FACULTY OF ENGINEERING

Scheme of Instruction & Examination

(AICTE Model Curriculum for the Academic Year 2019-2020)

and

Syllabus

M.E. I to IV Semester

of

Two Year Post Graduate Degree Programme

in

Mechanical Engineering
Specialization in Heating, Ventilation and Air-Conditioning (HVAC)

(With effect from the academic year 2019– 2020)
(As approved in the faculty meeting held on 25-06-2019)

Issued by

Dean, Faculty of Engineering

Osmania University, Hyderabad – 500 007

2019

SCHEME OF INSTRUCTION & EXAMINATION
M.E. (Mechanical Engineering) I – Semester
Specialization in Heating, Ventilation and Air-Conditioning (HVAC)

S. No.	Course Type/Code	Course Name	Scheme of Instruction				Scheme of Examination			Credits
			L	T	P/D	Contact Hrs/Wk	CIE	SEE	Duration in Hrs	
Theory Courses										
1	Core	Program Core – I	3	1	-	4	30	70	3	4
2	Core	Program Core – II	3	-	-	3	30	70	3	3
3	Elective	Professional Elective – I	3	-	-	3	30	70	3	3
4	Elective	Professional Elective – II	3	-	-	3	30	70	3	3
5	MC or OE	MC/Open Elective*	3	-	-	3	30	70	3	3
6	Audit	Audit Course – I	2	-	-	2	30	70	3	0
Practical/ Laboratory Courses										
7	Lab-I	Laboratory – I	-	-	2	2	25	50	3	1
8	PC 5254 HV	Seminar	-	-	2	2	25	50	3	1
		Total	**17**	**01**	**04**	**22**	**230**	**520**		**18**

PC: Program Core **PE:** Professional Elective **OE**: Open Elective **AD**: Audit Course
MC: Mandatory Course **HS**: Humanities and social science

L: Lecture **T**: Tutorial **P**: Practical **D**: Drawing
CIE: Continuous Internal Evaluation **SEE:** Semester End Examination (Univ. Exam)

Note:

1. Each contact hour is a Clock Hour.
2. The practical class can be of two and half hour (clock hours) duration as per the requirement of a particular laboratory.
3. * If the Mandatory Course is offered in I-Semester, the Open Elective course should be offered in II-semester. If Open Elective course is offered in I-Semester, then the Mandatory Course should be offered in II- semester.
4. ** Open Elective Subject is not offered to the students of Mechanical Engineering Department.

SCHEME OF INSTRUCTION & EXAMINATION
M.E. (Mechanical Engineering) II – Semester
Specialization in Heating, Ventilation and Air-Conditioning (HVAC)

S. No.	Course Type/Code	Course Name	Scheme of Instruction				Scheme of Examination			Credits
			L	T	P/D	Contact Hrs/Wk	CIE	SEE	Duration in Hrs	
Theory Courses										
1	Core	Program Core – III	3	1	-	4	30	70	3	4
2	Core	Program Core – IV	3	1	-	3	30	70	3	4
3	Elective	Professional Elective – III	3	-	-	3	30	70	3	3
4	MC or OE	Open Elective/MC	3	-	-	3	30	70	3	3
5	Audit	Audit Course – II	2	-	-	2	30	70	3	0
Practical/ Laboratory Courses										
6	Lab-II	Laboratory – II	-	-	2	2	25	50	3	1
7	Lab-III	Laboratory – III	-	-	2	2	25	50	3	1
8	PC 5255 HV	Mini Project with Seminar	-	-	4	4	25	50	3	2
		Total	**14**	**02**	**08**	**24**	**300**	**450**		**18**

PC: Program Core **PE:** Professional Elective **OE**: Open Elective **AD**: Audit Course
MC: Mandatory Course **HS**: Humanities and social science

L: Lecture **T**: Tutorial **P**: Practical **D**: Drawing
CIE: Continuous Internal Evaluation **SEE:** Semester End Examination (Univ. Exam)

Note:
1. Each contact hour is a Clock Hour.
2. The practical class can be of two and half hour (clock hours) duration as per the requirement of a particular laboratory.
3. ** Open Elective Subject is not offered to the students of Mechanical Engineering Department.

