JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU

DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech. HEAT POWER (REFRIGERATION & AIR-CONDITIONING)

(4 SEMESTER COURSE STRUCTURE AND SYLLABUS)

EFFECTIVE FROM THE YEAR 2015-16

I- SEMESTER:

Subject Code	SUBJECT	L	P	C
15D31101	Refrigeration	4	-	4
15D31102	Advanced Thermodynamics	4	-	4
15D31103	Conduction and Radiation Heat Transfer	4	-	4
15D31104	Principles of Air -Conditioning	4	-	4
	ELECTIVE-I	4	-	4
15D31105	Optimization of Design			
15D31106	Energy Conservation and Management			
15D31107	Advanced Thermal Storage Technologies			
15D31108	Design of Heat Exchangers			
	ELECTIVE-II	4	-	4
15D31109	Cogeneration and Waste Heat Recovery Systems			
15D31110	Total Quality Management			
15D32103	Renewable Energy Sources			
15D31111	Solar Refrigeration and Air - Conditioning			
15D31122	Refrigeration Lab	0	4	2
TOTAL		**24**	**4**	**26**

II - SEMESTER:

Subject Code	SUBJECT	L	P	C
15D31201	Design of Air-Conditioning Systems	4	-	4
15D31202	Convective Heat & Mass Transfer	4	-	4
15D31203	Refrigeration Equipment & Controls	4	-	4
15D31204	Advanced Fluid Mechanics	4	-	4
	ELECTIVE-III	4	-	4
15D31205	Cryogenic Engineering			
15D31206	Design of Heat Transfer Equipment			
15D31207	Air Handling Systems Design			
15D31208	Indoor Air Quality Control			
	ELECTIVE-IV	4	-	4
15D31209	HVAC System Design			
15D31210	Erection and Maintenance of Refrigeration and Air-conditioning Equipments			
15D31211	Food Preservation Techniques			
15D31212	Materials for Low Temperature Applications			
15D54201	Research Methodology (Audit Course)			
15D31213	Air-conditioning Lab	0	4	2
TOTAL		**24**	**4**	**26**

III & IV SEMESTERS:

Code	Subject	T	P	C
15D31301	**III Semester Seminar - I**	**0**	**4**	**2**
15D31401	**IV Semester Seminar - II**	**0**	**4**	**2**
15D31302	**III & IV Semester Project Work**	**--**	**--**	**44**
	Total	**24**	**8**	**48**

Note : All End Examinations (Theory and Practical) are of Three Hours Duration.

T – Tutorial L – Theory P- Practical / Drawing C - Credits

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EFFECTIVE FROM THE YEAR 2015-16

I-SEMESTER:

Subject Code	SUBJECT	L	P	C
15D31101	Refrigeration	4	-	4
15D31102	Advanced Thermodynamics	4	-	4
15D31103	Conduction and Radiation Heat Transfer	4	-	4
15D31104	Principles of Air -Conditioning	4	-	4
	ELECTIVE-I	4	-	4
15D31105	Optimization of Design			
15D31106	Energy Conservation and Management			
15D31107	Advanced Thermal Storage Technologies			
15D31108	Design of Heat Exchangers			
	ELECTIVE-II	4	-	4
15D31109	Cogeneration and Waste Heat Recovery Systems			
15D31110	Total Quality Management			
15D32103	Renewable Energy Sources			
15D31111	Solar Refrigeration and Air - Conditioning			
15D31122	Refrigeration Lab	0	4	2
TOTAL		**24**	**4**	**26**

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I SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

REFRIGERATION
(15D31101)

UNIT-I

Vapor Compression Refrigeration:

Analysis of vapor compression refrigeration cycle - reversed Carnot cycle for vapour - effect of suction temperature and condensing temperature on cycle performance – Practical refrigeration cycle – sub-cooled liquid and super heated vapor refrigeration cycles their effect on performance.

UNIT-II

Multi Pressure Systems- removal of flash gas- intercooling –compound compression (conversion)-multi vapor systems- cascade systems- dual compression- system practices.

UNIT-III

Simple vapor Absorption systems- actual vapor absorption cycle- H-C diagram- common refrigerant – Absorbent /Adsorbent systems.

Practical single effect Water- Lithium Bromide Absorption system- double effect system- Electrolux refrigerator- newer mixtures for absorption systems.

UNIT-IV

Aircraft Air refrigeration – working principle and types.

Steam jet refrigeration system - thermoelectric refrigeration systems - vortex refrigeration system - pulse tube refrigeration.

UNIT-V

Refrigerants:

Desirable properties- thermo dynamic-chemical and transport properties - designation of refrigerants - inorganic, halo carbon refrigerants - secondary refrigerants - Properties of mixtures of refrigerants.

Ozone depletion potential and global warming potential – effect of refrigerants- alternative refrigerants.

REFERENCE BOOKS:

1. R & A/C by F.Stoecker & Jerold. W.Jones-MGH Intrl.,1982.
2. R & A/C by C.P.Arora, TMGH-2000.
3. R & A/C by Manohar Prasad.
4. Principles of Refrigeration by Roy.J.Dossat, 1997.
5. Refrigeration by Gosney- Oxford University Press-1980.

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I SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

ADVANCED THERMODYNAMICS
(Common to R&A/C & Advanced I.C. Engines)
(15D31102)

UNIT-I
THERMODYNAMIC RELATIONS:
Introduction-Helmhotz free energy function-Gibbs free energy function-coeffficient of volumetric expansion-isothermal compressibility-differential relation for U,H,G&F-Masxwell re;;atopms.
GENERALIZED RELATIONS:
Generalized relation for Cp, Cv ,K, B-relations for internal energy and enthalpy-the various Tds equation-clapeyron equation-gas tables-enthalpy and internal energy- pressure ratio-volume ratio-change of entropy-Introduction to third law of thermodynamics.

UNIT-II
EXERGY:
Introduction-availability of heat –availability of a closed system-availability function of the closed system-availability of steady flow system- availability function of open system.
IRREVERSIBILITY:
Introduction-irreversibility for closed and open system-steady flow process effectiveness-second law analysis of the power plant.

UNIT-III
NONREACTIVE GAS MIXTURES:
Introduction-basic definitions for gas mixtures-PVT relations ship for mixtures of ideal gases-properties of mixtures of ideal gases-entropy change due to mixing – mixtures of perfect gases at different initial pressure and temperatures.

UNIT-IV
GAS SPOWER CYCLES:
Introduction-air standard cycles-carnot cycle-ottocycle –disel cycle-dual cycles-comparison between Otto,Diesel, dual cycles-variations between the air standard Otto cycle and actual cycle-Sterlling cycle-Erickson cycle-Atkinson cycle-Brayton cycle- Lenoir cycle.

UNIT-V
VAPOUR POWER CYCLES:
Introduction-the carnot vapor cycle-rankine cycle-effects of operation condition on efficiency-principles of increasing the thermal efficiency- method of increasing thermal efficiency.

DIRECT ENERGY CONVERSION:

Introduction-thermoelectric converters-thermo-ionic converters magneto hydrodynamics generators-solar power cells plant –fuel cell hydrogen –hydrogen fuel cells-direct and indirect oxidation fuel cells-biochemeical fuel cells.(no problems)

REFERENCE BOOKS:

1. Advanced Thermodynamics:Van Wyllan, TMGH
2. Engineering Thermodynamics:P.K.Nag,TMGH Advanced Thermodynamics:Ray & Sarao,Central Publishers.

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I SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

CONDUCTION AND RADIATION HEAT TRANSFER
(Common to R&A/C & Advanced I.C. Engines)
(15D31103)

UNIT-I
Introduction of three modes of heat transfer, steady, unsteady state heat transfer process, governing equations and boundary conditions

Two dimensional steady state conduction, semi-infinite and finite flat plate; temperature field in infinite and finite cylinders, Conduction through spherical shells.

UNIT-II
Numerical methods, relaxation method and finite difference methods - simple problems.

UNIT-III
Heating and cooling of bodies with negligible internal resistance, sudden changes in the surface temperature of infinite plates, cylinders and semi-infinite bodies analytical and graphical solutions -simple problems.

UNIT-IV
Review of the thermal radiation - gas radiation, mean beam length exchange between gas volume and black enclosure, heat exchange between gas volume and gray enclosure, problems.

UNIT-V
Radiation network for an absorbing and transmitting medium, radiation exchange with specular surfaces, radiation exchange with transmissivity and reflecting, and absorbing medium.
Solar radiation: Radiation properties of environment, effect of radiation on temperature measurement.

REFERENCE BOOKS :

1) Heat Transfer -Gibhart - Mc. Graw Hill.
2) Conduction Heat Transfer- -Schneder Addition Wieslthy
3) Conduction of Heat in Solids -Carslaw & Jaeger.
4) Heat transfer -J.P. Holman, International student edition
5) Fundamentals of heat and mass transfer -R.C. Sachdev New Age International Publishers
6). Heat Transfer by R. K. Rajput

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I SEMESTER	L	P	C
	4	-	4

PRINCIPLES OF AIR-CONDITIONING
(15D31104)

UNIT-I

Psychrometry: Properties of Moist air- Psychrometric relations - Psychrometric chart - Psychrometric processes - Bypass factor - Sensible heat factor

APPLIED PSYCHROMETRY: Effective and grand sensible heat factors- Selection of Air- Conditioning apparatus for cooling and dehumidification-High latent cooling load applications- All outdoor air application.

UNIT-II

Air-conditioning Processes –Mixing process- Summer, Winter and Year-round air conditioning systems - hot and dry out door condition, Hot and humid outdoor condition - winter air conditioning system - year round air-conditioning system.

UNIT-III

Process of Cooling, Heating and Dehumidifying coils - air washers - Cooling by dry and wet coils - use of hygroscopic solution in air washers - Adiabatic dehumidifier – Humidifier-water injection - steam injection. Heat pump - Different heat pump circuits air, ground water, earth - The linked air cycle heat pump - solar energy collections - Drying of materials.

UNIT-IV

Requirements of Comfort Air-conditions - Thermodynamics of human body - Body regulation process against heat or cold - comfort and comfort chart - Effective temperature - Factors governing optimum effective temperature -Design considerations- Selection of outside and Inside design conditions.

UNIT-V

Ventilation systems: Natural ventilation system - Mechanical - Extraction system - Supply system - Combined supply and extraction system - Air-cleaning - Equipment used for odour suppression and air sterilization. Air-conditioning controls systems - basic elements of the control systems - temperature, humidity and pressure controls and refrigeration flow controls - room thermostat.

REFERENCE BOOKS:

1.Hand Book of Air conditioning system design -Carrier
2.Refrigeration & Air-conditioning -C.P.ARORA, TMGH,2000.
3 Refrigeration & Air-conditioning --Domkundwar and Arora,DanpatRai& Sons,2000.
5 Refrigeration & Air-conditioning --Stoecker.
6 Refrigeration & Air-conditioning -V.K.Jain.
7. ASHRE - Guide and data book

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I SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

OPTIMIZATION OF DESIGN (ELECTIVE-I)
(15D31105)

UNIT I

SINGLE VARIABLE NON-LINEAR UNCONSTRAINED OPTIMITION:

One dimensional Optimization methods:- Uni-modal function, elimination method, Fibonacci method, golden section method, interpolation methods- quadratic & cubic interpolation methods.

UNIT II

Multi variable non-linear unconstrained optimization: Direct search method – Univariant Method – pattern search methods – Powell's – Hook – Jeeves, Rosenbrock search methods – gradient methods, gradient of function, steepest decent method, Fletcher reeves method. **Variable** metric method.

UNIT III

GEOMETRIC PROGRAMMING:

Polynomials – arithmetic – geometric inequality – unconstrained G.P – constrained G.P

DYNAMIC PROGRAMMING:

Multistage decision process, principles of optimality, examples, conversion of final problem to an initial value problem, application of dynamic programming, production inventory. Allocation, scheduling replacement.

UNIT IV

Linear programming – formulation – Sensivity analysis. Change in the constrints, cost coefficients , coefficients of the constraints, addition and deletion of variable, constraints.

Simulation – Introduction – Types – Steps – application – inventory – queuing – thermal system.

UNIT V

Integer Programming – introduction – formulation – Gomory cutting plane algorithm – Zero or one algorithm, branch and bound method.

STOCHASTIC PROGRAMMING:

Basic concepts of probability theory, random variables – distributions – mean, variance, Correlation, co variance, joint probability distribution – stochastic linear, dynamic programming.

REFERENCES:

1. Optimization theory & Applications/ S.S Rao/ New Age International
2. Introductory to operation research/Kasan & Kumar/Springar
3. Optimization Techniques theory and practice / M.C Joshi, K.M Moudgalya/ Narosa Publications.
4. S.D Sharma/Operations Research
5. Operation Research/H.A. Taha/TMH
6. Optimization in operations research/R.L Rardin
7. Optimization Techniques/Benugundu & Chandraputla/Person Asia.

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I- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

ENERGY CONSERVATION AND MANAGEMENT (ELECTIVE - I)
(15D31106)

UNIT-I
ENERGY CONSERVATION:
Rules for efficient energy conservation – technologies for energy conservation – outline of waste heat and material reclamation, load management, alternate energy sources, and energy storage.

UNIT-II
THERMAL INSULATION & REFRACTORS:
Heat loss through un-insulated surfaces, effects of insulation on current carrying wires – economic thickness of insulation – critical radius of insulation – properties of thermal insulators – classification of insulation materials – classification of refractors – properties of refractors – criteria for good refractory material – applications of insulating & refractory materials.

UNIT-III
WASTE HEAT RECOVERY SYSTEMS:
Guideline to identify waste heat – feasibility study of waste heat – shell and tube heat exchanger – thermal wheel – heat pipe heat exchanger – heat pump – waste heat boilers – incinerators.
HEAT RECOVERY SYSTEMS & HEAT EXCHANGER NETWORKS:
Liquid to liquid heat exchangers – gas to liquid heat recovery systems, regenerators, recuperators, rotating regenerators – miscellaneous heat recovery methods – selection of materials for heat exchangers – combined radiation and convective heat exchanger, U-tube heat exchanger, tube heat exchanger, fluidized bed heat exchanger – economizer.

UNIT-IV
ENGINEERING ECONOMICS:
Managerial objectives, steps in planning – efficiency of organization- capital budgeting – classification of costs – interest – types – nominal and effective interest rates – discrete and continuous compounding – discounting - time value of money – cash flow diagrams – present worth factor, capital recovery factor, equal annual payments – equivalent between cash flows.
ENERGY AUDITING:
A definition – objectives – level of responsibility – control of energy – uses of energy – check lists – energy conservation schemes – energy index – cost index – pie charts – sankey diagrams – load profiles – types of energy audits – questionnaire – energy audit of industries – general energy audit – detailed energy audit – energy saving potential.

