UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY CHENNAI : : CHENNAI 600 025

REGULATIONS - 2009

CURRICULUM I TO IV SEMESTERS (FULL TIME)

M.E. REFRIGERATION AND AIR CONDITIONING

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA 9107	Applied Mathematics for Thermal Engineers	3	1	0	4
2	IC 9112	Advanced Thermodynamics	3	1	0	4
3	IC 9111	Advanced Heat Transfer	3	1	0	4
4	RA 9111	Refrigeration Systems Design	3	0	0	3
5	E1	Elective I	3	0	0	3
6	E2	Elective II	3	0	0	3
PRACTICAL						
7	RA 9112	Refrigeration and Air conditioning lab	0	0	3	1
		TOTAL	18	3	3	**22**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	RA 9121	Air conditioning Systems Design	3	0	0	3
2	RA 9122	Computer Simulation of Refrigeration And Air conditioning Systems	3	0	0	3
3	IC 9123	Instrumentation for Thermal Systems	3	0	0	3
4	RA 9123	Design of Condensers Evaporators and Cooling Towers	3	0	0	3
5	E3	Elective III	3	0	0	3
6	E4	Elective IV	3	0	0	3
PRACTICAL						
7	RA 9124	Simulation lab	0	0	3	1
8	RA 9125	Seminar	0	0	3	1
		TOTAL	18	0	6	**20**

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	E5	Elective V	3	0	0	3
2	E6	Elective VI	3	0	0	3
3	E7	Elective VII	3	0	0	3
PRACTICAL						
4	RA 9131	Practical Training	0	0	0	1
5	RA 9132	Project Work - Phase I	0	0	12	6
		TOTAL	**9**	**0**	**12**	**16**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	RA 9141	Project Work - Phase II (Continuation of Phase I)	0	0	24	12
		TOTAL	0	0	24	**12**

Total number of credits to be earned for award of the degree = 70

- **The 4 weeks training will be undergone during II semester vacation, the results will be published along with III semester results.**

UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY CHENNAI : : CHENNAI 600 025

REGULATIONS - 2009

CURRICULUM I TO VI SEMESTERS (PART TIME)

M.E. REFRIGERATION AND AIR CONDITIONING

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA9107	Applied Mathematics for Thermal Engineers	3	1	0	4
2	IC9111	Advanced Heat Transfer	3	1	0	4
3	IC9112	Advanced Thermodynamics	3	1	0	4
		TOTAL	**9**	**3**	**0**	**12**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	RA9111	Refrigeration Systems Design	3	0	0	3
2	IC9123	Instrumentation for Thermal Systems	3	0	0	3
3		Elective I	3	0	0	3
PRACTICAL						
4	RA9112	Refrigeration and Air conditioning lab	0	0	3	1
		TOTAL	**9**	**0**	**3**	**10**

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	RA9121	Air conditioning Systems Design	3	0	0	3
2	E2	Elective II	3	0	0	3
3	E3	Elective III	3	0	0	3
PRACTICAL						
4	RA9125	Seminar	0	0	3	1
		TOTAL	**9**	**0**	**3**	**10**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	RA9122	Computer Simulation of Refrigeration and Air conditioning Systems	3	0	0	3
2	RA9123	Design of Condensers Evaporators and Cooling Towers	3	0	0	3
3	E4	Elective IV	3	0	0	3
PRACTICAL						
4	RA9124	Simulation lab	0	0	3	1
		TOTAL	**9**	**0**	**3**	**10**

SEMESTER V

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	E5	Elective V	3	0	0	3
2	E6	Elective VI	3	0	0	3
3	E7	Elective VII	3	0	0	3
PRACTICAL						
4	RA9131	Practical Training	0	0	0	1
5	RA9132	Project Work - Phase I	0	0	12	6
		TOTAL	**9**	**0**	**12**	**16**

SEMESTER VI

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	RA9141	Project Work - Phase II (Continuation of Phase I)	0	0	24	12
		TOTAL	0	0	24	**12**

Total number of credits to be earned for award of the degree = 70

* The 4 weeks training will be undergone during IV semester vacation the results will be published along with V semester results.

ELECTIVES FOR M.E. REFRIGERATION AND AIRCONDITIONING

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1	RA 9150	Behavioural Science and Engineering Management	3	0	0	3
2	RA 9151	Cryogenic Engineering	3	0	0	3
3	RA 9152	Sorption Heating and Cooling Systems	3	0	0	3
4	RA 9153	Food Processing Preservation and Transport	3	0	0	3
5	RA 9154	Refrigeration Machinery and Components	3	0	0	3
6	RA 9155	Design Of Thermal Systems	3	0	0	3
7	RA 9156	Building Architecture and HVAC Systems	3	0	0	3
8	RA 9157	Energy Conservation in HVACR Systems	3	0	0	3
9	RA 9158	Fans and Blowers	3	0	0	3
10	RA 9159	Erection and Maintenance of Refrigeration and Air-conditioning Equipments	3	0	0	3
11	RA 9160	Indoor Air Quality Control	3	0	0	3
12	RA 9161	Quantitative and Qualitative Research Methodologies	3	0	0	3
13	RA 9162	Energy Forecasting, Modeling And Project Management	3	0	0	3
14	RA 9163	Air Handling Systems Design	3	0	0	3
15	RA 9164	Industrial Refrigeration	3	0	0	3
16	RA 9166	Design of Cleanrooms and Containment areas	3	0	0	3
17	RA 9167	Materials For Low Temperature Applications	3	0	0	3
18	EY 9167	Green Buildings	3	0	0	3
19	IC 9162	Computational Fluid Dynamics	3	0	0	3
20	RA 9168	Mini Project	3	0	0	3

Note: Students can opt for electives from other streams of Thermal Engg. Viz. M.E.I.C Engines and M.E. Energy Engg. which will be also considered as electives from same Department while exercising **Regulation Clause No:- 3.7.4**

MA 9107 APPLIED MATHEMATICS FOR THERMAL ENGINEERS

L	T	P	C
3	1	0	4

UNIT I APPLICATIONS OF FOURIER TRANSFORM 9

Fourier Transform methods – one-dimensional heat conduction problems in infinite and semi-infinite rod – Laplace Equation – Poisson Equation.

UNIT II CALCULUS OF VARIATIONS 9

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

UNIT III CONFORMAL MAPPING AND APPLICATIONS 9

The Schwarz- Christoffel transformation – Transformation of boundaries in parametric form – Physical applications:Fluid flow and heat flow problems.

UNIT IV FINITE DIFFERENCE METHODS FOR PARABOLIC EQUATIONS 9

One dimensional parabolic equation – Explicit and Crank-Nicolson Schemes – Thomas Algorithm – Weighted average approximation – Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method.

