PROGRAM
M. Tech.
Thermal
Sciences & Energy Systems

Faculty of Engineering

Revised in October 2019

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PROGRAM OUTCOMES

PO	Program Objectives
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Ability to design and develop tools for management of thermal and energy systems using standard practices and technologies
PO5	Ability to demonstrate commitment to sustainable technologies and professional ethics

PROGRAM SPECIFIC OUTCOMES

PSO	Program Specific Objectives
PSO1	Prepare students to provide complete solutions to thermal and energy systems in real-world engineering applications.
PSO2	Train students to Create innovative and sustainable solutions for energy management.
PSO3	Motivate students to pursue research and development in the field of thermal and energy systems keeping in mind societal needs at large.

CURRICULUM STRUCTURE

First Semester

Course Code	Type	Course	LTP	Cr
18MA606	FC	Computational Methods in Fluid Flow and Heat Transfer	3 0 2	4
18TE601	FC	Advanced Heat Transfer	3 1 0	4
18TE602	FC	Advanced Fluid Mechanics	3 1 0	4
18TE603	FC	Thermal Power Plant Cycles and Systems	3 0 0	3
18TE621	SC	Renewable Energy Systems	3 0 0	3
18TE622	SC	Experimental Thermofluids	2 0 2	3
18HU601	HU	Amrita Values Program*		P/F
18HU602	HU	Career Competency – I*		P/F
			Credits	21

*Non Credit Course

Second Semester

Course Code	Type	Course	LTP	Cr
18TE623	SC	Design and Optimization of Thermal Systems	3 0 0	3
18TE624	SC	Computational Fluid Dynamics	3 0 2	4
18TE625	SC	Gas Turbines and Jet Propulsion	3 1 0	4
	E	Elective I / Live in lab	3 0 0	3
	E	Elective II	3 0 0	3
	E	Elective III	3 0 0	3
18TE626	SC	Thermal Science Lab	0 0 2	1

18RM600	SC	Research Methodology	2 0 0	2
18HU603	HU	Career Competency - II	0 0 2	1
			Credits	24

Third Semester

Course Code	Type	Course	LTP	Cr
18TE798	P	Dissertation		10
Credits				10

Fourth Semester

Course Code	Type	Course	LTP	Cr
18TE799	P	Dissertation		10
			Credits	10

18MA606 COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER 3-0-2-4

CO	Course Outcomes
CO1	Understand concepts of different types of errors, stability and consistency of different schemes used for solving ODEs and PDEs
CO2	Understand and implementdifferent methods like Runge-Kutta methods, finite difference methods to solve ODE
CO3	Understand and implement finite difference methods for solving PDEs - Parabolic and Laplace equations.
CO4	Understand and implement finite difference methods for solving Wave equation and Burgers equation.

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	Lab Component	30
4	End Semester Examination	40

SYLLABUS AND COURSE OUTCOME

Review of errors: Accuracy and Precision, round-off error and truncation error. Finite difference operators, interpolating polynomials using finite differences, Ordinary Differential Equations, Solutions of Ordinary Differential Equations: Initial value problems and Boundary Value Problems, Second, Third and Fourth order Runge Kutta Methods. Partial differential equations – classification, hyperbolic, parabolic and elliptic PDEs, discretization errors, stability and consistency. Applications of numerical methods to equations of Fluid Mechanics and Heat transfer-Wave equation, Heat equation, Laplace equation and Burgers' equation. Acquire mathematical knowledge and skills for addressing thermal and heat engineering related problems.

TEXTBOOKS / REFERENCES:

1. *Steven Chapra and Raymond Canale – 'Numerical Methods for Engineers', Sixth Edition, McGraw Hill – 2009.*
2. *Rizwan Butt - 'Introduction to Numerical Analysis Using MATLAB' - Jones and Bartlett Publisher – 2010.*
3. *Abdelwahab Kharab, Ronald B. – 'An Introduction to Numerical Methods: A MATLAB Approach',Third Edition,CRC Press, 2012.*
4. *Anderson, D. A, Tannehill, J. C. and R. H. Pletcher, "Computational Fluid Mechanics and Heat Transfer", Second Edition, Taylor & Francis, 1995.*
5. *Muraleedhar, K. and T. Sundararaja, T. (eds.), "Computational Fluid Flow and Heat Transfer", Second Edition, Narosa Publishing House, 2003.*