UNIT-V

PROJECT MANAGEMENT:

Method of investment appraisal – rate of return method, pay back method, net present value method (NPV) – adoption of the methods in energy conservation campaign – types of projects — propose of project management – classification – role and qualities of project manager – types of budgets - budget committee – budgeting.

ENERGY MANAGEMENT PROGRAMS:

Necessary steps of energy management programme – concepts of energy management – general principles of energy management – energy management in manufacturing and process industries – qualities and functions of energy managers – duties of energy manager - language of energy manager – checklist for top management.

REFERENCE BOOKS:

1. Waste heat recovery systems -D.A. Reay/Pergmon Press
2. Hand book of energy audits -Albert Thumann
3. Energy Management -W.R. Murphy & G.Mickay, Butterworths
4. Energy Conservation -P.W.O' Callaghan, Pargamon Press 1981
5. Engineering Heat Audits -C.P. Gupta & Rajendra Prakash, Nechand & Bros.
6. Hand book of energy audits -Albert Thumann, The F.Airmont Press Inc., Atlanta Georgia, 1979.
7. Energy Management Principles -Craig B. Smithm, Pergarmon Press
8. The rols of Energy Manger -EEO., U.K.
9. Industrial Engineering & Management -Dr. O.P.Khanna, Dhanapat Rai & Sons, 1992
10. 'PERT – CPM' -L.S. Srinath

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I- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

ADVANCED THERMAL STORAGE TECHNOLOGIES (ELECTIVE - I)
(15D31107)

UNIT I INTRODUCTION
Necessity of thermal storage – types-energy storage devices – comparison of energy storage technologies - seasonal thermal energy storage - storage materials.

UNIT II SENSIBLE HEAT STORAGE SYSTEM
Basic concepts and modeling of heat storage units - modeling of simple water and rock bed storage system – use of TRNSYS – pressurized water storage system for power plant applications – packed beds.

UNIT III REGENERATORS
Parallel flow and counter flow regenerators – finite conductivity model – non – linear model – transient performance – step changes in inlet gas temperature – step changes in gas flow rate – parameterization of transient response – heat storage exchangers.

UNIT IV LATENT HEAT STORAGE SYSTEMS
Modeling of phase change problems – temperature based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change.

UNIT V APPLICATIONS
Specific areas of application of energy storage – food preservation – waste heat recovery – solar energy storage – green house heating – power plant applications – drying and heating for process industries.

TEXT BOOK:
1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.

REFERENCES:
1. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.
2. Lunardini.V.J, Heat Transfer in Cold Climates, John Wiley and Sons 1981.

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I- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

DESIGN OF HEAT EXCHANGERS (ELECTIVE – I)
(15D31108)

UNIT I FUNDAMENTALS OF HEAT EXCHANGER 9
Temperature distribution and its implications types – shell and tube heat exchangers – regenerators and recuperators – analysis of heat exchangers – LMTD and effectiveness method.

UNIT II FLOW AND STRESS ANALYSIS 9
Effect of turbulence – friction factor – pressure loss – stress in tubes – header sheets and pressure vessels – thermal stresses, shear stresses - types of failures.

UNIT III DESIGN ASPECTS 9
Heat transfer and pressure loss – flow configuration – effect of baffles – effect of deviations from ideality – design of double pipe - finned tube - shell and tube heat exchangers - simulation of heat exchangers.

UNIT IV COMPACT AND PLATE HEAT EXCHANGERS 9
Types – merits and demerits – design of compact heat exchangers, plate heat exchangers – performance influencing parameters - limitations.

UNIT V CONDENSERS AND COOLING TOWERS 9
Design of surface and evaporative condensers – cooling tower – performance characteristics.

TEXT BOOK:
1. Sadik Kakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, 2002

REFERENCES
1. Arthur. P Frass, Heat Exchanger Design, John Wiley & Sons, 1988.
2. Taborek.T, Hewitt.G.F and Afgan.N, Heat Exchangers, Theory and Practice, McGraw-Hill Book Co. 1980.
3. Hewitt.G.F, Shires.G.L and Bott.T.R, Process Heat Transfer, CRC Press, 1994.

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I- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

Cogeneration and Waste Heat Recovery Systems (ELECTIVE - II)
(15D31109)

UNIT I
INTRODUCTION
Introduction – principles of thermodynamics – cycles – topping – bottoming – combined cycle – organic rankine cycles – performance indices of cogeneration systems – waste heat recovery – sources and types – concept of tri generation.

UNIT II
CONGENERATION TECHNOLOGIES
Configuration and thermodynamic performance – steam turbine congeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – combined cycles cogeneration systems – advanced cogeneration systems: fuel cell, Stirling engines etc.,

UNIT III
ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES
Cogeneration plants electrical interconnection issues – utility and cogeneration plant interconnection issues – applications of cogeneration in utility sector – industrial sector – building sector – rural sector – impacts of cogeneration plants – fuel, electricity and environment.

UNIT IV
WASTE HEAT RECOVERY SYSTEMS
Selection criteria for waste heat recovery technologies – recuperators – Regenerators – economizers – plate heat exchangers – thermic fluid heaters – Waste heat boilers – classification, location, service conditions, design Considerations – fluidized bed heat exchangers – heat pipe exchangers – heat pumps – sorption systems.

UNIT V
ECONOMIC ANALYSIS
Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves – sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems.

TEXT BOOKS:
1. Charles H. Butler, Cogeneration, McGraw Hill Book Co., 1984.11
2. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001

REFERENCES:
1. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.
2. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers,London, 1963.
3. Seagate Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
4. De Nevers, Noel., Air Pollution Control Engineering, McGrawHill, New York,1995

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I- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

TOTAL QUALITY MANAGEMENT (ELECTIVE-II)
(15D31110)

UNIT – I

TQM – Overview, Concepts, Elements – History-Quality Management Philosophies-Juran, Deming, Crosby , Feigenbaum, Ishikawa– Stages of Evolution– Continuous Improvement – Objectives – Internal and External Customers. Quality Standards – Need for Standardization - Institutions – Bodies of Standardization, ISO 9000 series – ISO 14000 series – Other Contemporary Standards – ISO Certification Process-Third Party Audit

UNIT – II

Process Management- Quality Measurement Systems (QMS) – Developing and Implementing QMS –TQM Tools & Techniques- 7 QC Tools- 7 New QC Tools.
Problem Solving Techniques - Problem Solving Process – Corrective Action – Order of Precedence– System Failure Analysis Approach – Flow Chart – Fault Tree Analysis – Failure Mode Assessment and Assignment Matrix – Organizing Failure Mode Analysis – Pedigree Analysis.

UNIT – III

Quality Circles – Organization – Focus Team Approach – Statistical Process Control – Process Chart – Ishikawa Diagram – Preparing and using Control Charts.

UNIT – IV

Quality Function Development (QFD) – Elements of QFD – Benchmarking-Types-Advantages & Limitations of Benchmarking – Taguchi Analysis – Loss function - Taguchi Design of Experiments, Robust Design, Poka-yoke, Kaizen, Deming Cycle.

UNIT – V

Value Improvement Elements – Value Improvement Assault – Supplier Teaming; Business Process Reengineering & Elements of Supply Chain Management. Six Sigma Approach – Application of Six Sigma Approach to various Industrial Situations.

TEXT BOOKS:

1Total Quality Management,DakhBesterfield, Pearson Edu.

2. Total Quality Management, K.ShridharBhat, Himalaya.

REFERENCE BOOKS:

1. Quality management, Howard Giltow-TMH

2. Quality management, Evans.

3. Quality management, Bedi

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I SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

RENEWABLE ENERGY SOURCES (ELECTIVE-II)
(15D32103)

UNIT – I
SOLAR ENERGY:
Availability of solar energy, Measurement of sunshine, solar radiation data, estimation of average solar radiation, the black body, absorptance and emittance, Kirchoff's law. Reflection from surfaces, Solar energy selection, selective surfaces, Construction of solar flat plate and evacuated tube collectors, Performance of solar energy collectors, Solar heating and cooling.

UNIT – II
WIND ENERGY:
Wind mills and wind turbine systems, Classification of wind machines: Horizontal & Vertical axis configuration. High and low solidity rotors, Elements of wind mills and wind turbine systems, Aerodynamic models, Rankine Froud Actuator disc model, Betz limit, angular momentum wake rotation theory, Aerofoil sections and their characteristics, Estimation of power output and energy production.

UNIT – III
OCEAN THERMAL ENERGY:
Ocean thermal energy sources, Ocean thermal energy power plant development, Closed and open cycles. Advantages and operating difficulties.
TIDAL & WAVE ENERGY
Tidal power sources, Conventional and latest design of tidal power system, The ocean wave, Oscillating water column (Japanese) and the Dam, Atol design.

UNIT – IV
GEOTHERMAL ENERGY :
Earth as source of heat energy, stored heat and renewability of earth's heat, Nature and occurrence of geo thermal field, Classification of thermal fields, Model of Hyper thermal fields & Semi thermal fields, drilling hot water measurements.

UNIT – V
FUEL CELL ENERGY:
Description, properties and operation of fuel cells, Major components & general characteristics of fuel cells, Indirect methanol fuel cell systems. Phosphoric acid fuel cell systems and molten carbonate fuel cell systems.

BIOMASS ENERGY:

Types of conversion techniques for the production of solid, liquid and gaseous fuels by chemical and biochemical methods, and Biomass gasifiers- Selection of a model and size, Technical, Climatic, geographical and economic issues.

BOOKS:

1. Principles of Solar Engineering: F.Kreith&J.F.Krieder/Mc.Graw Hill Book Co
2. Wind Energy conversion Systems: L.C.Freris, Prentice Hall, Inc..
3. Non-conventional Energy Sources: G.D. Rai
4. Energy Technology: S. Rao & B.B. Parulekar
5. Geo thermal energy: H.Christopher&H.Armstead.
6. Photo Voltaic Energy Systems, Design&Applications: Mathew Buresch, Mc Graw Hill Book Co..
7. Bio Gas Technology, A Practical Hand Book: K.C.Khendelwal&S.S.Mahdi Mc Graw Hill Book Co..
8. Hand Book of Batteries and Fuel cells: David Linden, Mc Graw Hill Book Co..
9. Energy Conversion Systems: H.A.Sorenson: John Wiely & S.jons
10. Renewable Energy Sources & Conversion technology: Bansal.K: Leemann&Meliss
11. Energy technology Hand Book: EdD.M.Considine
12. Principles of energy conversion AW.Culp

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I SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

SOLAR REFRIGERATION & AIR CONDITIONING (ELECTIVE - II)
(15D31111)

UNIT - I
Review of Psychometric and (Air-conditioning) cooling load calculations-outline of Vapour Compression Refrigeration Systems – Cycle on p-h and T-o charts – C.O.P – Simple problems using property tables.

UNIT - II
Principle of working of working of vapour Absorption Refrigeration, steam jet refrigeration, thermoelectric refrigeration – classification of refrigerants – Desirable properties of ideal refrigerant - Properties of solvent - Solvent refrigerant combination properties.

UNIT - III
Solar cooling systems: vapour compression systems, Rankine cycle, Striling cycle, using P.V.Modules. Solar operated vapour absorption systems – vapour jet refrigeration systems.

UNIT - IV
Solar thermal energy storage - Active and passive systems TROMBE wall – equivalent thermal circuit - Solar green houses.

Solar cooling and dehumidification: Desiccant cooling - Solid and liquid desiccants - improving desiccant cycles - hybrid systems.

UNIT - V
Non –mechanical systems - Australian Rock system – Solar assisted Heat Pump – Economics of solar cooling systems.

Simulation of solar thermal systems - Salient features of DYNSYS, TRNSYS – model formulation – flow diagram of cooling systems.

REFERENCE BOOKS:
1. A course in Refrigeration & Air –conditioning, S.Domakundwar & S.C.Arora
2. Principles of Solar engineering, F.Kreith &J.F.Kreider, Mc Graw Hill Book company
3. Solar Cooling & Heating Volumes, I,II,III., T.Negat Vezirogulu
4. Entrepreneurship Development in New & Renewable Energy Technologies APPC & IREDA

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
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I SEMESTER	**L**	**P**	**C**
	0	**4**	**2**

REFRIGERATION LAB
(15D31122)

Vapor compression Refrigeration system (v.c.r.s.)

1. Determination of C.O.P . and time taken for ICE making in the Domestic Vapor Compression Refrigeration.
2. Study on Compressor unit.
3. Determination of the pull-down characteristics of V.C.R.S.
4. Study of Condenser unit
5. Determination of the C.O.P of vapor Absorption Refrigeration system
6. Study on Expansion devices.
7. Determination of the cooling capacity and C.O.P. of evaporative condensing test rig.
8. Study of evaporators and condensers device.

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(II- SEMESTER COURSE STRUCTURE AND SYLLABUS)

EFFECTIVE FROM THE YEAR 2015-16

II - SEMESTER:

Subject Code	SUBJECT	L	P	C
15D31201	Design of Air-Conditioning Systems	4	-	4
15D31202	Convective Heat & Mass Transfer	4	-	4
15D31203	Refrigeration Equipment & Controls	4	-	4
15D31204	Advanced Fluid Mechanics	4	-	4
	ELECTIVE-III	4	-	4
15D31205	Cryogenic Engineering			
15D31206	Design of Heat Transfer Equipment			
15D31207	Air Handling Systems Design			
15D31208	Indoor Air Quality Control			
	ELECTIVE-IV	4	-	4
15D31209	HVAC System Design			
15D31210	Erection and Maintenance of Refrigeration and Air-conditioning Equipments			
15D31211	Food Preservation Techniques			
15D31212	Materials for Low Temperature Applications			
15D54201	Research Methodology (Audit Course)	3	-	-
15D31213	Air-conditioning Lab	0	4	2
TOTAL		**24**	**4**	**26**

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II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

DESIGN OF AIR-CONDITIONING SYSTEMS
(15D31201)

UNIT-I
AIR-DISTRIBUTION
Room air distribution - types of supply air outlets - Mechanism of flow through outlets – Considerations for selection and location of outlets - Distribution patterns of outlets friction loss in ducts- grills, diffusers - registers - location of outlets and return air opening - friction loss in ducts - Rectangular equivalents of circular ducts - Air ducts design: duct construction - Duct design procedures- Equal Friction, Static Regain, Velocity Reduction methods.

UNIT-I
BUILDING SURVEY & COOLING LOAD ESTIMATION:
Location of equipment and- Heat gain through glass-Shading from reveals, overhangs and fins-Effect of shading device-Calculation of Solar heat gain through ordinary glass using tables, Fabric heat gain, overall heat transfer coefficient, periodic heat transfer through walls and roofs- solair temperature-Empirical methods to calculate heat transfer through walls and roofs using decrement factor and time lag-Equivalent temperature difference method-Infiltration-Stack effect-wind action- load due to infiltration.

