ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

M.E. THERMAL ENGINEERING (with Specialisation in Refrigeration & Airconditioning)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I. To motivate students to excel in research and to practice the technologies in the field of Thermal Engineering with Specialization in Refrigeration and Air-conditioning.

II. To provide students with a solid understanding of Thermal Engineering fundamentals and applications required to solve real life problems.

III. To train students with scientific and Engineering knowledge so as to comprehend, analyze, and design products and systems pertaining to Refrigeration and Airconditioning.

IV. To inculcate an attitude to face challenging Thermal problems with confidence through multidisciplinary team approach.

V. To provide students with an academic environment that is aware of professional excellence and leadership through interaction with practicing engineers and professional bodies.

PROGRAMME OUTCOMES (POs):

On successful completion of the programme,

1. Graduates will demonstrate knowledge of Numerical methods in solving complex thermal problems in general and Refrigeration and Air conditioning problems in particular.
2. Graduates will be able to identify, define and solve Thermal Engineering problems.
3. Graduates will have the potential to design and conduct experiments, analyze and interpret data.
4. Graduates will demonstrate an ability to design systems, components or process as per needs and specifications.
5. Graduates will have a broad perspective of the Thermal behavior of commercial and Industrial Refrigeration and Air conditioning systems.
6. Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
7. Graduates will demonstrate a sincere attitude towards professional and ethical responsibilities.
8. Graduates will be able to understand published literature and technically communicate.
9. Graduates will be employable in different Refrigeration and Airconditioning industries.
10. Graduates will also possess a sound understanding of the scope for Research and development in the field of R & AC.

Mapping of PEOs with POs

Programme Educational Objectives	Programme Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
II	✓				✓		✓			
III		✓		✓	✓	✓	✓			
IV	✓	✓					✓	✓	✓	
V		✓	✓						✓	✓

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
YEAR 1	SEM 1	Advanced Numerical Methods	✓		✓		✓					
		Advanced Heat Transfer				✓	✓					
		Advanced Thermodynamics	✓									
		Refrigeration Systems	✓									
		Elective I										
		Elective II										
		Refrigeration and Airconditioning Lab	✓		✓							
	SEM 2	Airconditioning Systems	✓								✓	
		Instrumentations for Thermal Systems		✓	✓	✓		✓			✓	
		Design of Condensers Evaporators and Cooling Towers	✓		✓	✓		✓				
		Elective III										
		Elective IV										
		Elective V										
		Seminar		✓		✓	✓	✓				
		Analysis and Design Lab for Thermal Engineering	✓	✓				✓				
YEAR 2	SEM 1	Design and Optimization of Thermal Energy Systems										
		Elective VI										
		Elective VII										
		Project Work Phase I		✓		✓			✓	✓	✓	✓
	SEM 2	Project Work Phase II		✓		✓			✓	✓	✓	✓

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M. E. THERMAL ENGINEERING (with Specialisation in Refrigeration & Airconditioning)

SEMESTER I

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	IC7151	Advanced Heat Transfer	FC	4	4	0	0	4
2.	IC7152	Advanced Thermodynamics	FC	4	4	0	0	4
3.	MA7154	Advanced Numerical Methods	FC	4	4	0	0	4
4.	RA7101	Refrigeration Systems	PC	3	3	0	0	3
5.		Elective I	PE	3	3	0	0	3
6.		Elective II	PE	3	3	0	0	3
PRACTICALS								
7	RA7111	Refrigeration and Airconditioning Lab	EEC	4	0	0	4	2
			TOTAL	**25**	**21**	**0**	**4**	**23**

SEMESTER II

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	IC7251	Instrumentation for Thermal Systems	PC	3	3	0	0	3
2.	RA7201	Air Conditioning Systems	PC	3	3	0	0	3
3.	RA7202	Design of Condensers, Evaporators and Cooling Towers	PC	3	3	0	0	3
4.		Elective III	PE	3	3	0	0	3
5.		Elective IV	PE	3	3	0	0	3
6.		Elective V	PE	3	3	0	0	3
PRACTICALS								
7.	RA7211	Analysis and Design Lab for Thermal Engineering	EEC	4	0	0	4	2
8.	RA7212	Seminar	EEC	2	0	0	2	1
			TOTAL	**24**	**19**	**0**	**6**	**21**

SEMESTER III

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	RA7301	Design and Optimization of Thermal Energy Systems	PC	3	3	0	0	3
2.		Elective VI	PE	3	3	0	0	3
3.		Elective VII	PE	3	3	0	0	3
PRACTICALS								
4.	RA7311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER IV

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	RA7411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF DEGREE = 71

Note: Students can also opt for electives from other streams of Thermal Engg. Viz. M.E. ICE and M.E. Energy Engg. which will be also considered as Electives from same Department

FOUNDATION COURSES (FC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Advanced Numerical Methods	FC	4	4	0	0	4
2.		Advanced Thermodynamics	FC	4	4	0	0	4
3.		Advanced Heat Transfer	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Refrigeration Systems	PC	3	3	0	0	3
2.		Air Conditioning Systems	PC	3	3	0	0	3
3.		Design of condensers, evaporators and cooling towers	PC	3	3	0	0	3
4.		Design and Optimization of	PC	3	3	0	0	3

		Thermal Energy Systems						
5.		Instrumentation for Thermal Systems	PC	3	3	0	0	3
6.		Refrigeration and Airconditioning Lab	PC	4	0	0	4	2
7.		Analysis and Design Lab for Thermal	PC	4	0	0	4	2

PROFESSIONAL ELECTIVES (PE)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	EY7075	Environmental Engineering and Pollution Control	PE	3	3	0	0	3
2.	EY7251	Energy Efficient Buildings Design	PE	3	3	0	0	3
3.	IC7071	Computational Fluid Dynamics	PE	3	3	0	0	3
4.	RA7001	Air Handling Systems Design	PE	3	3	0	0	3
5.	RA7002	Building Architecture and HVAC Systems	PE	3	3	0	0	3
6.	RA7003	Cryogenic Engineering	PE	3	3	0	0	3
7.	RA7004	Design of Clean Rooms and Containment Areas	PE	3	3	0	0	3
8.	RA7005	Energy Conservation in HVACR Systems	PE	3	3	0	0	3
9.	RA7006	Erection and Maintenance of Refrigeration and Air Conditioning Equipments	PE	3	3	0	0	3
10.	RA7007	Fans, Blowers and Compressor in Air Conditioning Systems	PE	3	3	0	0	3
11.	RA7008	Food Processing, Preservation and Transport	PE	3	3	0	0	3
12.	RA7009	Indoor Air Quality and Control	PE	3	3	0	0	3
13.	RA7010	Industrial Refrigeration Systems	PE	3	3	0	0	3
14.	RA7011	Materials for Low Temperature Applications	PE	3	3	0	0	3
15.	RA7012	Refrigeration Machinery and Components	PE	3	3	0	0	3
16.	RA7013	Solar Systems for Buildings	PE	3	3	0	0	3

17.	RA7014	Sorption Heating and Cooling Systems	PE	3	3	0	0	3
18.	RA7015	Testing, Balancing and Commissioning of HVAC and R Systems	PE	3	3	0	0	3
19.	RA7071	Fuzzy Logic and Neural Networks	PE	3	3	0	0	3
20.	SY7071	Solar Refrigeration and Air Conditioning	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Seminar	EEC	2	0	0	2	1
2.		Project Work Phase I	EEC	12	0	0	12	6
3.		Project Work Phase II	EEC	24	0	0	24	12

IC7151 ADVANCED HEAT TRANSFER

L	T	P	C
4	0	0	4

OBJECTIVES

- To develop the ability to use the heat transfer concepts for various applications like finned systems, turbulence flows, high speed flows.
- To analyse the thermal analysis and sizing of heat exchangers and to learn the heat transfer coefficient for compact heat exchanges.
- To achieve an understanding of the basic concepts of phase change processes and mass transfer.

UNIT I CONDUCTION AND RADIATION HEAT TRANSFER 12

One dimensional energy equations and boundary condition - three-dimensional heat conduction equations - extended surface heat transfer - 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 II TURBULENT FORCED CONVECTIVE HEAT TRANSFER 12

Momentum and energy equations - turbulent boundary layer heat transfer - mixing length concept - turbulence model – k Є model - analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube - high speed flows

UNIT III PHASE CHANGE HEAT TRANSFER 12

Condensation with shears edge on bank of tubes - boiling – pool and flow boiling, Heat transfer enhancement techniques

UNIT IV HEAT EXCHANGERS 12

Heat exchanger –Є – NTU approach and design procedure - compact heat exchangers.Plate heat exchangers, Mini and Micro channel heat exchangers, Heat pipes.

UNIT V MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION 12

Mass transfer - vaporization of droplets - combined heat and mass transfers - heat transfer correlations in various applications like I.C. engines - compressors and turbines

TOTAL = 60 PERIODS

OUTCOME

- On successful completion of this course the student will be able to apply the concept of heat transfer to thermodynamic engines and systems

REFERENCES

1. Yunus A.Cengal, Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.
2. Holman.J.P, Heat Transfer, Tata Mc Graw Hill, 2002.
3. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985
4. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
5. Nag.P.K, Heat Transfer, Tata McGraw-Hill, 2002
6. Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004
7. Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.