18TE601 ADVANCED HEAT TRANSFER 3-1-0-4

CO	Course Outcomes
CO1	Understand the concepts of advanced heat transfer phenomena and Formulate the problems
CO2	Make use of analytical and computational tools to investigate heat transport phenomena.
CO3	Distinguish the broad technological context of heat transfer, like electronic cooling, spacecraft and energy technology, to explore the research problems.
CO4	Develop skills and design heat transfer systems to shoot the industrial problems

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	3 Quizzes	20
4	End Semester Examination	50

SYLLABUS

Review of basics of conduction, convection and radiation. Analysis of 2-D and 3-D heat conduction in solids. Extended surfaces. Analysis of transient heat conduction with complex boundaries. Numerical methods in solving conduction problems with different boundary conditions.

Convection: Conservation equations. Thermal boundary layer. Forced, Natural convection, combined forced and free convection and radiation in flows. Convection in high speed flows. Boiling and Condensation: Boiling – Pool and flow boiling, correlations. Condensation – modes and mechanisms – correlations. Analysis of Heat Exchangers, Heat pipes, compact heat exchangers.

Radiation: Radiant energy transfer through absorbing, emitting and scattering media. Combined conduction and radiation systems.

TEXTBOOKS / REFERENCES:

1. *F.P. Incropera and D. P. Dewit"Fundamentals of Heat and Mass Transfer",Fourth Edition, John Wiley & Sons, 1998.*
2. *Kays, W.M. and Crawford W"Convective Heat and Mass Transfer", McGraw Hill Inc., 1993.*
3. *D.D. Kern"Extended Surface Heat Transfer", New Age International Ltd., 1985.*
4. *M. Necati Ozisik, "Heat Conduction", John Wiley & Sons, Inc, 1993*
5. *Adrian Bejan, "Heat Transfer", John Wiley & Sons, Inc, 1993*

18TE602 ADVANCED FLUID MECHANICS 3-1-0-4

CO	Course Outcomes
CO1	Analyse the differential and Integral forms of basic equations of fluid flow
CO2	Apply the concept of stream function and potential function
CO3	Understand the boundary layer theory
CO4	Ability to address such problems in engineering, and to solve the problems

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	3 Quizzes	20
4	End Semester Examination	50

SYLLABUS

Fluid kinematics. Lagrangian and Eulerian description, Velocity and stress field, Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum and energy conservation equations, Navier-Stokes equations, exact solutions of Navier-Stokes Equations. Couette flow, Poiseuille flow, fully developed flows in non-circular cross-sections, unsteady flows, creeping flows. Boundary layer: derivation, exact solutions, Blasius solutions. Approximate methods. Momentum integral method. Description of turbulent flow, velocity correlations, Reynold's stresses, Prandtl's Mixing Length Theory, Viscous Flow in ducts: Internal and external Viscous flow, fully developed pipe flow, turbulence modelling, turbulent pipe flow, flow in non-circular ducts.

Problem solving skills in advanced fluid flow applications.

TEXTBOOKS / REFERENCES:

1. *Frank M. White, "Viscous Fluid Flow", Third Edition, McGraw-Hill Series of Mechanical Engineering, 2006.*
2. *Fox W. Robert, McDonald T. Alan, "Introduction to Fluid Mechanics", Fourth Edition, John Wiley & Sons, 1995.*
3. *Muralidhar K. and Biswas G., "Advanced Engineering Fluid Mechanics", Second Edition, Narosa, 2005.*
4. *Frank M. White, "Fluid Mechanics", Tata McGraw-Hill, Singapore, Sixth Edition, 2008.*
5. *Yuan Shao – Wen, "Foundations of Fluid Mechanics", Prentice Hall,1970.*

