VISION STATEMENT
Department of Mechanical Engineering strives to be recognized globally for excelling in Engineering education and research leading to innovative, entrepreneurial and competent graduates in Mechanical Engineering and allied disciplines.

MISSION STATEMENT
- To provide world class education through the conduct of pioneering and cutting-edge research for students and faculty to make impactful contribution to the society.
- To expand the frontiers of engineering and science in technological innovation while fostering academic excellence and scholarly learning in a collegial environment.
- To attract highly motivated students with enthusiasm, aptitude and interest in the field of Mechanical and allied Engineering.
- To excel in industrial collaboration and research leading to innovative technology development and transfer.
- To serve the society with Innovative and entrepreneurially competent graduates for the national and international community towards achieving the sustainable development goals.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):
This Master programme, Thermal Engineering (with specialisation in Refrigeration & Air-Conditioning) strives to produce graduates with the knowledge and skills to excel in the field of Thermal sciences.

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<th>PEO</th>
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<td>1.</td>
<td>Postgraduates will demonstrate technical competency and leadership leading to a excellence in diverse careers.</td>
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<td>Postgraduates will pursue curiously with commitment towards sustainable development solutions for the betterment of society.</td>
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<td>Postgraduates will pursue lifelong learning through solutions with the ability to act in the face of complexity and novelty.</td>
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PROGRAMME OUTCOMES (POs):

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<tr>
<td>1.</td>
<td>Ability to independently carry out research/investigations &amp; solve practical problems.</td>
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<td>Ability to write and present a substantial technical report(s)/document(s).</td>
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<td>Ability to design and conduct experiments, as well as to analyse and interpret data in a real time system and function on multidisciplinary teams.</td>
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<td>To produce industry ready post-graduates in the field of thermal sciences particularly in Refrigeration &amp; Air-Conditioning.</td>
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<td>5.</td>
<td>Ability to design a thermal system to meet the desired constraints such as economic, environment and sustainability.</td>
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<td>Ability to acquire and apply knowledge as needed, using appropriate learning strategies.</td>
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PEO/PO Mapping:

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"Attested"

DIRECTOR

Centre for Academic Courses
Anna University, Chennai-600 025
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*Summer Internship & Semester Internship is for 4-weeks duration.
*Summer Internship will be evaluated in third semester.

Total Credits for the Programme = 23 + 23 + 17 +12 = 75
### FOUNDATION COURSES (FC)

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**SUMMARY**

**M.E. THERMAL ENGINEERING**

(WITH SPECIALISATION IN REFRIGERATION AND AIR-CONDITIONING)

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OBJECTIVES:

- To familiarize the students in the field of differential equations.
- To enable them to solve boundary value problems associated with engineering applications using transform methods.
- To expose the students to the concepts of calculus of variations.
- To introduce conformal mappings and their applications to fluid flows and heat flows.
- To give the students a complete picture of tensor analysis.

UNIT I ALGEBRAIC EQUATIONS


UNIT II LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS

Laplace transform: Definitions, properties - Transform of error function, Bessel’s function, Dirac Delta function, Unit Step functions – Convolution theorem – Inverse Laplace Transform: Complex inversion formula – Solutions to partial differential equations: Heat equation, Wave equation

UNIT III FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS


UNIT IV CALCULUS OF VARIATIONS

Concept of variation and its properties – Euler’s equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries -Direct methods – Ritz and Kantorovich methods.

UNIT V TENSOR ANALYSIS

Summation convention – Contravariant and covariant vectors – Contraction of tensors – Inner product – Quotient law – Metric tensor – Christoffel symbols – Covariant differentiation – Gradient, divergence and curl.

TOTAL: 60 PERIODS

OUTCOMES:

On successful completion of the course, the students will be able to

CO1 get familiarized with the methods which are required for solving system of linear, Non linear equations and eigenvalue problems.

CO2 develop the mathematical methods of applied mathematics and mathematical physics

CO3 solve boundary value problems using integral transform methods apply the concepts of calculus of variations in solving various boundary value problems

CO4 familiarize with the concepts of tensor analysis.

REFERENCES:


**Mapping of CO with PO**

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IC3151 ADVANCED THERMODYNAMICS

COURSE OBJECTIVES:

- To achieve an understanding of basic principle and scope of thermodynamics.
- To predict the availability and irreversibility associated with the thermodynamic processes and Chemical availability of reactive systems.
- To arrive at the adiabatic flame temperature during combustion of air-fuel mixture

UNIT I THERMODYNAMIC PROPERTY RELATIONS 12

Thermodynamic Potentials, Maxwell relations, Generalised relations for changes in Entropy, Internal Energy and Enthalpy, Generalised Relations for Cp and Cv, Clausius Clapeyron Equation, Joule Thomson Coefficient, Bridgeman Tables for Thermodynamic Relations.