UNIT V FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 9

Solutions of Laplace and Poisson equations in a rectangular region – Finite difference in polar coordinates – Formulae for derivatives near a curved boundary while using a square mesh.

L +T: 45+15 = 60PERIODS

REFERENCE BOOKS:

1. Mitchell A.R. and Griffith D.F., The Finite difference method in partial differential equations, John Wiley and sons, New York (1980).
2. Sankara Rao, K., Introduction to Partial Differential Equations, Prentice Hall of India Pvt. Ltd., New Delhi (1997).
3. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi (1997).
4. Spiegel, M.R., Theory and Problems of Complex Variables and its Application (Schaum's Outline Series), McGraw Hill Book Co., Singapore (1981).
5. Andrews, L.C. and Shivamoggi, B.K., Integral Transforms for Engineers, Prentice Hall of India Pvt. Ltd., New Delhi (2003).
6. Elsgolts, L., Differential Equations and the Calculus of Variations, MIR Publishers, Moscow (1973).
7. Mathews, J.H. and Howell, R.W., Complex Analysis for Mathematics and Engineering, Narosa Publishing House, New Delhi (1997).
8. Morton, K.W. and Mayers, D.F. Numerical solution of partial differential equations, Cambridge University press, Cambridge (2002).
9. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. " Computational Methods for Partial Differential Equations", New Age International (P) Ltd., 2003.

IC9112 ADVANCED THERMODYNAMICS **L T P C**
3 1 0 4

UNIT I AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATIONS 10

Reversible work - availability - irreversibility and second – law efficiency for a closed system and steady – state control volume. Availability analysis of simple cycles. Thermodynamic potentials. Maxwell relations. Generalized relations for changes in entropy - internal energy and enthalpy - generalized relations for C_p and C_V Clausius Clayperon equation, Joule – Thomson coefficient.Bridgeman tables for thermodynamic relations.

UNIT II REAL GAS BEHAVIOUR AND MULTI – COMPONENT SYSTEMS 10

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 liquid - activity - equilibrium in multi phase systems - Gibbs phase rule for non – reactive components.

UNIT III CHEMICAL THERMODYNAMICS AND EQUILIBRIUM 10

Thermochemistry - First law analysis of reacting systems - Adiabatic flame temperature - entropy change of reacting systems - Second law analysis of reacting systems - Criterion for reaction equilibrium.Equilibrium constant for gaseous mixtures - evaluation of equilibrium composition.

UNIT IV STATISTICAL THERMODYNAMICS 8

Microstates and Macrostates - thermodynamic probability - degeneracy of energy levels - Maxwell – Boltzman, Fermi – Diarc and Bose – Einstein statistics - microscopic interpretation of heat and work, evaluation of entropy, partion function, calculation of the Macroscopic properties from partition functions.

UNIT V IRREVERSIBLE THERMODYNAMICS 7

Conjugate fluxes and forces - entropy production Onsager's reciprocity relations - thermo – electric phenomena, formulations.

TOTAL (L – 45 + T – 15): 60 PERIODS

REFERENCE BOOKS:

1. Kenneth Wark Jt.m, Advanced Thermodynamics for Engineers, McGrew – Hill Inc., 1995.
2. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Cons, 1988.
3. Holman, J.P., Thermodynamics, Fourth Edition, McGraw – Hill Inc., 1988.
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 Van Wylen, G, Introduction to Thermodynamics, Classical and Statistical Themodynamics, 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. DeHotf, R.T., Thermodynamics in Materials Science, McGraw – Hill Inc., 1993.
8. Rao, Y.V.C., Postulational and Statistical Thermodynamics, Allied Publisher Limited, New Delhi, 1999.

IC 9111 ADVANCED HEAT TRANSFER L T P C
3 1 0 4

AIM: The course is intended to build up necessary fundamentals for the understanding of the physical behaviour of conduction and convection

OBJECTIVE:

- To develop the ability to use the heat transfer concepts for various applications like finned systems, turbulence flows, high speed flows.
- To analyses 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 10

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 10

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 AND HEAT EXCHANGER 8

Condensation with shears edge on bank of tubes - boiling – pool and flow boiling - heat exchanger -Є – NTU approach and design procedure - compact heat exchangers.

UNIT IV NUMERICAL METHODS IN HEAT TRANSFER 9

Finite difference formulation of steady and transient heat conduction problems – discretization schemes – explicit - Crank Nicolson and fully implicit schemes - control volume formulation -steady one-dimensional convection and diffusion problems - calculation of the flow field – SIMPLER Algorithm.

UNIT V MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION 8

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

TOTAL (L – 45 + T – 15): 60 PERIODS

TEXT BOOKS:

1. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
2. Holman.J.P, Heat Transfer, Tata Mc Graw Hill, 2002.

REFERENCE BOOKS:

1. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985
2. Nag.P.K, Heat Transfer, Tata McGraw-Hill, 2002
3. Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004
4. Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.

RA9111 REFRIGERATION SYSTEMS DESIGN

L	T	P	C
3	0	0	3

AIM: To teach the students about Refrigeration System Design concepts.

OBJECTIVE:

- Teaching cycle analysis pertaining to Refrigeration systems.
- Teaching performance of system components and their balancing in cycles.

UNIT I REFRIGERATION CYCLES - ANALYSIS **10**

Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle-conditions for high COP-deviations from ideal vapor compression cycle , Multipressure Systems , Cascade Systems-Analysis .

UNIT II MAIN SYSTEM COMPONENTS **12**

Compressor- Types , performance , Characteristics of Reciprocating Compressors , Capacity Control , Types of Evaporators & Condensers and their functional aspects , Expansion Devices and their Behavior with fluctuating load.

UNIT III REFRIGERANTS **11**

Classification of Refrigerants , Refrigerant properties , Oil Compatibility , Environmental Impact-Montreal / Kyoto protocols-Eco Friendly Refrigerants.
Different Types of Refrigeration Tools , Evacuation and Charging Unit , Recovery and Recycling Unit , Vacuum Pumps.

UNIT IV SYSTEM BALANCING & CONTROLS **6**

Estimation of Cooling Load , System Equilibrium and Cycling Controls , Electric Circuits in- Refrigerators , Window A/C , Types of motors , Relays.

UNIT V OTHER REFRIGERATION CYCLES **6**

Vapor Absorption Systems-Aqua Ammonia & LiBr Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles.

TOTAL: 45 PERIODS

TEXT BOOKS:

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.