18TE603 THERMAL POWER PLANT CYCLES AND SYSTEMS 3-0-0-3

CO	Course Outcomes
CO1	Understand the sources of energy and their contributions to the energy and power needs of the nation and the world
CO2	Formulate combustion equations to determine A/F, adiabatic flame temperature and pollutant concentration.
CO3	Analyze different types of steam cycles including binary vapour cycles and estimate efficiencies in a steam power plant
CO4	Understand basic working principles of Diesel power plants, STAG power plants and define the performance characteristics and components of such power plants.
CO5	Understand the energy conversion systems for nuclear power plants, the advantages/disadvantages including overall environmental effects

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	3 Quizzes	20
4	End Semester Examination	50

SYLLABUS

Energy sources - Fossil fuels, Nuclear fuels, Solar and Conventional energy sources - Fuel storage, Preparation, Handling and Combustion - Combustion calculations - General layout of Conventional Thermal power plants - Design and Operation- Superheat, Reheat and Regeneration

Other auxiliaries of thermal power plant – High pressure boilers -Steam Generators control. Steam nozzles and Steam turbines - Working - Compounding - Governing of steam turbines - Condensers and Cooling towers - Cycles for Steam power plants - Rankine cycle and its analysis - Reheat cycle, Regenerative cycle and Binary power cycle - Steam piping - Waste heat management. Diesel electric power plant - working and fields of use - Different systems of diesel electric power plants and plant layout - Gas turbine and combined cycle analysis – Inter-cooling, reheating and regeneration - design for high temperature - Combined cycles with heat recovery boiler – Combined cycles with multi-pressure steam - STAG combined cycle power plant - Influence of component efficiencies on cycle performance. Nuclear power plants – Introduction - Nuclear fuels - Atomic number and mass number - Atomic mass unit - Nuclear energy conversion

- Chemical and nuclear equations - Nuclear reactions -Fission and fusion – Energy from fission and fuel burn-up - Radioactivity - Neutron energies - Fission reactor types - Fast breeder reactor - Production of nuclear fuels -

TEXTBOOKS / REFERENCES:

1. *M. M. El-Wakil, "Power Plant Technology", McGraw Hill, 1985.*
2. *A. W. Culp Jr, "Principles of Energy Conversion", McGraw Hill, 2001.*
3. *H. A. Sorensen, "Energy Conversion Systems", J. Wiley, 1983.*
4. *M. M. El-Wakil, "Nuclear Power Engineering", McGraw Hill, 1962.*
5. *Nag. P.K., "Power Plant Engineering", Tata McGraw-Hill, 2002.*

18TE621 RENEWABLE ENERGY SYSTEMS 3-0-0-3

CO	Course Outcomes
CO1	Analyze the performance of solar energy conversion systems
CO2	Performance analysis of various wind energy conversion systems
CO3	Compare various bio-energy conversion methods
CO4	Explore various ocean energy resources such as tidal, wave and ocean thermal energy and geothermal energy systems.

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	2 Quizzes & 1 Seminar	20
4	End Semester Examination	50

SYLLABUS

Introduction: Energy demand growth and supply: Historical Perspectives, Fossil fuels, Consumption and Reserve; Environmental Impacts of Burning of Fossil fuels. Sustainable development and role of renewable energy sources. Solar Energy: The Sun as energy source and its movement in the sky. Solar energy received on the earth; Primary and Secondary Solar energy and Utilization of Solar Energy. Solar concentrators and tracking; Dish and Parabolic trough concentrating generating systems, Central tower solar thermal power plants; Solar ponds. Photovoltaic cells. Wind Energy: Types of turbines, Coefficient of Power, Betz limit, Wind electric generators, Power curve; wind characteristics and site selection; Potential of wind electricity generation in India and its current growth rate. Biomass Energy: Biomass: Sources and Characteristics; Wet biogas plants; Biomass gasifiers: Classification and Operating characteristics; Updraft and Downdraft gasifiers; Gasifier based electricity generating systems. Ocean Energy: Tidal power plants: single basin and double basis plants, Variation in generation level; Ocean Thermal Electricity Conversion (OTEC); Power generation from Waves: Shoreline and Floating wave systems. Geothermal Energy: Conversion technologies- Steam and Binary systems; Geothermal power plants.