UNIT II REAL GAS BEHAVIOUR AND MULTI-COMPONENT SYSTEMS 12


UNIT III AVAILABILITY ANALYSIS 12


UNIT IV PHASE EQUILIBRIUM OF MIXTURES 12

Phase equilibrium – Two phase system – Multiphase systems, Gibbs phase rule. Simplified criteria for phase equilibrium – General criteria of any solution, Ideal solution and Raoult’s law, Vapour as Ideal gas mixture, Pressure and Temperature diagrams. Completely miscible mixtures – Liquid-vapour mixtures

UNIT V THERMO CHEMISTRY 12


TOTAL : 60 PERIODS

COURSE OUTCOMES:

On successful completion of this course the student will be able to

1. Find thermodynamic properties using various thermodynamic relations.
2. Apply the law of thermodynamics to thermal systems.
3. Perform second law analysis to thermal systems
4. Design and analyse a multi component thermodynamic system
5. Understand and analyse the combustion of different fuels

REFERENCES:


Mapping of CO with PO

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COURSE OBJECTIVES:
- To teach the fundamentals and advancements of heat transfer and its applications with emphasis on numerical solutions to the students and prepare them for research.
- To offer hands-on training on measurement, analysis of heat transfer phenomena with emphasis on data analysis and report preparation.

UNIT – I  CONDUCTION  9L, 6P

PRACTICALS:
Thermal conductivity of solids & liquids and effect of temperature, Thermal analysis of fins, Lumped heat method for analysis of different geometries

UNIT – II  CONVECTION  9L, 6P
Energy & Momentum equations, Laminar & Turbulent Boundary Layers, Entry length, Reynolds-Colburn Analogy, Heat transfer coefficient for flow over a flat surface, circular & non-circular ducts

PRACTICALS:
Thermal & hydraulic boundary layer development through fluid, Free & Forced convective heat transfer coefficient studies.

UNIT – III  TWO-PHASE FLOW  9L, 6P
Flow patterns, Void fraction, critical flow, Dispersed, slug, annular & stratified flow, Homogeneous, Drift & Separated flow model

PRACTICALS:
Temperature & Flow field visualisation

UNIT – IV  TWO-PHASE HEAT TRANSFER  9L, 6P
Pool & Convective boiling, critical heat flux, Dropwise & filmwise condensation, Melting & Solidification, Heat transfer enhancement methods.

PRACTICALS:
Plotting of boiling & condensation curves, T-t plots during melting & solidification

UNIT – V  THRUST AREAS  9L, 6P
Thermoregulation, Laser Generated Heat Transfer, Tissue Thermal Properties and Perfusion, Thermal Damage and Rate Processes in Biologic Tissues, Thermal Injury, Mathematical models of bio-heat transfer

PRACTICALS:
Irradiation studies & heat generation from lasers

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Demonstrate the concepts of conduction and experimentation in the thermal systems.
2. Illustrate the concept of conservation of energy, solve problems and conduct experiments in convection heat transfer.
3. Categorise & examine the different two-phase flow models and evaluate the parameters of flow fields through experimentation.
4. Analyse the phase change heat transfer and formulate practical problems and interpret data of experimentation.
5. Use engineering tools and appraise the heat transfer in biological systems.

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COURSE OBJECTIVE
To impart knowledge on Refrigeration so that the students gain proficiency on Refrigeration systems and their various ingredients to the extent of conducting research independently.

UNIT I BASIC CYCLES AND ACTUAL VCR CYCLES
Reversed Brayton, Carnot VCR cycle – Practical VCR cycle – Sub cooling, super heating, LSHX, Factors influencing performance, Multi pressure Cycles, Cascade Cycle

UNIT II REFRIGERANTS AND LUBRICANTS

UNIT III SYSTEM COMPONENTS
Classification and performance aspects of Compressors, Condensers, Expansion devices, Evaporators, Receivers, Driers, Accumulators, suction line risers

UNIT IV REFRIGERATION LOAD and BALANCING
Estimation of Cooling Load, Cold Storages, Cool Storages, System Balancing – Graphical Analysis, Capacity modulation and Cycling Controls

UNIT V NOT- IN- KIND SYSTEMS AND ELECTRICAL COMPONENTS

TOTAL: 60 PERIODS

COURSE OUTCOMES
On successful completion of the course the student will be able to
1. Examine and investigate the cycles in Refrigeration
2. Understand and Explain the Refrigerants and Oils used in Refrigeration systems
3. Understand and Evaluate the various components of Refrigeration systems.
4. Analyse and Design the system load in-order to evolve a balanced system.
5. Describe and Compare the different Refrigeration systems to make best use of the available ones as well as explain the associated Electrical components.
REFERENCES:

Mapping of CO with PO

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COURSE OBJECTIVES:
- To impart students with the fundamental background as well as practical knowledge to precisely measure and quantify various parameters in thermal systems.

UNIT – I DATA ANALYSIS 9
Statistical analysis of data, Regression analysis, Uncertainty analysis, Data reduction, Design of Experiments – Experimental design factors and protocols, Introduction to Data Analytics and Machine Learning.

