

ANNA UNIVERSITY COIMBATORE
REGULATIONS 2007

M.E. - REFRIGERATION AND AIRCONDITIONING
CURRICULAM AND SYLLABUS

Semester: 01

Sl.No.	Subject Code	Subject Title	L	T	P	M
THEORY						
1		Advanced Mathematics	3	1	0	100
2		Advanced Thermodynamics	3	1	0	100
3		Advanced Heat and Mass Transfer	3	1	0	100
4		Measurements and Control	3	0	0	100
5		Refrigeration Systems and Food Processing	3	0	0	100
6		Elective I	3	1	0	100
PRACTICAL						
7		Refrigeration and Air-conditioning Laboratory	0	0	3	100

Semester: 02

Sl.No.	Subject Code	Subject Title	L	T	P	M
THEORY						
1		Advanced Fluid Mechanics	3	1	0	100
2		Computational Fluid Dynamics	3	1	0	100
3		Design of Condensers, Evaporators and Cooling Towers	3	1	0	100
4		Testing of Air-conditioning and Refrigerating equipments	3	0	0	100
5		Elective II	3	0	0	100
6		Elective III	3	0	0	100
PRACTICAL						
7		Computational Fluid Dynamics Laboratory	0	0	3	100

Semester: 03

Sl.No.	Subject Code	Subject Title	L	T	P	M
1		Elective IV	3	0	0	100
2		Elective V	3	0	0	100
3		Elective VI	3	0	0	100
4		Project Phase - I	-	-	-	100

Semester: 04

Sl.No.	Subject Code	Subject Title	L	T	P	M
1		Project Phase II and Viva-voce	-	-	-	200

Note: L – Lecture T – Tutorial P – Practical M – Total Marks

ELECTIVE SUBJECTS

1. Psychrometry and Air-Conditioning systems
2. Cryogenic Engineering
3. Industrial and Commercial Air-conditioning systems
4. Commercial refrigerating Equipments and accessories
5. Controls in Heating, Ventilation and Air-Conditioning (HVAC) systems
6. Solar and Thermo Electric Refrigeration and Air-Conditioning Systems
7. Finite Element analysis
8. Advanced Refrigeration and Air-Conditioning Systems
9. Design and Optimization in Thermal Systems
(Syllabus common to M.E Thermal Engineering)
10. Environmental Engineering and Pollution Control

07RA101 ADVANCED MATHEMATICS
(Syllabus common to ME - Thermal Engg., Energy Engg., R&AC, IC Engg.,)

L T P M
3 1 0 100

UNIT I

9hrs

Fourier Transforms, Complex, Sine and Cosine Transforms, Finite Fourier Transforms.
Applications – One dimensional heat conduction problem, Laplace Equation, Poisson Equation.

UNIT II

9hrs

Variation and its properties – Euler's equation – Functionals dependent on first and higher order derivatives – Functionals dependent on functions of several independent variables – Some applications – Direct methods – Ritz and Kantorovich methods.

UNIT III

9hrs

The Schwarz – Christoffel transformation – Transformation of boundaries in parametric form – Physical applications – Application to fluid flow – Application to heat flow.

UNIT IV

9hrs

Matrix transformations – Direct methods – Gaussian Elimination method, Gauss modern method, Factorisation method. Iterative methods – Jacobi, Gauss Seidely and SOR methods.

UNIT V

9hrs Solution of

Laplace's and Poisson equation on a rectangular region by Liebmann's method – Diffusion equation by the explicit and Crank Nicolson – Implicit methods – Stability and Convergence criterion – Solution of wave equation by explicit scheme.

Tutorials - 15hrs
Total Hours - 60hrs

REFERENCES

1. Sneddon, I.N., Elements of partial differential equations, McGraw-Hill, 1986.
2. Spiegel, M.R., Theory and problems of complex variables with an introduction to conformal mapping and its applications, Schaum's outline series, McGraw-Hill Book Co., 1987.
3. Sankara Rao, K., Introduction to partial differential equations, Prentice-Hall of India, New Delhi, 1995
4. Elsgolts, L., Differential equation and calculus of variations, Mir Publishers, Moscow, 1996.
5. Carnahan. B., Luther. H.A., and Wilkes, J.O., Applied Numerical Methods, Wiley and Sons, 1976.

07RA102 ADVANCED THERMODYNAMICS
(Use of approved charts and Data Book permitted)
(Syllabus common to ME - Thermal Engg., Energy Engg., R&AC, IC Engg.,)

L T P M
3 1 0 100

UNIT I

10hrs

Availability, Irreversibility and Second-Law Efficiency for a closed System and steady-state Control Volume. Availability Analysis of Simple Cycles. Thermodynamic Potentials, Maxwell relations, Generalised relation for changes in Entropy, Internal Energy and Enthalpy, Generalised Relations for Cp and Cv Clausius Claypeyron Equation, Joule-Thomson Coefficient, Bridgman Tables for thermodynamic relations.