IC 7152	ADVANCED THERMODYNAMICS	L	T	P	C
		4	0	0	4

OBJECTIVES:

- To demonstrate the use of correlations for the important properties..
- To achieve an understanding of real gas equations and multi component systems.
- To predict the availability and irreversibility associated with the thermodynamic processes and Chemical availability of reactive systems
- To analyse the actual cycles of SI and CI engines
- To apply the first and second law of thermodynamics to reactive systems.

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, ClausiusClayperon Equation, Joule- Thomson Coefficient, Bridgeman Tables for Thermodynamic Relations.

UNIT II REAL GAS BEHAVIOUR AND MULTI-COMPONENT SYSTEMS 12

Equations of State (mention three equations), Fugacity, Compressibility, Principle of Corresponding States, Use of generalised charts for enthalpy and entropy departure, fugacity coefficient, Lee- Keslergeneralised 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 CHEMICAL AVAILABILITY 12

Introduction, Reversible work, Availability, Irreversibility and Second-Law Efficiency for a closed System and Steady-State Control Volume. Availability Analysis of Simple Cycles. Chemical availability, Environmental state, Air-conditioning processes. Fuel Chemical availability, availability analysis of chemical processes – steam power plant, combustion and heat transfer losses, preheated inlet air, problems.

UNIT IV FUEL – AIR CYCLES AND THEIR ANALYSIS 12

Ideal Models of Engine Processes, Fuel–Air Cycle Analysis – SI Engine cycle Simulation, CI Engine Cycle Simulation, Results of Cycle Calculations, Over expanded Engine Cycles, Availability Analysis of Engine Processes – Availability Relationships – Entropy changes in Ideal Cycles – Availability Analysis of Ideal Cycles – Effect of Equivalent Ratio, Comparison with Real Engine Cycles.

UNIT V THERMO CHEMISTRY 12

Ideal gas laws and properties of Mixtures, Combustion Stoichiometry, Application of First Law of Thermodynamics – Heat of Reaction – Enthalpy of Formation – Adiabatic flame temperature. Second law of Thermodynamics applied to combustion – entropy, maximum work and efficiency Chemical equilibrium: - Equilibrium combustion products. Dynamic properties of working fluids: - Unburned mixture – Low temperature combustion products – High temperature combustion products, problems.

TOTAL : 60 PERIODS

OUTCOME

- On successful completion of this course the student will be able to apply the law of thermodynamics to thermal systems.

REFERENCES:
1. Kenneth Wark., J. R, Advanced Thermodynamics For Engineers, McGraw-Hill Inc., 1995.
2. Yunus A. Cengel and Michael A . Boles, Thermodynamics, McGraw-Hill Inc., 2006.
3. B.P. Pundir, I.C. engine combustion and emissions. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1988.
4. Holman,J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988
5. Smith, J.M. and Van Ness., H.C., Introduction to Chemical Engineering Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1987.
6. Sonntag, R.E., and Van Wylen, G, Introduction to Thermodynamics, Classical and Statistical Third Edition, John Wiley and Sons, 1991
7. Sears, F.W. and Salinger G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Third Edition, Narosa Publishing House, New Delhi, 1993.
8. DeHotf, R.T., Thermodynamics in Materials Science, McGraw-Hill Inc., 1993.
9. Rao, Y.V.C., Postulational and Statistical Thermodynamics, Allied Publisher Limited, New Delhi,1994.

MA7154	**ADVANCED NUMERICAL METHODS**	**L T P C**
		4 0 0 4

OBJECTIVES

- To impart knowledge on numerical methods that will come in handy to solve numerically the problems that arise in engineering and technology. This will also serve as a precursor for future research

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, inverse power method, Faddeev – Leverrier Method

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION 12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme- Stability of above schemes.

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 12

Partial differential equations – Finite element method - orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method

TOTAL = 60 PERIODS

OUTCOME

- It helps the students to get familiarized with the numerical methods which are necessary to solve numerically the problems that arise in engineering.

REFERENCES

1. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
2. Gupta S.K., "Numerical Methods for Engineers", New Age Publishers, 1995
3. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", Cengage Learning, India Edition, New Delhi, 2009.
4. Jain M. K., Iyengar S. R., Kanchi M. B., Jain , "Computational Methods for Partial Differential Equations", New Age Publishers,1993.
5. Morton K.W. and Mayers D.F., "Numerical solution of partial differential equations", Cambridge University press, Cambridge, 2002.

RA7101 REFRIGERATION SYSTEMS **L T P C**
3 0 0 3

OBJECTIVES

- Teaching cycle analysis pertaining to Refrigeration systems.
- Teaching performance of system components and their balancing in cycles.
- Teaching the significance of Refrigerants and their impact on the environment

UNIT I INTRODUCTION AND REFRIGERANTS 6

Applications, Unit of refrigeration – Ideal cycles - Classification of Refrigerants, Refrigerant properties, Oil Compatibility, Environmental Impact-Montreal / Kyoto protocols-Eco Friendly Refrigerants, alternatives to HCFCS, Secondary Refrigerants

UNIT II REFRIGERATION CYCLES – ANALYSIS 12

Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle- conditions for high COP-deviations from ideal vapor compression cycle, Multipressure System, Cascade Systems- Analysis. Vapor Absorption Systems-Aqua Ammonia & Li-Br Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles, Heat pumps

UNIT III REFRIGERATION SYSTEM COMPONENTS 9

Compressor- Types, performance, Characteristics, Types of Evaporators & Condensers and their functional aspects, Expansion Devices and their Behaviour with fluctuating load, cycling controls

UNIT IV SYSTEM BALANCING 9

.Balance points and system simulation - compressor, condenser, evaporator and expansion devices performance – Complete system performance; graphical and mathematical analysis – sensitivity analysis

UNIT V ELECTRICAL DRIVES & CONTROLS 9

Electric circuits in Refrigeration systems, Types of Motors, Starters, Relays, Thermostats, Microprocessor based control systems, Pressure controls and other controls, Acoustics and noise controls

TOTAL = 45 PERIODS

OUTCOME

- The student will be able to understand different refrigeration systems and do the design of the same for a particular applications

REFERENCES
1. Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version, 2001.
2. Stoecker W.F., Refrigeration and Air conditioning, McGraw-Hill Book Company, 1989.
3. Jordan and Priester, Refrigeration and Air conditioning 1985.
4. Langley, Billy C., ‘Solid state electronic controls for HVACR’ Prentice-Hall 1986.
5. Rex Milter, Mark R.Miller., Air conditioning and Refrigeration, McGraw Hill, 2006
6. Arora, C.P., Refrigeration and Air conditioning, McGraw Hill, 3rd Ed., 2010.

RA7111 REFRIGERATION AND AIR CONDITIONING LAB

L	T	P	C
0	0	4	2

OBJECTIVES
- To understand the behavior of system at different operating conditions
- To understand the influence of individual components on the Overall performance of the system.
- To understand the usage of different refrigeration tools.

LIST OF EXPERIMENT
1. Studies on various components of Refrigeration and Air conditioning systems and tools
2. Performance studies on vapour compression refrigeration system with air / water cooled condensers
3. Performance studies on heat pump for different indoor and outdoor conditions
4. Performance study on Air conditioning system
5. Freeze drying of Agro products
6. Performance studies on cooling towers
7. Computation of pump & pumping system characteristics (pump curve, system curve and BEP)
8. Analysis on Blowers/fans characteristic curves
9. Studies on Heat Exchangers and their performance
10. Indoor air quality measurement and analysis

EQUIPMENT REQUIREMENTS
Cut section model of various Refrigeration and Air conditioning system components, Refrigeration and Air conditioning tools, Refrigerator with calorimeter Heat pump setup, Cooling tower experimental setup, Window air conditioner with air-cooled and water-cooled condenser, Freeze dryer experimental set-up, Pump and pumping systems experimental test rig, Blowers / fans test rig, Heat exchanger set up with controls, Instruments for IAQ

TOTAL = 60 PERIODS

OUTCOME
- On successful completion of this course, the student will be able to understand the basic analysis of any refrigeration system and design the heat exchanger for a particular application.