SCHEME OF INSTRUCTION & EXAMINATION
M.E. (Mechanical Engineering) III – Semester
Specialization in Heating, Ventilation and Air-Conditioning (HVAC)

S. No.	Course Type/Code	Course Name	Scheme of Instruction				Scheme of Examination			Credits
			L	T	P/D	Contact Hrs/Wk	CIE	SEE	Duration in Hrs	
Theory Courses										
1	Elective	Professional Elective – IV	3	-	-	3	30	70	3	3
2	Elective	Professional Elective – V	3	-	-	3	30	70	3	3
3	PC 5256 HV	Major Project Phase – I	-	-	20	20	100	-	3	10
		Total	**06**	**-**	**20**	**26**	**160**	**140**		**16**

M.E. (Mechanical Engineering) IV – Semester
Specialization in Heating, Ventilation and Air-Conditioning (HVAC)

S. No.	Course Type/Code	Course Name	Scheme of Instruction				Scheme of Examination			Credits
			L	T	P/D	Contact Hrs/Wk	CIE	SEE	Duration in Hrs	
Theory Courses										
1	PC 5257 HV	Major Project Phase – II (Dissertation)	-	-	32	32	-	200	3	16
		Total	**-**	**-**	**32**	**32**	**-**	**200**		**16**

PC: Program Core **PE:** Professional Elective **OE**: Open Elective **AD**: Audit Course
MC: Mandatory Course **HS**: Humanities and social science

L: Lecture **T**: Tutorial **P**: Practical **D**: Drawing
CIE: Continuous Internal Evaluation **SEE:** Semester End Examination (Univ. Exam)

Note:

1. Each contact hour is a Clock Hour
2. The practical class can be of two and half hour (clock hours) duration as per the requirement of a particular laboratory.
3. ** Open Elective Subject is not offered to the students of Mechanical Engineering Department.
4. The students who are willing to register for MOOCs in the M. Tech (HVAC) III – semester instead of Professional Electives – IV & V, should register for those of the courses, approved by the CBoS, OU and respective college MOOCs Coordinator. Those students are strictly not permitted to appear for either CIE or SEE of Professional Electives – IV & V if they abstain from attending the semester classwork. Further, for students willing to appear for both MOOCS and Professional Electives, they should fulfil the minimum attendance criteria.

List of subjects of Professional Core

S. No.	Course Code	Course Title
1	PC 5201 HV	Refrigeration
2	PC 5202 HV	Air-Conditioning
3	PC 5203 HV	Ventilation and Indoor Air Quality
4	PC 5204 HV	HVAC Systems Design

List of subjects of Professional Electives I to V

S. No.	Course Code	Course Title
1	PE 5216 HV	Energy Conversion and Management
2	PE 5217 HV	Cryogenic Engineering
3	PE 5218 HV	Climatology for Built Environment
4	PE 5219 HV	Refrigeration and Air-Conditioning Equipment
5	PE 5220 HV	Green Building Concepts
6	PE 5221 HV	Advanced Heat Transfer
7	PE 5222 HV	Design of Air Distribution System
8	PE 5223 HV	Automotive Air-Conditioning
9	PE 5224 HV	Air-Conditioning Instrumentation and Control Systems
10	PE 5225 HV	Maintenance of HVAC Equipment
11	PE 5226 HV	Unconventional Refrigeration and AC Systems
12	PE 5227 HV	Equipment Design for Thermal Systems
13	PE 5228 HV	Cold Storage Technology and Systems
14	PE 5229 HV	Alternative Energy Sources
15	PE 5230 HV	Renewable Energy Sources

List of Mandatory Courses

S. No.	Course Code	Course Title
1	MC 5161 ME	Research Methodology & IPR

List of Open Electives

S. No.	Course Code	Course Title
1	OE9101CE	Cost Management of Engineering Projects
2	OE9102CS	Business Analytics
3	OE9103EC	Embedded System Design
4	OE9104EE	Waste to Energy
5	OE9105ME**	Industrial Safety

Note: ** Open Elective Subject is not offered to the students of Mechanical Engineering Department.

List of subjects of Audit Course-I

S. No.	Course Code	Course Title
1	AD 9001 HS	English for Research Paper Writing
2	AD 9002 CE	Disaster Management
3	AD 9003 HS	Sanskrit for Technical Knowledge
4	AD 9004 HS	Value Education

List of subjects of Audit Course-II

S. No.	Course Code	Course Title
1	AD 9011 HS	Constitution of India and Fundamental Rights
2	AD 9012 HS	Pedagogy Studies
3	AD 9013 HS	Stress Management by Yoga
4	AD 9014 HS	Personality Development through life Enlightenment Skills