COOLING LOAD ESTIMATION:
Occupancy load, lighting load, appliance load-Product load-system heat gains-cooling and heating load estimates-Heat storage, diversity and stratification.

UNIT-III
AIR CONDITIONING SYSTEMS:-
Central station Air conditioning system- All water, all air, air water - unitary, Split, district Air conditioning systems.

UNIT-IV
THERMAL INSULATION & AIR HANDLING APPARATUS:
Method of Heat transfer, desired properties of ideal insulating materials, types of insulating materials, Heat transfer through insulation, economic thickness of insulation, insulation of heated Buildings, insulation for cooling Buildings and cold storage, pipe insulation. Fans and Blowers-types of Fans-Fan characteristics-Centrifugal Fans-Axial Fans-Fan arrangements-Filters- general service – Noise - sources &control

UNIT-V
APPLICATIONS OF AIR-CONDITIONING: -
Industrial, Commercial, transport Air conditioning-Special applications-Computer, Hospital Cold storages, Printing, Textile & Leather industries.

REFERENCES BOOKS:

1. Hand Book of Air conditioning system design -Carrier
2. Refrigeration & Air-conditioning -C.P.ARORA, TMGH,2000.
3. Refrigeration & Air-conditioning --Domkundwar and Arora, DanpatRai & Sons, 2000.
4. Refrigeration & Air-conditioning -Stoecker.
5. Refrigeration & Air-conditioning -V.K.Jain.
6. ASHRAE - Guide and Data Book

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II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

CONVECTIVE HEAT &MASS TRANSFER

(Common to R&A/C & Advanced I.C. Engines)

(15D31202)

CONVECTIVE HEAT TRANSFER:

UNIT-I

Introduction to convection, review of conservation equations - Forced convection in laminar flow - Exact and approximate solutions of Boundary layer energy equation for plane isothermal plate in longitudinal flow - problems.

UNIT-II

Forced convection heat transfer in laminar tube flow - forced convection in turbulent flow – Internal Flows-Correlations-Problems. Approximate analysis of laminar free convective heat transfer on a vertical plate-external flows-correlations-problems.

UNIT-III

Boiling and condensation: Analysis of film condensation on a vertical surface – pool boiling - forced convection boiling inside tubes - problems.

MASS TRANSFER:

UNIT-IV

Definitions of concentration and velocities relevant to mass transfer, Fick's law, species conservation equation in different forms. Steady state diffusion in dilute solutions in stationary media, transient diffusion in dilute solutions in stationary media, one dimensional non dilute diffusion in gases with one component stationary.

UNIT-V

Convective mass transfer - governing equations-forced diffusion from flat plate- Dimension less correlation’s for mass transfer. Simultaneous heat and mass transfer - analogy between heat, mass and momentum transfer.

REFERENCES BOOKS:

1. Heat transfer - J. P. Holman.
2. Heat and Mass transfer- R.C. Sachdeva
3. Convective Heat and Mass transfer-Kays.
4. Heat and Mass transfer - V.Gupta and I.Srinivasan - Tata Mc.Graw Hill

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II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

REFRIGERATION EQUIPMENT & CONTROLS
(15D31203)

UNIT-I

Compressors - types - equivalent shaft work - Volumetric efficiency - factors affecting total volumetric efficiency - compound compression with inters cooling - rotary compressors - surging - screw compressors - lubricating oils.

UNIT-II

Condensers - types -Water cooled Condensers-Air cooled, Evaporative types - Economic water rate - Economic water velocity - over all heat transfer co-efficient - design - temperature distribution and heat flow in a condenser - pressure drop - fouling factor - LMTD correction factor (no problems).

Cooling towers and spray ponds - classification - performance of cooling towers - analysis of counter flow cooling towers - enthalpy - temperature diagram of air and water - cooling ponds - types - cross flow cooling towers - procedure for calibration of outlet conditions.

UNIT-III

Evaporators - types - Flooded and dry Evaporators, natural and forced convection type - shell and tube - shell and coil, plate type - secondary Evaporators - temperature distribution and heat flow in evaporator - pressure drop - fouling correction factor (no problems).

Defrosting - necessity - methods - manual, automatic, periodic defrosting, solid and liquid adsorbents, water defrosting, defrosting by reversing the cycle, automatic hot gas defrosting, thermo balance defrosting, electric control defrosting. (no problems)

UNIT-IV

Expansion devices - Capillary tube, thermostatic expansion valve - float valves, externally equalized valves - automatic expansion valves - solenoid control valve - location of piping and pump design consideration.(no problems)

UNIT-V

Performance of complete Vapour compression system-Performance of condensing unit-compressor -Evaporator-balancing of load in two stage compression.(no problems)

Installation of vapour compression refrigeration system - evaluation and dehydration testing for leakages - charging - adding oil.(no problems)

REFERENCES:

1. 'Refrigeration and Air Conditioning'- by Stoecker – TMGH– International Edition,1982
2. 'Refrigeration and Air Conditioning' - by Domkundwar – Dhanpat Rai & Co., - 2000
3. 'Refrigeration and Air Conditioning' - by - C.P.Arora – TMGH - 2000

4. ASHRAE Guide and Data book applications.

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II SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

ADVANCED FLUID MECHANICS

(Common to R&A/C & Advanced I.C. Engines)

(15D31204)

UNIT - I

Basic concepts: Continuum hypothesis – Eulerian and Lagrangian descriptions. Derivation of general differential equations – continuity momentum and energy of incompressible flow-Navier Stokes equation for Viscous Fluids (Rectangular Co-Ordinate Systems)-Euler's equations for ideal fluids-Bernoulli's equations (one dimensional) – applications

UNIT - II

Laminar Flow Viscous Incompressible Fluids: Flow similarity – Reynolds number, flow between parallel flat plates, couette-flow, plane poiseuille flow, Hagen – poiseuille flow.

Laminar boundary layer: Boundary layer concept, Prandtl's approximations, Blassius solution for a flat plate without pressure gradient – momentum integral equation – Von-Kerman integral relation – Pohlhausen method of obtaining approximate solutions. Displacement thickness,momentum thickness and energy thickness.Boundary layer separation and control, Kerman's integral equation.

UNIT - III

Introduction to turbulence: Origin of turbulence, nature of turbulent flow – Reynolds equations and Reynolds stresses, velocity profile.

Compressible Fluid Flow Basics: Mach number, Flow pattern in compressible flow, classification of compressible flow, isentropic flow, stagnation properties.

UNIT - IV

Gas Dynamics: Compressible flow through ducts and nozzles – area velocity relations. Flow through convergent and convergent divergent nozzles. Real nozzles flow at design conditions. Introduction to normal compression shock – normal shock relations. Introduction to Fanno Raleigh equations.

UNIT - V

Flow in ducts with friction: Fanno line, adiabatic constant area- Flow of perfect gas, chocking due to friction in constant area flow- Introduction to constant area flow with heat transfer (Raleigh line)

REFERENCE:

1. Yuan S.W. "Foundations of Fluid Mechanics", Prentice Hall – Eastern economy edition 1983
2. Zucrwo M.J. and Hoffman J.D. "Gas Dynamics", Vol-I & Vol-II, John Wiley and Sons Inc. 1977
3. Yahya S.M. "Fundamentals of Compressible Flow", - Wiley Eastern
4. Young, Munsen and Okiisyi, " A Brief Introduction to Fluid Mechanics" 2nd Edition, John Wiley 2000.
5. Frank.M.White, " Fluid Mechanics 5th Edn – McGraw Hill 2005.

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II-SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

CRYOGENIC ENGINEERING (ELECTIVE-III)
(15D31205)

UNIT-I
Introduction necessity of low temperature - Multistage Refrigeration system -Cascade system - Manufacture of dry ice-Joule Thompson coefficient.
Liquification of air - Lindae system-Analysis-Dual pressure cycle analysis-Liquefaction of Hydrogen and Helium-problems.

UNIT-II
Application of Lower temperature-Effects on the properties of metals-strength-Thermal properties-super conductivity-super fluidity.
Applications like expansion fitting - cryobiology-cryosurgery - space research-computers under ground power lines.

UNIT-III
Low temperature insulation-Reflective insulation-Evacuated powders-Rigid foams-Super insulation.

UNIT-IV
Cooling by adiabatic de-magnetization - Gas separation and cryogenic systems-separation of gases- Rectifying columns-Air separating- single and double columns Air separation plant.

UNIT-V
Storage and handling of cryogenic liquids - Dewars and other types of containers.

REFERENCE BOOKS:
1. Cryogenics by Barron. Oxford University Press 1980.
2. Cryogenic Engineering by Timmerhaus
3. Cryogenic Engineering by Huston: McGraw Hill
4. Refrigeration and Air-conditioning by S.Domkundwar.

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II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

DESIGN OF HEAT TRANSFER EQUIPMENT (ELECTIVE - III)
(15D31206)

UNIT - I
DESIGN OF HEAT EXCHANGERS:
Exchangers-mean temperature differences for parallel and counter flow- effectiveness method(N.T.U)-keys and London charts.
DESIGN OF CONDENSERS:
Types overall heat transfer coefficients- temperature distribution and heat flow in a condenser-pressure drop in a condenser –extended fin surfaces-consideration of fouling factor-L.M.T.D. correction factor.

UNIT - II
DESIGN OF EVAPORATORS:
Temperature distribution and heat flow in an evaporator-pressure drop- factor to be consider in the design of heat transfer equipment-types of heat consideration of fouling factor – correction factor
DESIGN OF COMPRESSORS:
Types-equivalent shaft work-volumetric efficiency-factors affecting total volumetric efficiency –compound compression with inter cooling- rotary compressors-surging.

UNIT - III
DESIGN OF COOLING TOWERS AND SPRAY PONDS:
Classification-performance of cooling towers – analysis of counter flow cooling towers-enthalpy-temperature diagram of air and water- cooling ponds- types of cooling ponds –cross flow cooling towers- procedure for calculation of outlet conditions.

UNIT - IV
DESIGN OF DUCTS:
Continuity equation-Bernoulli’s equation-pressure losses-frictional charts- coefficient of resistance for fillings- duct sizing methods.
DESIGN OF FANS:
Standard air-fan horsepower-fan efficiency-similarity laws-fan laws-performance coefficients- theoretical expression for total pressure drop by a fan-centrifugal fan- axial flow fan-system resistance.
UNIT - V
PIPING SYSTEM:
Requirements of a good piping system-pressure drop in pipes-moody chart-refrigerant piping-discharge line-liquid line-suction line-piping arrangement

REFERENCE BOOKS:
1. Heat and mass transfer by Arora & Domkundwar.
2. Refrigeration & Air-Conditioning by P.L.Ballaney
3. .Refrigeration & Air-Conditioning by C.P.Arora.
4. .Refrigeration & Air-Conditioning by Stoecker

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M.Tech. HEAT POWER (REFRIGERATION & AIR-CONDITIONING)

II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

AIR HANDLING SYSTEMS DESIGN (ELECTIVE – III)
(15D31207)

UNIT I
BASIS CONCEPTS
Psychrometric, Classifications of Air-Handling Units, Main components, Selection of Air-Handling units, economizer cycle, single zone system, multi zone system-Design Consideration, duct designstatic Regain-equal friction-T method.

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

UNIT III
AIR SYSTEM: COMPONENTS
Fan-types, Construction, Arrangement, and Selection, Coil Characteristics and Accessories, Condensate control and Freeze-up protection

UNIT IV
VENTILATION FOR CONTROL OF WORK ENVIRONMENT
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
Demand control ventilations, Thermostats, Damper and damper motor, Automatic Valves, Direct digital control, Application of fuzzy logic & neural network-Demand control ventilation.

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. Allan T. Kirkpatrick & James S. Elleson, cold air distribution system design guide, ASHEAC - 1996 USA.
4. Shan K.Wang, Handbook of Air-conditioning and Refrigeration, McGraw -Hill, 2001.
5. SMACNA, HVAC System Duct Design, SMACNA Virginia - 1990.

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M.TECH. HEAT POWER (REFRIGERATION & AIR-CONDITIONING)

II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

INDOOR AIR QUALITY CONTROL (ELECTIVE - III)
(15D31208)

UNIT I AIR QUALITY

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

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.
5. ASHRAE Hand Book, HVAC Systems and Equipment, I-P Edition 1996.

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
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II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

HVAC SYSTEM DESIGN (ELECTIVE - IV)
(15D31209)

UNIT-I

Applied Psychrometry, Psychrometric processes using chart Load Estimation: solar heat gain, study of various sources of the internal and external heat gains, heat losses, etc. Methods of heat load calculations: Equivalent temperature Difference Method, Cooling Load Temperature Difference, and Radiance Method, RSHF, GSHF, ESHF, etc. Inside and outside design conditions.

UNIT-II

Air Distribution: Fundamentals of air flow in ducts, pressure drop calculations, design ducts by velocity reduction method, equal friction method and static regain method, duct materials and properties, insulating materials, types of grills, diffusers, wall registers.

UNIT-III

Ventilation and Infiltration: Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load. Fans and Blowers: Types, performance characteristics, series and parallel arrangement, selection procedure.

UNIT-IV

Direct and Indirect Evaporative Cooling: Basic psychometric of evaporative cooling, types of evaporative coolers, design calculations, Air Conditioning Equipments and Controls: Chillers, Condensing units, Cooling coils, bypass factors, humidifiers, dehumidifiers, various types of filters, air washers, thermostat, humidistat, cycling and sequence controls, modern control of parity, odour and bacteria, Air filtration- Study of different types of filters, Cooling Towers

UNIT-V

Air conditioning systems: Classification, design of central and unitary systems, typical air conditioning systems such as automobile, air plane, ships, railway coach air-conditioning, warm air system, hot water systems, heat pump, clean rooms (descriptive treatments only). Standards and Codes: ASHRAE/ARI, BIS standards study and interpretation, ECBC, NBC codes

REFERENCES:

1. ASHRAE Handbooks
2. ISHRAE Handbook.
3. Handbook of Air Conditioning System Design, Carrier Incorporation, McGraw Hill Book Co., USA.
4. Trane air conditioning manual,
5. Refrigeration and Air conditioning, ARI Prentice Hall, New Delhi.
6. Norman C. Harris, Modern air conditioning
7. Jones W. P., Air conditioning Engineering, Edward Arnold Publishers Ltd, London, 1984.
8. Jones W. P., Air conditioning Engineering - Applications, Edward Arnold Publishers Ltd, London, 1984
9. Hainer R. W., Control System for Heating, Ventilation and Air conditioning, Van Nastrand Reinhold Co., New York, 1984.
10. Refrigeration and Air conditioning- C P Arora, Tata McGraw Hill Publication, New Delhi.
11. McQuiston, Faye; Parker, Jerald; Spitler, Jeffrey 2000, Heating, Ventilating and Air Conditioning-Analysis and Design, 5th ed. John Wiley & Sons.