REFERENCE BOOKS:

1. Jordan and Priester , Refrigeration and Air conditioning 1985.
2. Goshnay W.B., Principles and Refrigeration , Cambridge , University Press , 1985.
3. Langley , Billy C., 'Solid state electronic controls for HVACR' pentice-Hall 1986.

RA9112 REFRIGERATION AND AIR CONDITIONING LAB L T P C
0 0 4 2

AIM: To impart knowledge on the practical aspects of refrigeration and air conditioning systems.

OBJECTIVE:

- To understand the behaviour 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.

I CYCLE

1. Study of Refrigeration and Air conditioning system components.
2. Study and use of Refrigeration and Air conditioning tools.
3. Performance study in a Refrigerator with calorimeter.
4. Performance study in a heat pump for different indoor and outdoor conditions
5. Performance study in a deep freezer for different coil temperature
6. Performance study in a cooling tower

II CYCLE

1. Performance comparison of a window Air conditioner with air-cooled and water-cooled condenser.
2. Performance study on Automobile Air conditioner.
3. Study of Air distribution in a scale model air-conditioned space.
4. Performance study in a walk-in cooler
5. Capillary optimization study in a refrigerator..
6. Performance study in a water cooler for various load conditions,

LABORATORY EQUIPMENT REQUIREMENTS:

1. Cut section model of various Refrigeration and Air conditioning system components.
2. Refrigeration and Air conditioning tools.
3. Refrigerator with calorimeter Heat pump setup
4. Deep freezer setup.
5. Cooling tower experimental setup
6. Window air conditioner with air-cooled and water-cooled condenser.
7. Automobile Air conditioner test rig
8. Walk-in cooler
9. Refrigerator with different length capillary
10. water cooler experimental setup

For all setup provisions are to be made to measure temperature and pressure across various sections.

RA9121 AIR CONDITIONING SYSTEM DESIGN L T P C
3 0 0 3

AIM: To impart knowledge on working principles and design aspects of Air conditioning systems.

OBJECTIVE:

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

UNIT I PSYCHROMETRY 9
Moist Air properties , use of Psychrometric Chart , Various Psychrometric processes , Air Washer , Adiabatic Saturation.

UNIT II SUMMER AND WINTER AIR CONDITIONING 9
Air conditioning processes-RSHF , summer Air conditioning , Winter Air conditioning Bypass Factor. Applications with specified ventilation air quantity- Use of ERSHF , Application with low latent heat loads and high latent heat loads.

UNIT III LOAD ESTIMATION & AIR CONDITIONING CONTROL 9
Solar Radiation-Heat Gain through Glasses , Heat Transfer through Walls and Roofs-Total Cooling Load Estimation. Controls of Temperature , Humidity and Air flow.

UNIT IV AIR DISTRIBUTION 9
Flow through Ducts , Static & Dynamic Losses , Air outlets , Duct Design–Equal Friction Method , Duct Balancing , Indoor Air Quality , Thermal Insulation , Fans & Duct System Characteristics , Fan Arrangement Variable Air Volume systems , Air Handling Units and Fan Coil units.

UNIT V WATER CIRCUITS 9
Water piping in Chilled Water Systems, Multiple Fan Coil Units, Condensers-Multiple Condensers and Cooling Towers.

TOTAL: 45 PERIODS

TEXT BOOKS :

1. Arora C.P. , Refrigeration and Air Conditioning , Tata McGraw Hill Pub. Company , New Delhi - 2000.

REFERENCE BOOKS:

1.Carrier Air Conditioning Co., Handbook of Air Conditioning Systems design , McGraw Hill , 1985.
2. Langley , Billy C. Refrigeration and Air Conditioning Ed. 3 , Engie wood Cliffs (N.J) Prentice Hall 1986.
3. ASHRAE , Fundamentals and equipment , 4 volumes-ASHRAE Inc. 2005.
4. Jones , Air Conditioning Engineering , Edward Amold pub. 2001.

RA9122 COMPUTER SIMULATION OF REFRIGERATION AND AIR-CONDITIONING SYSTEMS

L	T	P	C
3	0	0	3

AIM: To provide a clear understanding of mathematical modeling and to illustrate the student with various optimization techniques.

OBJECTIVE:

- To introduce the concept of mathematical model for simulation of R & AC system.
- To expose the students to various optimization techniques.

UNIT I INTRODUCTION **8**

Introduction to thermodynamic cycles , Process in Refrigeration and Air conditioning systems , Exergy concept , Computer application , and Simulation methodology.

UNIT II MATHEMATICAL MODELLING FOR SIMULATION **7**

Mathematical models , Workable and Optimal system Principles , Types , Curve fitting and Regression Analysis , Newton-Raphson method , Mathematical modeling of Refrigeration and Air Conditioning components

UNIT III OPTIMIZATION TECHNIQUES **10**

Information flow diagram , Optimization techniques-Lagrange method , Search method , Dynamic programming , Geometric programming method , Linear programming method , Case studies.

UNIT IV SIMULATION OF REFRIGERATION SYSTEMS **8**

Simulation of compressor, Condenser, Evaporator, and Expansion devices, simulation of refrigeration piping and control systems.

UNIT V SIMULATION OF AIR CONDITIONING SYSTEMS **12**

Computerized cooling load calculations , Packages , Simulation of psychrometric processes , Simulation of air flow in ducts , EER value assessment , Simulation of air diffusion in space.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Stoecker, W.F., Design of Thermal Systems , 3rd Edition , McGraw-Hill Book Company , New York, 1989.
2. Yogesh Jaluria., Design and Optimization of Thermal systems , McGraw-Hill Book Company , New York , 1998.

REFERENCE BOOKS:

1. Kapur J.N., Mathematical Modelling , Wiley Eastern Limited , New Delhi , 1989.
2. Stoecker,W.F., Refrigeration and air conditioning , McGraw Hill Pub. Company, 1989.
3. Anand A. Samuel , Computer Simulation of R&AC Systems- Web course hand book Anna University , 2000.
4. Dossat, R. J., Principles of refrigeration, John Wiley, 2001.
5. Lanqley, Billy C., Refrigeration and Air-conditioning Edn.3, Engle Wood Chiffs (NJ), Prentice Hall, 1986.

IC 9123 INSTRUMENTATION FOR THERMAL SYSTEMS **L T P C**
3 0 0 3

UNIT I MEASUREMENT CHARACTERISTICS **12**

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 MICROPROCESSORS AND COMPUTERS IN MEASUREMENT **5**

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

UNIT III MEASUREMENT OF PHYSICAL QUANTITIES **10**

Measurement of thermo – physical properties, instruments for measuring temperature - pressure and flow - use of sensors for physical variables

UNIT IV ADVANCE MEASUREMENT TECHNIQUES **8**

Shadow graph – Schileren – interferometer - Laser doppler anemometer - hot wire anemometer, heat flux sensors - telemetry in measurement.