UNIT – II SENSORS AND CALIBRATION 9

UNIT – III MEASUREMENTS IN THERMAL SYSTEMS 9

UNIT – IV CONTROL SYSTEMS AND COMPONENTS 9
Open and closed loop control, Transfer function, Interfaces & Protocols. Types of feedback and feedback control system characteristics – Control system parameters, Signal conditioning and processing. Data Acquisition System

UNIT – V CONTROLLERS 9

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Interpret the of sensitivity, resolution, random and bias error, and precision and accuracy in evaluating data.
2. Illustrate operating principles, calibration, and use of sensors for different measurements.
3. Classify the various measurement techniques, perform experiments and prepare technical reports.
4. Demonstrate the knowledge and understanding of data acquisition.
5. Outline and distinguish the various controllers suitable for thermal systems.
REFERENCES:
7. Liptak, Instrument Engineers’ Handbook, CRC Press, 2018

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OBJECTIVES:
To impart knowledge on
- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I  RESEARCH PROBLEM FORMULATION
Objectives of research, types of research, research process, approaches to research; conducting literature review - information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II  RESEARCH DESIGN AND DATA COLLECTION
Statistical design of experiments - types and principles; data types and classification; data collection - methods and tools

UNIT III  DATA ANALYSIS, INTERPRETATION AND REPORTING
Sampling, sampling error, measures of central tendency and variation; test of hypothesis-concepts; data presentation - types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References - Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV  INTELLECTUAL PROPERTY RIGHTS
Concept of IPR, types of IPR - Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V  PATENTS
Patents - objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

COURSE OUTCOMES
Upon completion of the course, the student can
CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiments; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

REFERENCES:
COURSE OBJECTIVES

1. This course will prepare you to prepare and deliver instructive, informational, and persuasive presentations based on well-defined and achievable outcomes
2. This course will improve the communication and lecture delivering skills

Selection of topics, Abstract writing for review articles, literature collection and critical review of articles, Writing conclusion and future research directions, Case studies on published review articles.

Selection of problem, Experimental design of the article, Checking the scientific originality and novelty of the designed experiment

Selection of template, Background, Planning of number of slides, Planning of content structure, Selection of font, font size, and color, Readability of the presentation, Animation, clarity on pictures, and videos

TOTAL: 30 PERIODS

COURSE OUTCOMES:
On successful completion of this course the student will be able to
CO1 Demonstrate theoretical knowledge to create and present effective technical presentation
CO2 Apply and adapt flexible process strategies to produce clear, high-quality deliverables in a multitude of technical writing genres
CO3 Gather and apply researched information that is appropriate to your field, as demonstrated by reading and analyzing documents, and citing sources correctly.

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COURSE OBJECTIVES:
- To impart the design concepts of different types of heat exchangers with practical experiments.
- To offer hands-on training and exercise simulation tools for heat exchangers and the sub-systems.

UNIT – I THERMAL DESIGN

PRACTICALS:
Plotting of friction factor, heat load & temperature profiles in a Concentric tube heat exchanger

UNIT – II SHELL AND TUBE HEAT EXCHANGERS
TEMA Classification, Construction, Mechanical & Thermal design considerations, fluids allocation, Shell Side Heat Transfer Coefficient & Pressure drop – Kern Method – Bell Delware method – Stream analysis method.

PRACTICALS:

UNIT – III FIN-AND-TUBE HEAT EXCHANGERS
Heat Transfer and Friction Characteristics – Periodic Flow type, Core pressure drop, Flow Distribution & Header design, Fin Geometries and Fin Efficiency, Heat Transfer Surface Geometries, Sizing of Heat Exchanger

PRACTICALS:
Overall thermal performance of Finned tube heat exchanger

UNIT – IV PLATE, SPIRAL & HELICAL HEAT EXCHANGERS
Spiral & Helical Heat Exchangers – Construction & Design, Applications

PRACTICALS:
Assembly & Dismantling of plate heat exchanger, comparison of plate, spiral & helical heat exchanger performance.

UNIT – V CONDENSERS & EVAPORATORS
PRACTICALS:
Heat Transfer analysis in the chiller unit, Use of thermal process design and simulation software

TOTAL: 75 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Demonstrate in practice the ability to model typical heat exchangers and interpret the results in experiments.
2. Select appropriate solution technique, analyse the performance of shell and tube heat exchangers and evaluate the significance of results.
3. Appraise the heat transfer enhancement methods in Fin and tube heat exchangers and formulate real-time problems.
4. Compare the thermo-hydraulic performance of different specialised heat exchangers and evaluate the same through experimentation.
5. Analyse and optimise the heat exchangers used in the refrigeration systems.

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COURSE OBJECTIVE
To impart knowledge so that the students gain mastery on Airconditioning and Ventilation principles as well as systems.

UNIT I  FUNDAMENTALS  9

UNIT II  COMFORT AIR CONDITIONING  9
Psychrometric analysis of Summer and Winter air conditioning, Selection of design conditions, Thermal Comfort models, Comfort charts, Adaptive Thermal Comfort models, Indoor Air Quality, Clean room concepts.

UNIT III  AIR CONDITIONING LOAD  9

UNIT IV  AIR DISTRIBUTION  9
Flow through Ducts, Static and Dynamic Losses, Diffusers, Duct Design – Equal Friction Method and Static Regain Method, Duct Balancing. Fan Duct Interactions, Selection of Fans, Fan Coil units.

