JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR
(Established by Govt. of A.P., ACT No.30 of 2008)
ANANTHAPURAMU – 515 002 (A.P) INDIA

M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

SEMESTER – I

S. No.	Course codes	Course Name	Category	Hours per week			Credits
				L	T	P	
1.	21D17101	Advanced Refrigeration	PC	3	0	0	3
2.	21D17102	Advanced Thermodynamics	PC	3	0	0	3
3.	21D17103a 21D17103b 21D17103c	**Program Elective Course - I** Conduction and Radiation Heat Transfer Design Optimization Food Preservation Techniques	PE	3	0	0	3
4.	21D17104a 21D17104b 21D17105c	**Program Elective Course – II** Principles of Air Conditioning Cryogenic Engineering Solar Refrigeration and Air Conditioning	PE	3	0	0	3
5.	21D17105	Refrigeration Laboratory	PC	0	0	4	2
6.	21D17106	Heat Transfer Laboratory	PC	0	0	4	2
7.	21DRM101	Research Methodology and IPR	MC	2	0	0	2
8.	21DAC101a 21DAC101b 21DAC101c	Audit Course – I English for Research paper writing Disaster Management Sanskrit for Technical Knowledge	AC	2	0	0	0
		Total					**18**

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SEMESTER – II

S.No.	Course codes	Course Name	Category	Hours per week			Credits
				L	T	P	
1	21D17201	Design of Air-Conditioning Systems	PC	3	0	0	3
2	21D17202	Convective Heat and Mass Transfer	PC	3	0	0	3
3.	21D17203a 21D17203b 21D17203c	**Program Elective Course – III** Refrigeration Equipments & Control Design of Heat Transfer Equipment Advanced Thermal Storage Technologies	PE	3	0	0	3
4.	21D17204a 21D17204b 21D17204c	**Program Elective Course – IV** Advanced Fluid Mechanics Design of HVAC Systems Energy Conservation and Management	PE	3	0	0	3
5	21D17205	Air-Conditioning Laboratory	PC	0	0	4	2
6	21D17206	Advanced Fluid Mechanics Lab	PC	0	0	4	2
7	21D17207	Technical seminar	PR	0	0	4	2
8.	21DAC201a 21DAC201b 21DAC201c	Audit Course – II Pedagogy Studies Stress Management for Yoga Personality Development through Life Enlightenment Skills	AC	2	0	0	0
Total							**18**

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SEMSTER - III

S.No.	Course codes	Course Name	Category	Hours per week			Credits
				L	T	P	
1.	21D17301a 21D17301b 21D11301c	**Program Elective Course – V** Design of Air Handling Systems Indoor Air Quality Control Cogeneration and Waste Heat Recovery	PE	3	0	0	3
2.	21DOE301c 21DOE301g 21DOE301h	**Open Elective** Business Analytics Internet Of Things Mechatronics	OE	3	0	0	3
3.	21D17302	Dissertation Phase – I	PR	0	0	20	10
4.	21D17303	Co-curricular Activities					2
Total							**18**

SEMESTER - IV

S.No.	Course codes	Course Name	Category	Hours per week			Credits
				L	T	P	
1.	21D17304	Dissertation Phase – II	PR	0	0	32	16
Total							**16**

Course Code	ADVANCED REFRIGERATION	L	T	P	C

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21D17101		**3**	**0**	**0**	**3**
	Semester	**I**			

Course Objectives:

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

Course Outcomes (CO): Student will be able to

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

UNIT - I	Lecture Hrs:9

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:9

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:9

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:8

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:8

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.

Reference Books:

1. R & A/C by Manohar Prasad.
2. Principles of Refrigeration by Roy.J.Dossat, 1997.
3. Refrigeration by Gosney- Oxford University Press-1980.

Online Learning Resources:

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

Course Code	**ADVANCED THERMODYNAMICS**	**L**	**T**	**P**	**C**

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COURSE STRUCTURE & SYLLABI

21D17102		**3**	**0**	**0**	**3**
Semester		**I**			

Course Objectives: Student will be able to

- 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 of single-phase and multi-phase systems.
- 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.
- Communicate engineering knowledge of thermodynamics through written and verbal means.

UNIT – I Lecture Hrs:09

AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATIONS

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

UNIT – II Lecture Hrs:09

REAL GAS BEHAVIOUR AND MULTI – COMPONENT SYSTEMS

Different equations of state – fugacity – compressibility - principle of corresponding States - Use of generalized charts for enthalpy and entropy departure - fugacity coefficient, Lee – Kesler generalized three parameter tables. Fundamental property relations for systems of variable composition Partial molar properties.Real gas mixtures - Ideal solution of real gases and liquid - activity - equilibrium in multi phase systems - Gibbs phase rule for non – reactive components

UNIT – III Lecture Hrs:09

CHEMICALTHERMODYNAMICSANDEQUILIBRIUM

Thermo chemistry-Firstlawanalysisofreactingsystems-Adiabaticflametemperature–entropy change of reacting systems-Second law analysis of reacting systems-Criterion for reaction equilibrium.
Equilibriumconstantforgaseousmixtures-evaluationofequilibriumcomposition.