UNIT V MEASUREMENT ANALYSERS **10**

Orsat apparatus - gas analysers - smoke meters - gas chromatography - spectrometry

TOTAL: 45 PERIODS

REFERENCE BOOKS:

1. Holman, J.P. Experimental methods for engineers, McGraw – Hill, 1988
2. Barney, Intelligent Instrumentation, Prentice Hall of India, 1988.
3. Prebrashensky, V.,Measurements and Instrumentation in Heat Engineering, Vol. 1 and 2, MIR Publishers, 1980
4. Raman, C.S., Sharma, G.R., and 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.

RA9123 DESIGN OF CONDENSERS, EVAPORATORS AND COOLING TOWERS

L	T	P	C
3	0	0	3

AIM: To equip the students in designing of condensers, evaporators and cooling powers.

OBJECTIVE:

- To provide design procedures in designing of different types of condensers.
- To provide design procedures in designing of different types of evaporators.
- To provide design procedures in designing of different types 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 **15**

Types of Cooling towers, Analytical and graphical design procedures, Tower Characteristics Parametric analysis, Packaging, Water treatment, Selection of pumps and fans, Energy conservation.

UNIT V COMPUTER AIDED DESIGN OF THERMAL SYSTEMS **5**

Principles of CAD, Drafting, Flowcharting, Computer programming, Packages, Case analysis.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ozisik, M.N., Design of Heat exchangers , condensers and evaporators , John Wiley , New York , 1985.
2. Kern K.H., Process heat transfer, McGraw-Hill, 2002.

REFERENCE BOOKS:

1. Ozisik M.N., Heat transfer, McGraw-Hill, 1993.
2. Nicholas Cheremisioff , Cooling tower , Ann Arbor Science pub. 1981.
3. TEMA Hand book, Tubular Exchanger Manufacturer Association, New York, 2004.

RA9124 **SIMULATION LAB**

L T P C
0 0 3 1

FOCUS: USE OF STANDARD APPLICATION SOFTWARE FOR SOLVING TYPICAL THERMAL PROBLEMS

I CYCLE

1) Steady state conduction in Solids
2) Steady state nature convection
3) Steady state Radiation between Black bodies
4) Combined conduction & convection (Fluid - Solid)
5) Unsteady state conduction in Solids
6) Unsteady state Conduction & Convection Fluid - Solid

II CYCLE

1) Steady state conduction in Fluids
2) Steady state Forced convection between Grey bodies.
3) Steady state Radiation
4) Combined conduction & convection in Fluids
5) Unsteady state conduction and convection in Fluids
6) Unsteady state Conduction & Convection in Fluids - Solid

NOTE: The above exercises are only guidelines to maintain the standard for teaching and conduct of examination.

SIMULATION LAB – REQUIREMENT:

1. Software - Modeling software like ProE, Gambit, Ansys etc
   Analysis software like Ansys, fluent, CFX, etc
   Equation solving software like Matlab, Engg equation solver

2. Every students in a batch must be provided with a terminal
3. Hardware are compatible with the requirement of the above software.

RA9150 BEHAVIOURAL SCIENCE AND ENGINEERING MANAGEMENT

L T P C

3 0 0 3

AIM:

To equip the students with managements skills and impact knowledge on total quality management.

OBJECTIVE:

- To improve the interactive behaviors among students.
- To make the students understand the need for total quality management in engineering industries.
- To train the students in project report preparation and in economic analysis.

UNIT I ORGANISATION BEHAVIORS 5

Principles-Framework-Personality-Understanding self and others-Learning methods-Development of Personality-Case study.

UNIT II GROUP DYNAMICS 10

Types-Attributes-Interactive behaviors-Transactional analysis-Johari Window-Stress management-Team building-Creative problem solving-Motivation-Maslows Theory-Managing People-Case study.

UNIT III CHANGE MANAGEMENT 5

Change Management Principles-Transition Model-Resistance to change-Conflict Management-Case study.

UNIT IV TOTAL QUALITY MANAGEMENT 20

Quality Management-Demings Philosophy-TQM Models-Customer Focus-Systems approach-ISO 9000 series certification-Benchmarking-Quality culture-Quality circles-PDCA cycle-Management Tools-Case study.

UNIT V PROJECT MANAGEMENT 5

Principles planning, Scheduling-Project Report Preparation-Economic Analysis-Case study.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Fred luthans , Organisational Behaviour , McGraw-Hill , Inc., USA , 2002.

2. Joel E. Ross, Total Quality Management, Kogan Page Ltd, USA, 1999.

REFERENCE BOOKS:

1. Max Hand & Brain Plowman, Quality Management, Butterworth Heinemann Ltd , UK , 1992.
2. Rao, K.S. Organisational Behaviour , Tata McGraw-Hill , New Delhi , 1997.
3. James L. Lamprecht, ISO 9000, ASQC Quality Press, USA, 1993.

RA9151 **CRYOGENIC ENGINEERING** **L T P C**
3 0 0 3

AIM:
To review the overall cryogenics fundamentals along with an introduction of low temperature applications and also it will familiarize students with various insulation instruments used cryogenic systems and as well as low temperature refrigeration systems

OBJECTIVE:
- 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-Space Programs, Superconductivity, Cryo Metallurgy, Medical applications.

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**
J.T.Cryocoolers, Stirling Cycle Refrigerators, G.M.Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Magnetic Refrigerators

UNIT V STORAGE AND TRANSPORTATION OF CRYOGENS **10**
Cryogenic Dewar Design, Cryogenic Transfer Lines. Insulations in Cryogenic Systems, Different Types of Vacuum Pumps, Instruments to measure Flow, Level and Temperature.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
2. Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1988.

REFERENCE BOOKS:

1.Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press New York, 1989.
2. Herald Weinstock , Cryogenic Technology , 1969.
3. Robert W. Vance, Cryogenic Technology, Johnwiley & Sons, Inc., New York, London, 1969.

RA9152 SORPTION HEATING AND COOLING SYSTEMS L T P C
3 0 0 3

AIM:
To provide comprehensive introduction to various sorption cooing systems and its design aspects.

OBJECTIVE:

- To Learn to thermodynamic simulation of both absorption and adsorption cooling systems.
- To design various components for sorption cooling systems.
- To utilize the concept of sorption cooling systems to save energy and study its use for climate change mitigation issues.