List of Laboratory Courses

S. No.	Lab No.	Course Code	Course Title
1	I	PC 5251 HV	Refrigeration Lab
2	II	PC 5252 HV	Air-Conditioning Lab
3	III	PC 5253 HV	HVAC Systems Design Lab

Course Code	Course Title						Core/Elective
PC 5201 HV	**Refrigeration**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**1**	**-**	**-**	**30**	**70**	**4**

Course Objectives

- To apply the principles of Thermodynamics to analyse different types of refrigeration systems and to understand the functionality of the major components.
- To analyse the cycle performance of vapour compression system under varying temperature and pressure variables
- To analyse the cycle performance of vapour absorption system with respect to varying enthalpy and concentration
- To compare and analyse different air craft refrigeration system and unconventional refrigeration system
- To analyse steam jet refrigeration system and industrial refrigeration processes
- To understand the classification and application of refrigerants and the need for alternative refrigerants

Course Outcomes

After completing this course, the student will be able to:

1. Understand the fundamental principles and applications of refrigeration systems
2. Differentiate between different types of refrigeration systems with respect to application
3. Differentiate between conventional and unconventional refrigeration systems.
4. Evaluate performance parameters of refrigeration systems
5. Classify the refrigerants and understand its applications
6. Choose the most appropriate system for a particular application

UNIT- I

Vapour Compression System: Analysis of vapour compression refrigeration cycle Reverse Carnot Cycle for vapour. Effect of suction temperature and condensing temperature on cycle performance. Practical refrigeration cycle, Sub cooled liquid and super-heated vapour refrigeration cycles, their effect on performance. Multi-pressure system. Removal of flash gas, inter cooling. Compound compression Multi vapour- Cascade system- dry ice system

UNIT -II

Vapour Absorption System: Simple Vapour Absorption System-Actual vapour absorption cycle representation on enthalpy concentration h-c diagram, Water lithium bromide absorption system. Electrolux refrigerator- Aqua Ammonia Refrigeration System – Enthalpy Concentration Diagram

UNIT-III

Aircraft Refrigeration: Thermodynamic Cycle – Different systems – Analysis – Comparison Un Conventional Refrigeration: Thermoelectric refrigeration system, Vortex refrigeration system, Pulse refrigeration.

UNIT-IV

Steam jet water vapour system: Analysis and Exercises Industrial Refrigeration: Chemical and process industries, Diary plants, Petroleum Refineries

UNIT-V

Refrigerants: Primary and secondary refrigerants. Designation of refrigerants, Desirable properties of refrigerants such as solubility in water and lubricating oil. Material compatibility, Toxicity, Flammability, Thermodynamic properties of refrigerants, Inorganic, Halocarbon refrigerants. Secondary refrigerants. Refrigerants mixtures, Need for Alternate refrigerants – Retrofitting aspects

Suggested Reading:

1. Principles of Refrigeration / Roy. J. Dossat
2. Refrigeration and Air Conditioning / F. Stoecker & Jerold. W. Jones./ MGH Intrl 1982
3. Refrigeration and Air Conditioning / C.P Arora./ TMG).
4. Refrigeration and Air Conditioning /Manohar Prasad.

Course Code	Course Title						Core/Elective
PC 5202 HV	**Air-Conditioning**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand Vapour compression and vapour absorption system operation
- To analyse the refrigeration cycles and methods for improving Performance
- To familiarize the components of refrigeration systems
- To design air conditioning systems using cooling load calculations
- To know Selection of outside and inside design conditions of an air conditioning system

Course Outcomes

After completing this course, the student will be able to:

1. Explain the principles and applications of refrigeration and air conditioning systems
2. Differentiate the various types of refrigeration and air conditioning systems.
3. Design and Analyse various refrigeration and air conditioning systems.
4. Select methods for performance improvement of refrigeration and air conditioning systems
5. Comparing the seasonal air conditioning refrigeration systems
6. Identifying the selection of outside and inside design conditions of air conditioning systems

UNIT - I

Psychrometry: Properties of moist air. Important Psychrometry properties, Dry bulb temperature, Humidity ratio, degree of saturation, Dew point temperature and Enthalpy, Psychometric chart and ASHRAE chart.

UNIT - II

Applied Psychrometry: Psychrometric processes in air conditioning equipment, Mixing, Bypass factor, Heating and dehumidifying coils, Air washers. Cooling by dry and wet coils, Use of hygroscopic solution in air washers, Adiabatic dehumidifiers. Humidifiers, Water injection. Steam injection.