TEXTBOOKS / REFERENCES:

1. *G.D Rai, "Non-Conventional Energy Source", Khanna Publishers,2008.*
2. *D.O. Hall and R.P. Overend, "Biomass Regenerable Energy", John Wiley and Sons, New York, 1987.*

3. *Freris L.L, "Wind Energy Conversion Systems", Prentice Hall1990*
4. *John W. Twidell and Anthony D.Weir, "Renewable Energy Resource", Taylor & Francis, 2006.*
5. *Sukhatme, S.P. and Nayak, J.K., "Solar Energy - Principles of Thermal Collection and Storage", Tata McGraw Hill, New Delhi, 2008.*
6. *John A. Duffie, William A and Beckman "Solar Engineering of Thermal Processes" Fourth Edition, Wiley,2013*

18TE622 EXPERIMENTAL THERMOFLUIDS 2-0-2-3

CO	Course Outcomes
CO1	Analyze the measuring instruments, calculation of errors and uncertainty analysis.
CO2	Understand the use and applications of pressure and temperature measuring instruments.
CO3	Understand the use and applications of flow measuring instruments and air pollution measuring instruments.
CO4	Develop familiarity with data acquisition systems.
CO5	Calibrate the instruments, analyze and interpret data to produce meaningful conclusions and recommendations.

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	Lab Component	30
4	End Semester Examination	40

SYLLABUS

Generalized configuration and functional description of measuring instruments, Analysis of experimental data- types of errors, uncertainty analysis, propagation of uncertainty; Statistical analysis of experimental data- normal error distributions, Chi-square test of goodness of fit, method of least squares (regression analysis, correlation coefficient), multivariable regression, Students' t-distribution, graphical analysis and curve fitting. Static and dynamic characteristics. System response - first and second order systems and analysis. Data logging and acquisition. Measurement of temperature – ideal gas thermometer, temperature measurement by electrical effects, Mechanical effects. Temperature measurement by radiation. Heat flux measurement. Measurement of pressure- manometer, bimetallic thermometers, diaphragm and bellow gauges, measurement of high pressure and vacuum pressures. Flow measurement and flow visualization methods – Positive displacement methods, obstruction methods, drag type meters, hot wire anemometer, Shadowgraph, Schlieren, Interferometer. Air pollution sampling and measurement – Units for air pollution measurement, Air sampling train, Measurement of CO, CO_2, HC, NO_x, SO_2, Smoke. Humidity measurement.

TEXTBOOKS / REFERENCES:

1. *Holman, J. P., "Experimental Methods for Engineers", Tata McGraw Hill Book Company, New Delhi, 2010*
2. *Thomas G. Beckwith and Lewis Buck, "Mechanical Measurements", Narosa Publishing House, 2009.*
3. *Doeblin, "Measurement System Application and Design", McGraw-Hill, 1978.*
4. *E. Rathakrishnan, "Instrumentation,Measurements, and Experiments in Fluids" CRC /Taylor & Francis, 2007*
5. *Morris. A.S, "Principles of Measurements and Instrumentation", Prentice Hall of India, 1998.*

18TE623 DESIGN AND OPTIMIZATION OF THERMAL SYSTEMS 3-0-0-3

CO	Course Outcomes
CO1	Understand the concepts of optimization, design and analysis and Formulate the problems
CO2	Make use of system simulation, curve fitting and mathematical modelling for fluid flow and heat transfer applications
CO3	Apply search methods for constrained and unconstrained optimization problems
CO4	Develop skills and design thermal systems using non-traditional optimization techniques to explore the research problems.

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	3 Quizzes	20
4	End Semester Examination	50

SYLLABUS

Thermal systems-Basic characteristics, analysis, types and examples. Formulation of design problem-steps involved.Modeling of thermal systems-importance and types. Mathematical modeling, curve fitting, physical modeling and dimensional analysis. Numerical modeling and simulation. Acceptable design of a thermal system: Design strategies, design of systems from different application areas; 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. Optimization-Problem formulation for optimization: Optimization methods, practical aspects in optimal design. Optimization of constrained and unconstrained problems, search methods: single-variable problem, multivariable constrained optimization, examples of thermal systems; geometric, linear, and dynamic programming and other methods for optimization