UNIT – IV Lecture Hrs:09

Analysis of vapour power & Vapour compression refrigeration cycles:
Rankine cycle with superheat, reheat and refrigeration-Exergy analysis, Super –critical and ultra-super-critical Rankine cycle.
Vapour compression refrigeration Systems, Analysis of vapour refrigeration systems, Commonly used refrigerants.

UNIT – V Lecture Hrs:09

Analysis of Gas power cycles:

IC Engines : Air standard Otto, Diesel and Dual cycle
Gas turbines: Air standard Brayton cycle, Effect of reheat, intercooling 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.

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3. Holman, J.P., Thermodynamics, Fourth Edition, McGraw–HillInc.,1988.
4. Fundamentals of Engineering Thermodynamics by V.Babu

Reference Books:

1. Smith, J.M. and Van Ness., H.C., Introduction to Chemical Engineering Thermodynamics, Fourth Edition, McGraw– HillInc.,1987.
2. Sonntag, R.E., and Van Wylen, G, Introduction to Thermodynamics, Classical and Statistical Themodynamics, Third Edition ,John Wiley and Sons, 1991.
3. Sears,F.W. and Salinger G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Third Edition, Narosa Publishing House,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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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	CONDUCTION AND RADIATION HEAT TRANSFER	L	T	P	C
21D17103a	PROGRAM ELECTIVE COURSE-I	3	0	0	3
Semester		I			

Course Objectives: Student will be able

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

Course Outcomes (CO): Student will be able to

- Determine these resistances for conduction, radiation, and convection heat transfer, using the fundamental relationships and correlations
- Learn to solve problems using solvers (multimode systems and design parameter sweep)
- Compare the various resistances, along with thermal energy conversion and storage, in the thermal systems and identifying the dominant resistance
- Learn to design modern, innovative thermal systems for various applications

UNIT – I Lecture Hrs:09

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:09

Conduction through spherical shells, numerical methods, relaxation method and finite difference methods - simple problems.

UNIT – III Lecture Hrs:09

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 Hrs09:

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:09

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 -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
6). Heat Transfer by R. K. Rajput Publishers

Reference Books:

1) Heat Transfer -Gibhart - Mc. Graw Hill.
2) Conduction Heat Transfer- -Schneder Addition Wieslthy
3) Conduction of Heat in Solids -Carslaw & Jaeger.

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4) Heat transfer -J.P. Holman, International student edition
5) Fundamentals of heat and mass transfer -R.C. Sachdev New Age International
6). Heat Transfer by R. K. Rajput Publishers

Online Learning Resources:

- https://nptel.ac.in/courses/112/105/112105271/

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COURSE STRUCTURE & SYLLABI

Course Code	DESIGN OPTIMIZATION	L	T	P	C
21D17103b	Program Elective Course-I	3	0	0	3
	Semester	I			

Course Objectives: Student will be able to

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

Course Outcomes (CO): Student will be able to

- Design of mechanical systems and interdisciplinary engineering applications and business solutions using suitable optimization technique.
- 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.
- Optimize the cost function in deciding economic factors of power systems.
- Design of electrical systems optimally using suitable techniques like univariate method,steepest descent method etc.

UNIT - I Lecture Hrs:09

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:09

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:09

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:09

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 Lecture Hrs:09

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.

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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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Course Code	FOOD PRESERVATION TECHNIQUES	L	T	P	C
21D17103c	Program Elective Course-I	3	0	0	3
	Semester	I			

Course Objectives: Student will be able to

- Locate and appraise legislative requirements or authoritative guidelines relevant to shelf life extension in fresh, minimally processed and processed foods.
- Recognise the elements of the Hazard Analysis Critical Control Point (HACCP) system
- 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.
- Apply principles of food preservation to pilot scale production of processed food and evaluate variation in processing parameters or product formulation on product properties
- Prepare for practical exercises, organise team work and reflect on issues arising from practical exercise(s) and or production simulation(s) utilising the communication tools
- Identify and examine the method of packaging, packaging materials and storage practices employed in shelf life extension of fresh, minimally processed and processed foods.
- Recognise and analyse 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

- 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.
- 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.
- 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

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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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Course Code	PRINCIPLES OF AIR-CONDITIONING	L	T	P	C
21D17104a	PROGRAM ELECTIVE COURSE-II	3	0	0	3
	Semester	I			

Course Objectives: Student

- Will understand well, the importance of maintaining the thermal environment for human comfort which ultimately enhances the working efficiency.
- Will be in a position to understand the necessity of maintaining the temperature and humidity for various processes in process and pharmaceutical industries.
- 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

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

UNIT - I	Lecture Hrs:9

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:8

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:9

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:9

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:9

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.
5 Refrigeration & Air-conditioning --Stoecker.

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6 Refrigeration & Air-conditioning -V.K.Jain. 7. 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. 5 Refrigeration & Air-conditioning --Stoecker. 6 Refrigeration & Air-conditioning -V.K.Jain. 7. ASHRE - Guide and data book
Online Learning Resources:
• https://onlinecourses.nptel.ac.in/noc19_me58/preview

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COURSE STRUCTURE & SYLLABI

Course Code	CRYOGENIC ENGINEERING	L	T	P	C
21D17104b	Program Elective Course-II	3	0	0	3
	Semester	I			

Course Objectives: Student will be able to

- Examine basic principles of cryogenics
- Apply the knowledge of cryogenics in different applications of cryogenics like space
- technology, gas industry, electronics
- Design low temperature system by considering properties and principles of mixtures
- Identify theoretical and mathematical methods of liquefaction systems
- Construction of liquefaction system for different gases

Course Outcomes (CO): Student will be able to

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

UNIT - I — Lecture Hrs:09

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:09

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 underground power lines.