UNIT I INTRODUCTION 9

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

UNIT II LIQUID SORPTION SYSTEMS
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 IV APPLICATIONS 7
Energy Storage–Cogeneration–Solar Cooling–Low grade Heat Utilization–Economics of Sorption Systems–Sorption refrigeration Systems for Climate Change Mitigation.

TOTAL: 45 PERIODS

TEXT BOOKS:

1.Herold K. E., Radermacher R. and Klein S. A., Absorption Chillers and Heat Pumps CRC Press , London (1996).

REFERENCE BOOKS:

1. Alefeld G. and Radermacher R. , Heat Conversion Systems , CRC Press , London (1994)
2. ASHRAE Hand Book–HVAC Systems & Equipment 2008 , ASHRAE Inc. Atlanta.

RA9153 FOOD PROCESSING, PRESERVATION AND TRANSPORT

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION **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 AND PRESERVATION **12**

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 AND DRYING **12**

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 AND INSTRUMENTATION **7**

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 **5**

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

TOTAL: 45 PERIODS

TEXT BOOKS:

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.

REFERENCE BOOKS:

1. Frazier W.C., Westhoff D.C., Food Microbiology, 4th Ed., McGraw-Hill, New York 1988.
2. Michael .J. Waites, Neil L. Morgan, John S. Rockey, Gary Higton, Industrial Microbiology, Wiley BlackWell, 2001.
3. S. Yanniotis, B. Sunden, Heat Transfer in Food Processing, Recent Developments and Applications, WIT Press, Southampton, 2007
4. C. V. J. Dellino, Cold and Chilled Storage Technology, Springer II Edition, 1997
5. Andrew D. Althouse, Carl H. Turnquist, Alfred F. Bracciano, Modern Refrigeration and Air Conditioning, Goodheart-Wilcox, 18th Edition, 2003.

RA9154 REFRIGERATION MACHINERY AND COMPONENTS L T P C
3 0 0 3

AIM:
This course is designed to understand each component and controls in a refrigeration and air conditioning system, application in various fields engineering and appliance testing using BIS standards

OBJECTIVE:
- 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 12
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 10
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 APPLIANCES TESTING (BIS) 6
Testing of Air conditioners, Refrigerators, Visicoolers , Cold rooms , Calorimetric tests.

UNIT IV APPLIANCES & ACCESSORIES 9
Air Conditioning in Automobiles, Railway Wagons, Marine Vessels, Aircraft and Other Commercial Applications.

UNIT V SYSTEM ACCESSORIES AND CONTROLS 8
Refrigerant Pumps, Cooling Tower fans, Compressor Motor protection devices, Oil equalising in multiple evaporators. Different Defrosting and capacity control methods and their implications.

TOTAL: 45 PERIODS

TEXT BOOKS:

1.Cooper &Williams, B. “Commercial, Industrial, Institutional Refrigeration, Design, Installation and Trouble Shooting” Eagle Wood Cliffs (NT) Prentice Hall, 1989.

REFERENCE BOOKS:

1. Dosset, R.J. “Principles of Refrigeration”, John Wiley & Sons, 2001.
2. Hains, J.B, “Automatic Control of Heating & Airconditioning” Mc Graw Hill, 1981.
3. Althose, A.D. & Turnquist, C.H. “Modern Refrigeration and Airconditioning” Good Heart-Wilcox Co. Inc., 1985.
4. Recent release of BIS Code for relevant testing practice.
5. ASHRAE Hand book (Fundamentals & Equipments), 2005.

RA9155 DESIGN OF THERMAL SYSTEMS L T P C
3 0 0 3

AIM:
To provide review and use knowledge from thermodynamics, heat transfer and fluid mechanics, modeling and stimulation techniques for thermal system component analysis and their synthesis in integral engineering systems and processes

OBJECTIVE:
- To learn basic principles underlying piping, pumping, heat exchangers; modeling 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.

UNIT II MATHEMATICAL MODELLING 9
Equation Fitting, Nomography , Empirical Equation , Regression Analysis , Different Modes of Mathematical Models , Selectio n, Computer Programmes for Models.

UNIT III MODELLING THERMAL EQUIPMENTS 10
Modelling Heat Exchangers , Evaporators , Condensers , Absorption and Rectification Columns , Compressors , Pumps , Simulation Studies , Information Flow Diagram , Solution Procedures.

UNIT IV OPTIMIZATION 12
Objective Function Formulation, Constraint Equations, Mathematical Formulation, Calculus Method, Dynamic Programming, Search Methods, ANN and Genetic Algorithm.

UNIT V DYNAMIC BEHAVIOUR 5
Steady state Simulation, Laplace Transformation, Feedback Control Loops, Stability Analysis, Non-Linearities.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Stoecker W. F., Design of Thermal Systems, McGraw Hill Edition, 1989.
2. Bejan A., George Tsatsaronis , Michael J. Moran , Thermal Design and Optimization , Wiley , 1996.

REFERENCE BOOKS:

1. Kapur J. N., Mathematical Modelling , Wiley Eastern Ltd , New York , 1989.
2. Yogesh Jaluria , Design and Optimization of Thermal Systems , CRC Press , 2007.
3. Rao S. S., Engineering Optimization Theory and Practice, New Age Publishers, 2000.

RA9156 BUILDING ARCHITECTURE AND HVAC SYSTEMS L T P C
3 0 0 3

AIM:
To introduce skills to needed for climate based design of building and HVAC systems and also to provide concept of intelligent building and environmental influence on IAQ.

OBJECTIVE:
- To learn climate variation and its effects on the building heat load.
- To learn building material characteristics and their influence on building heating / cooling load for all weather conditions.
- To study various conversation techniques related to built environment and codes for the same.

UNIT I CLIMATE AND ARCHITECTURE 9
Factors that determine climate , climatic variations–Natural and Man made 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
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 INTELLIGENT BUILDINGS AND HVAC SYSTEMS 9
Energy Resources and Conservation related to Building Environment, Building Automation and Energy Management–Passive and Active Systems, Solar heating, ECBC concept.

TOTAL: 45 PERIODS

TEXT BOOKS:

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 Edition , Van Nostrand Reinhold Co , New York , 1981.

REFERENCE BOOKS:

1. ASHRAE Hand Book–HVAC Systems & Equipment 2008, HVAC Applications 2007, ASHRAE Inc. Atlanta.
2. National Building Code of India , 2005 , Bureau of Indian Standards
3. Givoni B., Man, Climate & Architecture, Barking Esser Applied Science, 1982.

RA9157 ENERGY CONSERVATION IN HVACR SYSTEMS L T P C
3 0 0 3

AIM:

To provide the concept on general principles or energy conservation using first and second law analysis of HVAC systems and to establish energy and environmental emission reductions.