TEXTBOOKS / REFERENCES:

1. *W.F. Stoecker, "Design of Thermal Systems", McGraw-Hill, 1971*
2. *Y. Jaluria, "Design and Optimization of Thermal Systems", CRC Press, 2007.*
3. *Bejan, G. Tsatsaronis, M.J. Moran, "Thermal Design and Optimization", Wiley, 1996.*

18TE624 COMPUTATIONAL FLUID DYNAMICS 3-0-2-4

CO	Course Outcomes
CO1	Understand the general conservation equation and apply the same for mass, momentum and energy
CO2	Understand the characteristics equation of second order partial differential equation and classify the problem accordingly
CO3	Numerically solve 1D heat conduction problems using FEM, FDM and FVM
CO4	Apply FVM discretization scheme to unsteady (conduction and convection-diffusion) problems
CO5	Understand different turbulence models
CO6	Develop MAT lab code for conduction and convection-diffusion problems and compare the same with fluid flow and heat transfer commercial software (ANSYS-FLUENT)

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	Lab Component	30
4	End Semester Examination	40

SYLLABUS

A broad review in terms of historical background, application and purpose of study. Introduction to One- Dimensional Computation by FDM, FEM, FVM. Neumann boundary condition and Dirichlet boundary condition. Governing equation of Fluid Dynamics: Derivation, Discussion, Physical meaning and governing equation forms suitable for CFD. Turbulence and its modeling, Characteristics of simple turbulent flows, the effect of turbulent fluctuations on properties of the mean flow, Reynolds-averaged Navier–Stokes equations (RANS) and classical turbulence models- Mixing length model, k–ε model, Reynolds stress equation models, advanced turbulence models. Large eddy simulation (LES), Direct numerical simulation (DNS). Finite volume method for diffusion problems, convection-diffusion problems. Solution algorithms for pressure-velocity coupling in steady flows. The finite volume method for unsteady flows. Implementation of boundary conditions. Errors and uncertainty in CFD modeling. Finite Element Methods in CFD.

TEXTBOOKS / REFERENCES:

1. *H K Versteeg and W Malalasekera, "An Introduction to Computational Fluid Dynamics", Pearson Education Limited, 2007.*
2. *Jiyuan Tu, Guan Heng Yeoh and Chaoqun Liu, "Computational Fluid Dynamics", Elsevier Inc, 2008.*
3. *Anderson John, D. Jr. "Computational Fluid Dynamics-The Basics with Applications", McGraw Hill International Edition, 1995.*
4. *Fletcher, C. A., "Computational Techniques for Fluid Dynamics", Vol-1, Fundamental & General Techniques. Springer Verlag, Berlin 1988.*

18TE625 GAS TURBINES AND JET PROPULSION 3-1-0-4

CO	Course Outcomes
CO1	Understand compressible flow through variable area ducts, concept of shock waves, and flow with friction and heat addition.
CO2	Understand the thermodynamic cycle for Gas Turbine – the principle of operation of compressors, and turbines
CO3	Analyze the design concepts for components of Axial, Radial flow Multistage Gas Turbines, Axial flow and Centrifugal compressors for optimum performance including Surging and stalling and analyze types of Combustors
CO4	Interpret the basic principle of Jet Propulsion –for air-breathing Aircraft Engines and have clear understanding about the performance characteristics of Jet Propulsion.

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	3 Quizzes	20
4	End Semester Examination	50

SYLLABUS

Compressible Flow: One-dimensional flow, speed of sound, variable cross-section flow, converging diverging nozzle, flow with friction and heat transfer, normal and oblique shock waves. Fundamentals of turbo machines: ideal and actual cycles for shaft power and propulsion. Compressors: axial flow and centrifugal compressors, principle of operation, work done, elementary theory, performance, compressibility effects, surge and stall. Combustion Systems: types, requirements, combustion chamber performance, emissions. Axial and radial flow turbines: elementary theory, vortex theory, performance characteristics, blade cooling, design of gas turbines, off design performance, gas turbine blade materials. Thermodynamics of propulsion system, engine performance parameters. Air breathing and non-air breathing engines, aircraft gas turbine engine, cycle analysis of ideal and real engines. Turbojet, turboprop, turbofan engines, ramjet and pulsejet engines.