UNIT II

10hrs

Different Equations of State, Fugacity, Compressibility, Principle of Corresponding States, Use of generalized charts for enthalpy and entropy departure, fugacity coefficient, Lee-Kesler generalized three parameter tables. Fundamental property relations for systems of variable composition, partial molar properties, Real gas mixtures, Ideal solution of real gases and liquids, Equilibrium in multi phase systems, Gibbs phase rule for non-reactive components.

UNIT III

10hrs

Thermo chemistry, first Law analysis of reacting systems, Adiabatic Flame temperature, Entropy change of reacting systems, Second Law analysis of reacting systems, Criterion for reaction equilibrium composition.

UNIT IV

8hrs

Microstates and Macrostates, Thermodynamic probability, Degeneracy of energy levels, Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein Statistics, Microscopic Interpretation of heat and work, Evaluation of entropy, Partition function, Calculation of the Microscopic properties from partition functions. Collision Theory and Transport properties.

UNIT V

7hrs

Conjugate Fluxes and Forces, Entropy Production, Onsager's Reciprocity relations, thermoelectric phenomena and formulations. Thermodynamics of High-Gas flow.

Tutorials

- 15hrs

Total Hours - 60hrs

REFERENCES

1. Kenneth Wark Jr., Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 2001..
2. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1998.
3. Holman, J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1998.
4. Smith, J.M and Van Ness., H.C., Introduction to chemical Engineering Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1987.
5. Sonntag, R.E., and Vann Wylen, G, Introduction to Thermodynamics, Classical and Statistical, third Edition, John Wiley and Sons, 1991.
6. Sears, F.W. and Salinger G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, third Edition, Narosa Publishing House, New Delhi, 1993.
7. DeHoft, R.T. Thermodynamics in Materials Science, McGraw-Hill Inc., 1993.
8. Rao, Y.V.C., Postulational and Statistical thermodynamics, Allied Publisher Limited, New Delhi, 1994.

07RA103 ADVANCED HEAT AND MASS TRANSFER
(Use of approved handbook permitted)
(Syllabus common to ME - Thermal Engg., Energy Engg., R&AC, IC Engg.,)

L T P M
3 1 0 100

UNIT I

9hrs

One dimensional steady and transient heat transfer equations and boundary conditions, 2D, 3D heat conduction equations-varying thermal conductivity-Analytical and semi-analytical solutions, - Lumped Analysis-Heisler's chart, extended surface-geometric non linear heat transfer-Bessel function.

UNIT II

9hrs

Conduction with moving boundaries, Radiation in gases and vapour. Gas radiation and radiation heat transfer in enclosures containing absorbing and emitting media – interaction of radiation with conduction and convection.

UNIT III

9hrs

Momentum and Energy Equations, Turbulent Boundary Layer Heat Transfer, Mixing length concept, Turbulence Model – K- ϵ Model, Analogy between Heat and Momentum Transfer – Reynolds, Colburn, Prandtl Turbulent flow in a Tube, High speed flows.

UNIT IV

9hrs

Condensation with shear edge on bank of tubes, Boiling – pool and flow boiling, Heat exchanger, ϵ – NTU approach and design procedure, compact heat exchangers.

UNIT V

9hrs

Mass Transfer, Vaporization of droplets, combined heat and mass transfer, Heat Transfer Correlations in various applications like I.C. Engines, Compressors & turbines.

Tutorials

- 15hrs

Total Hours - 60hrs

REFERENCES

1. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 1996.
2. Ozisik. M.N., Heat Transfer – Basic Approach, McGraw-Hill Co., 1985
3. Schlichting, Gersten, Boundarylayer Theory, Springer, 2000
4. P.K. Nag, Heat Transfer, Tata McGraw-Hill, 2002
5. Rohsenow. W.M., Harnett. J.P., and Ganic. E.N., Handbook of Heat Transfer Applications, McGraw-Hill, NY1985
6. [Anthony F. Mills](#), Basic Heat and Mass Transfer, Irwin Publishers

07RA104 MEASUREMENTS AND CONTROL
(Syllabus common to ME - Thermal Engg., Energy Engg., R&AC, IC Engg.,)

L T P M
3 0 0 100

UNIT I

12hrs

Instrument Classification, Characteristics of Instruments – Static and dynamic, experimental error analysis, Systematic and random errors, Statistical analysis, Uncertainty, Experimental planning and selection of measuring instruments Reliability of instruments.

UNIT II

5hrs

Data logging and acquisition, use of intelligent instrument for error reduction, elements of micro-computer interfacing, intelligent instruments in use.

UNIT III

10hrs

Measurement of thermo-physical properties, instruments for measuring temperature pressure and flow, use of intelligent instruments for the physical variables.