IC7251 INSTRUCTIONS

IC7251 INSTRUMENTATION FOR THERMAL SYSTEMS **L T P C**
3 0 0 3

OBJECTIVES

- To understand the working of measuring instruments and errors associated with them
- To carry out error analysis and uncertainty of measurements
- To develop skills on the measurement and control applicable to a thermal systems

UNIT I MEASUREMENT CHARACTERISTICS 8

Introduction to measurements, Errors in measurements, Statistical analysis of data, Regression analysis, correlation, estimation of uncertainty and presentation of data, design of experiments – Experimental design factors and protocols

UNIT II MEASUREMENTS IN THERMAL SYSTEMS 10

Basic Electrical measurements, Transducers and its types, Signal conditioning and processing - Measurement of temperature, pressure, velocity, flow – basic and advanced techniques, and radiation properties of surfaces

UNIT III MESAURMENT OF FUEL PROPERTIES AND POLLUTANTS 10

Thermo / Physical / Chemical and transport properties of solids, liquids and gaseous fuels, Analysers – Flame Ionisation Detector, Non-Dispersive Infrared Analyser, Chemiluminescent detector, Smoke meters, and Gas chromatography

UNIT IV CONTROL SYSTEMS, COMPONENTS AND CONTROLLERS 10

Introduction, Open and closed loop control systems, Transfer function. Types of feedback and feedback control system characteristics – Control system parameters – DC and AC servomotors, servo amplifier, potentiometer, synchro transmitters, synchro receivers, synchro control transformer, stepper motors - Continuous, Discontinuous and Composite control modes – Analog and Digital controllers

UNIT V DESIGN OF MEASUREMENT AND CONTROL SYSTEMS 7

Data logging and acquisition - Sensors for error reduction, elements of computer interfacing, Timers, and Counters, Designing of measurement and control systems for specific applications - Fault finding – Computer based controls

TOTAL = 45 PERIODS

OUTCOME

- On successful completion of this course the student will be able to plan their experiments and understand the suitability, accuracy and uncertainty associated with the instrument used for measuring thermal system parameters**.**

REFERENCES

1. Holman, J.P., Experimental methods for Engineers, Tata McGraw-Hill, 7th Ed.2001.
2. Barney G.C, Intelligent Instrumentation, Second Edition, Prentice Hall of India, 1988.
3. Bolton.W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001.
4. Doblin E.O, Measurement System Application and Design, Second Edition, McGraw Hill, 1978.
5. Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis Tata McGraw Hill, New Delhi, 2nd Edition 2003.
6. Morris.A.S, Principles of Measurements and Instrumentation, Prentice Hall of India, 1998.

RA7201 AIR CONDITIONING SYSTEMS L T P C
3 0 0 3

OBJECTIVES

- To learn the psychometric concepts underlying Air conditioning process.
- To learn the design features and load estimation principles of specific Air conditioning system.
- To learn about the critical auxiliary systems such as air distribution circuits, water distribution circuits etc.

UNIT I PSYCHROMETRICS 9

Moist Air properties, use of Psychrometric Chart, Various Psychrometric processes, RSHF, GSHF, By pass factor, Air Washer, Adiabatic Saturation. Enthalpy potential and its insights

UNIT II LOAD ESTIMATION 9

Thermal comfort – Design conditions – Solar Radiation-Heat Gain through envelopes – Infiltration and ventilation loads – Internal loads – Procedure for heating and cooling load estimation.

UNIT III AIR CONDITIONING PROCESSES AND SYSTEMS 9

Summer and winter Air conditioning processes-ERSHF- High latent heat load applications. Radiant cooling systems ,Thermal distribution systems – Single, multi zone systems, terminal reheat systems, Dual duct systems, variable air volume systems, water systems and Unitary type systems.

UNIT IV AIR DISTRIBUTION AND CONTROL 9

Flow through Ducts , Static & Dynamic Losses , Diffusers , Duct Design–Equal Friction Method, System Balancing , Fans & Duct System Characteristics , Fan Arrangement, Air Handling Units and Fan Coil units – Control of temperature, humidity, air flow and quality

UNIT V APPLICATIONS 9

Automotive air conditioning, All outdoor air applications, Clean room, Evaporative cooling.

TOTAL = 45 PERIODS

OUTCOME

- On successful completion of this course the student will be able to understand conceptually the design of a HVAC system

REFERENCES

1. Arora C.P., Refrigeration and Air Conditioning, Tata McGraw Hill Pub. Company, 2010
2. ALI VEDAVARZ, SUNIL KUMAR, Mohammed Iqbal, Hussain Handbook of Heating**,** Ventilation and Air conditioning for Design Implementation, Industrial press Inc, 2007.
3. ASHRAE , Fundamentals and equipment , 4 volumes-ASHRAE Inc. 2005
4. Jones, Air Conditioning Engineering, Edward Amold pub. 2001.
5. Carrier Air Conditioning Co., Handbook of Air Conditioning Systems design, McGraw Hill,1985.
6. Langley, Billy C. Refrigeration and Air Conditioning Ed. 3, Engie wood Cliffs (N.J) Prentice Hall 1986.

RA7202 DESIGN OF CONDENSERS, EVAPORATORS AND COOLING TOWERS **L T P C 3 0 0 3**

OBJECTIVES

- To provide design procedures in designing of different types of condensers, evaporators and cooling towers

UNIT I INTRODUCTION 5

Principles of heat transfer, Types of heat exchangers, Standard Representation, Parts description, TEMA Classifications

UNIT II CONDENSERS 10

Estimation of heat transfer coefficient, Fouling factor, Friction factor. Design procedures, Wilson plots, designing different types of condensers, BIS Standards

UNIT III EVAPORATORS 10

Different types of evaporators, Design procedure, Selection procedure, Thermal Stress calculations, matching of components, Design of evaporative condensers

UNIT IV COOLING TOWERS 10

Types of Cooling towers, Analytical and graphical design procedures, Tower Characteristics Parametric analysis, Packaging, Flow control strategies and energy saving opportunities, Assessment of cooling towers

UNIT V COMPACT AND PLATE HEAT EXCHANGER 10

Types – Merits and Demerits – Design of compact heat exchangers, plate heat exchangers, Mixing of plates, performance influencing parameters, limitations

TOTAL = 45 PERIODS

OUTCOME

- On successful completion of this course, the student will be able to design different types of condensers, evaporators and cooling towers for HVAC applications

REFERENCES

1. Arthur, P. Frass, Heat Exchanger Design, John Wiley and Sons, 1988.
2. Kern K.H., Process heat transfer, McGraw-Hill, 2002.
3. Sarit Kumar Das, Process Heat Transfer, Narosa Publishing House, 2009.
4. Lieke Wang, Bengt Sunden, Raj M. Manglik, Plate Heat Exchangers: Design, Applications and Performance, WIT Press, 2007.
5. TEMA Hand book, Tubular Exchanger Manufacturer Association, New York, 2004.

RA7211 ANALYSIS AND DESIGN LAB FOR THERMAL ENGINEERING **L T P C**
0 0 4 2

OBJECTIVES

- To builds a solid foundation in the MATLAB, CFD software
- To encourage a “hand’s – on” approach to solving heat transfer problems
- To understand the behavior of system at different operating conditions

LIST OF EXPERIMENT

1. Heat exchanger analysis – NTU method
2. Heat exchanger analysis – LMTD method
3. Convection heat transfer analysis
4. Lumped heat transfer analysis
5. Radiation heat transfer analysis – Emissivity
6. Critical radius of insulation
7. Conduction heat transfer analysis
8. Condensation heat transfer analysis
9. Simulation of various refrigeration cycles
10. Simulation of air conditioning processes

Equipment requirements

Dynamic Linking of Mat Lab and Ref Prop Software
Simple CFD Problems For Practice
Simulation Lab – Requirement:
1. Software - Modeling Software Like Proe, Gambit, Ansys Etc analysis Software Like Ansys, Fluent, Cfx, Etc ,Equation Solving Software Like Matlab, IMST, Engineering Equation Solver
2. Every Students in a Batch must be Provided with a Terminal

TOTAL = 60 PERIODS

OUTCOME

- On successful completion of this course, the student can solve and analyse the practical heat transfer, refrigeration and air conditioning problems using MATLAB & CFD software

RA7212 SEMINAR **L T P C**
0 0 2 1

OBJECTIVES

- During the seminar session each student is expected to prepare and present a topic on refrigeration and air conditioning related issues / technology, for a duration of about 30 minutes.
- In a session of three periods per week, 4 students are expected to present the seminar.
- A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.

Students are encouraged to use various teaching aids such as power point presentation and demonstrative models.

TOTAL = 30 PERIODS

OUTCOME

- On successful completion of this course, the student will be able to present his thoughts and organize the material for presentation for a particular application / process / systems.