UNIT- III

Comfort Air Conditioning and Cooling Load Calculations: Sensible and Latent Heat Loads, sensible heat factor. Use of Effective and grand sensible heat factor, Relationship between ESHF, ADP and BF. Representation of All Fresh Air, Recirculated air, Bypassed Air and High Latent Heat Load systems on Psychrometric Chart

UNIT- IV

Air Conditioning Systems: Commercial, Residential and Industrial Air-Conditioning; Summer, Winter and Year round Air-Conditioning system, Hot and dry outdoor conditions. Hot and humid outdoor conditions.

UNIT - V

Selection of outside and inside design conditions: Thermodynamics of human body. Body regulation process against heat and cold. Comfort & Comfort chart, Effective temperature, Factors governing optimum effective temperature, Design considerations. Air conditioning control systems: Basic elements of the control system, Temperature, Humidity & Pressure controls, Refrigeration, Room thermostat.

Suggested Reading:

1. Refrigeration & Air Conditioning / C.P. Arora / TMH

2. Refrigeration & Air Conditioning / Arora & Domkundwar / Dhanpat Rai & Co.
3. Refrigeration & Air Conditioning / R C Arora / PHI / 2012
4. Hand Book of Air Conditioning System Design / Carrier
5. Refrigeration & Air Conditioning / S.C. Jain / Chand and Co.
6. ASHRAE Hand Book / Volume 1& 2.

Course Code	Course Title						Core/Elective
PC 5203 HV	**Ventilation and Indoor Air Quality**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**1**	**-**	**-**	**30**	**70**	**4**

Course Objectives

The objectives of this course is to impart knowledge of

- Learning the fundamentals of good indoor air quality, effects of relative humidity, control of microbial growth in building ventilation.
- The concepts of devices used in supply ventilation system
- Describe criteria and types of exhaust ventilation system
- Design considerations for kitchen ventilation system
- Basic design consideration for commercial and residential ventilation system

Course Outcomes

After completing this course, the student will be able to:

1. Illustrate the fundamentals of good indoor air quality need for building ventilation
2. Understand the devices used in supply ventilation system
3. Apply the design considerations for kitchen ventilation system
4. Analyse the exhaust ventilation system
5. Evaluate the international mechanical codes for kitchen ventilation system
6. Design Ventilation system for commercial and residential buildings

UNIT - I

Introduction: Fundamentals of good indoor air quality Need for building ventilation, Effects of R.H. in building ventilation, Control of microbial growth, Psychometric performance of contact volume system. Types of ventilation system. Supply system, Exhaust system.

UNIT - II

Devices Used in Supply Systems: Air Inlet system. Filters heating & cooling equipment, Fans, Duct, Grills, Diffusers, for distribution of air in the work place.

UNIT - III

Exhaust Systems: General exhaust systems. Local exhaust system, Removal of pollutants and contaminated air. Air cleaning devices, Fans.

UNIT - IV

Ventilation in Kitchen: Cooking, Exhaust flow, IMC (International Mechanical Code) Calculation of appliances area, contaminated air, free foot area. Total air flow volume with example. Types of hood, Design of hood. Design factors, integrated air curtains, Combination hood.

UNIT-V

Ventilation of Commercial Buildings: Design of commercial, Residential ventilation system.

Suggested Reading:

1. Ventilation Systems: Design and Performance/ Hazim B. Awbi. / Routledge / 2007.
2. Portable Ventilation Systems Hand Book / Neil McManus / CRC Press / 2000.
3. Design of Industrial Ventilation Systems / John L Alden / Industrial Press / 5th Edition.

4. Industrial Ventilation Applications / ISHRAE Hand Book / 2009.
5. Engineering bulletin / TRANE Company.
6. HVAC Hand book / ISHRAE.
7. Industrial Ventilation Applications / ASHRAE Hand Book / 2009.

Course Code	Course Title						Core/Elective
PC 5204 HV	**HVAC Systems Design**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**1**	**-**	**-**	**30**	**70**	**4**

Course Objectives

- To calculate direct, diffuse and reflected radiation as well as to understand clearly about various incident radiation related parameters
- To calculate angle of incidence for horizontal, vertical and tilted surfaces such as walls
- To compare and contrast the conventional cooling and heating load calculations
- To understand the concept and application of various air heating systems as well as to make aware the various trouble shooting measures for common arising problems
- To classify and contrast the various water heating systems based on piping arrangement and water circulation

Course Outcomes

After completing this course, the student will be able to:

1. List the factors that impact the heating & cooling loads in buildings
2. Understand the internal and external cooling loads on a building by separating sensible and latent parts
3. Calculate the heating & cooling loads using CLTD/CLF method
4. Analyse the various HVAC systems available and selecting the most appropriate one
5. Choose appropriate air heating system for a particular location and application
6. Design an HVAC system for a residential or commercial building

UNIT - I

Heat Transfer Through Building Structures: Building Survey, Periodic heat transfer through walls and roofs. Empirical methods to calculate heat transfer through walls and roofs; Heat gain through glass, calculation of solar heat gain through ordinary glass tables, shading devices, effect of shading devices. Equivalent temperature difference method, Thermal resistance of various building materials, Infiltration, stack effect, wind effect.

UNIT - II

Heat Load Calculations: Winter heating load calculation, heat losses through structure, heat losses due to infiltration, Effects of solar radiation and internal heat sources on heating loads. Methods for estimating energy requirements for heating.

UNIT - III

HVAC System Design: Principles of HVAC system design and analysis; component and system selection criteria including room air distribution, fans and air circulation, humidifying and dehumidifying processes, piping and ducting design. Air quality standards. Control systems and techniques; operational economics. The engineering principles and key factors influencing the thermal environments and quantification of these factors, functional requirements of utilities, and the design of systems to local codes.

UNIT - IV

Air conditioning systems: Ventilation Systems; Space Heating Systems; Automatic control; Commissioning, operation and maintenance; Introduction to HVAC & R analysis. Thermal equipment performance; Direct contact heat and mass transfer; Component modelling and simulation; Performance

analysis and optimization of environmental plant systems. Part-load and year-round operation, system performance and operational problems; Ventilation systems: outdoor air control, ventilation effectiveness, ADPI, fan-duct network; filtration systems

UNIT - V

Systems: Primary and secondary water loops, constant and variable flow; System control: air side control, water side control; Energy requirement: cooling load profile, fan and pump power, system operation for energy effectiveness and heat recovery, chiller optimization. Thermal environment; Air quality; Energy conservation measures; Energy codes; Noise and vibration control

Suggested Reading:

1. HVAC Fundamentals Volume-l / James E. Brumbou / Audel / 4th Edition
2. Fundamentals of HVAC Systems / Robert Mcdowall / Academic Press / 2007
3. Home Heating & Air Conditioning systems / James Kittle / MGH
4. HVAC Fundamentals / Samuel C. Sugarman / Fairmont Press / 2005.
5. Principles of Refrigeration – Dossat, Pearson
6. R&AC Hand Book by ISHRAE

Course Code	Course Title						Core/Elective
PE 5216 HV	**Energy Conversion and Management**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand and appreciate the energy crisis and environmental concerns associated with the energy management
- To be able to do Energy Audit
- To acquire the skills of energy efficiency analysis and energy conversion & management in the routinely used thermal and electrical energy systems
- To understand the energy conservation and management technologies and strategies

Course Outcomes

After completing this course, the student will be able to:

1. Understand concepts of energy crisis and environmental concerns and on the importance of energy efficiency, conservation and management
2. Comprehend the techniques and having the skills for the energy conservation and management in the thermal energy systems
3. Apply the techniques and having the skills for the energy conservation and management in the electrical energy systems
4. Analyze energy monitoring and auditing, and the energy management systems
5. Evaluate to the most used energy planning and management software.
6. Formulate strategy to use alternate sources of energy

UNIT - I

Introduction: Principles of energy management. Managerial organization, Functional areas for i) manufacturing industry, ii) Process industry, iii) Commerce, iv) Government, Role of Energy manager in each of these organizations. Initiating, Organizing and managing energy management programs

UNIT - II

Energy Audit: Definition and concepts. Types of energy audits, Basic energy concepts, Resources for plant energy studies. Data gathering, Analytical techniques.

Energy Conservation: Technologies for energy conservation, Design for conservation of energy materials, Energy flow networks. Critical assessment of energy usage. Formulation of objectives and constrains, Synthesis of alternative options and technical analysis of options. Process integration.

UNIT - III

Economic Analysis: Scope, Characterization of an investment project. Types of depreciation, Time value of money. Budget considerations, Risk analysis.

UNIT- IV

Methods of Evaluation of Projects: Payback, Annualized costs, Investor's rate of return, Present worth, Internal rate of return, Pros and cons of the common method of analysis, Replacement analysis.

UNIT - V

Alternative Energy Sources: Solar Energy, Types of devices for solar energy collections, Thermal storage system, Control systems. Wind Energy, Availability, Wind Devices, Wind Characteristics, performance of turbines and systems.