UNIT V  OPERATION OF DIFFERENT SYSTEMS  9
Room Air Conditioners, Packaged Air conditioning systems, Centralized Air conditioning systems, Radiant cooling systems, DCV and VAV systems, UFAD systems, Hydronic systems, Air handling systems, MAC systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES
On successful completion of the course the student will be able to:
1. Understand and Analyse the Air-conditioning systems in respect of fundamental aspects and their implications.
2. Describe and examine the systems designed for Comfort Air-conditioning.
4. Explain and Design the Ducts as well as select the Fans for proper Air distribution.
5. Describe and Compare the different Air-conditioning systems to make best use of available models.

REFERENCES:

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COURSE OBJECTIVES:
1. To impart fundamentals of Computational fluid dynamics and provide hands-on training to the students.
2. To teach the advancement of modern CFD tools students for complex systems.

UNIT – I GOVERNING DIFFERENTIAL EQUATIONS 9T, 6L
Finite Volume approach – Scalar, Vector, Tensor, Governing equations for conservation of mass, momentum and energy – Classification of partial differential equations – Types of Boundary Conditions, Initial and Boundary value problems, Taylor’s Series, Stoke’s law, Vorticity, Diffusion, Divergence theorem, Types of Errors

PRACTICALS: Determination of approximate solutions for Navier-Stokes equation using computer software

UNIT – II GRID GENERATION 9T, 6L

PRACTICALS: Mesh Generation for various geometries

UNIT – III DIFFUSION 9T, 6L

PRACTICALS: Simulation of steady & transient diffusion problem using CFD Tool with results and reports

UNIT – IV CONVECTION-DIFFUSION 9T, 6L
1D convection – diffusion problem, Discretisation using Central difference scheme, upwind scheme, QUICK scheme. Phase Change – Mathematical Formulation, Discretisation, Enthalpy method, Problems

PRACTICALS: Discretisation of governing equation using software, Simulation of phase-change problems using CFD Tool.

UNIT – V FLOW MODELLING 9T, 6L
Pressure-velocity coupling algorithms – SIMPLE, SIMPLEC, PISO, Turbulence Models – Governing equation for turbulent kinetic energy & dissipation (k-ε model), Large Eddy Simulation

PRACTICALS: Simulation of internal and external flows and execution of CFD Project with results and reports.

TOTAL: 75 PERIODS
COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Use the appropriate governing equations & to investigate flow and energy transfer in a physical system.
2. Demonstrate the appropriate mesh generation for an accurate solution using software.
3. Classify the different discretisation schemes and evaluate solutions using CFD tool.
4. Solve and investigate the convection-diffusion problems and interpret the result through hands-on training.
5. Determine various parameters of interest, such as flow rates, heat fluxes, pressure drops, losses, etc. through simulation.

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DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600025
COURSE OBJECTIVES:
1. To introduce microbiology of food products.
2. To give an overview of thermodynamic properties of food products and different food processing techniques.
3. To explain the freezing and drying principles and estimate freezing time calculation.
4. To give an understanding of the various cold storage design
5. To introduce about grain storage systems and its design features

UNIT I  INTRODUCTION and MICROBIOLOGY OF FOOD PRODUCTS  9
Importance and Scope of Food Preservation, Status in India, National Horticultural policy, Microbiology of food products, Mechanism of food spoilage, Critical microbial growth requirements, Design for control of micro-organisms, Regulations and Standards.

UNIT II  PROCESSING & PRESERVATION  9

UNIT III  FREEZING & DRYING  9

UNIT IV  COLD STORAGE DESIGN AND INSTRUMENTATION  9

UNIT V  STORAGE OF GRAINS  9
Types of Storage, Structural Aspects, Grain handling, Quality aspects, Operational and Safety issues, grain aeration and storage management, Dust and Insects control and Management

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Explain microbiology of food products.
2. Estimate the thermodynamic properties of food and discuss various food processing techniques
3. Calculate freezing and thawing time of food products.
4. Design the cold storage for various types food products.
5. Discuss the design feature of different systems for grain storage and management

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COURSE OBJECTIVE:
- To offer hands-on training on Modeling and simulation algorithms, and methods of energy-based systems.

**LIST OF EXPERIMENTS**

1. Solution to Laplace equation on a two-dimensional grid using program code.
2. Solution to linear wave equation on a two-dimensional grid using program code.
3. Simulation studies of fluid flow over a heated flat plate under laminar & turbulent flow conditions using CFD software.
4. Heat transfer analysis from a heatsink for electronic cooling applications using CFD software.
7. Transient Simulation of HVAC systems.
8. Transient Simulation of solar water heating systems.

TOTAL: 30 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Develop models and perform simulation studies.
2. Analyse and interpret data of simulated results.
3. Prepare technical reports for simulation of thermal systems.

LAB REQUIREMENTS:
1) Software – CAD Modeling software, CFD Meshing Software, FVM based CFD Solvers, Post-Processing tools, programming & computing software, equation-solving program, building energy simulation software, transient energy simulation software.
2) Computer Hardware compatible with the requirements of the above software.

**Mapping of CO with PO**

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DIRECTOR
COURSE OBJECTIVE:

- To provide hands-on training on various types of Refrigeration & Air-Conditioning systems for performance assessment.