RA7301 DESIGN AND OPTIMIZATION OF THERMAL ENERGY SYSTEMS **L T P C 3 0 0 3**

OBJECTIVES

- To learn basic principles underlying piping, pumping, heat exchangers; modelling and optimization in design of thermal systems.
- To develop representational modes of real processes and systems.
- To optimization concerning design of thermal systems

UNIT I DESIGN CONCEPTS 9

Design Principles, Workable Systems, Optimal Systems, Matching of System Components, Economic Analysis, Depreciation, Gradient Present Worth factor, modelling overview - levels and steps in model development - Examples of models – curve fitting and regression analysis

UNIT II MODELLING AND SYSTEMS SIMULATION 10

Modelling of thermal energy systems – heat exchanger - solar collectors – distillation - rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of nonlinear algebraic equations - successive substitution - Newton Raphson method- examples of thermal systems simulation

UNIT III OPTIMISATION 10

Objectives - constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions. Constrained optimization - Lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis - New generation optimization techniques – examples

UNIT IV DYNAMIC BEHAVIOUR 8

Steady state Simulation, Laplace Transformation, Feedback Control Loops, Stability Analysis, Non-Linearities

UNIT V APPLICATIONS AND CASE STUDIES 8

Case studies of optimization in thermal systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis

TOTAL = 45 PERIODS

OUTCOME

- Student will be able do to Simulation and Modelling of typical thermal energy systems
- Able to analysis effect of constraints on the performance of thermal energy systems
- Has a potential to do design HEN net work and perform Energy-Economic Analysis for a typical applications

REFERENCES

1. Stoecker W. F., Design of Thermal Systems, McGraw Hill Edition, 2011
2. Bejan A., George Tsatsaronis, Michael J. Moran, Thermal Design and Optimization, Wiley, 1996.
3. Kapur J. N., Mathematical Modelling, Wiley Eastern Ltd, New York, 1989.
4. Yogesh Jaluria , Design and Optimization of Thermal Systems , CRC Press , 2013
5. Rao S. S., Engineering Optimization Theory and Practice, New Age Publishers, 2010

RA7311 **PROJECT WORK PHASE I** **L T P C**
0 0 12 6

OBJECTIVES

- A research project topic may be selected either from published lists or from the creative ideas of the students themselves in consultation with their project supervisor.
- To improve the student research and development activities.

EVALUATION

Project work evaluation is based on Regulations of Credit system University Departments - Post graduate programmes of Anna University

TOTAL = 90 PERIODS

OUTCOME

- The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated in their project work phase – II.

RA7411 **PROJECT WORK PHASE II** **L T P C**
0 0 24 12

OBJECTIVES

- The objective of the research project work is to produce factual results of their applied research idea in the thermal Engineering, from phase – I.
- 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 Division.
- 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 Division based on oral presentation and the project report
- To improve the student research and development activities.

EVALUATION

- Project work evaluation is based on Regulations of Credit system University Departments - Post graduate programmes of Anna University

TOTAL = 180 PERIODS

OUTCOME

- The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated project outcome of the aimed work.

EY7075 ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL **L T P C 3 0 0 3**

OBJECTIVES

- To impart knowledge on the atmosphere and its present condition and, global warming and to detail on the sources of air, water and noise pollution and possible solutions for mitigating their degradation.

UNIT I INTRODUCTION 8

Man & Environment – Types of Pollution – Global Environmental issues – Environmental Impact Assessment – Global Warming Issues – CO2 Mitigation – Basic definition of Pollution Indicators –Noise Pollution

UNIT II WATER POLLUTION 9

Pollutants in Water & Wastewater – Physical and Chemical Treatment Methods – (An Overview) Neutralization – Aeration –Colour / Odour Removal - Sludge dewatering – Biological Treatment including Aerobic & Anaerobic Treatment

UNIT III AIR POLLUTION 10

Sources – Ambient Air Quality Standards – Emission Limits – Equipment for Ambient Air & Stack Monitoring – Principles of operation of Particulate Control Equipments (ESPs, Bag Filters, Cyclone Separators etc.,) – Vehicular Pollution and its Control

UNIT IV SOLID & HAZARDOUS WASTE MANAGEMENT 11

Types & Sources – Types (Municipal, Biomedical, Industrial, Hazardous etc.,) – Waste Generation –Composition – Physical / Chemical / Biological Properties – Transformation Technologies for Waste Treatment – Landfill Management – Leachate Generation – e Waste Disposal

UNIT V GLOBAL WARMING & CLIMATE CHANGE 7

Impact of Global Warming / Climate Change on various sectors – Green House Gases & Effect –Carbon Cycle – CDM – Carbon Trading – Carbon Sequestration – Carbon Capture & Storage - UNFCCC – IPCC Protocols

TOTAL = 45 PERIODS

OUTCOME

- Types and effects of each type of pollution on man – earth will be made known.
- Technical aspects of Global Warming will make them understand the impact they have on climate
- Cursory / superficial formation - the students – had in Hazardous waste, waste disposal hitherto will be deep & sensible enough after studying this subject

REFERENCES

1. G. Masters: Introduction to Environmental Engineering and Science, Prentice Hall of India Pvt Ltd,New Delhi, 2003
2. Peavy, H.S. and D.R. Rowe, G.Tchobanoglous: Environmental Engineering - McGraw-Hill BookCompany, NewYork, 1985
3. Ludwig, H. W.Evans: Manual of Environmental Technology in Developing Countries, International Book Company, Absecon Highlands, N.J, 1991
4. Arcadio P Sincero and G. A. Sincero, Environmental Engineering – A Design Approach,Prentice Hall of India Pvt Ltd, New Delhi, 2002

EY7251 ENERGY EFFICIENT BUILDINGS DESIGN L T P C
3 0 0 3

OBJECTIVES

- To learn the green buildings concepts applicable to modern buildings and to Acquaint students with the principle theories materials, construction techniques and to create energy efficient buildings

UNIT I INTRODUCTION 9

Conventional versus Energy Efficient buildings – Historical perspective - Water – Energy – IAQ requirement analysis – Future building design aspects – Criticality of resources and needs of modern living

UNIT II LANDSCAPE AND BUILDING ENVELOPES 9

Energy efficient Landscape design - Micro-climates – various methods – Shading, water bodies- Building envelope: Building materials, Envelope heat loss and heat gain and its evaluation, paints, Insulation, Design methods and tools

UNIT III HEATING, VENTILATION AND AIR-CONDITIONING 9

Natural Ventilation, Passive cooling and heating - Application of wind, water and earth for cooling, evaporative cooling, radiant cooling – Hybrid Methods – Energy Conservation measures, Thermal Storage

UNIT IV HEAT TRANSMISSION IN BUILDINGS 9

Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, wall and windows; Heat transfer due to ventilation/infiltration, internal heat transfer; Solar temperature; Decrement factor; Phase lag. Design of daylighting; Estimation of building loads: Steady state method, network method, numerical method, correlations; Computer packages for carrying out thermal design of buildings and predicting performance.

UNIT V PASSIVE COOLING & RENEWABLE ENERGY IN BUILDINGS 9

Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth air-tunnel. Introduction of renewable sources in buildings, Solar water heating, small wind turbines, Standalone PV systems, Hybrid system – Economics

TOTAL = 45 PERIODS

OUTCOME

Student will be able to do
(a) The energy audit in any type for buildings and suggest the conservation measures.
(b) Provide the renewable energy systems for the buildings

REFERENCES

1) Krieder, J and Rabi, A., Heating and Cooling of buildings: Design for Efficiency, Mc Graw Hill, 1994.
2) Ursala Eicker, “Solar Technologies for buildings”, Wiley publications, 2003.
Guide book for National Certification Examination for Energy Managers and Energy Auditors (Could be downloaded from www.energymanagertraining.com)

IC 7071 **COMPUTATIONAL FLUID DYNAMICS** **L T P C**
3 0 0 3

OBJECTIVES

- This course aims to introduce numerical modeling and its role in the field of heat, fluid flow and combustion it will enable the students to understand the various discretisation methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.
- To develop finite volume discretized forms of the CFD equations.
- To formulate explicit & implicit algorithms for solving the Euler Equations & Navier Strokes Equations.

UNIT I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES 8

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer – Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretisation techniques using finite difference methods – Taylor's Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II DIFFUSION PROCESSES : FINITE VOLUME METHOD 10

Steady one-dimensional diffusion, Two and three dimensional steady state diffusion problems, Discretisation of unsteady diffusion problems – Explicit, Implicit and Crank-Nicholson's schemes, Stability of schemes.

UNIT III CONVECTION - DIFFUSION PROCESSES : FINITE VOLUME METHOD 9

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.

UNIT IV FLOW PROCESSES : FINITE VOLUME METHOD 8

Discretisation of incompressible flow equations – Pressure based algorithms, SIMPLE, SIMPLER & PISO algorithms

UNIT V MODELLING OF COMBUSTION AND TURBULENCE 10

Mechanisms of combustion and Chemical Kinetics, Overall reactions and intermediate reactions, Reaction rate, Governing equations for combusting flows. Simple Chemical Reacting System (SCRS), Turbulence - Algebraic Models, One equation model & $k - \varepsilon$, $k - \omega$ models - Standard and High and Low Reynolds number models.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to apply the concepts of CFD to analyse the fluid flow and heat transfer in thermal systems.

REFERENCES:

1. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.
2. Ghoshdastidar, P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.
3. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
4. Subas and V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation,1980.
5. Jiyuan Tu, Guan Heng Yeoh, Chaogun Liu, "Computational Fluid Dynamics A Practical Approach" Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008
6. John D. Anderson . JR. "Computational Fluid Dynamics The Basics with Applications" McGraw-Hill International Editions, 1995.