Chemical. Thermal, magnetic and optical gas analysers, measurement of smoke, dust and moisture, gas chromatography, spectrometry, measurement of pH, Review of basic measurement techniques.

UNIT IV

8hrs

Techniques, shadow graph, Schlieren, interferometer, Laser Doppler anemometer, heat flux measurement, Telemetry in engines.

UNIT V

10hrs

Digital Transducers – Interface system and Standards – Computer automated measurements and controls (CAMAC) standards – IEEE 488 standard interface – Remote monitoring and control of boiler houses – D-DAC (Distributed Data acquisition and Control Systems) – Microprocessor based temperature control system – Introduction to Microcontrollers – Process control system – Pneumatic control systems.

Total Hours - 45hrs

REFERENCES

- 1.Holman, J.P., Experimental methods for engineers, McGraw-Hill, 1958.
- 2.Barney, Intelligent Instrumentation, Prentice Hall of India, 1988.
- 3.Prebrashensky. V., Measurement and Instrumentation in Heat Engineering, Vol.1 and 2 MIR Publishers, 1980.
- 4.Raman, C.S. Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems, Tata McGraw-Hill, New Delhi, 1983.
- 5.Doeblin, Measurement System Application and Design, McGraw-Hill, 1978.
- 6.Morris. A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 1998.
7. George C barney, Intelligent Instrumentation Microprocessor and Applications in Measurements and Control, Prentice Hall, New Delhi, 1995.

07RA105 REFRIGERATION SYSTEMS AND FOOD PROCESSING

UNIT I

9hrs Refrigeration –

Introduction- refrigeration cycles- representation on T-S and P-H and mollier charts, comparison of refrigerants, properties and advantages, eco-friendly refrigerants, Joule-Thomson principle, simple problems on refrigeration cycles, functions of compressor, condenser, expansion device and evaporator, selection and matching of components. Chillers- reciprocating, scroll, screw and centrifugal.

UNIT II

9hrs

Storage temperature and relative humidity of food stuffs in cold storage, disadvantages of high and low relative humidity, freezing methods, packing materials, frozen storage, types of freezers , refrigeration load in freezers, calculation of freezing time , Freeing in air, modified Planks equation for calculating freezing time Quick freezing Vs slow freezing.

UNIT III

9hrs

Freeze drying- heat and mass transfer through dried material, heat drying of foods-drying during constant rate period- drying during falling rate period-freezers and cold storage plants in transport vehicles-effect of frost and methods of defrosting. Design of freezers and cold storage plants using various refrigeration unit-importance of viscosity and dielectric strength of lubricating oil in refrigeration system-oil return and separators, crank case heaters, insulation of cold storage.

UNIT IV

9hrs

Food

preservation- causes of food spoilage, methods of food preservation, heat processing, dehydration, preservation of pulse grains, chemical preservation, radiation, cooling and heating of foods. Refrigerators and chest freezers. Dielectric and infrared absorption properties of food stuffs. Heat treatment of solids and liquid food stuffs.

UNIT V

9hrs

Food processing by refrigeration- candy manufacture, beverage processing, bakery products, meat products, poultry products, fishery products, fruits and vegetables, dairy products.

Total Hours - 45hrs

REFERENCES

1. Andrew D.Alothouse, Refrigeration and Air-conditioning, The Goodheart willcox company, Inc Publishers, 2002.
2. Dossat R.J.- Principles of Refrigeration, Prentice Hall, 1997.
3. ASHRAE data book Published 1968.
4. V.K. Jain, Refrigeration and Air-conditioning system S.Chand and Company, 2005.

L T P M
3 1 0 100

UNIT I

9hrs

Ideal and non-ideal flows, continuum view point and general equations of fluid motion, Newtonian fluids, Navier - Stokes equations and their exact solutions. Boundary layer theory, wedge flows, laminar flow over plates and through cylinders.

UNIT II

9hrs

Two dimensional flow – subsonic flow, physical significance of irrotational motion – Kelvin's theorem – Differential equation in terms of velocity Potential and stream function – Flow with small perturbation – flow past a wave shaped wall – Gothert's rule – Prandtl Glanert rule – Hodograph method

UNIT III

9hrs

Turbulence, models, and flow equations: steady and unsteady turbulent boundary layers

UNIT IV

9hrs

Introduction to compressible viscous flow, governing equations, flow with friction –Fanno flow, flow with heat transfer- Rayleigh flow, flow through nozzle and diffusers .