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II SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

ERECTION AND MAINTENANCE OF REFRIGERATION AND AIR-CONDITIONING EQUIPMENTS (ELECTIVE-IV)
(15D31210)

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

UNIT II ERECTION OF R&AC SYSTEMS
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
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
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
Maintenance procedures, leak detection, vacuumising , charging , trial run , prevention , lubrication , different methods. Studies on different maintenance schedules followed by various industries.

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 Airconditioning, 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.

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II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

FOOD PRESERVATION TECHNIQUES (ELECTIVE – IV)
(15D31211)

UNIT-I
Theories and method of chilling, freezing and free de-humidification – preparation for freezing, freezing methods: commercial freezing methods – sharp, quick and air blast freezing, freeze-drying. Methods of pre-cooling fruits and vegetables – hydro cooling, forced air cooling and vacuum cooling.

UNIT-II
Processing of meat products: Refrigeration systems for carcass chilling and holding – chilled brine spray, sprayed coil – dry coil systems, chilling and freezing variety meats – overnight chilling, quick chilling, effect of freezing temp on qualify of meat product
Fishery products: icing of fish – saltwater icing, freezing methods – slow freezing, blast freezing, plate freezing and immersion freezing of fish.

UNIT-III
Dairy products: Milk processing, handling, dairy plant procedure, standardizing, pasteurization, homogenizing, and container filling.

UNIT-IV
Fruit juice concentrations: Processing and quality control – selection, grading and handling of fresh fruit, washing, juice extraction, heat treatment, flavor fortification, packaging storage and distribution- convection methods- freezing and mechanical separation, low temperature vacuum evaporation, direct refrigerant contact method, indirect refrigerant contact methods, high temperature short time evaporations.

UNIT-V
Refrigerated warehouse: factors affecting ware house design- building location, design reduction, shipping and receiving plant forms, utility space, controlled atmospheric storage rooms, jacketed storages, automated ware house – insulation, cold storage doors. Refrigerated trucks, trailers & containers: temperature control methods, body design & construction, auxiliary equipment, types of refrigeration systems- railway refrigeration cars.

REFERENCE BOOKS:
1. ASHRE - Guide and data book
2. Refrigeration & Air-conditioning- C.P.Arora
3. Hand Book of Air conditioning system design –Carrier

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II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

MATERIALS FOR LOW TEMPERATURE APPLICATIONS (ELECTIVE - IV)
(15D31212)

UNIT-I
MATERIAL BEHAVIOR:
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
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
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
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
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.

TEXT BOOKS:

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

REFERENCES:

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

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING
M.TECH. HEAT POWER (REFRIGERATION & AIR-CONDITIONING)

II- SEMESTER	**L**	**P**	**C**
	-	**4**	**2**

AIR-CONDITIONING LAB
(15D31213)

1. Study the Humidification and Dehumidification process.
2. Find out the Efficiency of the Air-washer test rig.
3. Study on Gas charging unit
4. Find our over-all efficiency of cooling Tower.
5. Find out the capacity and by-pass factor of the window air conditioning.
6. Study the various process and by-pass factor by using Air conditioning test Rig.
7. Study on Heat pump
8. Study on Air-condition system. Split – Air conditioning system and Cnetral Air conditioning system.

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Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF MECHANICAL ENGINEERING

HEAT POWER REFRIGERATION AND AIR CONDITIONING

I SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D31101	Advanced Refrigeration	PC	3	0	0	3
2	21D31102	Advanced Thermodynamics	PC	3	0	0	3
3	**Professional Elective – I**						
	21D31103	Conduction and Radiation Heat Transfer	PE	3	0	0	3
	21D31104	Design Optimization					
	21D31105	Food Preservation Techniques					
4	**Professional Elective – II**						
	21D31106	Principle of Air Conditioning	PE	3	0	0	3
	21D31107	Cryogenic Engineering					
	21D31108	Solar Refrigeration and Air Conditioning					
5	21D11109	Research Methodology and IPR	MC	2	0	0	2
6	21D11110	English for Research Paper Writing	AC	2	0	0	0
	21D11111	Value Education					
	21D11112	Pedagogy Studies					
7	21D31109	Refrigeration Lab	PC	0	0	4	2
8	21D31110	Heat Transfer Lab	PC	0	0	4	2
Total				**16**	**00**	**08**	**18**

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Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF MECHANICAL ENGINEERING

HEAT POWER REFRIGERATION AND AIR CONDITIONING

II SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D31201	Design of Air-Conditioning Systems	PC	3	0	0	3
2	21D31202	Convective Heat and Mass Transfer	PC	3	0	0	3
3	**Professional Elective – III**						
	21D31203	Refrigeration Equipments & Control	PE	3	0	0	3
	21D31204	Design of Heat Transfer Equipment					
	21D31205	Advanced Thermal Storage Technologies					
4	**Professional Elective – IV**						
	21D31206	Advanced Fluid Mechanics	PE	3	0	0	3
	21D31207	Design of HVAC Systems					
	21D31208	Energy Conservation and Management					
5	21D11209	Technical Seminar	PR	0	0	4	2
6	21D11210	Disaster Management	AC	2	0	0	0
	21D11211	Constitution of India					
	21D11212	Stress Management by Yoga					
7	21D31209	Air-Conditioning Laboratory	PC	0	0	4	2
8	21D31210	Advanced Fluid Mechanics Lab	PC	0	0	4	2
Total				**14**	**00**	**12**	**18**

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Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF MECHANICAL ENGINEERING

HEAT POWER REFRIGERATION AND AIR CONDITIONING

III SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	**Professional Elective – V**						
	21D31301	Design of Air Handling Systems	PE	3	0	0	3
	21D31302	Indoor Air Quality Control					
	21D31303	Cogeneration and Waste Heat Recovery Systems					
2	**Open Elective**						
	21D30301	Mechatronics	OE	3	0	0	3
3	21D31304	Dissertation Phase – I	PR	0	0	20	10
4	21D00301	Co-curricular Activities	PR				2
Total				**06**	**00**	**20**	**18**

IV SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D31401	Dissertation Phase – II	PR	0	0	32	16
Total				**00**	**00**	**32**	**16**

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31101	ADVANCED REFRIGERATION	L	T	P	C
Semester	I	(21D31101)	3	0	0	3

Course Objectives:

1. To understand the principles of refrigeration.
2. To understand different vapor Absorption systems.
3. To know Aircraft Air refrigeration systems.
4. To gain knowledge about refrigerants.
5. Ozone depletion potential and global warming potential.

Course Outcomes (CO): Student will be able to

1. Illustrate the basic concepts of refrigeration system.
2. Analyze the vapour compression cycle and interpret the usage of refrigerants.
3. Explain the components of vapour absorption system.
4. Demonstrate the use of refrigerants.
5.Discuss the theory Ozone depletion potential and global warming potential.

UNIT - I		Lecture Hrs:

Vapor Compression Refrigeration:
Analysis of vapor compression refrigeration cycle - reversed Carnot cycle for vapour - effect of suction temperature and condensing temperature on cycle performance – Practical refrigeration cycle – sub-cooled liquid and super-heated vapor refrigeration cycles their effect on performance. Multi Pressure Systems- removal of flash gas- intercooling – compound compression (conversion)-multi vapor systems- cascade systems- dual compression- system practices.

UNIT – II		Lecture Hrs:

Simple vapor Absorption systems- actual vapor absorption cycle- representation of the cycle on H-C diagram- common refrigerant- (Absorbent)Adsorbent) systems.
Practical single effect Water- Lithium Bromide Absorption system- double effect system- Electrolux refrigerator- newer mixtures for absorption systems.

UNIT – III		Lecture Hrs:

Aircraft Air refrigeration – Functions – working conditions – types.
Steam jet water vapor systems- thermoelectric refrigeration systems - vortex refrigeration system - pulse tube refrigeration.

UNIT – IV		Lecture Hrs:

Refrigerants:
Desirable properties- thermo dynamic-chemical and transport properties - designation of refrigerants - inorganic, halo carbon refrigerants - secondary refrigerants - Properties of mixtures of refrigerants

UNIT – V		Lecture Hrs:

Ozone depletion potential and global warming potential – effect of refrigerants- alternative refrigerants- newer refrigerants.

Textbooks:

1. R & A/C by F.Stoecker& Jerold. W.Jones-MGH Intrl.,1982.
2. R & A/C by C.P.Arora, TMGH-2000.
3. R & A/C by Manohar Prasad.

4. Principles of Refrigeration by Roy.J.Dossat, 1997.
5. Refrigeration by Gosney- Oxford University Press-1980.

Reference Books:

1. R & A/C by F.Stoecker& Jerold. W.Jones-MGH Intrl.,1982.
2. R & A/C by C.P.Arora, TMGH-2000.
3. R & A/C by Manohar Prasad.
4. Principles of Refrigeration by Roy.J.Dossat, 1997.
5. Refrigeration by Gosney- Oxford University Press-1980.

Online Learning Resources:

https://nptel.ac.in/courses/112/105/112105129/

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31102	ADVANCED THERMODYNAMICS (21D31102)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives:

- The objective of this course is to prepare students to effectively solve theoretical and applied thermodynamics problems that are directly applicable to situations faced in research and industry.
- Significant emphasis is placed on the integration of recent thermodynamics-related research into the traditional resources in order to foster critical analysis of current work as it relates to fundamental principles.

Course Outcomes (CO): Student will be able to

- Describe and calculate thermodynamic properties
- Apply the laws of statistical and classical thermodynamics to chemically reactive systems, kinetics, and combustion.
- Relate course principles to solve problems regarding gas turbines, combustion, refrigeration, and solar energy.

UNIT – I	THERMODYNAMIC PROPERTYRELATIONS AND AVAILABILITY ANALYSIS	Lecture Hrs:9

Thermodynamic relations: Differential relation for U,H,G&F-Maxwell relations. Generalized relation for Cp, Cv ,K, B-relations for internal energy and enthalpy-the various Tds equation-clapeyron equation-gas tables-enthalpy and internal energy- pressure ratio-volume ratio-change of entropy-Introduction to third law of thermodynamics.

EXERGY:

Introduction-availability of heat –availability of a closed system-availability function of the closed system-availability of steady flow system- availability function of open system.

IRREVERSIBILITY:

Introduction-irreversibility for closed and open system-steady flow process effectiveness-second law analysis of the power plant.

UNIT – II	NON REACTIVE GAS MIXTURES	Lecture Hrs:9

Introduction-basic definitions for gas mixtures-PVT relations ship for mixtures of ideal gases-properties of mixtures of ideal gases-entropy change due to mixing – mixtures of perfect gases at different initial pressure and temperatures.

UNIT – III	CHEMICAL THERMODYNAMICS AND EQUILIBRIUM	Lecture Hrs:9

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

UNIT – IV	ANALYSIS OF VAPOUR POWER & VAPOUR COMPRESSION REFRIGERATION CYCLES	Lecture Hrs:9

Introduction-the carnotvapor cycle-rankine cycle-effects of operation condition on efficiency-principles of increasing the thermal efficiency- method of increasing thermal efficiency. Super –critical and ultra-super-critical Rankine cycle.

Vapour compression refrigeration Systems, Analysis of vapour refrigeration systems, Commonly used refrigerants.

UNIT – V	**ANALYSIS OF GAS POWER CYCLES**	**Lecture Hrs:9**

IC Engines : Air standard Otto, Diesel and Dual cycle
Gas turbines: Air standard Brayton cycle, Effect of reheat, inter cooling and regeneration**,** Combined gas and vapour power cycles.

Textbooks:

1. Kenneth Wark Jt. m, Advanced Thermodynamics for Engineers, McGrew – Hill Inc.,1995.
2. Bejan,A.,AdvancedEngineeringThermodynamics,JohnWileyandCons,1988.
3. Holman, J.P., Thermodynamics, Fourth Edition, McGraw–HillInc.,1988.
4. Fundamentals of Engineering Thermodynamics by V.Babu

Reference Books:

1. Smith,J.M.andVanNess., H.C.,Introductionto Chemical Engineering Thermodynamics, Fourth Edition, McGraw– HillInc.,1987.
2. Sonntag, R.E., and Van Wylen, G, Introduction to Thermodynamics, Classical andStatisticalThemodynamics,ThirdEdition,JohnWileyandSons, 1991.
3. Sears,F.W.andSalingerG.I.,Thermodynamics,KineticTheoryandStatisticalThermodynamics, ThirdEdition,NarosaPublishingHouse,NewDelhi,1993.
4. DeHotf, R.T., Thermodynamics in Materials Science, McGraw – Hill Inc., 1993. Rao,Y.V.C.Postulational and Statistical Thermodynamics, Allied Publisher Limited, NewDelhi,1999

Online Learning Resources:

1. https://nptel.ac.in/courses/103/103/103103162/
2. https://onlinecourses.nptel.ac.in/noc20_ch03/preview

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31103	CONDUCTION AND RADIATION HEAT TRANSFER (21D31103) PE – I	L	T	P	C
Semester	I		3	0	0	3

Course Objectives:

1. To understand three modes of heat transfer.
2. To understand Conduction through spherical shells.
3. To know Heating and cooling of bodies with negligible internal resistance.
4. To gain knowledge about thermal radiation.
5. To understand Radiation network for an absorbing and transmitting medium.

Course Outcomes (CO): Student will be able to

1. Tackle 2D heat transfer problems by applying appropriate governing equations and boundary conditions.
2. Apply suitable methods to solve various Conduction formulations.
3. Setup basic techniques to understand and analyze physical systems.
4. Examine several means and assumptions for analyze radiation heat transfer problems.
5. Use acquired knowledge to develop systems suitable for Industrial applications.

UNIT – I		Lecture Hrs:10

CONDUCTION : Introduction of three modes of heat transfer, steady, unsteady state heat transfer process, governing equations and boundary conditions
Two dimensional steady state conduction, semi-infinite and finite flat plate; temperature field in infinite and finite cylinders.

UNIT – II		Lecture Hrs:10

Conduction through spherical shells. Numerical method: finite difference method - simple problems.

UNIT – III		Lecture Hrs:10

Heating and cooling of bodies with negligible internal resistance, sudden changes in the surface temperature of infinite plates, cylinders and semi-infinite bodies-simple problems.

UNIT – IV		Lecture Hrs:10

RADIATION :
Review of the thermal radiation - gas radiation, mean beam length exchange between gas volume and black enclosure, heat exchange between gas volume and gray enclosure, problems.

UNIT – V		Lecture Hrs:10

Radiation network for an absorbing and transmitting medium, radiation exchange with specular surfaces, radiation exchange with transmissivity and reflecting absorbing medium. Formulation for numerical solution.
Solar radiation: Radiation properties of environment, effect of radiation on temperature measurement, the radiation heat transfer coefficient, problems.