RA7001 AIR HANDLING SYSTEMS DESIGN **L T P C**
3 0 0 3

OBJECTIVES

- To provide knowledge on various system configuration available of HVAC system.
- To understand the various steps involved in the design process.
- To learn to use standard practice and standard data

UNIT I BASIS CONCEPTS 10

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 II CONSTANT AND VARIABLE VOLUME SYSTEMS 9

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 III AIR SYSTEM: COMPONENTS 9

Fan-types, Construction, Arrangement, and Selection, Coil Characteristics and Accessories, Condensate control and Freeze-up protection

UNIT IV VENTILATION FOR CONTROL OF WORK ENVIRONMENT 10

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

UNIT V AIR CONTROLS 7

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

OUTCOME

- On successful completion of this course the student can demonstrates confidence, willingness to make, and implement decisions when investigating and designing HVAC systems

REFERENCES

1. Ysen - Yao Sun, Air handling system design, McGraw–Hill, Inc., NY – 1994
2. William A. Burges, Michael j. Ellen Becker, Robert D. Treitman, Ventilation for control of the work environment, A Wiley - Interscience Publication NY - 1989.
3. John I. Levenhagen, Donald H. Spethmann, HVAC controls and systems, McGraw – Hill international Edition. NY – 1992.
4. Allan T. Kirkpatrick & James S. Elleson, cold air distribution system design guide, ASHEAC - 1996 USA.
5. Shan K.Wang, Handbook of Air-conditioning and Refrigeration, McGraw -Hill, 2001.
6. SMACNA, HVAC System Duct Design, SMACNA Virginia - 1990.

RA7002 BUILDING ARCHITECTURE AND HVAC SYSTEMS **L T P C**
3 0 0 3

OBJECTIVES

- To impart knowledge on building architecture design and importance of HVAC systems
- To understand the energy consumption pattern of buildings and Utilization of Electrical Energy for Various applications

UNIT I CLIMATE AND ARCHITECTURE 9

Factors that determine climate , climatic variations–Natural and Manmade systems , Climate and Vernacular Architecture , Natural Cooling , Effects of Geographical Location

UNIT II WEATHER AND COMFORT 9

Climate and its components , Characteristics of human metabolic activities with changing climate, The sensation of heat and comfort zone, Design of solar shading devices and Mechanical ventilation systems.

UNIT III BUILDING MATERIALS–THERMAL STUDIES 9

Building Aesthetics and Thermal Infiltration, Periodic heat flow through building elements for weather conditions all round the air, tropical conditions

UNIT IV ENVIRONMENT INFLUENCE ON IAQ AIR QUALITY CONTROL 9

IAQ concepts, Air movement and Orientation of buildings, Landscaping in the tropics, Design consideration in different climate conditions, Tropical sky scrapers, Effects of greenery –Natural ventilation.

UNIT V HVAC SYSTEMS 9

HVAC systems, components, Building Automation and Energy Management–Passive and Active Systems, Solar heating, ECBC concept on buildings

TOTAL = 45 PERIODS

OUTCOME

- On successful completion of this course the student will be able to understand and appreciate the incorporation of building architectural aspects in the design procedures for HVAC systems

REFERENCES

1. Konya, A., Design Primer for Hot climates, Architectural Press, London, 1980.
2. Davis A. J. and Schubert P. P., Alternative Natural Energy Sources in Building Design , II
3. Edition, Van Nostrand Reinhold Co, New York, 1981.
4. ASHRAE Hand Book–HVAC Systems & Equipment 2011, HVAC Applications 2012, ASHRAE Inc. Atlanta
5. National Building Code of India , 2005, Bureau of Indian Standards
6. Givoni B., Man, Climate & Architecture, Barking Esser Applied Science, 1982.

RA7003 CRYOGENIC ENGINEERING L T P C
3 0 0 3

OBJECTIVES

- To builds a solid foundation in the fundamentals of cryogenics
- To encourage a “hand’s – on” approach to solving cryogenic problems
- To provide update cryogenic information

UNIT I INTRODUCTION 8

Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics- Mechanical, Space, Medicine, Gas industry, High energy physics, Superconductivity

UNIT II LIQUEFACTION CYCLES 10

Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve- Joule Thomson, Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claude Cycle Dual Pressure Cycle, Ortho-Para hydrogen conversion, Critical Components in Liquefaction Systems

UNIT III SEPARATION OF CRYOGENIC GASES 9

Binary Mixtures, T-C and H-C Diagrams , Principle of Rectification, Rectification Column Analysis-McCabe Thiele Method , Adsorption Systems for purification.

UNIT IV CRYOGENIC REFRIGERATORS 8

Joule-Thomson (J.T.) Cryocoolers, Stirling Cycle Refrigerators, Gifford-McMahon (G.M.) Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Magnetic Refrigerators

UNIT V HANDLING OF CRYOGENS 10

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

OUTCOME

- On successful completion of this course students can understand fundamentals of cryogenic cycles, cryogenic refrigerator, separation storage and transportation of cryogenic liquids

REFERENCES

1. Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
2. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press New York, 1989.
3. Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1988.
4. Herald Weinstock, Cryogenic Technology, 1969.
5. Robert W. Vance, Cryogenic Technology, Johnwiley & Sons, Inc., New York, London, 1969.
6. Mukhopadhay Mamata, Fundamentals of cryogenic engineering, PHI learning, 2010.

RA7004 DESIGN OF CLEAN ROOMS AND CONTAINMENT AREAS L T P C
3 0 0 3

OBJECTIVES

- To have knowledge of different classes of clean room standard for various application and Appreciation of quality concerns in designing clean room

UNIT I INTRODUCTION 9

The History of Clean rooms, Containment of Contamination, Supply of Liquid and Gases to Cleanrooms, International Standards for the Design of Cleanrooms, cleanroom Classes-Present Engineering Classes, New ISO Classification Standard, Bio contamination and Pharmaceutical Classes, Containment Classes, Other Standards for the Cleanroom, Abbreviations/ Source Code.

UNIT II CLEANROOM DESIGN 12

Microelectronics Industry-Manufacturing Semiconductor Circuits, Design Guidelines, Design Features–Air flow pattern, air quantity, Pharmaceutical Industry-Types of Pharmaceutical Processes, Facility Design, Environmental Cleanliness, Commissioning and Performance Qualification, Medical Device Industry, Biotechnology Industry

UNIT III HIGH EFFICIENCY AIR FILTRATION 7

Construction of High Efficiency Filters-HEPA Filters, ULPA Filters, Particle Removal Mechanisms, High Efficiency Filter Testing of High Efficiency Filters, Filter Housings for High Efficiency Filters, In service Tests for High Efficiency Filters , Filter Standards

UNIT IV CONSTRUCTIONAL FEATURES 10

General Considerations, Performance Criteria of Construction Materials and Surfaces, Specific Components, Materials and Features of Construction, Assembly, Materials for Services Pipework- Metallic Pipeline Materials, Polymeric Pipeline Materials

UNIT V COST AND ENERGY EFFICIENCY 7

Air Flow Rate Optimum for Cost, Optimization of Energy Consumption in Clean room Systems, Cost Indications

TOTAL = 45 PERIODS

OUTCOME

- Students will be able to understands the clean room requirements and able to design a system as per the requirements and also construct containment areas.

REFERENCES

1. Whyte W., Cleanroom Design , Second Edition , John Wiley & Sons , 1999
2. Bengt Ljungqvist and Berit Reinmuller CLEAN ROOM DESIGN: Minimizing Contamination Through Proper Design , CRC; 1 edition , 1996
3. Whyte W., Cleanroom Technology: Fundamentals of Design, Testing and Operation, Wiley, 2001.
4. David M. Carlberg , Cleanroom Microbiology for the Non-Microbiologist, Second Edition, CRC; 2nd edition, 2004

RA7005 ENERGY CONSERVATION IN HVACR SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES

- To learn energy audit and management practices on HVAC systems.
- Learn to analysis heat conversion systems for HVAC applications
- To update new system/ equipments for the utilization of both thermal and electrical energy optimally

UNIT I FIRST AND SECOND LAW ANALYSIS 8

Thermodynamics of Energy conservation-Second law -Exergy-Irreversibility and efficiency – Analysis of Refrigeration and Air conditioning cycles, Heat pumps

UNIT II ENERGY CONSERVATION TECHNIQUES 8

Principle of Energy audit, Identifying avenues for Energy conservation, Conservation through periodic maintenance of HVAC systems, Predictive and Preventive maintenance, Thermal insulation

UNIT III REFRIGERATION AND AIR CONDITIONING EQUIPMENTS 10

Energy conservation in Air Handling units-Fans, Air conditioning apparatus-Unitary equipments, Refrigeration Equipments-Reciprocating Refrigeration Machine, Centrifugal Refrigeration Machine, Absorption Refrigeration Machine, Heat Rejection Equipments, and Energy Efficient motors

UNIT IV HEATING AND VENTILATING SYSTEMS 10

Energy conservation feasibility analysis-conventional ventilating systems, constant volume induction system, Multizone unit system, Variable volume induction system, constant temperature system. Heat Pipe Applications in Air conditioning systems

UNIT V HEAT CONVERSION SYSTEMS 9

Theory of Heat transformers-Heat Pumps, Two temperature level, Three Temperature level-Vapour compression, Heat pump

TOTAL = 45 PERIODS

OUTCOME

- On successful completion of this course the student can create and evaluates the building environments, demonstrating consideration of sustainability, safety and functional issues in terms of Energy.