UNIT V

9hrs

Normal and oblique shocks – Prandtl – Meyer expansion – Rankine – Hugoniot relation, Application of method of characteristics applied to two dimensional cases – simple supersonic wind tunnel -Design of supersonic wind tunnel and nozzle

Tutorials

- 15hrs

Total Hours - 60hrs

REFERENCES

- 1 T Radhakrishnan Gas Dynamics Prentice Hall, New Delhi
- 2 Mohanty A K Fluid Mechanics, Prentice Hall of India, 1986
- 3 Shapiro A F The Dynamics of Compressible flow Vd 1, The Ronald Press Company 1963
- 4 Shames, Mechanics of Fluids, MC grow Hill 1962 Book Company 1962
- 5 Schlichting H Boundary layer theory MC Grow Hill Book company 1979
- 6 S M Yahya, Compressible Fluid Flow

07RA202 COMPUTATIONAL FLUID DYNAMICS
(Syllabus common to ME - Thermal Engg., Energy Engg., R&AC, IC Engg.,)

L T P M

3 1 0 100

UNIT I

9hrs

Continuum hypothesis, Lagrangian and Eulerian formulation, Governing equations-continuity equation, momentum equation, energy equation, boundary conditions-classification, initial and boundary value problems-Finite difference schemes-forward, central and backward difference, basics of Finite volume schemes, Implicit and explicit approaches.

UNIT II

9hrs

FDM for Steady one-dimensional conduction, Two and Three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems, Finite Volume formulation for 1D heat transfer. Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT III

9hrs

Governing Equations, Stream Function – Vorticity method, Determination of pressure for viscous flow, SIMPLE Procedure of Patankar and spalding, Computation of Boundary layer flow, Finite difference approach, Unstructured Grids for Viscous Flows.

UNIT IV

9hrs

Steady One-Dimensional and Two-Dimensional Convection – Diffusion, Unsteady one-dimensional convection – Diffusion, Unsteady two-dimensional convection – Diffusion – Introduction to finite element method – Solution of steady one dimensional heat conduction by FEM – Incompressible flow – Simulation by FEM.

UNIT V

9hrs

Turbulence, Effect of Turbulence and time averaged Navier Stokes Equation, Algebraic Models – One equation model, $k - \epsilon$ Models, k - ω model, Algebraic stress model, Reynolds stress equation model, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes.

Tutorials

- 15hrs

Total Hours - 60hrs

REFERENCES

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
2. Ghoshdasdar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw-Hill Publishing Company Ltd., 1998.
3. Subas, V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing corporation 1980.
4. Taylor, C and Hughes, J.B. "Finite Element Programming of the Navier Stock Equation", Pineridge Press Limited, U.K
5. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., "Computational fluid Mechanics and Heat Transfer" Hemisphere Publishing Corporation, Newyork, USA,.
6. Bose, T.X., Numerical Fluid Dynamics, Narosa Publishing House, 1997.
7. H.K.Versteeg and W.Malalalsekara,An Introduction to CFD,The Finite Volume Method,Addition Wesley Longman Ltd.

07RA203 DESIGN OF CONDENSERS, EVAPORATORS AND COOLING TOWERS

L T P M
3 1 0 100

UNIT I **9hrs** Water cooled condensers, types, applications, operation, optimum condenser pressure, optimum cooling water rate and velocity, heat rejection ratio, condensing heat transfer coefficient, water side heat transfer coefficient, Wilson plots, effect on non-condensable gases, design of condensers, construction codes.

UNIT II **9hrs** Air-cooled condensers, types, applications, finned air-cooled condensers, selection and rating of condensers, design, augmentation of condensation heat transfer.

UNIT III **9hrs** Evaporators, applications- flooded and natural convection coils, spray type, direct expansion type, air conditioning coils, design of evaporators, heat transfer during boiling.

UNIT IV **9hrs** Evaporative condensers and air washers, sensible and latent heat transfer, diffusion constant, Lewis number, heat transfer using enthalpy potential, application, condenser- calculation of air supply, water sprayed, air washer – spray characteristics, design of air washers.

UNIT V **9hrs** Cooling Towers, spray ponds, natural draught and mechanical draught, theory and design of cooling tower, tower characteristics, approach, range, predicting outlet conditions, comparison of evaporative condensers with cooling towers, relative merits.

Tutorials **- 15hrs**
Total Hours - 60hrs

REFERENCES

1. W.F Stoecker, and J.W Jones Refrigeration and air conditioning McGraw-Hill, New York, 1982.
2. V.K. Jain, Refrigeration and Air conditioning, S. Chand and Company, 2005.
3. S.C. Arora and Dumkundwar, Refrigeration & Air conditioning, Dhanpathirai publishers, 2006.
4. C. P. Arora, Refrigeration & Air conditioning, Tata-McGraw Hill Publishers, 2005.

07RA204 TESTING OF AIR - CONDITIONING AND

REFRIGERATING EQUIPMENTS

L T P M
3 0 0 100

UNIT I **9hrs** Performance characteristics of centrifugal and reciprocating compressors. Testing of reciprocating compressors-open type and hermetically sealed compressors-metric test- vapour cycle methods. Refrigerant flow measurements-code of practice and measurement. Procedure for above testing as per I.S. standards.