Textbooks:

1) Heat transfer -J.P. Holman, International Student Edition, TMH.
2) Heat Transfer -Gibhart - Mc. Graw Hill.
3) Conduction Heat Transfer- -Schneider Addison -Wiesthly
4) Conduction of Heat in Solids -Carslaw& Jaeger, ASME

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DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Reference Books:
1) Fundamentals of Heat and Mass Transfer -R.C. Sachdev New Age International 2) Heat and Mass Transfer by R. K. Rajput, S.Chand Technical Publishers
Online Learning Resources:
https://nptel.ac.in/courses/112/105/112105271/

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31104	DESIGN OPTIMIZATION	L	T	P	C
Semester	I	(21D31104) PE – I	3	0	0	3

Course Objectives:

1. Understand the various optimization techniques such as classified optimization, linear programming. One dimensional minimization methods, unconstrained optimization techniques, constrained optimization techniques and dynamic programming.
2. Understand the necessary sufficient conditions for finding the solution of the problems in classical optimization.
3. Comprehend the numerical methods for finding approximate solution of complicated problems.
4. Apply methods like North West corner rule, least count method etc. to solve the transportation problem.

Course Outcomes (CO): Student will be able to

1. Design of mechanical systems and interdisciplinary engineering applications and business solutions using suitable optimization technique.
2. Apply numerical or iterative techniques in power systems for optimal power flow solutions. Optimize the parameters in control systems for desired steady state or transient response.
3. Optimize the cost function in deciding economic factors of power systems.
4. Design of electrical systems optimally using suitable techniques like univariate method,steepest descent method etc.

UNIT - I Lecture Hrs:

SINGLE VARIABLE NON-LINEAR UNCONSTRAINED OPTIMITION:
One dimensional Optimization methods:Uni-modal function, elimination method, Fibonacci method, golden section method, interpolation methods- quadratic & cubic interpolation methods.

UNIT - II Lecture Hrs:

Multi variable non-linear unconstrained optimization: Direct search method – Univariant Method – pattern search methods – Powell's – Hook – Jeeves, Rosenbrock search methods – gradient methods, gradient of function, steepest decent method, Fletcher reeves method. **Variable** metric method.

UNIT - III Lecture Hrs:

GEOMETRIC PROGRAMMING:
Polynomials – arithmetic – geometric inequality – unconstrained G.P – constrained G.P
DYNAMIC PROGRAMMING:
Multistage decision process, principles of optimality, examples, conversion of final problem to an initial value problem, application of dynamic programming, production inventory. Allocation, scheduling replacement.

UNIT - IV Lecture Hrs:

Linear programming – formulation – Sensitivity analysis. Change in the constraints, cost coefficients, coefficients of the constraints, addition and deletion of variable, constraints.
Simulation–Introduction–Types–Steps –application –inventory – queuing – thermal system.

UNIT - V		Lecture Hrs:

Integer Programming – introduction – formulation – Gomory cutting plane algorithm – Zero or one algorithm, branch and bound method.

STOCHASTIC PROGRAMMING:

Basic concepts of probability theory, random variables – distributions – mean, variance, Correlation, co variance, joint probability distribution – stochastic linear, dynamic programming.

Textbooks:

1. Optimization theory & Applications/ S.S Rao/ New Age International
2. Introductory to operation research/Kasan& Kumar/Springar
3. Optimization Techniques theory and practice / M.C Joshi, K.M Moudgalya/ Narosa Publications.
4. S.D Sharma/Operations Research
5. Operation Research/H.A. Taha/TMH
6. Optimization in operations research/R.L Rardin

Reference Books:

1. Optimization theory & Applications/ S.S Rao/ New Age International
2. Introductory to operation research/Kasan& Kumar/Springar
3. Optimization Techniques theory and practice / M.C Joshi, K.M Moudgalya/ Narosa Publications.
4. S.D Sharma/Operations Research
5. Operation Research/H.A. Taha/TMH
6. Optimization in operations research/R.L Rardin

Online Learning Resources:

- https://nptel.ac.in/courses/112/101/112101298/

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31105	FOOD PRESERVATION TECHNIQUES (21D31105) PE – I	L	T	P	C
Semester	I		3	0	0	3

Course Objectives:

1. Locate and appraise legislative requirements or authoritative guidelines relevant to shelf life extension in fresh, minimally processed and processed foods.
2. Recognize the elements of the Hazard Analysis Critical Control Point (HACCP) system
3. Identify the principles of preservation processes Operate or observe equipment used in preservation processes with an understanding of the mechanism of preservation employed and the effects of the individual unit operations.
4. Apply principles of food preservation to pilot scale production of processed food and evaluate variation in processing parameters or product formulation on product properties
5. Prepare for practical exercises, organize team work and reflect on issues arising from practical exercise(s) and or production simulation(s) utilizing the communication tools
6. Identify and examine the method of packaging, packaging materials and storage practices employed in shelf life extension of fresh, minimally processed and processed foods.
7. Recognize and analyze spoilage symptoms in fresh, minimally processed and processed foods and relate same to the causes of food spoilage.

Course Outcomes (CO): Student will be able to

1. Participation in practical sessions in the pilot plant and laboratory culminating with the submission of a scientific report with feedback on your prac performance and reporting.
2. Submission of a literature review assignment on a topic of significance and relevance to the area of study with feedback on your selection, review and critical appraisal of literature.
3. A two hour closed book final examination at the end of the semester that will address specific learning outcomes.

UNIT – I		Lecture Hrs:

Theories and method of chilling, freezing and free de-humidification – preparation for freezing, freezing methods: commercial freezing methods – sharp, quick and air blast freezing, freeze-drying. Methods of pre-cooling fruits and vegetables – hydro cooling, forced air cooling and vacuum cooling.

UNIT – II		Lecture Hrs:

Processing of meat products: Refrigeration systems for carcass chilling and holding – chilled brine spray, sprayed coil – dry coil systems, chilling and freezing variety meats – overnight chilling, quick chilling, effect of freezing temp on qualify of meat product

Fishery products: icing of fish – saltwater icing, freezing methods – slow freezing, blast freezing, plate freezing and immersion freezing of fish.

UNIT – III		Lecture Hrs:

Dairy products: Milk processing, handling, dairy plant procedure, standardizing, pasteurization, homogenizing, and container filling.

UNIT – IV		Lecture Hrs:
Fruit juice concentrations: Processing and quality control – selection, grading and handling of fresh fruit, washing, juice extraction, heat treatment, flavor fortification, packaging storage and distribution- convection methods- freezing and mechanical separation, low temperature vacuum evaporation, direct refrigerant contact method, indirect refrigerant contact methods, high temperature short time evaporations.		
UNIT – V		Lecture Hrs:
Refrigerated warehouse: factors affecting ware house design- building location, design reduction, shipping and receiving plant forms, utility space, controlled atmospheric storage rooms, jacketed storages, automated ware house – insulation, cold storage doors. Refrigerated trucks, trailers & containers: temperature control methods, body design & construction, auxiliary equipment, types of refrigeration systems- railway refrigeration cars.		
Textbooks:		
1. ASHRE - Guide and data book 2. Refrigeration & Air-conditioning- C.P.Arora 3. Hand Book of Air conditioning system design –Carrier		
Reference Books:		
1. ASHRE - Guide and data book 2. Refrigeration & Air-conditioning- C.P.Arora 3. Hand Book of Air conditioning system design –Carrier		
Online Learning Resources:		
• http://ecoursesonline.iasri.res.in/course/view.php?id=639		

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31106	PRINCIPLES OF AIR-CONDITIONING (21D31106) PE – II	L	T	P	C
Semester	I		3	0	0	3

Course Objectives:

1. Will understand well, the importance of maintaining the thermal environment for human comfort which ultimately enhances the working efficiency.
2. Will be in a position to understand the necessity of maintaining the temperature and humidity for various processes in process and pharmaceutical industries.
3. Will become fully aware of the techniques for controlling the contamination of environment which is a must for modern A C systems.

Course Outcomes (CO): Student will be able to

1. Define the need and importance of HVAC, handling of different HVAC systems.
2. Describe thermal comfort, its principles and practices, clothing and activities and their impact on comfort and productivity
3. Interpret ventilation impact on human comfort, productivity and health.
4. Propose psychrometry application to HVAC engineering and design different HVAC systems.
5. Explain air and water/refrigerant flow in ducts and pipes, duct and piping design, air distribution in rooms.
6. Paraphrase control of HVAC systems- automatic and manual, different control systems used.

UNIT - I		Lecture Hrs:

Psychrometry: Properties of Moist air- Psychrometric relations - Psychrometric chart - Psychrometric processes in air-conditioning equipment - Bypass factor - Sensible heat factor APPLIED PSYCHROMETRY: Effective and grand sensible heat factors- Selection of Air-Conditioning apparatus for cooling and dehumidification-High latent cooling load applications- All outdoor air application.

UNIT - II		Lecture Hrs:

Air-conditioning Processes –Mixing process- Summer, Winter and Year-round air conditioning systems - hot and dry out door condition, Hot and humid outdoor condition - winter air conditioning system - year round air-conditioning system.

UNIT - III		Lecture Hrs:

Process of Cooling, Heating and Dehumidifying coils - air washers - Cooling by dry and wet coils - use of hygroscopic solution in air washers - Adiabatic dehumidifier – Humidifier-water injection - steam injection. Heat pump - Different heat pump circuits air, ground water, earth - The linked air cycle heat pump - solar energy collections - Drying of materials.

UNIT - IV		Lecture Hrs:

Requirements of Comfort Air-conditions - Thermodynamics of human body - Body regulation process against heat or cold - comfort and comfort chart - Effective temperature - Factors governing optimum effective temperature -Design considerations- Selection of outside and Inside design conditions.

UNIT - V		Lecture Hrs:

Ventilation systems: Natural ventilation system - Mechanical - Extraction system - Supply

system - Combined supply and extraction system - Air-cleaning - Equipment used for odour suppression and air sterilization. Air-conditioning controls systems - basic elements of the control systems - temperature, humidity and pressure controls and refrigeration flow controls - room thermostat.
Textbooks:
1.Hand Book of Air conditioning system design -Carrier 2. Refrigeration & Air-conditioning -C.P.ARORA, TMGH,2000. 3 Refrigeration & Air-conditioning --Domkundwar and Arora,DanpatRai& Sons,2000. 4 Refrigeration & Air-conditioning --Stoecker. 5 Refrigeration & Air-conditioning -V.K.Jain. 6. ASHRE - Guide and data book
Reference Books:
1.Hand Book of Air conditioning system design -Carrier 2. Refrigeration & Air-conditioning -C.P.ARORA, TMGH,2000. 3 Refrigeration & Air-conditioning --Domkundwar and Arora,DanpatRai& Sons,2000. 4 Refrigeration & Air-conditioning --Stoecker. 5 Refrigeration & Air-conditioning -V.K.Jain. 6. ASHRE - Guide and data book
Online Learning Resources:
• https://onlinecourses.nptel.ac.in/noc19_me58/preview

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31107	CRYOGENIC ENGINEERING (21D31107) PE – II	L	T	P	C
Semester	I		3	0	0	3

Course Objectives:

1.Examine basic principles of cryogenics
2.Apply the knowledge of cryogenics in different applications of cryogenics like spacetechnology, gas industry, electronics
3.Design low temperature system by considering properties and principles of mixtures
4.Identify theoretical and mathematical methods of liquefaction systems
5.Construction of liquefaction system for different gases

Course Outcomes (CO): Student will be able to

1.Acquire knowledge about cryogenics and properties of cryogenic fluids
2.To recognize the liquefaction systems for different gases
3.Apply theoretical and mathematical methods of liquefaction system
4.Design low temperature system by considering properties and principles of mixtures
5.Understand and demonstrate the insulation required for fluid storage and transfer
6.Apply the knowledge of cryogenic fluid storage and transfer systems

UNIT - I		Lecture Hrs:

Introduction necessity of low temperature - Multistage Refrigeration system -Cascade system - Manufacture of dry ice-Joule Thompson coefficient.
Liquification of air - Lindae system-Analysis-Dual pressure cycle analysis-Liquefaction of Hydrogen and Helium-problems.

UNIT - II		Lecture Hrs:

Application of Lower temperature-Effects on the properties of metals-strength-Thermal properties-super conductivity-super fluidity.
Applications like expansion fitting - cryobiology-cryosurgery - space research-computers under ground power lines.

UNIT - III		Lecture Hrs:

Low temperature insulation-Reflective insulation-Evacuated powders-Rigid foams-Super insulation.

UNIT - IV		Lecture Hrs:

Cooling by adiabatic de-magnetization - Gas separation and cryogenic systems-separation of gases- Rectifying columns-Air separating- single and double columns Air separation plant.

UNIT - V		Lecture Hrs:

Storage and handling of cryogenic liquids - Dewars and other types of containers.

Textbooks:

1. Cryogenics by Barron. Oxford University Press 1980.
2. Cryogenic Engineering by Timmerhaus
3. Cryogenic Engineering by Huston: McGraw Hill
4. Refrigeration and Air-conditioning by S.Domkundwar.

Reference Books:
1. Cryogenics by Barron. Oxford University Press 1980. 2. Cryogenic Engineering by Timmerhaus 3. Cryogenic Engineering by Huston: McGraw Hill 4. Refrigeration and Air-conditioning by S.Domkundwar.
Online Learning Resources:
1. www.nasa.gov 2. www.cryogenicsociety.org/ 3. www.iifiir.org/ 4. www.linde.com 5. www.airliquide.com/ 6. www.cern.ch

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31108	SOLAR REFRIGERATION AND AIR-CONDITIONING (21D31108) PE – II	L	T	P	C
Semester	I		3	0	0	3

Course Objectives:

1. To understand thermodynamic relations.
2. To understand exergy and irreversibility.
3. To understand different types of solar cooling systems
4. To understand the thermodynamic modeling
5. To understand the Economics of different cooling systems

Course Outcomes (CO): Student will be able to

1. To be able to state the Psychometric and (Air-conditioning) cooling load calculations-outline of Vapour Compression Refrigeration Systems.
2. To be able to identify and describe energy Principle of working of working of vapour Absorption Refrigeration, steam jet refrigeration, thermoelectric refrigeration.
3. To be able to explain at a level understandable by a non-technical person how various P.V.Modules. Solar operated vapour absorption systems.
4. To be able to apply the Solar thermal energy storage.
5. To be able to perform Simulation of solar thermal systems - Salient features of DYNSYS, TRNSYS.

UNIT - I		Lecture Hrs:

Review of Psychometric and (Air-conditioning) cooling load calculations-outline of Vapour Compression Refrigeration Systems – Cycle on p-h and T-o charts – C.O.P – Simple problems using property tables.