REFERENCES

1. George Alefeld and Reinhard Radermacher , Heat conversion systems , CRC press , 1994
2. Carrier Air conditioning Co., Hand Book of Air conditioning System Design , McGraw-Hill , 1985.
3. Plant Engineers and Manager's Guide to Energy Conservation, Fair Mount Press, 2008.
4. ASHRAE Hand Book–Equipment, 2011.
5. Energy conservation in Heating, Cooling and Ventilating Building, Proceeding Hemisphere Publishing Corporation, 1988.
6. Edward Hartmann, Maintenance Management, Productivity and Quality Publishing Pvt. Ltd. Madras, 1995.

RA7006	ERECTION AND MAINTENANCE OF REFRIGERATION AND AIR CONDITIONING EQUIPMENTS	L T P C 3 0 0 3

OBJECTIVES

- To learn about the erection procedures involved in different systems and on the testing and maintenance schedules for different R & AC system.

UNIT I INTRODUCTION 10

Refrigeration and air-conditioning plant layout, parameters affecting the location, organizational approach.

UNIT II ERECTION OF R&AC SYSTEMS 10

Erection methodology , foundation , padding , network analysis, critical path , interconnections ; safety precautions, air handling equipments , locations in the systems , corrosion , noise , vibration monitoring and control

UNIT III TESTING OF EQUIPMENTS 10

Testings/ISI standards, testing of compressors, condensers, evaporators, and cooling towers. Testing of control systems, circuitry and trouble shoot, condition monitoring.

UNIT IV PREVENTIVE MAINTENANCE 10

TPM Principles , Corrective and preventive measures , Reliability analysis , Signature analysis , Different types of preventive maintenance procedures , Practical hints , Failure Mode and Effect Analysis , Problem Solving Techniques

UNIT V MAINTENANCE ASPECTS 5

Maintenance procedures, leak detection, vacuumising, charging, trial run, prevention, lubrication, different methods. Studies on different maintenance schedules followed by various industries.

TOTAL = 45 PERIODS

OUTCOME

- Students can understand various procedures on the erection, testing and maintenance of refrigeration and air conditioning components, lay out and whole plant installation.

REFERENCES
1) Robert C.Rosciler, HVAC Maintenance and operations Hand Book,Mc Graw.Hill,1997.
2) Althouse A.D. and Turnquist C.H., Modern Refrigeration and Airconditioning, Good Heart-Wilcoz Co Inc., 2004.
3) Nelson C.W., Commercial and Industrial Refrigeration, McGraw-Hill, 1982.
4) Reed G.H., Refrigeration, A Practical Manual, Applied Science Publishers Ltd., London, 1982.
5) Russel E. Smithy, Electricity for Refrigeration, Heating and Air-conditioning, Duxbury Press, Massachusetts, 1980.

RA7007	FANS, BLOWERS AND COMPRESSORS IN AIR CONDITIONING SYSTEMS	L T P C 3 0 0 3

OBJECTIVES

- To understand the basic characteristics and special features of fans, blowers and compressors and analyze fans, blowers and compressors and acquire a limited design experience of fans and blowers

UNIT I PRINCIPLES OF TURBO MACHINERY 10

Introduction to turbo machines-Transfer of energy to fluids-Performance characteristics-fan laws-Dimensionless parameters-Specific speed-selection of centrifugal, axial, mixed flow, Axial flow Machines.

UNIT II CENTRIFUGAL BLOWERS 10

Centrifugal Blowers: Theoretical characteristic curves, Eulers characteristics and Eulers velocity triangles, losses and hydraulic efficiency, flow through impeller casing inlet nozzle volute, diffusers, leakage disc friction mechanical losses multivane impellers of impulse type , cross flow fans.

UNIT III AXIAL FLOW FANS 10

Axial flow fans: Rotor design airfoil theory, vortex theory, cascade effects, degree of reaction, blade twist stage design, surge and stall, stator and casing, mixed flow impellers

UNIT IV COMPRESSORS 8

Reciprocating compressors, Constructional details – open, hermetic and semi sealed, effect of cylinder cooling, heating and friction, Dynamic compressor, centrifugal compressor, velocity triangles, performance characteristics, part load operation, Capacity control

UNIT V DESIGN AND APPLICATIONS 7

Special design and applications of compressors for air conditioning plants, Multi stage refrigeration

TOTAL = 45 PERIODS

OUTCOME

- On successful completion of this course, the students will be able to design the fans and blowers for HVAC application

REFERENCES
1. Austin H. Church, Centrifugal pumps and blowers, John Wiley and Sons, 1980.
2. Royce N. Brown, Compressors: Selection and Sizing, Elsevier, 2005.
3. Dixon, Fluid Mechanics, Thermodynamics of turbomachinery Pergamon Press, 1984.
4. Tony Giampaolo, Compressor Hand Book Principles and Practice, The Fairmont Press, 2010.
5. S. M. Yahya, Turbines compressors and fans(4th Edition), Tata McGraw-Hill, 2010

RA7008 FOOD PROCESSING, PRESERVATION AND TRANSPORT

L	T	P	C
3	0	0	3

OBJECTIVES

- To builds a solid foundation in the fundamentals of food processing and preservation techniques and to study the thermodynamic properties of food materials

UNIT I MICROBIOLOGY OF FOOD PRODUCTS 9

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

Thermodynamic Properties, Water Content, Initial Freezing Temperature, Ice Fraction, Transpiration of Fresh Fruits and Vegetables, Food Processing Techniques for Dairy Products, Poultry, Meat ,Fruits and Vegetables

UNIT III FREEZING & DRYING 10

Precooling, Freeze Drying Principles, Cold Storage and Freezers , Freezing Drying limitations, Irradiation Techniques , Cryo Freezing, Energy Conservation in Food industry , Numerical and Analytical Methods in Estimating Freezing , Thawing Times.

UNIT IV COLD STORAGE DESIGN & INSTRUMENTATION 9

Cold storage of Agricultural products, Initial Building Consideration, Building Design , Specialized Storage Facility , Construction Methods, Refrigeration Systems , Insulation Techniques , Control and Instrumentation , Fire Protection, Inspection and Maintenance

UNIT V TRANSPORT 8

Refrigerated Transportation refrigerated Containers and Trucks, Design Features, Piping and Role of Cryogenics in Freezing and Transport

TOTAL = 45 PERIODS

OUTCOME

- Students can understand various food processing techniques, analysis of thermodynamic properties of food and cold storage design

REFERENCES

1. Peter Fellows, Food Processing Technology: Principles and Practice, Wood Head, 2000.
2. Romeo T. Toledo, Fundamentals of Food Process Engineering, Springer III Edition, 2007.
3. Frazier W.C., Westhoff D.C., Food Microbiology, 4th Ed., McGraw-Hill, New York 1988.
4. Michael .J. Waites, Neil L. Morgan, John S. Rockey, Gary Higton, Industrial Microbiology, Wiley BlackWell, 2001.
5. S. Yanniotis, B. Sunden, Heat Transfer in Food Processing, Recent Developments and Applications, WIT Press, Southampton, 2007
6. C. V. J. Dellino, Cold and Chilled Storage Technology, Springer II Edition, 1997
7. Andrew D. Althouse, Carl H. Turnquist, Alfred F. Bracciano, Modern Refrigeration and Air Conditioning, Goodheart-Wilcox, 18th Edition, 2003.
8. Sivasankar. B, Food processing and preservation, PHI learning, 2005.

RA7009 INDOOR AIR QUALITY AND CONTROL **L T P C**
3 0 0 3

OBJECTIVES

- To insist importance of maintaining indoor air quality.
- To gain knowledge on maintaining IAQ.
- To learn the use various international standard on IAQ.
- To have knowledge on threshold limit of various indoor air pollutants

UNIT I AIR QUALITY 8

Air Pollution–Indoor, Outdoor; statistics in India-Contaminants-sources-effects of air quality on health and productivity-IAQ-ASHRAE standards

UNIT II INDOOR AIR QUALITY & SICK BUILDING SYNDROME 10

Effect of temperature , Velocity , Pressure , Humidity on IAQ-Noise-Source-damping methods-Air distribution-diffuser design-location-air charge calculations-age of air-SBS- psycho social effects-Parameters causing SBS-Bio contaminants-diagnosing Building problems-NIOSH standards

UNIT III AIR FILTRATION 7

Principles of air filtration-impingement filters, HEPA & ULPA filters, Electronic air cleaners, filters-Filter Standards-filter efficiency-filter testing methods-NAFA certification

UNIT IV DESIGN OF CLEANROOMS 12

History of clean rooms-classification-clean room standards-different contaminants-ISO classification interiors-Recommended practices-Design of clean rooms for Hospitals, Pharmaceutical, microelectronic, Bio technology food industries and manufacture industries-International standards.

UNIT V IAQ MEASUREMENTS & CONTROL 8

Contaminants measurement-sampling sampling methods-Quality assurance-calibration-data interpretation – instruments specifications - source control–prevention-Dilution Ventilation-demand control volume method.