TEXTBOOKS / REFERENCES:

1. *Sarvanamuttoo, H.I.H., Rogers, G. F. C. and Cohen, H., "Gas Turbine Theory", Sixth Edition, Pearson Prentice Hall, 2008.*
2. *Ganesan, V., "Gas Turbines", Third Edition, Tata McGraw Hill, 2010.*
3. *Yahya, S. M., "Turbines, Compressors and Fans", Fourth Edition, Tata McGraw Hill, 2010.*
4. *Mattingly, "Elements of Gas Turbine Propulsion", McGraw-Hill Publications, 1996.*
5. *N.A.Cumpsty, "Jet Propulsion", Cambridge University Press, 2000.*

18TE626 THERMAL SCIENCE LAB 0-0-2-1

CO	Course Outcomes
CO1	Analyze the performance of different types of heat exchangers
CO2	Analyze the Coefficient of performance of refrigerator and air conditioning units.
CO3	Analyze the performance and emission characteristics of Internal combustion engines.

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Continuous Assessment	60
2	Midterm Examitation	20
3	End Semester Examination	20

SYLLABUS

Heat transfer test rigs, Nano and micro heat transfer test rigs, heat pipe systems, heat exchangers, refrigeration and air conditioning systems, fluidized bed system etc.

18RM600 RESEARCH METHODOLOGY 2-0-0-2

CO	Course Outcomes
CO1	To define research, methodology and steps involved in research
CO2	To learn to define a problem, and research hypothesis. To understand the importance of literature survey, gaps and challenges
CO3	To learn the basic concepts of research design, sampling, modeling & simulation and understand the importance of citation, H-index, Scopus
CO4	To learn to write technical report, paper and thesis
CO5	To know about intellectual property rights, ethics in research and plagiarism

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15

3	Seminars and Reports	20
4	End Semester Examination	50

SYLLABUS

Unit I:

Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach, Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Importance of reasoning in research.

Unit II:

Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III:

Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and

Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:

Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

Unit V:

Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science

TEXT BOOKS/ REFERENCES:

1. *Bordens, K. S. and Abbott, B. B., "Research Design and Methods – A Process Approach", 8th Edition, McGraw-Hill, 2011*
2. *C. R. Kothari, "Research Methodology – Methods and Techniques", 2nd Edition, New Age International Publishers*
3. *Davis, M., Davis K., and Dunagan M., "Scientific Papers and Presentations", 3rd Edition, Elsevier Inc.*
4. *Michael P. Marder," Research Methods for Science", Cambridge University Press, 2011*

5. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
6.Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age". Aspen Law & Business; 6th Edition July 212

ELECTIVES

18TE702 COOLING OF ELECTRONIC SYSTEMS 3-0-0-3

CO	Course Outcomes
CO1	Understand the heat transfer mechanisms of electronic cooling systems. and assess their capability and applicability
CO2	Describe different cooling techniques and its applications in various domains
CO3	Analyse new cooling methods in the present scenario and use of commercial tools

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	3 Quizzes	20
4	End Semester Examination	50

SYLLABUS

Introduction, objectives of thermal control, heat sources, heat transmission, steady and unsteady heat transfer. Electronic equipment for airplanes, missiles, satellites, spacecraft, ships, submarines, personal computers, microcomputers and microprocessors. Cooling techniques: i) air cooling-natural cooling ii) air cooling-forced convection iii) liquid cooling.Thermal contact conductance, fundamentals of heat transfer across an interface, real contact area, applications to microelectronics, enhancement of contact conductance. Extended surface arrays for air cooled systems, parameterizations, the fin input admittance, the limitations of the fin efficiency, Introduction to impinging jet theory, description of the principal flow regimes, single nozzle and multi-nozzle test rig, Taxonomy of liquid jet impingement conditions. Unconfined: free surface and submerged jets, semi confined, submerged jets. Heat transfer for unconfined free-surface and submerged jets i) circular ii) planar jets. Multiple impinging jets. Synthetic jets design and measurement approaches, enhancing heat transfer with synthetic jets (free and forced convection). Introduction to heat pipe, working principle, thermal performance, design, thermal resistance considerations, types of heat pipes, cylindrical, flat, micro and oscillating heat pipes.