LIST OF EXPERIMENTS

1. Studies on various components of Refrigeration and Air conditioning systems and tools.
2. Thermal analysis of vapour compression refrigeration system.
3. Study of heat pump performance under different indoor and outdoor conditions.
4. Pull-down test in a Deep freezer at various load conditions.
5. Performance analysis of heat pump dryer.
6. Determination of Coefficient of Performance of a Thermoelectric refrigeration system.
7. Performance evaluation of a Vortex refrigeration system.
9. Performance evaluation of Hybrid Evaporative Cooler
10. Environment air quality measurement and analysis.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:
1. Conduct studies on different types of refrigeration & air-conditioning systems.
2. Analyse the performance of HVAC systems including energy consumption and environmental impacts.
3. Arriving the major specifications of various components and prepare a technical report.

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DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
COURSE OBJECTIVES

1. The main learning objective of this course is to prepare the students for identifying a specific problem for the current need of the society and or industry, through detailed review of relevant literature, developing an efficient methodology to solve the identified specific problem.

Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

COURSE OUTCOMES:

On successful completion of this course the student will be able to

**CO1** Identify a suitable industrial problem with regard to engines.
**CO2** Develop the required setup for testing

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COURSE OBJECTIVE:

- To perform experiments through online platform for enhancing the practical skills of the students for better understanding of concepts.

LIST OF EXPERIMENTS

1. Development of Thermal and velocity boundary layers.
3. Two Phase Flow in Horizontal & Vertical Tubes.
4. Melting of Ice.
6. Simulation of VCR / VAR system.
7. Simulation of Piston compressor and expansion valves in refrigeration system.
10. Study of characteristics for different types of fans.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

1. Make use of the ICT for exploring the underlying mechanisms in a thermal system.
2. Analyse the results and improve the understanding of concepts.
3. Design efficient thermal system for specific applications.

LAB REQUIREMENTS:

- ICT based tools and software.
- Computer Hardware compatible with the requirements of ICT tools.

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COURSE OBJECTIVES

1. The main learning objective of this course is to prepare the students for solving the specific problem for the current need of the society and or industry, through the formulated efficient methodology, and to develop necessary skills to critically analyse and discuss in detail regarding the project results and making relevant conclusions.

Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

COURSE OUTCOMES:

On successful completion of this course the student will be able to

**CO1** Conduct the experiments, interpret and analyse the data

**CO2** Validate, present and publish the findings

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COURSE OBJECTIVES:
1. To understand the HVAC systems and Components
2. To understand various heating and cooling systems
3. To know the HVAC air distributions equipment
4. To gain knowledge on HVAC dehumidification and dehumidification components
5. To learn about the ventilation and control components

UNIT – I HVAC SYSTEM

UNIT – II HEATING AND COOLING SYSTEMS

UNIT – III HVAC AIR DISTRIBUTION EQUIPMENT

UNIT – IV HVAC DEHUMIDIFICATION AND DEHUMIDIFICATION COMPONENTS
Humidifiers, Air-Cooling and Dehumidifying Coils, Desiccant Dehumidification and Pressure-Drying Equipment, Mechanical Dehumidifiers and Related Components

UNIT – IV HVAC VENTILATION AND CONTROL COMPONENTS
Unit Ventilators, Unit Heaters, and Makeup Air Units, Air Cleaners for Particulate Contaminants, Industrial Gas Cleaning and Air Pollution, Control Equipment

TOTAL: 45 PERIODS

REFERENCES:

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Understand various HVAC systems.
2. Analysis of various heating and cooling systems
3. To select suitable air distribution equipment
4. Know the HVAC dehumidification and dehumidification components
5. Understand the HVAC ventilation systems and control components
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RA3053 THERMAL MANAGEMENT OF ELECTRONICS AND BATTERIES

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COURSE OBJECTIVES:

- To impart the knowledge on thermal management of electronic devices and batteries.
- To provide students with an appreciation for the application of heat transfer to problems in industries related to thermal management of electronics and batteries.

UNIT – I FUNDAMENTALS
Heat transfer modes, electronics packaging, Properties of materials used in electronics and equipment, contact and spreading resistances, heat sink design, Thermal Interface Materials & Heat Spreaders, Jedec Standards.

UNIT – II COOLING TECHNOLOGIES

UNIT – III APPLICATIONS
Automobiles, Trains, Ships, Avionics, Data Centres, Laptop / Computers / Mobile phone, Internet of Things, Television, RADAR, Satellite Electronics, LED – Lights and Display units, LASER.

UNIT – IV BATTERIES

UNIT – V BATTERY THERMAL MANAGEMENT SYSTEM
Mechanical and Thermal design of battery pack, Thermal management system – Air based, Liquid based and Phase Change Material based systems. Recent developments.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Understand the heat transfer mechanisms, need for thermal management and sources of heat generation in electronics.
2. Compare and analyse the performance of various cooling technologies.
3. Select the appropriate cooling system for specific applications.
4. Categorise the major components of batteries and elucidate the battery characteristics.
5. Identify the challenges and requirements for thermal management of batteries.