TOTAL = 45 PERIODS

OUTCOME

- Student can understand the Indoor air quality issues and procedure to maintain them in buildings using various control methods.

REFERENCES

1. Whyte W. Clean Room Design II Edition, John Wiley & Sons (NY)–1999.
2. American Institutes of Architects (AIA), Guidelines for Design & Construction of Hospital & Health care facilities, AIA, Washington–2001.
3. Thad Godish, Sick Buildings, Lecois Publishers, Ann Arbor, 1994.
4. National Air Filtration Association, NAFA guide to Air Filtration-III edition-NAFA Washington DC-2001.
5. ASHRAE Hand Book, HVAC Systems and Equipment, Edition, 2012

RA7010 INDUSTRIAL REFRIGERATION SYSTEMS **L T P C**
3 0 0 3

OBJECTIVES

- To understand the operational features of compressors in large systems, Evaporators & Condensers and energy conservation aspects in Industrial Refrigeration System.

UNIT I INTRODUCTION 6

Introduction to industrial refrigeration-difference from conventional system -industrial and comfort air conditioning- Different applications

UNIT II COMPRESSORS 10

Reciprocating and screw compressor: effect of evaporating temperature and condensing temperature on volumetric efficiency refrigerating effect and COP. Variable speed drive of screw compressor, variable volume ratio, oil injection and separation-oil cooling methods- capacity regulation-Economizers-side port options.

UNIT III EVAPORATORS AND CONDENSERS 12

Types of Evaporators, Liquid circulation: Mechanical pumping and gas pumping- advantage and disadvantage of liquid re-circulation-circulation ratio, top feed and bottom feed refrigerant, Net Positive Suction Head (NPSH), two pumping vessel system, suction risers, design-piping loses. Different Industrial Condensers functional aspects. Lubricating oil: types-physical property terms-solubility – viscosity - contaminants and its effect - discharge line oil separator-oil removal from high and low side for ammonia and halocarbon refrigerants

UNIT IV VESSELS 8

Vessels in industrial refrigeration: High pressure receiver-flash tank-liquid and vapour separator - separation enhancers-low pressure receivers-surge drum-surge line accumulator-thermosyphon receiver-oil pots.

UNIT V ENERGY CONSERVATION ASPECTS 9

Energy conservation and design considerations - source of losses - energy efficient components -heat reclaim - thermal storage: ice builder and ice harvester. Insulation: critical thickness - insulation cost and energy cost - vapour barriers - construction methods of refrigerated spaces.

TOTAL = 45 PERIODS

OUTCOME

- Student can understand the compressor, condenser, evaporator and vessels used in R&AC Industry and its energy conservation techniques.

REFERENCES

1. Wilbert F.Stoecker, Industrial Refrigeration Hand Book, McGraw-Hill, 1998
2. ASHRAE Hand Book: Fundamentals, 2013.
3. ASHRAE Hand Book: Refrigeration, 2014
4. ASHRAE Hand Book: HVAC Systems and Equipment, 2012

RA7011 MATERIALS FOR LOW TEMPERATURE APPLICATIONS **L T P C**
3 0 0 3

OBJECTIVES

- To understand the behavioural changes in materials at low temperature.
- To understand the selection of material for low temperature applications and the testing methods for low temperature behaviour of materials

UNIT I MATERIAL BEHAVIOR 10

Deformation process in pure, impure metals and alloys–effect of low temperature transformation, plastic deformation at constant stress-creep , Role of dislocations , Tensile , Shear strength of perfect and real crystals , Strengthening mechanisms , Work hardening , strain and strain rate on plastic behaviour–super plasticity Ductile and Brittle Failure , Crack Propagation-Fracture , Toughness– fracture toughness , Griffith's theory , stress intensity factor and fracture toughness Toughening mechanisms–Ductile , brittle transition in steel

UNIT II MATERIALS SELECTION 10

Compatibility with liquid oxygen and other process fluids-external environment, Toughness-pressure vessel codes, Motivation for selection-cost basis and service requirements–Selection for surface durability, corrosion and wear resistance– Relationship between materials selection and processing–Case studies in materials selection

UNIT III NON METALLIC MATERIALS 7

Polymeric materials for Cryogenic Application , Ceramics and Glasses, Cryogenic properties of Composites , Polymeric materials–Formation of polymer structure– Production techniques of fibres, foams , adhesives and coatings–Structure , properties and applications of engineering polymers– Advanced structural ceramics, WC, TiC, TaC, Al2O3, Sic, Si3N4, CBN and diamond–properties, processing and applications

UNIT IV TESTING METHODS AND TECHNIQUES 10

Basic types of Cryostat and cooling system, Modification, Variations, and special purpose attachments–multiple specimen testing, compression testing, Flexural, torsional, fatigue and impact testing, Extensometry-Resistive strain gauges, Displacement Transducers, Capacitance gauges.

UNIT V MODERN METALLIC MATERIALS 8

Dual phase steels , micro alloyed , High strength low alloy (HSLA) steel , Transformation induced plasticity (TRIP) steel , Maraging steel-intermettallics , Ni and Ti aluminides–smart materials , shape
memory alloys–Metallic glass–Quasi crystal and nano crystalline materials

TOTAL = 45 PERIODS

OUTCOME

- Students will be able to understands the material behaviour, selection and testing techniques at low temperature

REFERENCES

1. Wigley D.A., "Mechanical Properties of Materials at Low Temperatures", Plenum Press, New York, 1972.
2. Richard P. Reed, Alan F. Clark, Materials at low Temperature, ASME International, Dec 1983.
3. Thomas H.Courtney , "Mechanical Behavior of Materials", (2nd Edition), McGraw-Hill , 2004

RA7012 REFRIGERATION MACHINERY AND COMPONENTS **L T P C**
3 0 0 3

OBJECTIVES

- To master how refrigeration components and systems perform their tasks
- To identify and explain various system accessories and controls in refrigeration systems
- To know BIS standard for appliance testing practice

UNIT I REFRIGERANT COMPRESSORS 9

Hermetic compressors - Reciprocating, Rotary, Scroll compressors, Open type compressors - Reciprocating, Centrifugal, Screw Compressors. Semi hermetic compressors - Construction, working and Energy Efficiency aspects. Applications of each type.

UNIT II REFRIGERATION SYSTEM COMPONENTS 9

Evaporators and condensers-Different types, capacity control, circuitry, Oil return, Oil separators- Different types Refrigerant driers strainers, Receivers, Accumulators, Low pressure receivers, Air Washers, Spray ponds..

UNIT III HYDRONIC SYSTEMS 9

Water piping in Chilled Water Systems, Multiple Fan Coil Units, Condensers - Multiple Condensers and Cooling Towers. System components – Expansion tank, Balancing valves, Pumping systems, Pump selection, Freeze prevention

UNIT IV APPLIANCES & ACCESSORIES 9

Special components for refrigeration / air Conditioning in Automobiles, Railway Wagons, Marine Vessels, Aircraft and Other Commercial Applications

UNIT V SYSTEM ACCESSORIES AND CONTROLS 9

Refrigerant Pumps, Cooling Tower fans, Compressor Motor protection devices, Oil equalizing in multiple evaporators. Different Defrosting and capacity control methods and their implications.

TOTAL = 45 PERIODS

OUTCOME

- On successful completion of this course, the students will be able to understand working of the refrigeration components and systems with the accessories and controls

REFERENCES

1. Cooper &Williams, B. “Commercial, Industrial, Institutional Refrigeration, Design, Installation and Trouble Shooting” Eagle Wood Cliffs (NT) Prentice Hall, 1989.
2. Dosset, R.J. “Principles of Refrigeration”, John Wiley & Sons, 2001
3. Hains, J.B, “Automatic Control of Heating & Airconditioning” Mc Graw Hill, 1981.
4. Althose, A.D. & Turnquist, C.H. “Modern Refrigeration and Airconditioning” Good Heart-Wilcox Co.Inc., 1985.
5. Recent release of BIS Code for relevant testing practice. ASHRAE Hand book (Fundamentals & Equipments), 2005

RA7013 SOLAR SYSTEMS FOR BUILDINGS **L T P C**
3 0 0 3

OBJECTIVES

- To explain the concept of solar thermal and electrical applications of building and to summarize basic economics of solar buildings

UNIT I INTRODUCTION 9

Elements of Buildings - Traditional, Modern and Alternative Buildings - Concepts and Elements of Thermal Comfort - Materials and Methods of Construction - Thermal Properties of Building Elements

UNIT II SOLAR HEAT GAIN IN BUILDINGS 9

Building orientations - Geometric Shapes / Factors - Building Thermal Resistance - Computation of R and U Values for Building Elements and their comparison - Calculation of Solar Heat incident on various building surfaces - Diurnal and Seasonal Variation - Solar Space Conditioning

UNIT III SOLAR THERMAL SYSTEMS FOR BUILDINGS 9

Intuitive and responsive building design - Solar Collectors, Cookers, Thermal Energy Storage Systems and their Integration with Buildings – Advantages and Limitations - Sizing, Area and Performance Calculations.