TEXTBOOKS / REFERENCES:

1. *Kakac Sadik, Yuncu Hafit, Hijikata, K. "Cooling of Electronic systems", Springer Science+ Business Media, Dordrecht, 1994.*
2. *Dave S. Steinberg "Cooling Techniques for Electronic Equipment", John Wiley and sons Inc, Canada, 1991*
3. *S M Sohel Murshed "Electronics Cooling", ExLi4EvA, 2016*
4. *Madhusudan Iyengar, Karl J L Geisler, Bahgat Sammakia "Cooling of Microelectronic and Nanoelectronic Equipment: Advances and Emerging Research",*

WSPC ltd, Singapore, 2015
5. *Bahman Zohuri "Heat pipe Design and Technology", Taylor and Francis ltd, U.S., 2011*

18TE707 EMERGING REFRIGERATION TECHNOLOGIES 3-0-0-3

CO	Course Outcomes
CO1	Recognizing refrigeration process fundamental and practical limitations thereof
CO2	Computing COP of vapour compression and vapour adsorption refrigeration system
CO3	Evaluating the alternatives vis a vis thermoelectric, pulse tube, magnetic and other refrigeration systems
CO4	Understanding fundamentals of alternative refrigerants for vapour compression system

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	3 Quizzes	20
4	End Semester Examination	50

SYLLABUS

Introduction to refrigeration systems, methods of conventional refrigeration, units of refrigeration, COP, Review of vapour compression refrigeration system, vapour absorption system. Introduction to nonconventional refrigeration technologies- Thermoelectric refrigeration, magnetic refrigeration, pulse tube refrigeration, acoustic refrigeration, steam jet refrigeration, vortex tube refrigeration.Thermoelectric refrigeration-principle, thermoelectric properties, Sea- beck effect, Peltier effect, System description, performance analysis, applications. Introduction to Magnetic refrigeration, magneto-caloric effect, magnetic materials, magnetic refrigeration near room temperature.Advantages over traditional refrigeration system, cryo-coolers, pulse tube refrigerators.Principles and application of steam jet refrigeration system, performance analysis.Vortex tube refrigeration system, system description. Refrigerants, applications- Modern refrigerants - Need for alternative refrigerants – eco-friendly refrigerants - mixtures of refrigerants. Modifications required for retrofitting, safety precautions and compatibility of refrigerants with the materials.

TEXTBOOKS / REFERENCES:

1. *Arora C.P, "Refrigeration and Air Conditioning", Tata McGraw Hill, 2004.*
2. *Gosney W. B, "Principles of Refrigeration", Cambridge University Press, 1983.*
3. *Stanley W Angrist, "Direct Energy Conversions", Allyn & Bacon, 1982.*
4. *HJ Goldsmid, "Thermoelectric Refrigeration", First Edition,Springer, 1995.*

18TE710 ENERGY AND ENVIRONMENT 3-0-0-3

CO	Course Outcomes
CO1	Understand the types of energy resources and its utilization, Energy scenario, Energy conservation and management.
CO2	Understand the sources of air pollution, its measurement and control
CO3	Understand the sources of water, water pollution, its measurement and control and water treatment

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	2 Quizzes & 1 Seminar	20
4	End Semester Examination	50

SYLLABUS

Basics of energy: Types of energy and its utilization; Energy characteristics; Energy scenario - India energy scenario- Energy crisis. Energy conservation. Environment studies: Water cycle - Oxygen cycle - Carbon cycle - Nitrogen cycle - Phosphorous cycle; Bio-diversity. Environmental aspects of energy utilization. Hazards of environmental Pollution.

Air Pollution: air pollutants, sources of emission;Air quality standards; Physical and chemical characteristics - Meteorological aspects; Temperature lapse rate and stability. Dispersal of air pollutant - Air pollution dispersion models: sampling and measurement, Analysis of air pollutants. Air Pollution Control methods: Particulate emission control; Gaseous emission control.