REFERENCES:
6. Jerry E. Sergent, Al Krum, Thermal Management Handbook: For Electronic Assemblies,

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COURSE OBJECTIVES:

1. To teach fundamentals of sorption cooling systems and analysis and design of LiBr and Ammonia systems.
2. To teach pumpless system and solid sorption systems and their design of components.
3. To teach various applications of sorption systems for heating, cooling and power generation in buildings, industries etc.
4. To teach polygeneration systems
5. To teach the merits of the system for climate change mitigation

UNIT I INTRODUCTION

UNIT II LIQUID SORPTION SYSTEMS

UNIT III PUMPLESS AND SOLID SORPTION SYSTEM

UNIT IV COMPONENT DESIGN

UNIT V APPLICATIONS OF SORPTION SYSTEMS
Combined power and cooling, Solar Cooling, Low and medium grade Industrial waste heat Utilization, Gas turbine inlet cooling, Polygeneration systems, Economics of Sorption Systems–Sorption refrigeration Systems for Climate Change Mitigation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:

1. Understand the fundamentals of sorption heating and cooling systems, processesess and the working fluids requirement and their properties
2. Analyze the energy input requirements for both LiBr and Ammonia systems for various applications
3. Understand the principle of working in respects of pumpless refrigerators and solid sorption heating and cooling systems.
4. Design various components used both in liquid and solid sorption heating and cooling systems.
5. Appreciate the use of the systems for various building energy requirements such as heating, cooling and power and its ability for climate change mitigation.
REFERENCES


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COURSE OBJECTIVE
To impart knowledge on Low Temperature Refrigeration as well as Cryogenics so that the students gain confidence in working independently with high end systems related to liquefaction of gases, Material behaviour at Cryogenic applications

UNIT I  LOW TEMPERATURE REFRIGERATION  9
Temperature limits for Low Temperature Refrigeration and Cryogenics, Material characteristics, Applications of Low Temperature in Industries, Space, Medicine, Gas Industry, High Energy Physics, Super-conductivity, Levitation principle

UNIT II  LIQUEFACTION OF GASES  9

UNIT III  PURIFICATION OF GASES  9

UNIT IV  CRYO COOLERS  9
J.T Cryo-coolers, Stirling Cycle Refrigerators, G.M.Cryo-coolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Magnetic Refrigerators.

UNIT V  STORAGE AND TRANSPORT  9
Cryogenic Dewar Design, Cryogenic Transfer Lines. Insulations in Cryogenic Systems, Operating principle of different Types of Vacuum Pumps, Instruments to measure Flow, Level and Temperature operating principles

TOTAL: 45 PERIODS

COURSE OUTCOMES
On successful completion of the course the student will be able to:
1. Recognize and explain the material characteristics and Applications at Low temperature.
2. Analyse and evaluate the systems used for Liquefaction of Gases.
3. Understand and Evaluate the systems for purification of Gases.
4. Explain and Differentiate the different Cryo-coolers.
5. Discuss and Compare the different systems /components in handling the Cryogens.

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COURSE OBJECTIVES:
1. To understand the need of Chillers and its operations
2. To Design Chillers for various applications
3. To learn about the selection, classification of Air-Handling units and duct design methods
4. To gain knowledge about the constant and variable volume systems in air handling systems.
5. To learn about the ventilation, the test methods for air filters and digital controlling methods for the ventilation

UNIT – I WATER CHILLERS: FUNDAMENTALS, APPLICATION, AND OPERATION
Chilled Water for HVAC Applications - Determining the Chilled Water Supply Temperature
Establishing the Temperature Range - Chiller Configurations - The Single-Chiller System,
Multichiller Systems, One-Pump Parallel Configuration, Multiple-Pump Parallel Configuration,
Primary Secondary Parallel Configuration, Variable Primary Flow Parallel Configuration, System
Peak Cooling Load and Load Profile, Selecting Water Chillers, Basic Chiller Requirements, Part
Load Efficiency, Load versus Capacity, Atmospheric Impacts, Mixed Energy Source Chiller Systems

UNIT – II CHILLER DESIGN AND APPLICATION
Chilled Water System Elements, Chiller Placement and Installation, Chilled Water Piping - Pump
Selection and Piping - Chilled Water System Control and Performance - Cooling Thermal Energy
Storage - Special Chiller Considerations

UNIT – III AIR-HANDLING UNITS
Psychrometric, Classifications of Air-Handling Units, Main components, Selection of Air-Handling
units, economizer cycle, single zone system, multi zone system - Design Consideration, duct design
static Regain-equal friction-T method.

UNIT IV CONSTANT AND VARIABLE VOLUME SYSTEMS
Terminals reheat system, Double-Duct systems, Sub zone heating, Draw-through cooling, Triple-
Duct system, Fan Coil Unit, Induction system. Various System Configurations - Hydronic heat
pump, Heat recovery and Economizer, Indirect evaporative cooling, Energy conservation and
system retrofit.

UNIT V VENTILATION AND AIR CONTROLS
Ventilation, Measurements control and exhaust, Air cleaning devices, Rating and Assessments,
Test method for air filters, and replacement - Air system, evaluation and control of the thermal
Environment, Indoor Air Quality and Outside Air Requirements, Demand control ventilations,
Thermostats, Damper and damper motor, Automatic Valves, Direct digital control, Application of
fuzzy logic & neural network - Demand control ventilation

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Know the various Chillers and its operations
2. Design the Chillers, on the Industrial requirements
3. Know the basic terms in psychrometric analysis, briefly about Air-Handling Units and duct design methods.
4. Understand the constant and variable volume systems used in heating and cooling applications
5. Understand the ventilation in work environment, and the digital controlling methods for the ventilation

REFERENCES:
3. Allan T. Kirkpatrick & James S. Elleson, cold air distribution system design guide, ASHEAC - 1996 USA.