UNIT II **9hrs** Testing of condensers and evaporators-different types of evaporators and condensers and their selection and matching with refrigeration systems.

UNIT III **9hrs** Testing of physical conditions in cold storage-code of practice for fire safety for general storage, ware housing and cold storage. Specification and testing of room air conditioners. Testing procedure for airflow measurement. Test procedure for packed air conditioners.

UNIT IV **9hrs** Specification for metal air duct-seams and connections-duct construction- inspection and testing. Testing of evaporative air coolers-air flow and temperature measurements, method of testing of panel type air filters for air conditioning and ventilation purposes.

UNIT V **9hrs** Erection and charging of refrigerators and air conditioners. Leak detection and troubleshooting. Matching of thermostatic expansion valve. Design of capillary tube for refrigerators. Procedure for long shut down, descaling of condenser.

Total Hours - 45hrs

REFERENCES

1. I.S.I. Code books ISI 1391-1971. IS 3315- 1974, IS 5111- 1969, IS 7613-1975, IS 8148-1976, IS 655- 1963.
2. Andrew D.Althouse and Carl H.Turnquist, Modern refrigeration and air conditioning, Goodheart-Wilcox, 2004.
3. R.J Dossat, Principles of refrigeration, Prentice Hall., 1997.
4. Guide and data book- ASHRAE Journal. (Fundamentals and Equipments).
5. Nelson C.W Commercial and Industrial refrigeration, McGraw Hill, 1952.
6. Elonka & Minich, Standard Refrigeration and Air-conditioning McGraw Hill Book company, 1961.

07RA205 COMPUTATIONAL FLUID DYNAMICS LABORATORY

L T P M
0 0 3 100

Software: Fluent /Star CD/ ANSYS/CFX / user defined codes.

1. Steady State Conduction in Solid
2. Steady State Convection in Solid
3. Steady State Radiation in Solid
4. Combined conduction and convection
5. Unsteady state conduction and convection
6. Unsteady state conduction and radiation
7. Steady state conduction in Fluids
8. Steady state convection in Fluids
9. Two-phase flows
10. Condensation and boiling heat transfer

ELECTIVE SUBJECTS

07RA001 PSYCHROMETRY AND AIR-CONDITIONING SYSTEMS

L T P M
3 0 0 100

UNIT I **9hrs** Psychrometry- introduction-basic definitions, psychrometric processes, humidification, de-humidification, sensible heating and cooling, adiabatic heating and cooling, actual coil conditioner curve, simple problems.

UNIT II **9hrs** Cooling Load calculations, Selection of standard comfort conditions, design of Air-conditioning system, selection of cooling unit, Air-cleaning systems and air filters-design of pipelines, air distribution systems.

UNIT III **9hrs** Lubricants, dryers, dehydrators, desiccants, cooling and dehumidification coil–types. Surface area of evaporator coil, moisture removal, problem solving for required outlet conditions, dry coil.

UNIT IV **9hrs** Selection of Duct arrangements, Duct layout, Duct insulation–duct maintenance-sheet metal standards, duct materials, pressure balancing of ducts, duct sizing, static regain method, problems.

UNIT V **9hrs** Duct insulation, thermal and acoustics insulations, chilled water and brine piping insulations, insulation materials.

Tutorials - 15hrs
Total Hours - 60hrs

REFERENCES

1. C.P. Arora, Refrigeration and Air-conditioning, Tata McGraw-Hill Edn, 2006.
2. Ananthanarayanan, Basic Refrigeration and Air-conditioning, Tata McGraw-Hill Edn, 2006.
3. Stoecker and Jones- Refrigeration and Air conditioning McGraw Hill International Book company, 2002.
4. Manohar Prasad, Refrigeration and Air-conditioning, S.Chand Publications, 2004.

07RA002 CRYOGENIC ENGINEERING

(Syllabus common to ME – R & AC, Energy and Thermal Engineering)

L T P M

UNIT I**8hrs** Introduction to

Cryogenic systems- Present areas involving Cryogenic Engineering, Low temperature properties of materials- Mechanical properties, Thermal properties, Electrical and Magnetic Properties, Properties of Cryogenic Fluids- Applications of cryogenics in various fields.

UNIT II**10hrs** Liquefaction

Systems - Production of Low temperatures- Joule Thomson effect, adiabatic expansion, Liquefaction systems for gasses other than neon, Hydrogen and Helium and for hydrogen neon and helium, Comparison of Liquefaction systems, Critical components involved in Liquefaction systems.

UNIT III**11hrs**

Separation and Purification systems - Properties of mixtures - characteristics- Temperature composition diagrams- Enthalpy Composition diagrams, Enthalpy Composition diagrams, Principles of gas separation-Rectification principles-Flash calculations-Theoretical plate Calculations for columns-Minimum number of theoretical plates-Rectification column types. Air Separation systems, Hydrogen Separation, Helium Separation and Gas Purification systems.