OBJECTIVE:

- 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 & SECOND LAW ANALYSIS 8

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

UNIT II ENERGY CONSERVATION TECHNIQUES 8

Energy auditing in Engineering and process Industry, Identifying avenues for Energy conservation, Conservation through periodic maintenance of HVAC systems, Predictive and Preventive maintenance.

UNIT III REFRIGERATION & 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, 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

TEXT BOOKS:

1.George Alefeld and Reinhard Radermacher , Heat conversion systems , CRC press , 1994.

REFERENCE BOOKS:

1. Carrier Air conditioning Co., Hand Book of Air conditioning System Design , McGraw-Hill , 1985.
2. Plant Engineers and Manager's Guide to Energy Conservation, Fair Mount Press, 2008.
3. ASHRAE Hand Book–Equipment, 2005.
4. Energy conservation in Heating, Cooling and Ventilating Building, Proceeding Hemisphere Publishing Corporation, 1988.
5.Edward Hartmann, Maintenance Management, Productivity and Quality Publishing Pvt. Ltd. Madras, 1995.

RA9158 **FANS AND BLOWERS** **L T P C**
3 0 0 3

AIM:
To enable the students to know the basic principles of fluids dynamic and thermodynamic to various kinds of turbo machinery and the impact of these machine field of refrigeration and air-conditioning systems

OBJECTIVE:
- To understand the basic characteristics and special features of fans and blowers
- To have basic skills to analyze fans and blowers
- To acquire a limited design experience of fans and blowrs

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 , crossflow 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 TESTING AND CONTROL OF FANS **5**
Fan testing, noise control , materials and components blower regulation , speed control , throttling , control at discharge and inlet.

UNIT V DESIGN AND APPLICATIONS **10**
Special design and applications of blowers induced and forced draft fans for air conditioning plants, cooling towers, ventilation systems, booster systems.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Brunoeck, Fans, Pergamon Pres s, 1973.
2. Austin H. Church, Centrifugal pumps and blowers, John Wiley and Sons, 1980.

REFERENCE BOOKS:

1. Stepanoff A.J., Turboblowers , John Wiley & Sons , 1970.
2. Dixon, Fluid Mechanics, Thermodynamics of turbomachinery Pergamon Press, 1984.
3. Dixon, Worked examples in turbomachinery , Pergamon Press , 1984.

RA9159 ERECTION AND MAINTENANCE OF REFRIGERATION AND AIR CONDITIONING EQUIPMENTS

L T P C
3 0 0 3

AIM:

To impart knowledge of on the erection and maintenance of different A/C systems.

OBJECTIVE:

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

UNIT I INTRODUCTION 7

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

UNIT II ERECTION OF R&AC SYSTEMS 9

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 9

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

TOTAL: 45 PERIODS

TEXT BOOKS:

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 Air-conditioning, Good Heart-Wilcoz Co Inc., 2004.

REFERENCE BOOKS:

1. ISHRAE Hand book on Refrigeration & Air conditioning, ISHRAE Bangalore, 1998.
2. Nelson C.W., Commercial and Industrial Refrigeration, McGraw-Hill, 1982.
3. Paul F. Goliber , Laboratory Manual , Depuar publishing Inc., 1980.
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.

RA9160 INDOOR AIR QUALITY CONTROL L T P C
3 0 0 3

AIM:
To ensure that the student have a sound understanding of the fundamentals concepts of indoor air quality control and to asset their ability to identify and react to IAQ problems.

OBJECTIVE:
- 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-diagonising 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, micro electronic, 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

TEXT BOOKS:
1. Whyte W. Clean Room Design II Edition, John Wiley & Sons (NY)–1999.

REFERENCES:
1. American Institutes of Architects (AIA) , Guidelines for Design & Construction of Hospital & Health care facilities , AIA, Washington–2001.
2. Thad Godish , Sick Buildings , Lecois Publishers , Ann Arbor , 1994.
3. National Air Filtration Association, NAFA guide to Air Filtration-III edition-NAFA Washington DC-2001.
4. ASHRAE Hand Book, HVAC Systems and Equipment, I-P Edition 1996.

RA9161 QUANTITATIVE AND QUALITATIVE RESEARCH METHODOLOGIES

L	T	P	C
3	0	0	3

AIM:

To educate quantitative and qualitative research methodologies to the students.

OBJECTIVE:

- To train the students in conducting patent survey and literature review.
- To prepare the students to adopt standard tools and computer packages in their research.
- To guide the students in writing of syrupsis, tnesis and case studies.

UNIT I RESEARCH METHODOLOGY 8

Types of research-Literature survey-Patent survey-literature review reporting-ethics and interventions of research-planning for research-research tools-seven management tools- graphical representations-Codes-Standards.

UNIT II QUANTITATIVE METHODS 10

Descriptions-statistics-distribution-sampling-hypothesis testing–regression-ANOVA-reliability-validity-uncertainty-sensitivity analysis-use of SPSS.

UNIT III QUALITATIVE METHODS 10

Historical analogy-market research-survey-analysis-DELPHI methodology-determination of index-life cycle analysis-modeling and simulation.

UNIT IV MEASUREMENTS IN RESEARCH 12

Need for measurement-types of measuring instruments-configurations and functional descriptions of instruments–performance–characteristics-static and dynamic characteristics- manipulation, transmission and recording of data-data acquisition and processing systems- Computer aided experimentation.

UNIT V RESEARCH REPORT PREPARATION 5

Principles of Written communication-content preparation-synopsis writing-result analysis- discussion section-case studies.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Robert B. Burns, Introduction to Research methods, SAGE Publications London, 2000
2. Herman J. Ader, Gidon J. mellenbergh , Research Methodology , SAGE Publications London , 1999

REFERENCES:

1. Jeremy Miles& Mark Sherlin , Applying Regression and Correlation , A Guide for students and researchers SAGE Publications London , 2001
2. Ernest O. Doebelin, Measurement Systems-Application and Design IV Edition McGraw-Hill International Edition NY-1990.

RA9162 ENERGY FORECASTING, MODELING AND PROJECT MANAGEMENT

L	T	P	C
3	0	0	3

AIM:

To impact knowledge on energy prediction for the future and to develop skills on the development of optimization model to meet the future energy demand.

OBJECTIVE:

- To develop forecasting models and optimization models for energy planning.
- To equip the students in writing project proposals and making project cost estimation.
- To evaluate the limit cost of energy for various renewable energy systems.

UNIT I ENERGY CONSERVATION 10

Avenues for Energy Conservation - Energy Conservation in Pumps, Fans, Blowers - Refrigeration Equipments - Heat Rejection Equipments - Insulation - Efficient Lighting and Economics.