Water pollution: Sources and hazards, water quality standards; Waste water sampling and analysis;Waste water treatment: Primary treatment - Secondary treatment - Advanced treatment. Feed water treatment. Pollution prevention and control acts;Methodology of Environmental impact assessment, Air and water quality impacts by project type.

TEXTBOOKS / REFERENCES:

1. *C. S. Rao, "Environmental Pollution Control Engineering", Wiley Eastern, 1992.*
2. *Y. Anjaneyulu, "Air Pollution and Control Technologies", Allied Publishers, 2002.*
3. *J. Rau and D.C. Wooten, "Environmental Impact Analysis Handbook", McGraw Hill, 1980.*
4. *D.H.T. Liu, "Environmental Engineers Handbook", Lewis, 1997.*
5. *James A. Fay and Dan S. Golomb, "Energy and the Environment", Oxford University Press, 2002.*

18TE712 IC ENGINE COMBUSTION AND POLLUTION 3-0-0-3

CO	Course Outcomes
CO1	Understand the thermochemistry of Fuel-air mixtures, Thermodynamic analysis of IC engines and models used in IC engines.
CO2	Understand gas exchange process, combustion in SI engines.
CO3	Understand the combustion in diesel engines.
CO4	To identify the nature and extent of the problem of pollutant formation and control and modern developments in IC engines.

EVALUATION SCHEME

Sl No	Component Name	Weightage in %
1	Periodical Test 1	15
2	Periodical Test 2	15
3	2 Quizzes & 1 Seminar	20
4	End Semester Examination	50

SYLLABUS

Thermochemistry of Fuel-air mixtures, Properties of working fluids, chemical kinetics, First law analysis, Availability analysis of engine processes. Conceptual SI engine combustion models, features of SI engine combustion processes Thermodynamic analysis of SI engine combustion, Flame structure and speed, abnormal combustion. Features of CI engine combustion process, conceptual CI engine combustion models, combustion process characterization. Fuel injection, spray structure, atomization, penetration, drop size distribution, spray evaporation. Ignition delay, factors affecting delay. Mixing controlled combustion, heat release rates, effect of engine design variables, swirl, injection rates. Thermodynamic analysis of CI engine combustion. Supercharging of SI & CI engines and its limitations, methods of supercharging, supercharging arrangements , turbochargers , methods of turbo charging & its limitations. Air Pollution - Sources and nature of various types of pollutants, Pollutant formation, control, Pollution monitoring instruments and techniques. Modern developments in IC Engines, EGR, MPFI, HCCI, Gasoline Direct Injection. Alternative fuels to reduce emissions: Alcohols, natural gas, biodiesel, hydrogen.

TEXTBOOKS / REFERENCES:

1. *H.B. Heywood, "Fundamentals of I.C. Engines", McGraw Hill, 1988.*
2. *C.F. Taylor, "I.C.Engine Theory and Practices", Vol.I & II, MIT Press, 1985*
3. *Mathur and Sharma, "I.C.Engine", Dhanpat Rai and Sons, 2006.*
4. *Ganeshan, "Fundamentals of I.C.Engine", Tata McGraw Hill, 2006.*

EVALUATION SCHEME AND GRADING SYSTEM

Base on the performance in each course, a student is awarded, at the end of the semester, a letter grade in each of the courses registered, in a ten point scale.

The letter grades, the corresponding grade points and the rating are as follows:

Letter Grade	**Grade Points**	**Ratings**
O	10	Outstanding
A+	*9.5*	Excellent
A	*9*	Very Good
B+	*8*	Good
B	*7*	Above Average
C	*6*	Average
P	*5*	Pass
F	*00*	Fail
FA	*00*	Failed due to Insufficient attendance
I	*00*	Incomplete (awarded only for Lab Courses/ Project / Seminar)
W	-	Withheld

Generally the following rule is applied while grading

- Decide on the cut-off marks for passing and 'A+' grade
- Exclude 'F' , 'A^+' and 'O' category from the total strength [$T - (F + A^+ + O) = Y$]
- Divide the remaining by 9 ($Y/9 = X$)

Grading Model	
1X	A
2X	B+
3X	B
2X	C
1X	P