Mapping of CO with PO

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COURSE OBJECTIVES:

- To teach the fundamentals, concepts and types, facilities of various cold chains and its application for various sectors including socio-economic and environmental impacts.

UNIT – I  FUNDAMENTALS  9
History of Cold storage, Traditional Methods, Modern Storage Methods, Controlled Atmosphere Storage, Modified Atmosphere Packing, Socio-economic and environmental impacts.

UNIT – II  COLD CHAIN & REFRIGERATION  9

UNIT – III  COLD CHAIN APPLICATIONS  9
Food cold chains – Handling, Storage & Transportation of Citrus, Mango, Pear, Banana, subtropical fruits, Fish and Meat. Medicinal and Vaccine cold chains.

UNIT – IV  MANAGEMENT OF COLD CHAIN  9

UNIT – V  WAREHOUSE  9
Types, Construction, Location, Functions, Site Selection, Storage Capacity, Basic Warehouse Equipment, Renewable energy based warehouses, Cost analysis.

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Classify the various types of cold chains and its applications.
2. Select the appropriate cold chain refrigeration system for various applications.
3. Elucidate the thrust applications of cold chain in Food and Healthcare sectors.
4. Infer the different control strategies in cold chain.
5. Design and analyse the warehouse for cold storage applications.

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COURSE OBJECTIVES:

- To teach the concepts of clean rooms its classification and its standards.
- To teach clean room design and the requirements of the components and filtration. To teach constructional features of clean room
- To teach high efficiency filtration techniques related to clean rooms
- To teach estimation of its cost and efficiency of clean rooms for various applications.

UNIT–I INTRODUCTION
The History of Clean rooms -classification - Containment of Contamination, different contaminants - Supply of Liquid and Gases to Clean rooms, clean room standards- International Standards for the Design of Clean rooms, clean room Classes-Present Engineering Classes, New ISO Classification Standard, Bio contamination and Pharmaceutical Classes, Containment Classes, Recommended practices - Other Standards for the Clean room, Abbreviations/ Source Code

UNIT–II CLEAN ROOM DESIGN

UNIT–III HIGH EFFICIENCY AIR FILTRATION

UNIT–IV CONSTRUCTIONAL FEATURES

UNIT– V COST AND ENERGY EFFICIENCY

OUTCOMES:
Upon completion of this course, the students will be able to:

1. Identify the energy storage technologies for suitable applications.
2. Analyze the energy storage systems using TRNSYS.
3. Recognize the concepts and types of batteries.
4. Diagnose the principle operations of Hydrogen and Biogas storage.
5. Analyze the concepts of Flywheel and compressed energy storage systems

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COURSE OBJECTIVES:
- To impart strategies and technologies for assessing energy utilization in building and improving energy efficiency
- To introduce the sustainability concepts in buildings.

UNIT – I  FUNDAMENTALS

UNIT – II  BUILDING MATERIALS

UNIT – III  ENERGY MODELLING OF BUILDINGS
General approaches, Forward and data-driven model, simplified methods and special applications, Simulation tools – Commercial and open source, validation of tools and calibration procedure.

UNIT – IV  BUILDING ENERGY EFFICIENCY

UNIT – V  SUSTAINABILITY

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Understand energy consumption and usage pattern in buildings.
2. Select the suitable materials for energy efficient buildings.
3. Utilise the various model for computing performance of buildings.
4. Demonstrate the various methods for enhancing the energy efficiency in buildings.
5. Summarise the adaption of various methods towards sustainability.

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OBJECTIVE:
To understand the significance and need for various types of energy storage technologies and their uses for real world applications. This course will also enable students to understand the Green Energy Storage of Hydrogen and the challenges associated.

UNIT – I  INTRODUCTION TO ENERGY STORAGE  9

UNIT – II  THERMAL ENERGY STORAGE SYSTEM  9

UNIT – III  ELECTRICAL ENERGY STORAGE  9

UNIT – IV  HYDROGEN ENERGY STORAGE  9

UNIT – V  ALTERNATE ENERGY STORAGE TECHNOLOGIES  9

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1  Identify the energy storage technologies for suitable applications.
CO2  Apply the appropriate thermal energy storage methods suitably.
CO3  Introduce the concepts, types and working of various batteries.
CO4  Understand the use of Hydrogen as Green Energy for our Future.
CO5  Recognize and choose appropriate methods of Energy Storage and Hybrid Systems.

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OBJECTIVES:
The major objective of this course is to learn about the utilization of solar energy for cooling applications in both buildings and industries in economical way through the systems such as absorption, adsorption, desiccant and organic Rankine Cycles.