UNIT - III — Lecture Hrs:09

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

UNIT - IV — Lecture Hrs:09

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:09

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/

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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
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3. www.iifiir.org/
4. www.linde.com
5. www.airliquide.com/
6. www.cern.ch

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Course Code	SOLAR REFRIGERATION AND AIR- CONDITIONING	L	T	P	C
21D17104c	Program Elective Course-II	3	0	0	3
Semester		I			

Course Objectives: Student will be able

- To understand thermodynamic relations.
- To understand exergy and irreversibility.
- To understand different types of solar cooling systems
- To understand the thermodynamic modeling
- To understand the Economics of different cooling systems

Course Outcomes (CO): Student will be able to

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

Textbooks:

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

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

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3. Solar Cooling & Heating Volumes, I,II,III., T.Negat Vezirogulu
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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Course Code	**REFRIGERATION LABORATORY**	**L**	**T**	**P**	**C**
21D17105		**0**	**0**	**4**	**2**
	Semester	**I**			

Course Objectives: Student will be able

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

- **Course Outcomes (CO):** Student will be able

- Analyze the performance Domestic Vapor Compression Refrigeration system
- Evaluate the performance of the Vapor compression and Air conditioning units
- Analyze the Expansion devices
- 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.

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Course Code	HEAT TRANSFER LABORATORY	L	T	P	C
21D17106		0	0	4	2
Semester		I			

Course Objectives: Student will be able to

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

Course Outcomes (CO): Student will be able to

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

List of Experiments:

1. Thermal conductivity of insulating powder material through Concentric Sphere apparatus.
2. Thermal conductivity of insulating material through lagged pipe apparatus
3. Overall heat transfer co-efficient through Composite Slab Apparatus
4. Thermal Conductivity of metal (conductor).
5. Heat transfer in pin-fin
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. Experiment on Critical Heat flux apparatus.
14. Study of heat pipe and its demonstration.
15. Study of Two – Phase flow.

References:

1. Yunus A. Cengel, “Heat Transfer a Practical Approach”, Tata McGraw-Hill Education, 4th Edition,2012.
2. R. C. Sachdeva, “Fundamentals of Engineering, Heat and Mass Transfer”, New Age publication, 3 rd Edition, 2012. Web Refer

Online learning resources/Virtual labs:

Course Code	RESEARCH METHODOLOGY AND IPR	L	T	P	C

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21DRM101		**2**	**0**	**0**	**2**
	Semester	**I**			

Course Objectives:

- Identify an appropriate research problem in their interesting domain.
- Understand ethical issues understand the Preparation of a research project thesis report.
- Understand the Preparation of a research project thesis report
- Understand the law of patent and copyrights.
- Understand the Adequate knowledge on IPR

Course Outcomes (CO): Student will be able to

- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

UNIT - I		Lecture Hrs:

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, scope, and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT - II		Lecture Hrs:

Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

UNIT - III		Lecture Hrs:

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT - IV		Lecture Hrs:

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT - V		

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Textbooks:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

Reference Books:

1. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.

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3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Asimov, "Introduction to Design", Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.

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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	DESIGN OF AIR-CONDITIONING SYSTEMS	L	T	P	C
21D17201		3	0	0	3
	Semester	**II**			

Course Objectives: Student will be able to

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

Course Outcomes (CO): Student will be able to

- Analyze and understand the design of the air-distribution Room air distribution - types of supply air outlets plants.
- Thorough knowledge of the basic design principles of building survey & cooling load estimation.
- Location of equipment power plants.
- Understand the economic, environmental, and regulatory issues related to central station air conditioning system.
- 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		Lecture Hrs:

APPLICATIONS OF AIR-CONDITIONING: -

Industrial, Commercial, transport Air conditioning-Special applications-Computer, Hospital Cold storages, Printing, Textile & Leather industries.

Textbooks:

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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.

Reference Books:

1. Refrigeration & Air-conditioning -Stoecker.
2. Refrigeration & Air-conditioning -V.K.Jain.
3. ASHRAE - Guide and Data Book

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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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	CONVECTIVE HEAT &MASS TRANSFER	L	T	P	C
21D17202		3	0	0	3
	Semester	II			

Course Objectives: Student will be able

- To understand the convective heat transfer.
- To ability to forced convection heat transfer in laminar tube flow.
- To understand boiling and condensation
- To understand mass transfer.
- To familiarize Convective mass transfer - governing equations.

Course Outcomes (CO): Student will be able to

- Understand the hydrodynamic, thermal boundary layer concept and the relationship between fluid friction and heat transfer.
- Understand the concept and mechanism of forced and natural convection.
- Understand the mass transfer theories.
- Ability to apply the various empirical correlations used in different fluid flow situations.
- Ability to analyze and solve complex heat transfer phenomenon.
- 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-problem.