UNIT II FORECASTING MODEL 10

Forecasting Techniques - Regression Analysis - Double Moving Average - Double Experimental Smoothing - Triple Experiential Smoothing – ARIMA model - Validation techniques – Qualitative forecasting – Delphi technique - Concept of Neural Net Works.

UNIT III OPTIMIZATION MODEL 10

Principles of Optimization - Formulation of Objective Function - Constraints - Multi Objective Optimization – Mathematical Optimization Software – Development of Energy Optimization Model - Development of Scenarios – Sensitivity Analysis - Concept of Fuzzy Logic.

UNIT IV PROJECT MANAGEMENT 10

Project Preparation – Feasibility Study – DPR - Project Appraisal – Social-cost benefit Analysis - Project Cost Estimation – Project Risk Analysis - Project Financing – Financial Evaluation.

UNIT V RENEWABLE ENERGY FOR COOLING 5

Solar Energy - Bio Energy - Other Renewable Energy Sources for Cooling Purpose – Cost Analysis.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. S. Makridakis, Wiley (1983) Forecasting Methods and applications.
2. Yang X.S. (2008) Introduction to mathematical optimization: From linear programming to Metaheuristics, Cambridge, Int. Science Publishing.

REFERENCES:

1. Austin H. Church, centrifugal pumps and blowers, John Wiley and sons, 1980.
2. Fred Luthans, Organisational Behaviour, McGraw Hill, Inc, USA, 1992.
3. Armstrong, J.Scott (ed.)(2001). Principles of forecasting: a hand book for researchers and practitioners, Norwell, Masschusetts:Kluwer Academic Publishers.

RA9163 AIR HANDLING SYSTEMS DESIGN L T P C
3 0 0 3

AIM: To impart knowledge on various AHU unit, design procedure, energy saving methods and the International standard for maintaining thermal comfort and IAQ.

OBJECTIVE:

- 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 INTRODUCTION 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, two fan, 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

Thermostats, Damper and damper motor, Automatic Valves, Direct digital control, Application of fuzzy logic & neural network-Demand control ventilation.

TOTAL: 45 PERIODS

TEXT BOOKS:

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.

REFERENCES:

1. John I. Levenhagen, Donald H. Spethmann, HVAC controls and systems, McGraw - Hill international Edition. NY - 1992. Allan T. Kirkpatrick & James S. Elleson, cold air distribution system design guide, ASHEAC - 1996 USA.
2. Shan K.Wang, Handbook of Air-conditioning and Refrigeration, McGraw - Hill, 2001.
3. SMACNA, HVAC System Duct Design, SMACNA Virginia - 1990.

RA9164 INDUSTRIAL REFRIGERATION L T P C
3 0 0 3

AIM:

To impart knowledge on Industrial Refrigeration System components and special energy conservation measures in them.

OBJECTIVE:

- To understand the key issues in Industrial Refrigeration systems.
- To understand the operational features of compressors in large systems.
- To understand the operational features of Evaporators & Condensers in Industrial Refrigeration System.
- To understand the energy conservation aspects of 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 & 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 decisions-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. Secondary coolants: Phase diagram-physical property comparison-low temperature refrigeration.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Wilbert F.Stoecker, Industrial Refrigeration Hand Book, McGraw-Hill, 1998.

REFERENCE BOOKS:

1. ASHRAE Hand Book: Fundamentals, 2005.
2. ASHRAE Hand Book: Refrigeration, 2006.
3. ASHRAE Hand Book: HVAC Systems and Equipment, 2008.
4. Transport properties of SUVA Refrigerants, Du-Pont Chemicals, 2007.

RA9166 DESIGN OF CLEANROOMS AND CONTAINMENT AREAS

L	T	P	C
3	0	0	3

AIM: The student has to acquire a basic knowledge of, and skills in, the design maintenance of clean rooms and containment areas.

OBJECTIVE:

- To have knowledge of different classes of clean room standard for various application.
- Appreciation of quality concerns in designing clean rooms.
- To provide sufficient knowledge on cot and energy efficiency.

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 , Biocontamination 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 IV COST AND ENERGY EFFICIENCY 7

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

TOTAL: 45 PERIODS

TEXT BOOKS:

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

REFERENCES:

1. Whyte W., Cleanroom Technology: Fundamentals of Design, Testing and Operation, Wiley, 2001.
2. David M. Carlberg , Cleanroom Microbiology for the Non-Microbiologist, Second Edition, CRC; 2 edition, 2004.

RA9167 MATERIALS FOR LOW TEMPERATURE APPLICATIONS

L	T	P	C
3	0	0	3

AIM: To impart knowledge on material characterization at low temperature and selection for low temperature applications.

OBJECTIVE:

- To understand the behavioral changes in materials at low temperature.
- To understand the selection of material for low temperature applications.
- To understand the testing methods for low temperature behavior 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 behavior–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

TEXT BOOKS:

1. Wigley D.A., "Mechanical Properties of Materials at Low Temperatures", Plenum Press, New York, 1972.

REFERENCE BOOKS:

1. Richard P. Reed, Alan F. Clark, Materials at low Temperature, ASME International, Dec 1983.
2. Thomas H.Courtney , "Mechanical Behavior of Materials", (2nd Edition), McGraw-Hill , 2004.

EY9167	GREEN BUILDINGS	L	T	P	C
		3	0	0	3

AIM: To provide an introduction to initiatives, materials, theories, and practices of green building planning, design, construction, operation, deconstruction and assessment.

OBJECTIVE:

- To acquaint students with the principle theories, materials and construction and techniques used to create green building or retrofit existing buildings to be greener
- To learn green building processes and historical ecological design concept applicable to modern buildings.
- To provide exposure to various national / international rating systems and compliance requirements for green buildings.