UNIT I THERMODYNAMIC CYCLES FOR SOLAR COOLING 9
Carnot cycles for refrigeration and Heat Pumps, Vapour compression cycle, Absorption Cycle, Adsorption Cycle, Desiccant cycle, Organic Rankine Cycle and Super Critical CO₂ Cycle

UNIT II SOLAR THERMAL COLLECTORS AND STORAGE SYSTEMS 9
Non-concentrating solar collectors, concentrating solar collectors, Collector applications – Medium and high temperature – Sensible and Latent heat Storage, Heat transfer enhancement techniques, Thermal Chemical storages

UNIT III SOLAR THERMAL COOLING TECHNOLOGIES 9

UNIT IV PV DRIVEN COOLING AND HEATING SYSTEMS 9
PV cell, Design of PV systems for Vapour compression cycles, Thermo electric cycle, Solar PV based chillers, Photovoltaic thermal systems - Energy and environment analysis – Thermo economic analysis for cooling applications

UNIT V ALTERNATE AND HYBRID COOLING SYSTEMS 9

TOTAL : 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:

CO1 Analyze the performance of different thermodynamic solar cooling cycles.
CO2 Design the different types of solar collectors for a given cooling load.
CO3 Understand and Analyze the performance of solar thermal based chillers.
CO4 Design the solar PV powered cooling system
CO5 Apply various alternate and hybrid systems for cooling applications

REFERENCES
5. Reinhard Radermacher, S AKelin and K Herold, “Absorption chillers and heat...
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OBJECTIVES:
- To gain understanding of the various forms of crystals, principles of their synthesis techniques and some characterization techniques
- To gain an understanding of the principles underlying the properties of functional materials
- To understand the electronic, magnetic, and optical properties of materials
- To acquire knowledge on how materials are tailor-made for specific applications
- To teach the materials for polymer electronics

UNIT I  INTRODUCTION

UNIT II  SYNTHESIS AND FABRICATION OF FUNCTIONAL MATERIALS
Carbon nanotube, graphene, chalcogenide quantum dots, nanowires and nanobelts, multiferroics, superconducting oxides, and intermetallics, GMR oxides, nonlinear optical crystals, and other novel functional materials; Preparation of bulk polycrystalline materials and composites; Preparation of nanomaterials

UNIT III  TECHNIQUES OF CHARACTERIZATION
Destructive Techniques: Principles of chemical analysis, DTA, TGA, DSC - Non-Destructive Techniques: use of x-ray electron and neutron diffraction techniques; density determination, electrical transport, and magnetic properties; Surface area measurements and hardness testing, basics of electron microscopy, microstructure analysis.

UNIT IV  APPLICATIONS OF FUNCTIONAL MATERIALS

UNIT V  MATERIALS FOR POLYMER ELECTRONICS
Polymers for Electronics, Organic Light Emitting Diodes, Working Principle of OLEDs, Illustrated Examples, Organic Field-Effect Transistors Operating Principle, Design Considerations, Polymer FETs vs Inorganic FETs, Liquid Crystal Displays, Engineering Aspects of Flat Panel Displays, Intelligent Polymers for Data Storage, Polymer-based Data Storage-Principle, Magnetic Vs. Polymer-based Data Storage.

TOTAL: 45 PERIODS

OUTCOMES:
- Students will be able to differentiate among various functional properties and select appropriate material for certain functional applications, analyze the nature and potential of functional material.
- It will enable students to synthesize and characterize different materials.

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COURSE OBJECTIVES:

- To emphasise the essentiality and impart knowledge on energy audit in HVAC systems.

UNIT – I  INTRODUCTION  9

UNIT – II  ELECTRICAL ENERGY AUDIT  9
Overview of Electrical equipment, Electrical Distribution system, Power Factor, Power quality, Various devices for electrical energy audit in Motors, Lighting systems – Fluorescent Lamps, Compact Fluorescent Lamps, Compact Halogen Lamps, LED, Lighting Controls, Appliances.

UNIT – III  HVAC ENERGY AUDIT  9

UNIT – IV  ENERGY AUDIT INSTRUMENTS  9

UNIT – V  CASE STUDIES  9

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

1. Explain the standard procedure for performing energy audit.
2. Relate the energy consumption of various electrical equipment and consumption patterns.
3. Estimate the energy consumption of electrical & HVAC appliances.
4. Make use of the various instruments used for energy audit.
5. Analyse the energy consumption in various sectors of buildings.

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COURSE OBJECTIVES:
- To impart the fundamentals concepts, design and selection of turbomachines for HVAC applications.

UNIT – I FUNDAMENTALS

UNIT – II CENTRIFUGAL FANS & BLOWERS

UNIT – III AXIAL, CROSS FLOW & VORTEX FANS / BLOWERS
Construction, Velocity triangle, Flow pattern, Performance of axial, cross & vortex blowers, Design of axial blower, Comparison, Noise level, applications.

UNIT – IV APPLICATIONS OF FANS & BLOWERS
Fans / Blowers in series, parallel, Air flow through ventilation system, pressure losses, Variation of static pressure in ventilation system, Roof ventilators, Tunnel ventilation, Mines ventilation. Air Distribution system for small / medium / Large capacity HVAC applications.

UNIT – V COMPRESSORS

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
1. Infer the fan curves and system resistance of various types of fans.
2. Analyse the characteristics of different centrifugal fans & blowers.
3. Select the appropriate axial fans for specific applications.
4. Outline the applications of fans & blowers in different fields.
5. Elucidate the compressors and controls in HVAC systems.

REFERENCES:
## Mapping of CO with PO

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