UNIT - II		Lecture Hrs:

Principle of working of working of vapour Absorption Refrigeration, steam jet refrigeration, thermoelectric refrigeration – classification of refrigerants – Desirable properties of ideal refrigerant - Properties of solvent - Solvent refrigerant combination properties.

UNIT - III		Lecture Hrs:

Solar cooling systems: vapour compression systems, Rankine cycle, Striling cycle, using P.V.Modules. Solar operated vapour absorption systems – vapour jet refrigeration systems.

UNIT - IV		Lecture Hrs:

Solar thermal energy storage - Active and passive systems TROMBE wall – equivalent thermal circuit - Solar green houses.
Solar cooling and dehumidification: Desiccant cooling - Solid and liquid desiccants - improving desiccant cycles - hybrid systems.

UNIT - V		Lecture Hrs:

Non –mechanical systems - Australian Rock system – Solar assisted Heat Pump – Economics of solar cooling systems.
Simulation of solar thermal systems - Salient features of DYNSYS, TRNSYS – model formulation – flow diagram of cooling systems.

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Textbooks:
1. A course in Refrigeration & Air –conditioning, S.Domakundwar&S.C.Arora 2. Principles of Solar engineering, F.Kreith&J.F.Kreider, McGraw Hill Book company 3. Solar Cooling & Heating Volumes, I,II,III., T.NegatVezirogulu 4. Entrepreneurship Development in New & Renewable Energy Technologies APPC & IREDA
Reference Books:
1. A course in Refrigeration & Air –conditioning, S.Domakundwar&S.C.Arora 2. Principles of Solar engineering, F.Kreith&J.F.Kreider, McGraw Hill Book company 3. Solar Cooling & Heating Volumes, I,II,III., T.NegatVezirogulu 4. Entrepreneurship Development in New & Renewable Energy Technologies APPC & IREDA
Online Learning Resources:
• https://www.coursera.org/learn/photovoltaic-solar-energy

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31109	REFRIGERATION LABORATORY (21D31109)	L	T	P	C
Semester	I		0	0	4	2

Course Objectives:

1.To make student understand working of various machines related to refrigeration and their energy efficiency related performance
2.To explain student working of various components of refrigeration systems

Course Outcomes (CO):

1.Analyze the performance Domestic Vapor Compression Refrigeration system
2.Evaluate the performance of the Vapor compression and Air conditioning units
3.Analyze the Expansion devices
4.Evaluate the performance of capacity and cop. of evaporative condensing test rig.

List of Experiments:

1. Find out the Cop. and time taken for ICE making in the Domestic Vapor Compression Refrigeration.
2. Study on Compressor unit.
3. Find out the pull-down characteristics of V.C.R.S.
4. Study of Condenser unit
5. Find our the c.o.p. of vapor Absorption Refrigeration system
6. Study on Expansion devices.
7. Find our the cooling capacity and cop. of evaporative condensing test rig.
8. Study on Evaporating device.

References:
Online learning resources/Virtual labs:

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31110	HEAT TRANSFER LABORATORY (21D31110)	L	T	P	C
Semester	I		0	0	4	2

Course Objectives:

1.Understand the various forms of heat transfer and their applications in real life problems.
2.Analyze different methods to calculate the heat transfer coefficient in various heat transfer problems.
3.Analyze the theoretical knowledge and apply it in conducting experiments in the forms of heat transfer.

Course Outcomes (CO):

1. Perform steady state conduction experiments to estimate thermal conductivity of different materials for plane, cylindrical and spherical geometries
2. Perform the transient heat conduction experiment and obtain variation of temperature along the length of the pin fin.
3. Estimate heat transfer coefficients in forced convection, free convection and determine effectiveness of heat exchangers
4. Perform radiation experiments:determine surface emissivity of a test plane and stefan-Boltzmann's constant and compare with theoretical values
5. Estimate heat transfer coefficients in condensation, boiling and effectiveness of heat pipe

List of Experiments:

1. Determine heat transfer in shell and tube heat exchanger(Parallel and Counter).
2. Thermal conductivity of insulating material through lagged pipe apparatus
3. To phenomenon of critical radius of insulation
4. Thermal Conductivity of metal rod (conductor).
5. Determine effectiveness of finned tube heat exchanger by LMTD Method
6. Experiment on Transient Heat Conduction
7. Heat transfer coefficient in forced convection.
8. Heat transfer coefficient in natural convection
9. Experiment on Parallel and counter flow heat exchanger.
10. Emissivity of a gray body through Emissivity apparatus.
11. Experiment on Stefan Boltzman Apparatus.
12. Heat transfer in drop and film wise condensation.
13. Pin Fin apparatus (Forced convection)
14. Study of heat pipe and its demonstration.
15. Study of Two – Phase flow.

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31201	DESIGN OF AIR-CONDITIONING SYSTEMS (21D31201)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

1. Understand the environmental and social impact of old and alternative refrigerants.
2. Ability to design and select the various components of refrigeration systems.
3. Ability to carry out thermodynamic analysis of multi pressure, cryogenic and other non-conventional refrigeration systems.
4. Ability to carry out heat load calculation

Course Outcomes (CO): Student will be able to

1. Analyze and understand the design of the air-distribution Room air distribution - types of supply air outlets plants.
2. Thorough knowledge of the basic design principles of building survey & cooling load estimation.Location of equipment power plants.
3. Understand the economic, environmental, and regulatory issues related to central station air conditioning system.
4. Understand applications of air-conditioning Industrial, commercial, transport air conditioning.

UNIT –I	AIR-DISTRIBUTION	Lecture Hrs:

Room air distribution - types of supply air outlets - Mechanism of flow through outlets – Considerations for selection and location of outlets - Distribution patterns of outlets friction loss in ducts- grills, diffusers - registers - location of outlets and return air opening - friction loss in ducts - Rectangular equivalents of circular ducts - Air ducts design: duct construction - Duct design procedures- Equal Friction, Static Regain, Velocity Reduction methods.

UNIT – II	BUILDING SURVEY & COOLING LOAD ESTIMATION:	Lecture Hrs:

Location of equipment and- Heat gain through glass-Shading from reveals, overhangs and fins-Effect of shading device-Calculation of Solar heat gain through ordinary glass using tables, Fabric heat gain, overall heat transfer coefficient, periodic heat transfer through walls and roofs- solar temperature-Empirical methods to calculate heat transfer through walls and roofs using decrement factor and time lag-Equivalent temperature difference method-Infiltration-Stack effect-wind action- load due to infiltration.

COOLING LOAD ESTIMATION:

Occupancy load, lighting load, appliance load-Product load-system heat gains-cooling and heating load estimates-Heat storage, diversity and stratification.

UNIT – III	AIR CONDITIONING SYSTEMS:	Lecture Hrs:

Central station Air conditioning system- All water, all air, air water - unitary, Split, district Air conditioning systems.

UNIT – IV	THERMAL INSULATION & AIR HANDLING APPARATUS:	Lecture Hrs:

Method of Heat transfer, desired properties of ideal insulating materials, types of insulating materials, Heat transfer through insulation, economic thickness of insulation, insulation of heated Buildings, insulation for cooling Buildings and cold storage, pipe insulation. Fans

and Blowers-types of Fans-Fan characteristics-Centrifugal Fans-Axial Fans-Fan arrangements- Filters- general service – Noise - sources &control		
UNIT – V	**APPLICATIONS OF AIR-CONDITIONING: -**	Lecture Hrs:
Industrial, Commercial, transport Air conditioning-Special applications-Computer, Hospital Cold storages, Printing, Textile & Leather industries.		
Textbooks:		
1. Hand Book of Air conditioning system design -Carrier 2. Refrigeration & Air-conditioning -C.P.ARORA, TMGH,2000. 3. Refrigeration & Air-conditioning --Domkundwar and Arora, DanpatRai& Sons, 2000. 4. Refrigeration & Air-conditioning -Stoecker. 5. Refrigeration & Air-conditioning -V.K.Jain. 6. ASHRAE - Guide and Data Book		
Reference Books:		
Online Learning Resources:		
• https://www.free-education.in/hvac-design-and-drafting-course-online-free/ • https://www.usbr.gov/tsc/techreferences/mands/mands-pdfs/HVACManl.pdf		

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31202	CONVECTIVE HEAT &MASS TRANSFER (21D31202)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

1. Understand the convective heat transfer.
2. Ability to forced convection heat transfer in laminar tube flow.
3. To understand boiling and condensation
4. To understand mass transfer.
5. To familiarize Convective mass transfer - governing equations.

Course Outcomes (CO): Student will be able to

1. Understand the hydrodynamic, thermal boundary layer concept and the relationship between fluid friction and heat transfer.
2. Understand the concept and mechanism of forced and natural convection.
3. Understand the mass transfer theories.
4. Ability to apply the various empirical correlations used in different fluid flow situations.
5. Ability to analyze and solve complex heat transfer phenomenon.
6. Ability to design the heat exchangers for various industrial applications

UNIT – I	CONVECTIVE HEAT TRANSFER:	Lecture Hrs:

Introduction to convection, review of conservation equations - Forced convection in laminar flow - Exact and approximate solutions of Boundary layer energy equation for plane isothermal plate in longitudinal flow - problems.

UNIT – II		Lecture Hrs:

Forced convection heat transfer in laminar tube flow - forced convection in turbulent flow – Internal Flows-Correlations-Problems. Approximate analysis of laminar free convective heat transfer on a vertical plate-external flows-correlations-problems.

UNIT – III		Lecture Hrs:

Boiling and condensation: Analysis of film condensation on a vertical surface – pool boiling - forced convection boiling inside tubes - problems.

UNIT – IV	MASS TRANSFER:	Lecture Hrs:

Definitions of concentration and velocities relevant to mass transfer, Fick's law, species conservation equation in different forms. Steady state diffusion in dilute solutions in stationary media, transient diffusion in dilute solutions in stationary media, one dimensional non dilute diffusion in gases with one component stationary.

UNIT – V		Lecture Hrs:

Convective mass transfer - governing equations-forced diffusion from flat plate- Dimension less correlation’s for mass transfer. Simultaneous heat and mass transfer - analogy between heat, mass and momentum transfer.

Textbooks:

1. Heat transfer - J. P. Holman.
2. Heat and Mass transfer- R.C. Sachdeva
3. Convective Heat and Mass transfer-Kays.
4. Heat and Mass transfer - V.Gupta and I.Srinivasan - Tata Mc.Graw Hill

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Reference Books:
1. Heat transfer - J. P. Holman. 2. Heat and Mass transfer- R.C. Sachdeva 3. Convective Heat and Mass transfer-Kays. 4. Heat and Mass transfer - V.Gupta and I.Srinivasan - Tata Mc.Graw Hill
Online Learning Resources:
• https://nptel.ac.in/courses/112/106/112106170/

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DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31203	REFRIGERATION EQUIPMENT & CONTROL (21D31203)	L	T	P	C
Semester	II	PE – III	3	0	0	3

Course Objectives:

1. To understand the principles of Compressors - types - equivalent shaft work .
2. To understand different Condensers.
3. To know Evaporator systems.
4. To gain knowledge about Expansion devices.
5. To know Performance of complete Vapour compression system.

Course Outcomes (CO): Student will be able to

1. To be able to state principles of Compressors - types - equivalent shaft work.
2. To be able to identify and describe Condensers, types, Water cooled Condensers-Air cooled, Evaporative types.
3. To be able to explain at a level understandable by a non-technical person how various Evaporators work.
4. To be able to apply the Expansion devices with in the system.
5. To be able to apply evaluation and dehydration testing for leakages, charging, adding oil.

UNIT – I Lecture Hrs:

Compressors - types - equivalent shaft work - Volumetric efficiency - factors affecting total volumetric efficiency - compound compression with inters cooling - rotary compressors - surging - screw compressors - lubricating oils.

UNIT – II Lecture Hrs:

Condensers - types -Water cooled Condensers-Air cooled, Evaporative types - Economic water rate - Economic water velocity - over all heat transfer co-efficient - design - temperature distribution and heat flow in a condenser - pressure drop - fouling factor - LMTD correction factor (no problems).

Cooling towers and spray ponds - classification - performance of cooling towers - analysis of counter flow cooling towers - enthalpy - temperature diagram of air and water - cooling ponds - types - cross flow cooling towers - procedure for calibration of outlet conditions.

UNIT – III Lecture Hrs:

Evaporators - types - Flooded and dry Evaporators, natural and forced convection type - shell and tube - shell and coil, plate type - secondary Evaporators - temperature distribution and heat flow in evaporator - pressure drop - fouling correction factor (no problems).

Defrosting - necessity - methods - manual, automatic, periodic defrosting, solid and liquid adsorbents, water defrosting, defrosting by reversing the cycle, automatic hot gas defrosting, thermo balance defrosting, electric control defrosting. (no problems)

UNIT – IV Lecture Hrs:

Expansion devices - Capillary tube, thermostatic expansion valve - float valves, externally equalized valves - automatic expansion valves - solenoid control valve - location of piping and pump design consideration.(no problems)

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UNIT – V		Lecture Hrs:
Performance of complete Vapour compression system-Performance of condensing unit-compressor -Evaporator-balancing of load in two stage compression. (no problems) Installation of vapour compression refrigeration system - evaluation and dehydration testing for leakages - charging - adding oil.(no problems)		
Textbooks:		
1. 'Refrigeration and Air Conditioning'- by Stoecker – TMGH– International Edition,1982 2. 'Refrigeration and Air Conditioning' - by Domkundwar – DhanpatRai& Co., - 2000 3. 'Refrigeration and Air Conditioning' - by - C.P.Arora – TMGH - 2000 4. ASHRAE Guide and Data book applications.		
Reference Books:		
1. 'Refrigeration and Air Conditioning'- by Stoecker – TMGH– International Edition,1982 2. 'Refrigeration and Air Conditioning' - by Domkundwar – DhanpatRai& Co., - 2000 3. 'Refrigeration and Air Conditioning' - by - C.P.Arora – TMGH - 2000 4. ASHRAE Guide and Data book applications.		
Online Learning Resources:		
• http://ecoursesonline.iasri.res.in/course/view.php?id=418		

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DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31204	DESIGN OF HEAT TRANSFER EQUIPMENT (21D31204)	L	T	P	C
Semester	II	PE – III	3	0	0	3

Course Objectives:

1. To understand the design of heat exchangers.
2. To understand design of evaporators and compressors.
3. To know design of cooling towers and spray ponds.
4. To gain knowledge about design of ducts and fans
5. To know piping system.