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

Reference Books:

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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COURSE STRUCTURE & SYLLABI

Course Code	REFRIGERATION EQUIPMENT & CONTROLS	L	T	P	C
21D17203a	Program Elective Course – III	3	0	0	3
	Semester	II			

Course Objectives: Student will be able

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

Course Outcomes (CO): Student will be able to

- To be able to state principles of Compressors - types - equivalent shaft work.
- To be able to identify and describe Condensers , types, Water cooled Condensers-Air cooled, Evaporative types.
- To be able to explain at a level understandable by a non-technical person how various Evaporators work.
- To be able to apply the Expansion devices with in the system.
- 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)

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 – Dhanpat Rai & Co., - 2000
3. 'Refrigeration and Air Conditioning' - by - C.P.Arora – TMGH - 2000

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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 – Dhanpat Rai & 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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Course Code	DESIGN OF HEAT TRANSFER EQUIPMENT	L	T	P	C
21D17203b	Program Elective Course – III	3	0	0	3
	Semester	II			

Course Objectives: Student will be able

- To understand the design of heat exchangers.
- To understand design of evaporators and compressors.
- To know design of cooling towers and spray ponds.
- To gain knowledge about design of ducts and fans
- To know piping system.

Course Outcomes (CO): Student will be able to

- To be able to state the Exchangers-mean temperature differences for parallel and counter flow-effectiveness method.
- 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.
- To be able to explain Classification-performance of cooling towers – analysis of counter flow cooling towers- enthalpy-temperature diagram of air and water.
- To be able to explain design of cooling towers and spray ponds
- 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.

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:

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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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Course Code	ADVANCED THERMAL STORAGE TECHNOLOGIES	L	T	P	C
21D17203c	Program Elective Course – III	3	0	0	3
	Semester	II			

Course Objectives: Student will be able

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

Course Outcomes (CO): Student will be able to

- To be able to state the types-energy storage devices – comparison of energy storage technologies.
- To be able to identify and describe Basic concepts and modeling of heat storage units - modeling of simple water and rock bed storage system.
- To be able to explain at a level understandable by a non-technical person how various Parallel flow and counter flow regenerators.
- To be able to calculate Modeling of phase change problems
- To be able to explain green house 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.

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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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	ADVANCED FLUID MECHANICS	L	T	P	C
21D17204a	Program Elective Course – IV	3	0	0	3
Semester		II			

Course Objectives: Student will be able to

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

Course Outcomes (CO): Student will be able to

- Apply knowledge of mathematics, science and engineering.
- Derive the governing equations of fluid flow and applying them to simple flow problems.
- Emphasizing the mathematical formulation of various flow problems.
- 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, Kerman's integral equation.

UNIT – III Lecture Hrs:

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 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)

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

Reference Books:

1. Yahya S.M. "Fundamentals of Compressible Flow", - Wiley Eastern
42. Young, Munsen and Okiisyi, " A Brief Introduction to Fluid Mechanics" 2nd Edition, John Wiley 2000.
3. Frank.M.White, " Fluid Mechanics 5th Edn – McGraw Hill 2005.

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Online Learning Resources:
• https://nptel.ac.in/courses/112/105/112105218/

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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	DESIGN OF HVAC SYSTEM	L	T	P	C
21D17204b	Program Elective Course – IV	3	0	0	3
Semester		II			

Course Objectives: Student will be able

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

Course Outcomes (CO): Student will be able to

- To be able to state the Applied Psychrometry, Psychrometric processes using chart Load Estimation.
- To be able to identify and describe Fundamentals of air flow in ducts, pressure drop calculations, design ducts by velocity reduction method.
- 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.
- To be able to apply the Basic psychometric of evaporative cooling, types of evaporative coolers, design calculations.
- 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.

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COURSE STRUCTURE & SYLLABI

4. Trane air conditioning manual,
5. Refrigeration and Air conditioning, ARI Prentice Hall, New Delhi.

Reference Books:

1. Norman C. Harris, Modern air conditioning
2. Jones W. P., Air conditioning Engineering, Edward Arnold Publishers Ltd, London, 1984.
3. Jones W. P., Air conditioning Engineering - Applications, Edward Arnold Publishers Ltd, London, 1984
4. Hainer R. W., Control System for Heating, Ventilation and Air conditioning, Van Nastrand Reinhold Co., New York, 1984.
5. Refrigeration and Air conditioning- C P Arora, Tata McGraw Hill Publication, New Delhi.
6. 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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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	ENERGY CONSERVATION AND MANAGEMENT	L	T	P	C
21D17204c	Program Elective Course – IV	3	0	0	3
	Semester	II			

Course Objectives: Student will be able

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

Course Outcomes (CO): Student will be able to

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

UNIT – I Lecture Hrs:

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 Lecture Hrs:

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 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:

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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

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

Reference Books:

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

Online Learning Resources:

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

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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	AIR-CONDITIONING LABORATORY	L	T	P	C
21D17205		0	0	4	2
	Semester	II			

Course Objectives: Student will be able

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

Course Outcomes (CO):

- Ability to apply the theoretical knowledge to solve problems in Heat Power Engineering.
- Hands on experience through actual experimentation or simulation.
- Ability to formulate and analyze practical problems.
- Ability to prepare mathematical/geometrical model and solve it using appropriate software.
- Ability to analyze data obtained through experimentation/simulation and drawing suitable technical
- conclusion
- 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

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COURSE STRUCTURE & SYLLABI

Course Code	ADVANCED FLUID MECHANICS LAB	L	T	P	C
21D17206		0	0	4	2
	Semester	II			

Course Objectives: to

- Student will be able to make the students understand the fluid flow concepts and get familiarity with flow measuring devices.