Suggested Reading:

1. Energy Management Hand Book / W. C. Turner (Ed)
2. Energy Management Principles / CB Smith/ Pergamon Press
3. Energy Management / W. R. Murthy and G. Mc. Kay / BS Publication
4. Management / H. Koontz and Cyrill Donnel / McGraw Hill
5. Financial Management / S. C. Kuchhal / Chaitanya Publishing House

Course Code	Course Title						Core/Elective
PE 5217 HV	**Cryogenic Engineering**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Learning the mechanical properties, methods to protect the cryogenic fluids
- To describe liquefaction system for Neon, Hydrogen and Helium
- To explain the cryogenic gas separation and purification system
- To explain the cryogenic refrigeration systems
- To embark on a research career in Cryogenic Engineering

Course Outcomes

1. List the applications of cryogenic systems
2. Understand the principles of cryogenics engineering
3. Analyse the performance of cryogenics gas liquefaction system
4. Analyse performance of cryogenics gas separation and purification system
5. Evaluate material properties at cryogenic temperature
6. Design the cryogenic storage system & cryo coolers

UNIT - I

Introduction to Cryogenic Systems: Mechanical Properties at low temperatures. Properties of Cryogenic Fluids. Gas Liquefaction: Minimum work for liquefaction. Methods to protect low temperature. Liquefaction systems for gages other than Neon. Hydrogen and Helium.

UNIT - II

Liquefaction Systems for Neon, Hydrogen and Helium: Components of Liquefaction systems. Heat exchangers. Compressors and expanders. Expansion valve, Losses in real machines.

UNIT- III

Gas Separation and Purification Systems: Properties of mixtures, Principles of mixtures, Principles of gas separation, Air separation systems.

UNIT-IV

Cryogenic Refrigeration Systems: Working Medium, Solids, Liquids, Gases, Cryogenic fluid storage & transfer, Cryogenic storage systems, Insulation, Fluid transfer mechanisms, Cryostat, Cryo Coolers

UNIT-V

Applications: Space technology, In-Flight air separation and collection of LOX, Gas industry, Biology, Medicine, Electronics.

Suggested Reading:

1. Cryogenic Systems/ R.F. Barren/ Oxford University Press
2. Cryogenic Engineering- Thomas Flynn- CRC Press-2nd Edition
3. Cryogenic Research and Applications: Marshal Sitting/ Von Nostrand/ Inc. New Jersey
4. Cryogenic Heat Transfer/ R.F.Baron
5. Cryogenic Engineering Edit / B.A. Hands/ Academic Press, 1986
6. Cryogenic Engineering/ R.B. Scottm Vin Nostrand/ Inc. New Jersey, 1959

7. Experimental Techniques in Low Temperature Physics- O.K. White, Oxford Press, 1968
8. Cryogenic Process Engineering/ K. D. Timmerhaus & TM Flynn/ Plenum Press, 1998
9. Hand Book of Cryogenic Engineering – J.G. Weisend –II, Taylor and Francis, 1998

Course Code	Course Title						Core/Elective
PE 5218 HV	**Climatology foe Built Environment**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand the basic science of sustainable development.
- To familiarize and understand the different climatic zones in the country
- Comprehend and calculate the heat transfer in buildings
- To appreciate the importance of solar shades and natural ventilation
- To utilize the potential of energy conservation though passive cooling.

Course Outcomes

After completing this course, the student will be able to:

1. Define the built environment and building climatology
2. Understand the external and climatic effects on the indoor environment
3. Demonstrate understanding of building materials and heat transfer through buildings
4. Analyse the impact of shading devices and natural ventilation on interior heat loads
5. Evaluate the effectiveness of energy conservation through passive cooling strategies
6. Design thermally comfortable and energy efficient buildings

UNIT I

Introduction to Building Climatology: Climate and built form interaction. Global Climatic factors, elements of climate, macro and micro climate; challenge of rapid, extreme environmental change

UNIT II

Tropical Climates: Definition, classification of tropical climates, characteristics of different climatic zones, Design considerations for warm-humid, hot-dry, composite and upland climates.

UNIT III

Thermal Comfort: Thermal comfort factors, Physiological aspects, Body heat balance, Heat flow through Buildings: Basic principles of heat transfer through buildings, performance of different materials, Periodic heat flow.