Course Outcomes (CO): Student will be able to

1. To be able to state the Exchangers-mean temperature differences for parallel and counter flow- effectiveness method.
2. To be able to identify Temperature distribution and heat flow in an evaporator-pressure drop- factor to be consider in the design of heat transfer equipment.
3. To be able to explain Classification-performance of cooling towers – analysis of counter flow cooling towers- enthalpy-temperature diagram of air and water.
4. To be able to explain design of cooling towers and spray ponds
5. To be able to explain Requirements of a good piping system-pressure drop in pipes-moody chart-refrigerant piping

UNIT – I Lecture Hrs:

DESIGN OF HEAT EXCHANGERS:
Exchangers-mean temperature differences for parallel and counter flow- effectiveness method(N.T.U)-keys and London charts.
DESIGN OF CONDENSERS:
Types overall heat transfer coefficients- temperature distribution and heat flow in a condenser-pressure drop in a condenser –extended fin surfaces-consideration of fouling factor-L.M.T.D. correction factor.

UNIT – II Lecture Hrs:

DESIGN OF EVAPORATORS:
Temperature distribution and heat flow in an evaporator-pressure drop- factor to be consider in the design of heat transfer equipment-types of heat consideration of fouling factor – correction factor
DESIGN OF COMPRESSORS:
Types-equivalent shaft work-volumetric efficiency-factors affecting total volumetric efficiency –compound compression with inter cooling- rotary compressors-surging.

UNIT – III Lecture Hrs:

DESIGN OF COOLING TOWERS AND SPRAY PONDS:
Classification-performance of cooling towers – analysis of counter flow cooling towers-enthalpy-temperature diagram of air and water- cooling ponds- types of cooling ponds – cross flow cooling towers- procedure for calculation of outlet conditions.

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UNIT – IV		Lecture Hrs:
DESIGN OF DUCTS: Continuity equation-Bernoulli's equation-pressure losses-frictional charts- coefficient of resistance for fillings- duct sizing methods. **DESIGN OF FANS:** Standard air-fan horsepower-fan efficiency-similarity laws-fan laws-performance coefficients- theoretical expression for total pressure drop by a fan-centrifugal fan- axial flow fan-system resistance.		
UNIT – V		Lecture Hrs:
PIPING SYSTEM: Requirements of a good piping system-pressure drop in pipes-moody chart-refrigerant piping-discharge line-liquid line-suction line-piping arrangement		
Textbooks:		
1. Heat and mass transfer by Arora&Domkundwar. 2. Refrigeration & Air-Conditioning by P.L.Ballaney 3. Refrigeration & Air-Conditioning by C.P.Arora. 4. Refrigeration & Air-Conditioning by Stoecker		
Reference Books:		
1. Heat and mass transfer by Arora&Domkundwar. 2. Refrigeration & Air-Conditioning by P.L.Ballaney 3. Refrigeration & Air-Conditioning by C.P.Arora. 4. Refrigeration & Air-Conditioning by Stoecker		
Online Learning Resources:		
• https://nptel.ac.in/courses/112/105/112105248/		

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
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(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31205	ADVANCED THERMAL STORAGE TECHNOLOGIES (21D31205) PE – III	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

1. To Understand The Necessity Of Thermal Storage – Types-Energy Storage Devices
2. To Understand Sensible Heat Storage System.
3. To Know Parallel Flow And Counter Flow Regenerators.
4. To Gain Knowledge About Specific Areas Of Application Of Energy Storage.
5. Latent Heat Storage Systems.

Course Outcomes (CO): Student will be able to

1. To be able to state the types-energy storage devices – comparison of energy storage technologies.
2. To be able to identify and describe Basic concepts and modeling of heat storage units - modeling of simple water and rock bed storage system.
3. To be able to explain at a level understandable by a non-technical person how various Parallel flow and counter flow regenerators.
4. To be able to calculate Modeling of phase change problems
5. To be able to explain greenhouse heating – power plant applications – drying and heating for process industries.

UNIT – I Lecture Hrs:

INTRODUCTION

Necessity of thermal storage – types-energy storage devices – comparison of energy storage technologies - seasonal thermal energy storage - storage materials.

UNIT – II Lecture Hrs:

SENSIBLE HEAT STORAGE SYSTEM

Basic concepts and modeling of heat storage units - modeling of simple water and rock bed storage system – use of TRNSYS – pressurized water storage system for power plant applications – packed beds.

UNIT –III Lecture Hrs:

REGENERATORS

Parallel flow and counter flow regenerators – finite conductivity model – non – linear model – transient performance – step changes in inlet gas temperature – step changes in gas flow rate – parameterization of transient response – heat storage exchangers

UNIT – IV Lecture Hrs:

LATENT HEAT STORAGE SYSTEMS

Modeling of phase change problems – temperature based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change

UNIT – V Lecture Hrs:

APPLICATIONS

Specific areas of application of energy storage – food preservation – waste heat recovery – solar energy storage – green house heating – power plant applications – drying and heating for process industries.

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DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Textbooks:
1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
Reference Books:
1. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981. 2. Lunardini.V.J, Heat Transfer in Cold Climates, John Wiley and Sons 1981.
Online Learning Resources:
• http://iitk.ac.in/cce/courses/2019/TES/

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DEPARTMENT OF MECHANICAL ENGINEERING
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Course Code	21D31206	ADVANCED FLUID MECHANICS (21D31206) PE – IV	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

1. Establish an understanding of the fundamental concepts of fluid mechanics.
2. Understand and apply the potential flow equations to basic flows.
3. Understand and apply the differential equations of fluid mechanics including the ability to applyand understand the impact of assumptions made in the analysis.
4. Understand the boundary layer concepts with respect to fluid flow
5. Understand and apply the compressible flow equations.

Course Outcomes (CO): Student will be able to

1. Apply knowledge of mathematics, science and engineering.
2. Derive the governing equations of fluid flow and applying them to simple flow problems.
3. Emphasizing the mathematical formulation of various flow problems.
4. Apply the boundary layer concept to the fluid flow problems.

UNIT – I		Lecture Hrs:

Basic concepts: Continuum hypothesis - Eulerian and Lagrangian descriptions. Derivation of general differential equations – continuity momentum and energy of incompressible flow-Navier Stokes equation for Viscous Fluids (Rectangular Co-Ordinate Systems)-Euler's equations for ideal fluids-Bernoulli's equations (one dimensional) – applications

UNIT – II		Lecture Hrs:

Laminar Flow Viscous Incompressible Fluids: Flow similarity – Reynolds number, flow between parallel flat plates, couette-flow, plane poiseuille flow, Hagen – poiseuille flow.
Laminar boundary layer: Boundary layer concept, Prandtl's approximations, Blassius solution for a flat plate without pressure gradient – momentum integral equation – Von-Kerman integral relation – Pohlhausen method of obtaining approximate solutions. Displacement thickness,momentum thickness and energy thickness. Boundary layer separation and control.

UNIT – III		Lecture Hrs:

Turbulent Flow: Reynolds experiment, Frictional Loss in pipe flow, Resistance of smooth and rough pipes.
Compressible Flow: Mach number, Propagation of pressure waves or disturbances in compression fluid, Velocity of sound or pressure wave in a fluid, Stagnation properties,

UNIT – IV		Lecture Hrs:

Gas Dynamics: Compressible flow through ducts and nozzles – area velocity relations. Flow through convergent and convergent divergent nozzles. Real nozzles flow at design conditions. Introduction to normal compression shock – normal shock relations. Introduction to Fanno Raleigh equations.

UNIT – V		Lecture Hrs:

Flow in ducts with friction: Fanno line, adiabatic constant area- Flow of perfect gas, chocking due to friction in constant area flow- Introduction to constant area flow with heat transfer (Raleigh line)

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Textbooks:

1. Yuan S.W. "Foundations of Fluid Mechanics", Prentice Hall – Eastern economy edition 1983
2. Zucrwo M.J. and Hoffman J.D. "Gas Dynamics", Vol-I &Vol-II, John Wiley and Sons Inc. 1977
3. Yahya S.M. "Fundamentals of Compressible Flow", - Wiley Eastern
4. Young, Munsen and Okiisyi, " A Brief Introduction to Fluid Mechanics" 2nd Edition, John Wiley 2000.
5. Frank.M.White, "Fluid Mechanics 5th Edn – McGraw Hill 2005.

Reference Books:

1. Yuan S.W. "Foundations of Fluid Mechanics", Prentice Hall – Eastern economy edition 1983
2. Zucrwo M.J. and Hoffman J.D. "Gas Dynamics", Vol-I &Vol-II, John Wiley and Sons Inc. 1977
3. Yahya S.M. "Fundamentals of Compressible Flow", - Wiley Eastern
4. Young, Munsen and Okiisyi, "A Brief Introduction to Fluid Mechanics" 2nd Edition, John Wiley 2000.
5. Frank.M.White, "Fluid Mechanics 5th Edn – McGraw Hill 2005.

Online Learning Resources:

- https://nptel.ac.in/courses/112/105/112105218/

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31207	DESIGN OF HVAC SYSTEM DESIGN	L	T	P	C
Semester	II	(21D31207) PE - IV	3	0	0	3

Course Objectives:

1. To understand the principles of Applied Psychrometry, Psychrometric processes using chart Load Estimation.
2. To understand Air Distribution.
3. To know Ventilation and Infiltration.
4. To gain knowledge about Direct and Indirect Evaporative Cooling.
5. To impart knowledge on Air conditioning systems.

Course Outcomes (CO): Student will be able to

1. To be able to state the Applied Psychrometry, Psychrometric processes using chart Load Estimation.
2. To be able to identify and describe Fundamentals of air flow in ducts, pressure drop calculations, design ducts by velocity reduction method.
3. To be able to explain at a level understandable by a non-technical person how Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load.
4. To be able to apply the Basic psychometric of evaporative cooling, types of evaporative coolers, design calculations.
5. To be able to apply Classification, design of central and unitary systems, typical air conditioning systems such as automobile, air plane, ships.

UNIT – I		Lecture Hrs:

Applied Psychrometry, Psychrometric processes using chart Load Estimation: solar heat gain, study of various sources of the internal and external heat gains, heat losses, etc. Methods of heat load calculations: Equivalent temperature Difference Method, Cooling Load Temperature Difference, and Radiance Method, RSHF, GSHF, ESHF, etc. Inside and outside design conditions.

UNIT – II		Lecture Hrs:

Air Distribution: Fundamentals of air flow in ducts, pressure drop calculations, design ducts by velocity reduction method, equal friction method and static regain method, duct materials and properties, insulating materials, types of grills, diffusers, wall registers.

UNIT – III		Lecture Hrs:

Ventilation and Infiltration: Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load. Fans and Blowers: Types, performance characteristics, series and parallel arrangement, selection procedure.

UNIT – IV		Lecture Hrs:

Ventilation and Infiltration: Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load. Fans and Blowers: Types, performance characteristics, series and parallel arrangement, selection procedure.

UNIT – V		Lecture Hrs:

Air conditioning systems: Classification, design of central and unitary systems, typical air conditioning systems such as automobile, air plane, ships, railway coach air-conditioning,

warm air system, hot water systems, heat pump, clean rooms (descriptive treatments only). Standards and Codes: ASHRAE/ARI, BIS standards study and interpretation, ECBC, NBC codes

Textbooks:

1. ASHRAE Handbooks
2. ISHRAE Handbook.
3. Handbook of Air Conditioning System Design, Carrier Incorporation, McGraw Hill Book Co., USA.
4. Trane air conditioning manual,
5. Refrigeration and Air conditioning, ARI Prentice Hall, New Delhi.
6. Norman C. Harris, Modern air conditioning
7. Jones W. P., Air conditioning Engineering, Edward Arnold Publishers Ltd, London, 1984.
8. Jones W. P., Air conditioning Engineering - Applications, Edward Arnold Publishers Ltd, London, 1984
9. Hainer R. W., Control System for Heating, Ventilation and Air conditioning, Van Nastrand Reinhold Co., New York, 1984.
10. Refrigeration and Air conditioning- C P Arora, Tata McGraw Hill Publication, New Delhi.
11. McQuiston, Faye; Parker, Jerald; Spitler, Jeffrey 2000, Heating, Ventilating and Air Conditioning-Analysis and Design, 5th ed. John Wiley & Sons.

Reference Books:

1. ASHRAE Handbooks
2. ISHRAE Handbook.
3. Handbook of Air Conditioning System Design, Carrier Incorporation, McGraw Hill Book Co., USA.
4. Trane air conditioning manual,
5. Refrigeration and Air conditioning, ARI Prentice Hall, New Delhi.
6. Norman C. Harris, Modern air conditioning
7. Jones W. P., Air conditioning Engineering, Edward Arnold Publishers Ltd, London, 1984.
8. Jones W. P., Air conditioning Engineering - Applications, Edward Arnold Publishers Ltd, London, 1984
9. Hainer R. W., Control System for Heating, Ventilation and Air conditioning, Van Nastrand Reinhold Co., New York, 1984.
10. Refrigeration and Air conditioning- C P Arora, Tata McGraw Hill Publication, New Delhi.
11. McQuiston, Faye; Parker, Jerald; Spitler, Jeffrey 2000, Heating, Ventilating and Air Conditioning-Analysis and Design, 5th ed. John Wiley & Sons.

Online Learning Resources:

- http://www.mecciengineer.com/hvac-design.aspx

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31208	ENERGY CONSERVATION AND MANAGEMENT (21D31208) PE – IV	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

1. To understand the principles of energy conservation.
2. To understand thermal insulation & refractors.
3. To know waste heat recovery systems.
4. To gain knowledge about engineering economics.
5. To impart knowledge Energy management programs.

Course Outcomes (CO): Student will be able to

1. Ability to understand the basic concept of energy conservation and its role in energy management.
2. Learn the purpose and detailed methodology of energy audit.
3. Ability to analyze the energy conservation opportunities in the energy intensive industries.
4. Ability to analyze the quantum of electrical energy that can be saved by the use of energy efficient lighting systems.
5. Learn the concept of cogeneration, tri generation and waste heat recovery in detail.

UNIT – I	ENERGY CONSERVATION:	Lecture Hrs:

Rules for efficient energy conservation – technologies for energy conservation – outline of waste heat and material reclamation, load management, alternate energy sources, and energy storage.

UNIT – II	THERMAL INSULATION & REFRACTORS:	Lecture Hrs:

Heat loss through un-insulated surfaces, effects of insulation on current carrying wires – economic thickness of insulation – critical radius of insulation – properties of thermal insulators – classification of insulation materials – classification of refractors – properties of refractors – criteria for good refractory material – applications of insulating & refractory materials.

UNIT – III		Lecture Hrs:

WASTE HEAT RECOVERY SYSTEMS:

Guideline to identify waste heat – feasibility study of waste heat – shell and tube heat exchanger – thermal wheel – heat pipe heat exchanger – heat pump – waste heat boilers – incinerators.