UNIT IV**8hrs** Cryogenic

Refrigeration Systems- Ideal Refrigeration systems - Joule Thomson Refrigeration systems, Philips refrigerator, Solvay refrigerator, Mac Mohan Refrigerator, Regenerator. Refrigerators above 2K and below 2K. Magnetic cooling, Thermodynamics of Magnetic cooling, Magnetic moment and Entropy of Paramagnetic materials, Magnetic refrigeration systems, thermal valves, Dilution refrigerators.

UNIT V**8hrs**

Instrumentation, measurement systems – Temperature, Pressure, Flow rate, Fluid quality, Liquid level measurement systems. Cryogenic fluid storage systems - Cryogenic transfer systems - Cryogenic insulation, Radiation shield, Vacuum technology.

Total Hours - 45hrs**REFERENCES**

1. Arkharov and others – Theory and design of cryogenic systems. MIR Publishers, 1981.
2. Randall F. Barron – Cryogenic systems. Oxford University Press 1985.
3. Marshall Sitting – Cryogenic research and application.
4. Scott R.B. – Cryogenic Engineering. Van Nostrand, 1959.
5. Richard J. Allen - **Cryogenics**, University of London Press.

07RA003 INDUSTRIAL AND COMMERCIAL AIR CONDITIONING SYSTEMS

L T P M
3 0 0 100

UNIT I

9hrs

Air conditioning equipment - Room air conditioner - window type, package type, split and Central Air-conditioning units.

UNIT II

8hrs

Flow of air in duct system - Air movement in rooms - Air distribution devices - Automatic control, air circuits, and Air supply system.

UNIT III

8hrs

Air pollution and ventilation - Effect of particle size, outdoor and indoor contaminants, odour, necessity of ventilation and its requirements for various applications.

UNIT IV

12hrs

Air conditioning requirements for hotels, restaurants, hospitals, operating theatres, computer rooms, radio and television studio, auditorium departmental stores, breweries, dairy, fishery, textile mill humidifiers, ice manufacture, refrigeration in LNG liquefaction, photographic industry.

UNIT V

8hrs

AC in automobiles - Railways, marines and air crafts, superconductors for electric power transmission.

Total Hours - 45hrs

REFERENCES

1. S.C. Arora- Refrigeration and air conditioning, Tata Mc Graw Hill publishing Co Ltd, 1979.
2. Harris- Modern air conditioning practice, McGraw Hill International book Company, 1983.
3. Carrier W.H. Modern air conditioning, heating and ventilating- Pitman publishing Corporation, New York, 2000.
4. Arora and Domkundawar- Refrigeration and Air conditioning, Dhanpath Rai and sons, Delhi, 2006.

07RA004 COMMERCIAL REFRIGERATING EQUIPMENTS AND ACCESSORIES

UNIT I

9hrs

Principle types of commercial refrigerating equipments - House hold refrigerators - Chest freezers, water coolers, bottle coolers, walk coolers, window air conditioners, split air conditioners, central air conditioners, air cooler and desert coolers.

UNIT II

6hrs

Ice cream freezers-principle of ice production, methods of ice manufacturing, treatment of water-freezing tanks- ice cans quality of ice.

UNIT III

10hrs

Hermetically sealed compressor units-Ecofriendly refrigerants and lubricating oil properties. Advantages of hermetically sealed units, semi hermitic units, electrical connections, and automatic relay and over load protection for motors, automatic-defrosting devices.

UNIT IV

10hrs

Condensers, receivers and evaporators, matching the various equipments with the cooling equipments. Constructional features of various types of machines, assembling and factory testing of machines, methods of drying, evacuating and charging, performance test, running and maintenance.

UNIT V

10hrs

Heat pump circuit-Different heat pump circuits. Analysis of heat pump cycle, working fluids for heat pump, decentralized heat pumps, industrial heat pumps, Heat sources of heat pump. Performance- sizing of heat pump, Expansion devices.

Total Hours - 45hrs

REFERENCES

1. Stoecker and Jones- Refrigeration and Air conditioning McGraw Hill International Book company, New York 1982.
2. S.C. Arora and Domkundwar- Refrigeration and Air conditioning, 2005.
3. Dossat R.J – Principle of Refrigeration, Published, 1996.
4. ASHRAE Data Book, 1968.

UNIT I **9hrs** Elements of open and closed loop controls, mechanical, pneumatic, electrical and electronic control elements. Two position switching, proportional control, time lag, component symbols, ladder diagrams.

UNIT II **10hrs** Control elements hardware - Thermostatic expansion valve, Control valves - two way and three way modulating valves, pressure control devices for the high and low side pressures, pressure operated expansion valves, water valves. Over load and starting relays, temperature control and defrosting of small hermetic systems. Thermostatic expansion valves.