UNIT I GREEN BUILDING PROCESS AND ECOLOGICAL DESIGN 9

Conventional versus Green Building Delivery Systems-Executing the Green Building Project-The Integrated Design Process-Green Building Documentation Requirements-Design versus Ecological Design-Historical Perspective-Contemporary Ecological Design-Future Ecological Design-Green Design to Regenerative Design

UNIT II GREEN BUILDING SYSTEMS 9

Sustainable sites and landscaping–Enhancing ecosystems-building envelop–Selection of green materials, products and practices-passive design strategy–Internal load reduction–Indoor environment quality–building water and waste management–relevance to LEED/IGBC standards

UNIT III GREEN BUILDING IMPLEMENTATION 9

Site Protection Planning, Health and Safety Planning, Construction and Demolition Waste Management-Reducing the Footprint of Construction Operations- Maximizing the Value of Building Commissioning-HVAC System, Lighting Commissioning, Commissioning of Nonmechanical Systems-Costs and Benefits of Building Commissioning relevance standards

UNIT IV GREEN BUILDING ASSESSMENT 9

USGBC LEED Building Assessment Standard -LEED Certification Process–Green Globes Building Assessment Protocol-International Building Assessment Systems- a LEED-NC Platinum / Gold / Silver Building–IGBC standards–ECBC compliance requirements

UNIT V ECONOMICS OF GREEN BUILDINGS 9

Case for High-Performance Green Buildings-Economics of Green Building-Quantifying Green Building Benefits-Managing Costs-The Cost Barrier-Project management-long term environment benefits.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Jerry Yudelson , Green Building Through Integrated Design , McGrawhill , 2008
2. Green building guidelines: meeting the demand for low-energy, resource-efficient homes. Washington, D.C.: Sustainable Buildings Industry Counci l, 2004. EnvDesign Design TJ163.5.D86.G74 2004
3. Green building: project planning & cost estimating: a practical guide for constructing sustainable buildings: cost data. Kingston, Mass.: R.S. Means, 2006. Includes resource efficient building systems, embodied energy, photovoltaics , solar energy. EnvDesign NA2542.36.K44 2002 Reference
4. Green building: project planning & cost estimating: a practical guide to materials, systems & standards; green..2nd ed. Kingston, Mass.: R.S. Means, c2006. Engineering TH880.G74 2006 Shelved: Accompanying CD-ROM shelved in Reserves Environ Dsgn TH880.G74 2006 Reference Shelved: CD Reserve; book in Reference Library has: Book & CD
5. Green Building Products: the GreenSpec guide to residential building materials/edited by Alex Wilson and Mark Peipkorn. 2nd ed. Gabriola Island, BC: New Society Publishers, c2006. EnvDesign TH455.G739 2006 Reference
6. The green guide to specification: an environmental profiling system for building materials and components / Jane Anderson, David E. Shiers with Mike Sinclair. 3rd ed. Oxford; Malden, MA: Blackwell Science, c2002. British focus, good for materials that will have a lower impact on the environment, ranked by usage based on life cycle assessment studies. Envdesign TD196.B85 A53 2002
7. Charles J. Kibert, Sustainable Construction: Green Building Design and Delivery, 2nd Edition , Wiley , 2007

IC 9162 COMPUTATIONAL FLUID DYNAMICS L T P C
3 0 0 3

AIM: This course aims to introduce numerical modeling and its role in the field of heat and fluid flow, 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.

OBJECTIVE:

(i) To develop finite difference and finite volume discretized forms of the CFD equations.
(ii) To formulate explicit & implicit algorithms for solving the Euler Eqns & Navier Stokes Eqns.

UNIT I GOVERNING DIFFERENTIAL EQUATION AND FINITE DIFFERENCE METHOD 10

Classification, Initial and Boundary conditions – Initial and Boundary Value problems – Finite difference method, Central, Forward, Backward difference, Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II CONDUCTION HEAT TRANSFER 10

Steady one-dimensional conduction, two and three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems.

UNIT III INCOMPRESSIBLE FLUID FLOW 10

Governing Equations, Stream Function – Verticity method, Determination of pressure for viscous flow, SIMPLE Procedure of Patankar and Spalding, Computation of Boundary layer flow, finite difference approach.

UNIT IV CONVECTION HEAT TRANSFER AND FEM 10

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 heat conduction by FEM – Incompressible flow – simulation by FEM.

UNIT V TURBULENCE MODELS 5

Algebraic Models – One equation model, K – ϵ Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes.

TOTAL: 45 PERIODS

TEXT BOOKS:

1.Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 1995.
2. Ghoshdasdidar, 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.

REFERENCE BOOKS:

1. Taylor, C and Hughes, J.B. “Finite Element Programming of the Navier-Stokes Equation”, Pineridge Press Limited, U.K., 1981.
2. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., “Computational fluid Mechanics and Heat Transfer “ Hemisphere Publishing Corporation, New York, USA,1984.
3. Fletcher, C.A.J. “Computational Techniques for Fluid Dynamics 1” Fundamental and General Techniques, Springer – Verlag, 1987.
4. Fletcher, C.A.J. “Computational Techniques for fluid Dynamics 2” Specific Techniques for Different Flow Categories, Springer – Verlag, 1987.
5. Bose, T.X., “Numerical Fluid Dynamics” Narosa Publishing House, 1997.

UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY CHENNAI : : CHENNAI 600 025

REGULATIONS - 2009

CURRICULUM I TO VI SEMESTERS (PART TIME)

M.E. REFRIGERATION AND AIR CONDITIONING

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA 9107	Applied Mathematics for Thermal Engineers	3	1	0	4
2	IC 9111	Advanced Heat Transfer	3	1	0	4
3	IC 9112	Advanced Thermodynamics	3	1	0	4
		TOTAL	**9**	**3**	**0**	**12**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA 9107	Refrigeration Systems Design	3	0	0	3
2	IC 9112	Instrumentation for Thermal Systems	3	0	0	3
3	IC 9111	Elective I	3	0	0	3
PRACTICAL						
4	RA 9112	Refrigeration and Air conditioning lab	0	0	3	1
		TOTAL	**9**	**0**	**3**	**10**

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	RA 9121	Air conditioning Systems Design	3	0	0	3
2	E2	Elective II	3	0	0	3
3	E3	Elective III	3	0	0	3
PRACTICAL						
4	RA 9125	Seminar	0	0	3	1
		TOTAL	**9**	**0**	**3**	**10**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	RA 9122	Computer Simulation of Refrigeration and Air conditioning Systems	3	0	0	3
2	RA 9123	Design of Condensers Evaporators and Cooling Towers	3	0	0	3
3	E4	Elective IV	3	0	0	3
PRACTICAL						
4	RA 9124	Simulation lab	0	0	3	1
		TOTAL	**9**	**0**	**3**	**10**

SEMESTER V

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	E5	Elective V	3	0	0	3
2	E6	Elective VI	3	0	0	3
3	E7	Elective VII	3	0	0	3
PRACTICAL						
4	*RA 9131	Practical Training	0	0	0	1
5	RA 9132	Project Work - Phase I	0	0	12	6
		TOTAL	**9**	**0**	**12**	**16**

SEMESTER VI

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	RA 9141	Project Work - Phase II (Continuation of Phase I)	0	0	24	12
		TOTAL	0	0	24	**12**

Total number of credits to be earned for award of the degree = 70

*** The 4 weeks training will be undergone during IV semester vacation the results will be published along with V semester results.**