HEAT RECOVERY SYSTEMS & HEAT EXCHANGER NETWORKS:

Liquid to liquid heat exchangers – gas to liquid heat recovery systems, regenerators, recuperators, rotating regenerators – miscellaneous heat recovery methods – selection of materials for heat exchangers – combined radiation and convective heat exchanger, U-tube heat exchanger, tube heat exchanger, fluidized bed heat exchanger – economizer.

UNIT – IV		Lecture Hrs:

ENGINEERING ECONOMICS:

Managerial objectives, steps in planning – efficiency of organization- capital budgeting – classification of costs – interest – types – nominal and effective interest rates – discrete and

continuous compounding – discounting - time value of money – cash flow diagrams – present worth factor, capital recovery factor, equal annual payments – equivalent between cash flows.

ENERGY AUDITING:

A definition – objectives – level of responsibility – control of energy – uses of energy – check lists – energy conservation schemes – energy index – cost index – pie charts – sankey diagrams – load profiles – types of energy audits – questionnaire – energy audit of industries – general energy audit – detailed energy audit – energy saving potential.

UNIT – V		Lecture Hrs:

PROJECT MANAGEMENT:

Method of investment appraisal – rate of return method, pay back method, net present value method (NPV) – adoption of the methods in energy conservation campaign – types of projects –– propose of project management – classification – role and qualities of project manager – types of budgets - budget committee – budgeting.

ENERGY MANAGEMENT PROGRAMS:

Necessary steps of energy management programme – concepts of energy management – general principles of energy management – energy management in manufacturing and process industries – qualities and functions of energy managers – duties of energy manager - language of energy manager – checklist for top management.

Textbooks:

1. Waste heat recovery systems -D.A. Reay/Pergmon Press
2. Hand book of energy audits -Albert Thumann
3. Energy Management -W.R. Murphy &G.Mickay, Butterworths
4. Energy Conservation -P.W.O' Callaghan, Pargamon Press 1981
5. Engineering Heat Audits -C.P. Gupta &RajendraPrakash, Nechand& Bros.
6. Hand book of energy audits -Albert Thumann, The F.Airmont Press Inc., Atlanta Georgia, 1979.
7. Energy Management Principles -Craig B. Smithm, Pergarmon Press
8. The rols of Energy Manger -EEO., U.K.
9. Industrial Engineering & Management -Dr. O.P.Khanna, DhanapatRai& Sons, 1992
10. 'PERT – CPM' -L.S. Srinath

Reference Books:

1. Waste heat recovery systems -D.A. Reay/Pergmon Press
2. Hand book of energy audits -Albert Thumann
3. Energy Management -W.R. Murphy &G.Mickay, Butterworths
4. Energy Conservation -P.W.O' Callaghan, Pargamon Press 1981
5. Engineering Heat Audits -C.P. Gupta &RajendraPrakash, Nechand& Bros.
6. Hand book of energy audits -Albert Thumann, The F.Airmont Press Inc., Atlanta Georgia, 1979.
7. Energy Management Principles -Craig B. Smithm, Pergarmon Press
8. The rols of Energy Manger -EEO., U.K.
9. Industrial Engineering & Management -Dr. O.P.Khanna, DhanapatRai& Sons, 1992
10. 'PERT – CPM' -L.S. Srinath

Online Learning Resources:

https://nptel.ac.in/courses/112/105/112105221/

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31209	AIR-CONDITIONING LABORATORY (21D31209)	L	T	P	C
Semester	II		0	0	4	2

Course Objectives:

1. To understand Humidification and Dehumidification process.
2. To understand Gas charging unit.
3. To know various process and by-pass factor by using Air conditioning test Rig.
4. To gain knowledge on Air-condition system. Split – Air conditioning system and Central Air conditioning system.
5. To understand over-all efficiency of cooling Tower.

Course Outcomes (CO):

1. Ability to apply the theoretical knowledge to solve problems in Heat Power Engineering.
2. Hands on experience through actual experimentation or simulation.
3. Ability to formulate and analyze practical problems.
4. Ability to prepare mathematical/geometrical model and solve it using appropriate software.
5. Ability to analyze data obtained through experimentation/simulation and drawing suitable technical conclusion
6. Ability to prepare technical report for the given case study.

List of Experiments:

1. Study the Humidification and Dehumidification process.
2. Find out the Efficiency of the Air-washer test rig.
3. Study on Gas charging unit
4. Find our over-all efficiency of cooling Tower.
5. Find out the capacity and by-pass factor of the window air conditioning.
6. Study the various process and by-pass factor by using Air conditioning test Rig.
7. Study on Heat pump
8. Study on Air-condition system. Split – Air conditioning system and Cnetral Air conditioning system

References:

Online learning resources/Virtual labs:

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DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31210	ADVANCED FLUID MECHANICS LAB (21D31210)	L	T	P	C
Semester	II		0	0	4	2

Course Objectives:

The object of the course to make the students understand the fluid flow concepts and get familiarity with flow measuring devices.

Course Outcomes (CO):

Able to understand course to make the students understand the fluid flow concepts and get familiarity with flow measuring devices.

List of Experiments:

1. Calibration of Venturimeter
2. Calibration of Orifice meter
3. Determination of Coefficient of discharge for a small orifice by a constant head method.
4. Determination of Coefficient of discharge for an external mouth piece by variable head method.
5. Calibration of contracted Rectangular Notch and /or Triangular Notch.
6. Determination of Coefficient of loss of head in a sudden contraction and friction factor.
7. Verification of Bernoulli's equation.
8. Impact of jet on vanes.
9. Study of Hydraulic jump.
10. Performance test on Pelton wheel turbine.
11. Performance test on Francis turbine.
12. Efficiency test on centrifugal pump.

References:

Online learning resources/Virtual labs:

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR
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DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code		Program Elective Course – V	L	T	P	C
Semester	III	a. DESIGN OF AIR HANDLING SYSTEMS	3	0	0	3

Course Objectives:

1.To understand basis concepts air-handling units
2. To understand constant and variable volume systems.
3. To know air system: components.
4. To gain knowledge about ventilation for control of work environment.
5. To acquire knowledge on Air controls.

Course Outcomes (CO): Student will be able to

1. To be able to duct designstatic Regain-equal friction-T method.
2. To be able to identify and describe Energy conservation and system retrofit.
3. To be able to explain at a level understandable by a non-technical person how various Indoor Air Quality and Outside Air Requirements.
4. To be able to justify Condensate control and Freeze-up protection
5. To be able to apply various Demand control ventilations.

UNIT – I		Lecture Hrs:

BASIS CONCEPTS

Psychrometric, Classifications of Air-Handling Units, Main components, Selection of Air-Handling units, economizer cycle, single zone system, multi zone system-Design Consideration, duct designstatic Regain-equal friction-T method.

UNIT – II		Lecture Hrs:

CONSTANT AND VARIABLE VOLUME SYSTEMS

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

UNIT – III		Lecture Hrs:

AIR SYSTEM: COMPONENTS

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

UNIT – IV		Lecture Hrs:

VENTILATION FOR CONTROL OF WORK ENVIRONMENT

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		Lecture Hrs:

AIR CONTROLS

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

Textbooks:

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. Allan T. Kirkpatrick & James S. Elleson, cold air distribution system design guide, ASHEAC - 1996 USA.
4. Shan K.Wang, Handbook of Air-conditioning and Refrigeration, McGraw -Hill, 2001.
5. SMACNA, HVAC System Duct Design, SMACNA Virginia - 1990.

Reference 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.
3. 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.
4. Shan K.Wang, Handbook of Air-conditioning and Refrigeration, McGraw -Hill, 2001.
5. SMACNA, HVAC System Duct Design, SMACNA Virginia - 1990.

Online Learning Resources:

- https://www.tpctraining.com/products/air-handling-systems
- https://www.trox.de/ (design manual)

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DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code		Program Elective Course – V	L	T	P	C
Semester	III	b. INDOOR AIR QUALITY CONTROL	3	0	0	3

Course Objectives:

1. To impart knowledge on the principles and design of control of indoor/particulate/gaseous air pollutant and its emerging trends.
2. To understand air filtration.
3. To know air pollution–indoor, outdoor; statistics in india.
4. To gain knowledge about design of cleanrooms.
5. IAQ measurements & control.

Course Outcomes (CO): Student will be able to

1. Apply sampling techniques
2. Apply modeling techniques
3. Suggest suitable air pollution prevention equipments and techniques for various gaseous and particulate pollutants to Industries. Discuss the emission standards

UNIT – I		Lecture Hrs:

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

UNIT – II		Lecture Hrs:

AIR QUALITY & SICK BUILDING SYNDROME
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		Lecture Hrs:

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

UNIT – IV		Lecture Hrs:

DESIGN OF CLEANROOMS
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		Lecture Hrs:

IAQ MEASUREMENTS & CONTROL
Contaminants measurement-sampling sampling methods-Quality assurancecalibration-data interpretation-instruments-specifications-source control–prevention-Dilution Ventilation- demand control volume method.

Textbooks:

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

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Reference Books:
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. 5. ASHRAE Hand Book, HVAC Systems and Equipment, I-P Edition 1996.
Online Learning Resources:
• https://www.epa.gov/indoor-air-quality-iaq/introduction-indoor-air-quality • https://www.wfinstitute.com/post/air-filtration-training-course

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DEPARTMENT OF MECHANICAL ENGINEERING
(HEAT POWER REFRIGERATION AND AIR-CONDITIONING)

Course Code	21D31303	COGENERATION AND WASTE HEAT RECOVERY SYSTEMS (PE – V)	L	T	P	C
Semester	III		3	0	0	3

Course Objectives: To impart knowledge on

1. The basic energy generation cycles
2. The concept of cogeneration, its types and probable areas of applications
3. Significance of waste heat recovery systems and carryout its economic analysis

Course Outcomes (CO): Student will be able to

1. Analyse the basic energy generation cycles
2. Do the economic analysis of waste heat recovery systems

UNIT – I **Lecture Hrs:**

Introduction – principles of thermodynamics – cycles – topping – bottoming – combined cycle – organic rankine cycles – performance indices of cogeneration systems – waste heat recovery – sources and types – concept of tri generation.

UNIT – II **Lecture Hrs:**

CONGENERATION TECHNOLOGIES

Configuration and thermodynamic performance – steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – combined cycles cogeneration systems – advanced cogeneration systems: fuel cell, Sterling engines etc.,

UNIT – III **Lecture Hrs:**

ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES

Cogeneration plants electrical interconnection issues – utility and cogeneration plant interconnection issues – applications of cogeneration in utility sector – industrial sector – building sector – rural sector – impacts of cogeneration plants – fuel, electricity and environment.

UNIT – IV **Lecture Hrs:**

WASTE HEAT RECOVERY SYSTEMS

Selection criteria for waste heat recovery technologies – recuperators – Regenerators – economizers – plate heat exchangers – thermic fluid heaters – Waste heat boilers – classification, location, service conditions, design Considerations – fluidized bed heat exchangers – heat pipe exchangers – heat pumps – sorption systems.

UNIT – V **Lecture Hrs:**

ECONOMIC ANALYSIS

Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves – sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems.

Textbooks:

1. Charles H. Butler, Cogeneration, McGraw Hill Book Co., 1984.11
2. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001

Reference Books:

1. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.

2. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers,London, 1963.
3. Seagate Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
4. De Nevers, Noel., Air Pollution Control Engineering, McGrawHill, New York,1995

Online Learning Resources:

1. https://nptel.ac.in/courses/112/105/112105221/
2. https://www.udemy.com/course/waste-heat-recovery/

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DEPARTMENT OF MECHANICAL ENGINEERING
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Course Code		Open Elective	L	T	P	C
Semester	III	Mechatronics	3	0	0	3

Course Objectives:

To impart knowledge on

To impart knowledge on about the elements and techniques involved in Mechatronics systems which are very much essential to understand the emerging field of automation.

Course Outcomes (CO): Student will be able to

1.Students can able to understand the concepts,need and importance of mechatronics.
2. They can able to know the concepts of 8085 microprocessor, 8051 microcontroller
3. They can able to understand the Programmable peripheral Interface
4. Students can able to know the structure, programming and selection of PLC
5. They can able to know the working principle and design concepts of actuators, mechatronic system.

UNIT – I	Lecture Hrs:

Introduction to Mechatronics – Systems – Concepts of Mechatronics approach – Need for Mechatronics – Emerging areas of Mechatronics – Classification of Mechatronics. Sensors and Transducers: Static and dynamic Characteristics of Sensor, Potentiometers – LVDT – Capacitance sensors – Strain gauges – Eddy current sensor – Hall effect sensor – Temperature sensors – Light sensors.

UNIT – II	Lecture Hrs:

8085 MICROPROCESSOR AND 8051 MICROCONTROLLER

Introduction – Architecture of 8085– Pin Configuration – Addressing Modes –Instruction set, Timing diagram of 8085 – Concepts of 8051 microcontroller – Block diagram,.

UNIT – III	Lecture Hrs:

PROGRAMMABLE PERIPHERAL INTERFACE

Introduction – Architecture of 8255, Keyboard interfacing, LED display –interfacing, ADC and DAC interface, Temperature Control – Stepper Motor Control – Traffic Control interface.

UNIT – IV	Lecture Hrs:

PROGRAMMABLE LOGIC CONTROLLER

Introduction – Basic structure – Input and output processing – Programming – Mnemonics – Timers, counters and internal relays – Data handling – Selection of PLC.

UNIT – V	Lecture Hrs:

ACTUATORS AND MECHATRONIC SYSTEM DESIGN

Types of Stepper and Servo motors – Construction – Working Principle – Advantages and Disadvantages. Design process-stages of design process – Traditional and Mechatronics design concepts – Case studies of Mechatronics systems – Pick and place Robot – Engine Management system – Automatic car park barrier.

Textbooks:

1.Bolton, “Mechatronics”, Printice Hall, 2008 2. Ramesh S Gaonkar, “Microprocessor Architecture, Programming, and Applications with the 8085”, 5th Edition, Prentice Hall, 2008.

Reference Books:

1. Michael B.Histand and Davis G.Alciatore, "Introduction to Mechatronics and Measurement systems", McGraw Hill International edition,2007.
2. Bradley D.A, Dawson D, Buru N.C and Loader A.J, "Mechatronics", Chapman and Hall, 1993.
3. Smaili.A and Mrad.F , "Mechatronics Integrated Technologies for Intelligent Machines", Oxford University Press,2007.
4. DevadasShetty and Richard A. Kolk, "Mechatronics Systems Design", PWS publishing company,2007.
5. Krishna Kant, "Microprocessors & Microcontrollers", Prentice Hall of India,2007.
6. Clarence W, de Silva, "Mechatronics" CRC Press, First Indian Re-print,2013

Online Learning Resources:

https://nptel.ac.in › courses › noc21 › SEM1 › noc21-me27