UNIT III **9hrs** Pneumatic control - Air supply system - The air compressor, filter, regulator and line lubricator. Control valves for liquids and conditioned air. Pressure and solenoid actuation, damper controls, electro - pneumatic controls - Typical circuit design.

UNIT IV **9hrs** Electronic controls - D.C. analog systems. Typical electronic controls using bridge circuits, amplifier and actuators - Elements of microprocessor based direct digital controls used in HVAC systems.

UNIT V **8hrs** Vibration and noise from air moving and handling units - measurement, record and control of relative humidity. Control of parameters in thermic fluid - air-heating systems.

Total Hours - 45hrs

REFERENCES

1. Stanford H.W, Analysis and design of heating, ventilation and air conditioning systems, Prentice Hall 1988.
2. W.F.Stoecker and J.W.Jones – Refrigeration and air conditioning McGraw Hill international book Co., 1982.
3. John E. Traisker – HVAC controls – Design and applications. Prentice Hall 1988.

UNIT I **10hrs** Solar energy- its source and its measurement- Solar radiation at the earth surface, solar heating system design- Passive and active system- Basic hot air system- Basic hot water system, Thomson-solaris solar heating system, solar dehumidification- heat gain through glass, shading from reveals, overhangs & fins, effect of shading device.

UNIT II **8hrs** Solar operated vapour compression and vapour absorption systems- Intermittent and continuous systems- COP- Effect of operating temperature on performance of the system.

UNIT III **9hrs** Design parameter for the design of solar cooling system, design of heating system for a building, F-chart, evaporative cooling solar heat pump- Climate data for evaporative cooling for major Indian cities.

UNIT IV **9hrs** Thermo electric effect- Seebeck peltier and Thomson effect- Variation of thermo electric parameters with thermal conductivity, thermo electric materials.

UNIT V **9hrs** Thermodynamic analysis of thermo electric refrigeration systems, Advantages of thermo electric refrigeration system- Comparison with vapour compression system, multistage thermo electric refrigeration.

Total Hours - 45hrs

REFERENCES

1. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 1968.
2. Herbert W. Standfrod, Analysis and Design of Heating, Ventilating and Air-Conditioning systems, Prentice Hall Publishers, 1988.
3. Manohar Prasad, Refrigeration and Air conditioning, Wiley Eastern Ltd, 2002.
4. G.D. Rai, Solar Energy Utilisation, Khanna publishers, 2004.

UNIT I**10hrs**

Introduction and basic concepts of Finite Element Method - engineering application of finite element - comparison of finite element with other methods - strain displacement relations, stress-strain-temperature relations, plane stress and plane strain conditions, energy principles, principles of virtual work.

UNIT II**10hrs** General

Procedure of finite element method, discretization of the domain -interpolation polynomials - formulation of element characteristic matrices vectors - variational approach - and weighted residual approach - assembly of element matrices and vectors and derivation of system equation - solution of finite element equation -computation of element resultants.

UNIT III**9hrs** Higher

order iso parametric and axisymmetric element formulations - higher order one-dimensional element - continuity equation-comparative study of elements - isoparametric elements, axisymmetric elements and its formulations, numerical integration.

UNIT IV**8hrs** Heat

transfer - basic equations of heat transfer - derivation of finite element equations-one and two dimensional heat transfer-simple problems.

UNIT V**8hrs** Fluid

Mechanics - basic equations of fluid mechanics - inviscid incompressible flows, potential and stream function formulation one and two-dimensional fluid flow problems

Total Hours - 45hrs**REFERENCES**

1. S.S.Rao, The finite element method in Engineering, Pergamon Press, 1981.
2. C.S.Krishnamurthy, Finite Element Analysis, Tata McGraw-Hill Publishing Co, Ltd, 2nd Edition, 1994.
3. Kenneth H.Huebner, The finite element method for engineers, John Wiley&sons, 2nd Edition, 1982.
4. Vince Adams and Abraham Askenazi, Finite element analysis, Onword Press, 1st Edition, 1999.
5. Tirupathi.R.Chandrupatla and Ashok.D.Belegundu, Introduction to Finite elements in Engineering, Prentice-Hall of India Pvt, Ltd, 2nd Edition, 2000.
6. Robert D.Cook, David S.Malkus and Mickael E.Plesha, Concepts and Applications of Finite Element Analysis, John Wiley&sons, New York, 2002.

07RA008 Advanced Refrigeration and Air-conditioning systems

L T P M
3 0 0 100

UNIT I **9hrs** Refrigeration and vapour compression systems - cycles using P-H and T-S charts - design and selection of condenser, evaporator, cooling tower-Matching of components - Design of expansion devices and its sizing - Design of refrigerant pipe lines.