Course Outcomes (CO):

- Student will 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.

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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	DESIGN OF AIR HANDLING SYSTEMS	L	T	P	C
21D17301a	Program Elective Course – V	3	0	0	3
	Semester	III			

Course Objectives: Student will be able

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

Course Outcomes (CO): Student will be able to

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

Reference Books:

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1. Shan K.Wang, Handbook of Air-conditioning and Refrigeration, McGraw -Hill, 2001.
2. 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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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	INDOOR AIR QUALITY CONTROL	L	T	P	C
21D17301b	Program Elective Course – V	3	0	0	3
Semester		III			

Course Objectives: Student will be able

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

Course Outcomes (CO): Student will be able to

- Apply sampling techniques
- Apply modeling techniques
- 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 assurance calibration-
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

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:

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- 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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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	COGENERATION AND WASTE HEAT RECOVERY SYSTEMS (PE-V)	L	T	P	C
21D17301c		3	0	0	3
Semester		III			

Course Objectives: Student will be able

To impart knowledge on
- The basic energy generation cycles
- The concept of cogeneration, its types and probable areas of applications
- Significance of waste heat recovery systems and carryout its economic analysis

Course Outcomes (CO): Student will be able to
- Analyse the basic energy generation cycles
- 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 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 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:

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

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AUDIT COURSE-I

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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
21DAC101a		2	0	0	0
	Semester	I			

Course Objectives: This course will enable students:

- Understand the essentials of writing skills and their level of readability
- Learn about what to write in each section
- Ensure qualitative presentation with linguistic accuracy

Course Outcomes (CO): Student will be able to

- Understand the significance of writing skills and the level of readability
- Analyze and write title, abstract, different sections in research paper
- Develop the skills needed while writing a research paper

UNIT - I	Lecture Hrs:10
1Overview of a Research Paper- Planning and Preparation- Word Order- Useful Phrases - Breaking up Long Sentences-Structuring Paragraphs and Sentences-Being Concise and Removing Redundancy -Avoiding Ambiguity	
UNIT - II	Lecture Hrs:10
Essential Components of a Research Paper- Abstracts- Building Hypothesis-Research Problem - Highlight Findings- Hedging and Criticizing, Paraphrasing and Plagiarism, Cauterization	
UNIT - III	Lecture Hrs:10
Introducing Review of the Literature – Methodology - Analysis of the Data-Findings - Discussion-Conclusions-Recommendations.	
UNIT - IV	Lecture Hrs:9
Key skills needed for writing a Title, Abstract, and Introduction	
UNIT - V	Lecture Hrs:9
Appropriate language to formulate Methodology, incorporate Results, put forth Arguments and draw Conclusions	

Suggested Reading

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books) Model Curriculum of Engineering & Technology PG Courses [Volume-I]
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	DISASTER MANAGEMENT	L	T	P	C
21DAC101b		2	0	0	0
	Semester	I			

Course Objectives: This course will enable students:

- Learn to demonstrate critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Critically evaluatedisasterriskreduction and humanitarian response policy and practice from
- Multiple perspectives.
- Developanunderstandingofstandardsofhumanitarianresponseandpracticalrelevanceinspecific types of disasters and conflict situations
- Criticallyunderstandthestrengthsandweaknessesofdisastermanagementapproaches,planningand programming in different countries, particularly their home country or the countries they work in

UNIT - I

Introduction:
Disaster:Definition,FactorsandSignificance;DifferenceBetweenHazardandDisaster;Naturaland Manmade Disasters: Difference, Nature, Types and Magnitude.
Disaster Prone Areas in India:
Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post- Disaster Diseases and Epidemics

UNIT - II

Repercussions of Disasters and Hazards:
Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes,Volcanisms,Cyclones,Tsunamis,Floods,DroughtsandFamines,Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

UNIT - III

Disaster Preparedness and Management:
Preparedness: Monitoring of Phenomena Triggering ADisasteror Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT - IV

Risk Assessment Disaster Risk:
Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. TechniquesofRiskAssessment,GlobalCo-OperationinRiskAssessmentand Warning, People's Participation in Risk Assessment. Strategies for Survival.

UNIT - V

Disaster Mitigation:
Meaning,ConceptandStrategiesofDisasterMitigation,EmergingTrendsInMitigation.Structural Mitigationand Non-Structural Mitigation, Programs of Disaster Mitigation in India.

