and Utilizability Methods - Water Heating Systems - Active and Passive - Passive Heating and Cooling of Buildings - Solar Distillation - Solar Drying. **Photovoltaic Solar Cell:** P-N Junction - Metal - Schottky Junction, Electrolyte - Semiconductor Junction, Types of Solar Cells - their Applications - Experimental Techniques to determine the Characteristics of Solar Cells - Photovoltaic Hybrid Systems Photovoltaic Thermal Systems – Storage Battery - Solar Array and their Characteristics Evaluation - Solar Chargeable Battery. **Wind:** Its Structure - Statistics - Measurements and Data Presentation - Wind Turbine Aerodynamics - Momentum Theories - Basics Aerodynamics - Airfoils and their Characteristics - HAWT - Blade Element Theory - Prandtl's Lifting Line Theory (prescribed wake analysis) - VAWT Aerodynamics - Wind Turbine Loads - Aerodynamic Loads in Steady Operation - Wind Turbulence - Yawed Operation and Tower Shadow. **Wind Energy Conversion System (WECS):** Siting - Rotor Selection - Annual Energy Output - Horizontal Axis Wind Turbine (HAWT) Vertical Axis Wind Turbine - Rotor Design Considertions - Number of Blades – Blade Profile -2/3 Blades and Teetering - Coning - Upwind/Downwind - Power Regulation - Yaw System - Tower

- Synchronous and Asynchronous Generators and Loads – Integration of Wind Enengy Converters to Electrical Networks - Inverters - Testing of WECS - WECS Control System

- Requirements and Startegies - Miscellaneous Topics - Noise etc - Other Applications.

TEXT BOOKS:

1. L.L.Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.
2. J.A.Duffie and W.A.Beckman-Solar Engineering of Thermal Processes-JohnWiley (1991).

REFERNECE BOOKS:

1. S.P.Sukhatme-Solar Energy: principles of Thermal Collection and Storage, TataMcGraw-Hill (1984).
2. J.F.Kreider and F.Kreith-Solar Energy Handbook McGraw-Hill (1981).
3. D.A.Spera, Wind Turbine Technology: Fundamental concepts of Wind TurbineEngineering, ASME Press.