UNIT II **9hrs** Air distribution system – duct –types, losses, aspect ratio - Duct layout and duct insulation and duct sizing-duct design procedures-duct piping and piping materials – duct vibration – air filters – clean rooms.

UNIT III **9hrs** Cooling load calculations - design of comfort air conditioning systems - cooling and dehumidifying-air washer-design and selection. Air conditioning requirements for hotels, operation theaters, computer room library, textile mills and television studio.

UNIT IV **8hrs** Performance characteristics of refrigeration system and equipment - compressor (reciprocating, rotary, scroll and centrifugal) - capacity of compressor – condenser - flow control devices.

UNIT V **10hrs** Energy utilization and conservation-energy standards and codes, sources of energy –principle of energy utilization-measuring energy conservation-cooling equipment-heat pump-heating equipment-pump and fans-COP and EER-The degree of day method-air to air heat recovery-thermal storage-commissioning and evaluation of system performance-operation and maintenance-preventive maintenance-service-trouble shooting.

Total Hours - 45hrs

REFERENCES

1. Edward Pita, Air-conditioning Principles and Systems, Wiley, New York,1981.
2. B.L. Balani, Refrigeration and Air-conditioning, Khanna Publications, 2005.
3. S. Kumar, Refrigeration and Air-conditioning, Rainbow Book Company, 2005.
4. C. P. Arora, Refrigeration & Air conditioning, Tata-McGraw Hill Publishers, 2004.

07RA009 DESIGN AND OPTIMIZATION OF THERMAL SYSTEMS
(Syllabus common to ME- IC Engg., R & AC and Energy Engg.,)

L T P M
3 0 0 100

UNIT I

5hrs

Basics of fluid flow and heat transfer required for design of thermal systems, mathematical analysis, regression analysis and equation fitting.

UNIT II

12hrs

Heat exchangers, fans, pumps, compressors, turbines, piping, ducts, etc. efficiency analysis.

UNIT III

10hrs

steady state simulation of thermal systems, using successive substitution, Newton Raphson Method, examples.

UNIT IV

10hrs

Optimization of thermal systems, using Lagrange multipliers, search methods (e.g.steepest ascent),geometric programming, dynamic programming, linear programming and stochastic methods.

UNIT V

8hrs

System identification, parameter estimation, thermodynamic properties, graph theory and object-oriented simulation.

Total Hours - 45hrs

REFERENCES

1. Stoecker W.G., "Design of Thermal Systems" , McGraw Hill, 2001.
2. Smith T.F., "Thermal Fluid System Design Notes", The University of Iowa, Iowa City, 2001.
3. Jaluria Y., " Design and Optimization of Thermal Systems", McGraw Hill, 1998.
4. Burmeister L.C., "Thermal Fluid System Design", Prentice Hall, 1998.
5. Bejan A. Tsatsaronics G. and Moran M., "Thermal Design and Optimization", John Wiley & Sons, New York, 1998.
6. Arora J.S., Introduction to Optimum Design", McGraw Hill, 1989.

07RA010 ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL

UNIT I

9hrs

Global atmospheric change – Green house gases and effect –Global warming–Ozone Depletion –Acid rain, Natural Cycles - Mass and Energy Transfer – Material balance – Environmental chemistry and biology – Impacts – Environmental legislations.

UNIT II

9hrs

Pollutants - Sources and Effect – Air Pollution meteorology - natural purification process - Diffusion Theories – Modeling- dispersion and plume raise and numerical problems - Air sampling and measurement - Control Methods and Equipments - Issues in Air Pollution control

UNIT III

9hrs

Water resources - Water Pollutants – Composition, Characteristics and analysis of waste water, Advanced Wastewater treatment - unit operation- physical, chemical, biological, Disposal of Sludge - Monitoring compliance with Standards

UNIT IV

9hrs

Sources and Classification – Solid waste – Hazardous waste - Characteristics, Collection and Transportation - Disposal – Reuse and recycling - Biogas and Energy Recovery Processes– Waste minimization

UNIT V

9hrs

Noise Pollution and its impact - Oil Pollution - Pesticides - Instrumentation for EIA test - Instrumentation related with parameter of pollutants, – Environment Impact assessment for various projects – Case studies

Total Hours - 45

TEXT BOOKS

1. G.Masters (2003): Introduction to Environmental Engineering and Science, Prentice Hall of India Pvt Ltd, New Delhi.
2. H.S.Peavy, D.R..Rowe, G.Tchobanoglous (1985): Environmental Engineering - McGraw- Hill BookCompany, NewYork.

REFERENCE BOOKS

- 1 H.Ludwig, W.Evans (1991): Manual of Environmental Technology in Developing Countries, . International Book Company, Absecon Highlands, N.J.
2. Arcadio P Sincero and G. A. Sincero, (2002): Environmental Engineering – A Design Approach, Prentice Hall of India Pvt Ltd, New Delhi.