Suggested Reading

1. R.Nishith,SinghAK,"DisasterManagementinIndia:Perspectives,issuesandstrategies
2. "'New Royal book Company..Sahni,PardeepEt.Al.(Eds.),"DisasterMitigationExperiencesAndReflections",PrenticeHall OfIndia, New Delhi.
3. GoelS.L.,DisasterAdministrationAndManagementTextAndCaseStudies",Deep&Deep Publication Pvt. Ltd., New Delhi

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M.TECH. IN REFRIGERATION & AIR-CONDITIONING
COURSE STRUCTURE & SYLLABI

Course Code	**SANSKRITFOR TECHNICAL KNOWLEDGE**	**L**	**T**	**P**	**C**
21DAC101c		**2**	**0**	**0**	**0**
	Semester	**I**			

Course Objectives: This course will enable students:

- To get a working knowledge in illustrious Sanskrit, the scientific language in the world
- Learning of Sanskrit to improve brain functioning
- LearningofSanskrittodevelopthelogicinmathematics,science&othersubjects enhancing the memory power
- The engineering scholars equipped with Sanskrit will be able to explore the huge
- Knowledge from ancientliterature

Course Outcomes (CO): Student will be able to

- Understanding basic Sanskrit language
- Ancient Sanskrit literature about science &technology can be understood
- Being a logical language will help to develop logic in students

UNIT - I		
Alphabets in Sanskrit,		
UNIT - II		
Past/Present/Future Tense, Simple Sentences		
UNIT - III		
Order, Introduction of roots		
UNIT - IV		
Technical information about Sanskrit Literature		
UNIT - V		
Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics		

Suggested Reading

1.“Abhyaspustakam” –Dr.Vishwas, Sanskrit-Bharti Publication, New Delhi
2.“Teach Yourself Sanskrit” Prathama Deeksha- VempatiKutumbshastri, RashtriyaSanskrit Sansthanam, New Delhi Publication
3.“India’s Glorious ScientificTradition” Suresh Soni, Ocean books (P) Ltd.,New Delhi

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AUDIT COURSE-II

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COURSE STRUCTURE & SYLLABI

Course Code	PEDAGOGY STUDIES	L	T	P	C
21DAC201a		2	0	0	0
	Semester	II			

Course Objectives: This course will enable students:

- Reviewexistingevidenceonthereviewtopictoinformprogrammedesignandpolicy making undertaken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

Course Outcomes (CO): Student will be able to

- Students will be able to understand:
- Whatpedagogicalpracticesarebeingusedbyteachersinformalandinformalclassrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what
- conditions, and with what population of learners?
- Howcanteachereducation(curriculumandpracticum)andtheschoolcurriculumand guidance materials best support effective pedagogy?

UNIT - I

Introduction and Methodology: Aims and rationale, Policy back ground, Conceptual frame work and terminology Theories oflearning,Curriculum,Teachereducation.Conceptualframework,Research questions. Overview of methodology and Searching.

UNIT - II

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

UNIT - III

Evidence on theeffectivenessofpedagogicalpractices,Methodologyfortheindepthstage:quality assessmen t of included studies. How can teacher education (curriculumandpracticum) andthescho curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of th body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT - IV

Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head
teacherandthecommunity.Curriculumandassessment,Barrierstolearning:limitedresourcesand large class sizes

UNIT - V

Researchgapsandfuturedirections:Researchdesign,Contexts,Pedagogy,Teachereducation, Curriculum and assessment, Dissemination and research impact.

Suggested Reading

1. AckersJ,HardmanF(2001)ClassroominteractioninKenyanprimaryschools,Compare, 31 (2): 245-261.
2. AgrawalM(2004)Curricularreforminschools:Theimportanceofevaluation,Journalof
3. Curriculum Studies, 36 (3): 361-379.
4. AkyeampongK(2003) Teacher training in Ghana - does it count? Multi-site teachereducation research project (MUSTER) country report 1. London: DFID.
5. Akyeampong K, LussierK, PryorJ, Westbrook J (2013)Improving teaching and learning of basic maths and reading in Africa: Does teacherpreparation count?International Journal Educational Development, 33 (3): 272–282.
6. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education.

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Oxford and Boston: Blackwell.
Chavan M (2003)ReadIndia: A mass scale, rapid, 'learning to read'campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

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COURSE STRUCTURE & SYLLABI

Course Code	**STRESSMANAGEMENT BY YOGA**	**L**	**T**	**P**	**C**
21DAC201b		**2**	**0**	**0**	**0**
	Semester	**II**			

Course Objectives: This course will enable students:

- To achieve overall health of body and mind
- To overcome stres

Course Outcomes (CO): Student will be able to

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

UNIT - I		
Definitions of Eight parts of yog.(Ashtanga)		
UNIT - II		
Yam and Niyam.		
UNIT - III		
Do`sand Don't'sin life. i) Ahinsa,satya,astheya,bramhacharyaand aparigrahaii) Shaucha,santosh,tapa,swadhyay,ishwarpranidhan		
UNIT - IV		
Asan and Pranayam		
UNIT - V		
i)Variousyogposesand theirbenefitsformind &body ii)Regularizationofbreathingtechniques and its effects-Types ofpranayam		

Suggested Reading

1.'Yogic Asanas forGroupTarining-Part-I": Janardan SwamiYogabhyasiMandal, Nagpur
2."Rajayogaor conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

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Course Code	PERSONALITY DEVELOPMENT THROUGHLIFE	L	T	P	C
21DAC201c	ENLIGHTENMENTSKILLS	2	0	0	0
	Semester	II			

Course Objectives: This course will enable students:

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

Course Outcomes (CO): Student will be able to

- StudyofShrimad-Bhagwad-Geetawillhelpthestudentindevelopinghispersonalityand achieve the highest goal in life
- The person who has studied Geetawilllead the nation and mankind to peace and prosperity
- Study of Neetishatakam will help in developing versatile personality of students

UNIT - I

Neetisatakam- Holistic development of personality
Verses-19,20,21,22(wisdom)
Verses-29,31,32(pride &heroism)
Verses-26,28,63,65(virtue)

UNIT - II

Neetisatakam- Holistic development of personality
Verses-52,53,59(dont's)
Verses-71,73,75,78(do's)

UNIT - III

Approach to day to day work and duties.
ShrimadBhagwadGeeta:Chapter2-Verses41,47,48,
Chapter3-Verses13,21,27,35,Chapter6-Verses5,13,17,23,35,
Chapter18-Verses45,46,48.

UNIT - IV

Statements of basic knowledge.
ShrimadBhagwadGeeta:Chapter2-Verses 56,62,68
Chapter12 -Verses13,14,15,16,17,18
Personality of Rolemodel. Shrimad Bhagwad Geeta:

UNIT - V

Chapter2-Verses 17,Chapter3-Verses36,37,42,
Chapter4-Verses18,38,39
Chapter18– Verses37,38,63

Suggested Reading

1."SrimadBhagavadGita"bySwamiSwarupanandaAdvaitaAshram(PublicationDepartment), Kolkata
2.Bhartrihari'sThree Satakam (Niti-sringar-vairagya) by P.Gopinath, RashtriyaSanskrit Sansthanam, New Delhi.

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OPEN ELECTIVE

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COURSE STRUCTURE & SYLLABI

Course Code	BUSINESS ANALYTICS	L	T	P	C
21DOE301c		3	0	0	3
Semester		III			

Course Objectives:

- The main objective of this course is to give the student a comprehensive understanding of business analytics methods.

Course Outcomes (CO): Student will be able to

- Students will demonstrate knowledge of data analytics.
- Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
- Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
- Students will demonstrate the ability to translate data into clear, actionable insights.

UNIT - I Lecture Hrs:

Business Analysis: Overview of Business Analysis, Overview of Requirements, Role of the Business Analyst.
Stakeholders: the project team, management, and the front line, Handling Stakeholder Conflicts.

UNIT - II Lecture Hrs:

Life Cycles: Systems Development Life Cycles, Project Life Cycles, Product Life Cycles, Requirement Life Cycles.

UNIT - III Lecture Hrs:

Forming Requirements: Overview of Requirements, Attributes of Good Requirements, Types of Requirements, Requirement Sources, Gathering Requirements from Stakeholders, Common Requirements Documents.Transforming Requirements: Stakeholder Needs Analysis, Decomposition Analysis, Additive/Subtractive Analysis, Gap Analysis, Notations (UML & BPMN), Flowcharts, Swim Lane Flowcharts, Entity-Relationship Diagrams, State-Transition Diagrams, Data Flow Diagrams, Use Case Modeling, Business Process Modeling

UNIT - IV Lecture Hrs:

Finalizing Requirements: Presenting Requirements, Socializing Requirements and Gaining Acceptance, Prioritizing Requirements. Managing Requirements Assets: Change Control, Requirements Tools

UNIT - V Lecture Hrs:

Recent Trands in: Embedded and colleborative business intelligence, Visual data recovery, Data Storytelling and Data Journalism.

Textbooks:

1. Business Analysis by James Cadle et al.
2. Project Management: The Managerial Process by Erik Larson and, Clifford Gray

Reference Books:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

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COURSE STRUCTURE & SYLLABI

Course Code	**INTERNET OF THINGS (IOT)**	**L**	**T**	**P**	**C**
21DOE301g		**3**	**-**	**-**	**3**
	Semester	**III**			

Course Objectives: Student will be able

- To study fundamental concepts of IoT
- To understand roles of sensors in IoT
- To Learn different protocols used for IoT design
- To be familiar with data handling and analytics tools in IoT
- Appreciate the role of big data, cloud computing and data analytics in a typical IoT system

Course Outcomes (CO): Student will be able to

- Understand the various concepts, terminologies and architecture of IoT systems.
- Use sensors and actuators for design of IoT.
- Understand and apply various protocols for design of IoT systems
- Use various techniques of data storage and analytics in IoT
- Understand various applications of IoT
- Understand APIs to connect IoT related technologies

UNIT – I	Lecture Hrs:09

Fundamentals of IoT: Introduction, Definitions & Characteristics of IoT, IoT Architectures, Physical & Logical Design of IoT, Enabling Technologies in IoT, History of IoT, About Things in IoT, The Identifiers in IoT, About the Internet in IoT, IoT frameworks, IoT and M2M

UNIT – II	Lecture Hrs: 09

Sensors Networks : Definition, Types of Sensors, Types of Actuators, Examples and Working, IoT Development Boards: Arduino IDE and Board Types, RaspberriPi Development Kit, RFID Principles and components, Wireless Sensor Networks: History and Context, The node, Connecting nodes, Networking Nodes, WSN and IoT.