UNIT IV SOLAR PV SYSTEMS FOR BUILDINGS 9

Solar PV Systems for stand alone and Grid Interconnected Applications - Integration of SPV components with buildings. Sizing, Area and Performance Calculations

UNIT V ECONOMIC ANALYSIS 9

Economic analysis for alternative selection of materials - Life Cycle Analysis for Thermal and Electrical Solar Systems

TOTAL = 45 PERIODS

OUTCOME

- Students will be able to explain the concept of solar thermal and electrical applications of buildings and will be able to sort out the basic economics of solar buildings and its components

REFERENCES

1. Jan F. Kreider, The solar heating design process: active and passive systems, McGraw-Hill, 2007.
2. David A. Bainbridge, Ken Haggard, Kenneth L. Haggard,Passive Solar Architecture: Heating, Cooling, Ventilation,Daylighting, and More Using Natural Flows, Chelsea Green Publishing, 2011.
3. John Schaeffer, Doug Pratt, Douglas R. Pratt, Solar living sourcebook, 2007.
4. A common-sense guide to alternative homebuilding, the good house.
5. Joseph F. Kennedy, Catherine Wanek, Michael G. Smith, The art of natural building: design, construction, resources, New Society Publishers, 2004.
6. Sukhatme and Nayak, Solar Energy: Principles of Thermal Collection & Storage, Tata McGraw- Hill, 2008.
7. Ibrahim Dincer and Marc A Rosan, Thermal Energy Storage: Systems & Applications, John Wiley, 2006.
8. Duffie J.A. and Beckman W.A., 'Solar Engineering of Thermal Processes', Wiley, New York.1, 2006.

RA7014 SORPTION HEATING AND COOLING SYSTEMS L T P C
3 0 0 3

OBJECTIVES

- To educate the students on the types of sorption cycles with their constructional and functional significance.
- To understand the working and design of absorption cooling systems.
- To introduce the concept of combined heating, cooling and power generation and trigeneration concepts

UNIT I INTRODUCTION 9

Carnot cycle–Refrigerator–Heat Pump–Heat Transformer, Working Fluids, Properties–Thermodynamic Processes with Mixtures

UNIT II LIQUID SORPTION SYSTEMS 12

Water–LiBr Systems; Single Effect, Double Effect Systems, Types–Analysis of Advanced Cycles for Refrigeration Systems–Heat Pumps and Heat Transformers. Ammonia–Water Systems–Single Effect–GAX Systems

UNIT III PUMPLESS AND SOLID SORPTION SYSTEM 9

Diffusion Absorption Systems–Bubble Pump Systems–Solid Sorption Systems– Working Fluids–Single and Multi effect Systems–Metal Hydride Heating and Cooling Systems–Applications and Issues.

UNIT IV COMPONENT DESIGN 8

Design of Generator–Absorber–Condenser–Evaporator–Solution Heat Exchanger– Reactors–Rectifiers–Overall System Balance

UNIT V APPLICATIONS 7

Energy Storage– Combined power and cooling–Solar Cooling–Low grade Heat Utilization–Economics of Sorption Systems–Sorption refrigeration Systems for Climate Change Mitigation.

TOTAL = 45 PERIODS

OUTCOME

- On successful completion of this course the student will be able to analyse Sorption Systems for its energy efficiency and cooling capacity

RA7015	TESTING, BALANCING AND COMMISSIONING OF HVAC AND R SYSTEMS	L T P C 3 0 0 3

OBJECTIVES

- To review and study about the functions of different systems and components of HVAC & R Systems
- To understand the general and specific testing and balancing procedures for HVAC & R systems

UNIT I HVAC & R SYSTEM COMPONENTS 8

Fans, pumps, air distribution, water distribution, motors, electrical, fluid flow, refrigeration, and instrument usage and care.

UNIT II TESTING OF HVAC & R SYSTEMS 10

General and specific testing and its procedures for constant air volume systems, variable air volume systems, return air systems, Cooling towers and performance, fans and fan performance

UNIT III BALANCING OF HVAC & R SYSTEMS 10

HVAC systems, centrifugal pumps and pump performance, analog and digital controls and water balancing procedures using flow meters, system components, and temperatures

UNIT IV HVAC & R COMMISSIONING 10

HVAC Commissioning Cost / Benefit Analysis, Selection of Commissioning Provider, The HVAC Commissioning Team Comprehensive HVAC Commissioning, Construction HVAC Commissioning HVAC Commissioning in Existing Buildings and Commissioning of Non-HVAC Building Systems

UNIT V SPECIAL APPLICATIONS 7

TBC of fume hood systems, cleanrooms and report writing on testing, balancing and commissioning and documents for clients

TOTAL = 45 PERIODS

OUTCOME

- The student must able to carry out independent testing, balancing and commissioning of HVAC&R plants and provide the report on the same

REFERENCES

1. Samuel C Sugarman, Testing and Balancing of HVAC Air and Water systems, Fifth Edition, Fairmont Press, 2014
2. ACG Commissioning guide line, AABC Group, 2005
3. ASHRAE Standard 202-2013, Commissioning Process for Buildings and Systems, 2013

RA7071 FUZZY LOGIC AND NEURAL NETWORKS L T P C
3 0 0 3

OBJECTIVES

- To understand the concept of ANN and different search techniques and to impart knowledge on MATLAB implementation of Fuzzy control.

UNIT I INTRODUCTION 9

Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule based systems, the AI approach. Knowledge representation. Expert systems.

UNIT II ARTIFICIAL NEURAL NETWORKS 9

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Data Processing: Scaling, Fourier transformation, principal-component analysis and wavelet transformations. Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller

UNIT III FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning - Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self organizing fuzzy logic control. Fuzzy logic control for nonlinear time-delay system.

UNIT IV GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters, Solution of typical control problems using genetic algorithm, Concept on some other search techniques like tabu search and ant-colony search techniques for solving optimization problems.

UNIT V APPLICATIONS 9

GA application to power system optimization problem, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox. Stability analysis of Neural-Network interconnection systems. Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox. Stability analysis of fuzzy control systems

TOTAL = 45 PERIODS

OUTCOME

- The student will be able to understand the concepts of ANN and different search techniques and MATLAB implementation of Fuzzy Logic Control.

REFERENCES

1. Timothy J.Ross, Fuzzy Logic with Engineering Applications, Wiley 2011.
2. Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning,2009.
3. S.Rajasekaran, G.A.Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI Learning Private Limited, 2004.
4. Laurene Fausett, Fundamentals of Neural Networks, Pearson Education India, 2006.
5. Russell, Artificial Intelligence, Pearson Education India, 2003.

SY7071 SOLAR REFRIGERATION AND AIR CONDITIONING **L T P C**
3 0 0 3

OBJECTIVES

- To learn the fundamental concepts about solar energy refrigeration and air-conditioning systems and to study solar cooling, vapour absorption refrigeration and air-conditioning system, vapour compression systems with implementation techniques for detailed knowledge about solar refrigeration and air-conditioning systems

UNIT I INTRODUCTION 8

Introduction - Potential and scope of solar cooling - Types of solar cooling systems - Solar collectors and storage systems for solar refrigeration and air-conditioning – Refrigerants.

UNIT II SOLAR COOLING 9

Need for solar cooling - Jet ejector solar cooling systems - Fuel assisted solar cooling systems – Solar thermo acoustic cooling and hybrid air-conditioning - Solar desiccant cooling systems – Advanced solar cooling systems.

UNIT III ABSORPTION COOLING 10

Basics of absorption cooling - Principle of absorption cooling - Solar operation of vapour absorption refrigeration cycle - Open cycle absorption / desorption solar cooling alternatives – Lithium Bromide- Water absorption System – Aqua-ammonia absorption system – Intermittent absorption refrigeration System - Refrigerant storage for solar absorption cooling systems

UNIT IV VAPOUR COMPRESSION REFRIGERATION 10

Vapour compression refrigeration cycles - Rankine cycle - Sterling cycle based solar cooling systems - Thermal modelling for continuous and intermittent solar refrigeration and air-conditioning systems

UNIT V IMPLEMENTATION TECHNIQUES 8

PV powered refrigerator – Free cooling - Solar thermoelectric refrigeration and air-conditioning – Solar economics of cooling systems - Case studies.

TOTAL = 45 PERIODS

OUTCOME

- The fundamental concepts about solar energy refrigeration and air-conditioning systems were learnt. And the principles, theories and the materials used for solar cooling, vapour absorption refrigeration and air-conditioning systems were studied in detail with implementation techniques.

REFERENCES

1. Rakosh Das Begamudre, Energy Conversion Systems, New Age International, 2007.
2. Tom P. Hough, Solar Energy: New Research, Nova Publishers, 2006.
3. Alefeld G. and Radermacher R., Heat Conversion Systems, CRC Press, 2004.
4. ASHRAE Hand Book–HVAC Systems & Equipment, ASHRAE Inc. Atlanta, 2008.
5. Reinhard Radermacher, S A Kelin and K Herold, Absorption chillers and heat pumps, CRC Press, 1996.