UNIT – III	Lecture Hrs: 09

Wireless Technologies for IoT: WPAN Technologies for IoT: IEEE 802.15.4, Zigbee, HART, NFC, Z-Wave, BLE, Bacnet, Modbus.
IP Based Protocols for IoT IPv6, 6LowPAN, RPL, REST, AMPQ, CoAP, MQTT. Edge connectivity and protocols

UNIT – IV	Lecture Hrs: 09

Data Handling& Analytics: Introduction, Bigdata, Types of data, Characteristics of Big data, Data handling Technologies, Flow of data, Data acquisition, Data Storage, Introduction to Hadoop. Introduction to data Analytics, Types of Data analytics, Local Analytics, Cloud analytics and applications

UNIT - V	Lecture Hrs: 09

Applications of IoT: Home Automation, Smart Cities, Energy, Retail Management, Logistics, Agriculture, Health and Lifestyle, Industrial IoT, Legal challenges, IoT design Ethics, IoT in Environmental Protection.

Textbooks:

1.Hakima Chaouchi, — "The Internet of Things Connecting Objects to the Web" ISBN : 978-1-84821-140-7, Wiley Publications
2.Olivier Hersent, David Boswarthick, and Omar Elloumi, — "The Internet of Things: Key Applications and Protocols", WileyPublications
3.Vijay Madisetti and ArshdeepBahga, — "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014.
4.J. Biron and J. Follett, "Foundational Elements of an IoT Solution", O'Reilly Media, 2016.
5.Keysight Technologies, "The Internet of Things: Enabling Technologies and Solutions for Design

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and Test", Application Note, 2016.
Reference Books:
1.Daniel Minoli, — "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN: 978-1-118-47347-4, Willy Publication 2.Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press
Online Learning Resources:
https://onlinecourses.nptel.ac.in/noc17_cs22/course http://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_prot/index.html

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Course Code	**MECHATRONICS**	**L**	**T**	**P**	**C**
21DOE301h		**3**	**0**	**0**	**3**
	Semester	**III**			

Course Objectives: Student will be able

- To study fundamental concepts of Signal condition
- To understand the concepts of precision mechanical systems
- To Learn different electronic interface subsystems
- To be familiar with microcontrollers overview.
- To understand the concepts of programmable logic controllers

Course Outcomes (CO): Student will be able to

- Understand the various concepts, terminologies of Signal condition
- Understand the basics electronic interface subsystems
- Understand and apply various precision mechanical systems
- Understand various applications of microcontrollers overview
- Understand the controlling of programmable logic and programmable motion.

UNIT – I	Lecture Hrs:09

INTRODUCTION : Definition – Trends - Control Methods: Standalone , PC Based (Real Time Operating Systems, Graphical User Interface , Simulation) - Applications: SPM, Robot, CNC, FMS, CIM.

SIGNAL CONDITIONING : Introduction – Hardware - Digital I/O, Analog input – ADC, resolution , speed channels Filtering Noise using passive components – Resistors, capacitors - Amplifying signals using OP amps – Software - Digital Signal Processing – Low pass , high pass , notch filtering.

UNIT – II	Lecture Hrs: 09

PRECISION MECHANICAL SYSTEMS : Pneumatic Actuation Systems - Electro-pneumatic Actuation Systems - Hydraulic Actuation Systems - Electro-hydraulic Actuation Systems - Timing Belts – Ball Screw and Nut - Linear Motion Guides - Linear Bearings - Harmonic Transmission - Bearings- Motor / Drive Selection.

UNIT – III	Lecture Hrs: 09

ELECTRONIC INTERFACE SUBSYSTEMS : TTL, CMOS interfacing - Sensor interfacing – Actuator interfacing – solenoids , motors Isoation schemes- opto coupling, buffer IC's - Protection schemes – circuit breakers , over current sensing , resetable fuses , thermal dissipation - Power Supply - Bipolar transistors / mosfets

ELECTROMECHANICAL DRIVES : Relays and Solenoids - Stepper Motors - DC brushed motors – DC brushless motors - DC servo motors - 4-quadrant servo drives , PWM's - Pulse Width Modulation – Variable Frequency Drives, Vector Drives - Drive System load calculation

UNIT – IV	Lecture Hrs: 09

MICROCONTROLLERS OVERVIEW: 8051 Microcontroller , micro processor structure - DigitalInterfacing - Analog Interfacing - Digital to Analog Convertors - Analog to Digital Convertors - Applications. Programming –Assembly , C (LED Blinking , Voltage measurement using ADC).

UNIT - V	Lecture Hrs: 09

PROGRAMMABLE LOGIC CONTROLLERS : Basic Structure - Programming : Ladder diagram -Timers, Internal Relays and Counters - Shift Registers - Master and Jump Controls - Data Handling - Analog input / output - PLC Selection - Application.

PROGRAMMABLE MOTION CONTROLLERS : Introduction - System Transfer Function – Laplace transform and its application in analysing differential equation of a control system - Feedback Devices :Position , Velocity Sensors - Optical Incremental encoders - Proximity Sensors : Inductive , Capacitive ,

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Textbooks:
1. A text book of Mechatronics by Er.R.K. RAJPUT ., S.CHAND publications 2. A text book of Mechatronics by Nitalgour Premchand Mahalik ., McGraw Hill publications
Reference Books:
1. A text book of Mechatronics by W.Bolton ., Pearson Publications