UNIT IV

Sun and the Design process: Solar geometry, Solar charts, Sun angles and shadow angles, orientation for sun, shading devices, building form and heat gain, basic principles of day lighting, sunlight and glare.

Natural Ventilation: Air movement around and through buildings, Orientation for wind, stack effect, Induced ventilation.

UNIT V

Passive Cooling:

Passive methods of Cooling, roof pond, desiccant cooling, evaporative Cooling, and earth sheltered buildings etc. Site Planning (including landscaping) and building planning and design considering climate factors. Detailed appraisal/analysis of climatological performance of an existing residence and or a workplace; followed by redesigning or the same to improve climatological performance.

Suggested Reading:

1. Koenigsberger, O.H. and Others. Manual of Tropical Housing and Building. Orient Longman, Chennai, 2003.
2. Konya, Allan. Design for Hot Climates.
3. Kukreja, C.P. Tropical Architecture. Tata McGraw-Hill Pub. Co. Ltd., New Delhi, 1978.
4. Markus, T.A. and Morris. E.N. Buildings, Climate and Energy. Pitman Pub. Ltd., London, 1980.
5. Olgyay and Olgyay. Solar Control and Shading Devices.

Course Code	Course Title						Core/Elective
PE 5219 HV	**Refrigeration and Air-Conditioning Equipment**						**Elective**
	Contact Hours per Week						
Prerequisite	L	T	D	P	CIE	SEE	Credits
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of and problem solving skills in

- The types of compressors, comparison and their control circuits
- The types of condensers and the transfer heat from medium.
- The types of evaporators, comparison and working
- The installation and testing &commissioning of the refrigeration.

Course Outcomes

After completing this course, the student will be able to:

1. Define the types and compare compressor control circuits
2. Understand the types of condensers and explain their working principles
3. Apply the fouling correction factor in evaporators
4. Analyse the counter flow cooling tower
5. Weigh the types of expansion devices & flow controls
6. Design the vapour compression refrigeration system

UNIT - I

Compressors: Types, constructional details of reciprocating compressors, volumetric efficiency factors affecting volumetric efficiency, effects of evaporator and condenser pressures, centrifugal compressor, constructional details, applications: Comparison with reciprocating compressors, screw compressors, working principle, single screw and double screw compressor, lubricating oils, rotary compressor, single vane and multi vane compressor surging, Electric motors and control circuits.

UNIT - II

Condensers: Types - water cooled & air cooled condensers-evaporative type, thermal design of compressor-temperature distribution and heat flow in a condenser, pressure drop, fouling factor, LMTD correction factor. (No problems) Cooling Towers: Classification, performance of cooling towers, analysis of counter flow cooling towers, enthalpy-temperature diagram of air and water. Cooling ponds: types, cross flow cooling towers, procedure for calibration of outlet conditions.

UNIT - III

Evaporators: Types - flooded & dry evaporators, natural & forced convection type, shell &tube, shell & coil, plate type-secondary evaporators, temperature distribution and heat flow in evaporators-pressure drop, fouling correction factor, (no problems)

UNIT - IV

Expansion Devices - Capillary tube, thermostatic expansion valve, float valve, automatic expansion valve, solenoid control valve, pipe design, general-water piping, refrigerant piping & steam piping water treatment corrosion control, scale formation control-Refrigerant flow controls.

UNIT - V

Installation of Vapour Compression Refrigeration System: evaluation & dehydration, testing for leakages, charging, adding oil defrosting, methods-material, automatic, periodic defrosting-solid & liquid

adsorbents; water defrosting, defrosting by reversing the cycle, automatic hot gas defrosting-thermo balance defrosting, electric control defrosting (no problems)

Suggested Reading:

1. Principles of Refrigeration/Roy J. Dossat
2. Refrigeration & Air-Conditioning / C. P. Arora/
3. Refrigeration & Air-Conditioning / Stoecker/ TMGH 1982
4. Refrigeration & Air-Conditioning / Domkundwar/Danapath Rai
5. ASHRAE guide & data book application

Course Code	Course Title						Core/Elective
PE 5220 HV	**Green Building Concepts**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- Identify and compare existing energy codes, green building codes and green rating systems.
- Identify and compare cost and performance of building materials.
- Identify and use construction materials and methods that more easily allow for salvage and re-use of building materials.
- Perform demolition in ways that allow for salvage of re-usable building materials.
- Understand the techniques and benefits of building performance testing, monitoring and metering.
- Identify and make use of techniques for sustainable remodeling of existing structures

Course Outcomes

After completing this course, the student will be able to:

1. State the key regulatory tools, including building codes, design guidelines, as well as relevant legislation governing the consumption of resources and emission of environmental pollutants by buildings
2. Understand the multidisciplinary process of conceptualizing an eco-friendly building
3. Choose and size building components, as well as energy and environmental systems suitable for different categories of buildings, and for different climate zones
4. Utilize a variety of tools and methodologies suitable for evaluating the resource consumption and overall environmental performance (environmental footprint) of buildings in different stages of their life cycles
5. Evaluate the economic performance of buildings (operating & maintenance costs, real estate value)
6. Design an environmentally friendly green building

UNIT-I

Overview of the significance of energy use and energy processes in building: Indoor activities and environmental control, Internal and external factors on energy use and the attributes of the factors, Characteristics of energy use and its management, Macro aspect of energy use in dwellings and its implications.

UNIT-II

Indoor environmental requirement and management: Thermal comfort, Ventilation and air quality, Air-conditioning requirement, Visual perception, Illumination requirement, Auditory requirement.

UNIT-III

Climate, solar radiation and their influences: Sun-earth relationship and the energy balance on the earth's surface, Climate, wind, solar radiation, and temperature, Sun shading and solar radiation on surfaces, Energy impact on the shape and orientation of buildings.

UNIT-IV

End-use, energy utilization and requirements: Lighting and day lighting, End-use energy requirements - Status of energy use in buildings Estimation of energy use in a building. Heat gain and thermal performance

of building envelope, Steady and non-steady heat transfer through the glazed window and the wall, Standards for thermal performance of building envelope, Evaluation of the overall thermal transfer.

UNIT-V

Energy management options: Energy audit and energy targeting, Technological options for energy management.

Suggested Reading:

1. J. Krieder and A. Rabl, Heating and Cooling of Buildings - Design for Efficiency, McGraw Hill, 1994.
2. S.M. Guinnes and Reynolds, Mechanical and Electrical Equipment for Buildings, Wiley, 1989.
3. Shaw, Energy Design for Architects, AEE Energy Books, 1991.
4. ASHRAE, Handbook of Fundamentals, Atlanta, 1997.
5. Donald W. Abrams, Low Energy Cooling – A Guide to the Practical Application of Passive
6. Cooling and Cooling Energy Conservation Measures, Van Nostrand Reinhold Co., New York, 1986.

Course Code	Course Title						Core/Elective
PE 5221 HV	**Advanced Heat Transfer**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- To provide the technical understanding the concepts of heat transfer in real engineering problems
- To understand the fundamentals of heat transfer mechanisms in fluids and solids
- To know the applications of various heat transfer equipment in process industries
- To understand the heat transfer concepts, apply to other domain of thermal engineering in general

Course Outcomes

After completing this course, the student will be able to:

1. Ability to understand and solve conduction, convection and radiation problems
2. Apply the basic principles of classical heat transfer in real engineering application
3. Analyse the analytical and numerical solutions for heat transfer problem
4. Evaluate heat transfer coefficients for natural convection and forced convection
5. Develop solutions for transient heat conduction in simple geometries
6. Compare radiation heat transfer between black body surfaces and grey boy surfaces

UNIT - I

Brief Introduction to Different Modes of Heat Transfer: Conduction: General heat Conduction equation-initial and boundary conditions.

ID Steady State Heat Conduction – Composite Systems – Systems with Heat Generation – Fins

2D Steady State Heat Conduction – Analytical solution for simple boundary conditions – Product Solution

UNIT - II

Transient heat conduction: Lumped system analysis-1D Transient Heat Conduction, Heisler charts, semi-infinite solid, use of shape factors in conduction.

Finite Difference Methods for Conduction: ID & 2D steady state and simple transient heat conduction problems-implicit and explicit methods.

UNIT - III

Forced Convection: Equations of fluid flow-concepts of continuity, momentum equations-derivation of energy equation-methods to determine heat transfer coefficient: Analytical methods-dimensional analysis and concept of exact solution. Approximate method-integral analysis.

External Flows: Flow over a flat plate: integral method for laminar heat transfer coefficient for different velocity and temperature profiles. Application of empirical relations to variation geometries for laminar and turbulent flows.

UNIT - IV

Internal flows: Fully developed flow: integral analysis for laminar heat transfer coefficient, types of Flow, constant wall temperature and constant heat flux boundary conditions, hydrodynamic &thermal entry lengths; use of empirical correlations.

Free Convection: Boussinesque approximation, different geometries, combined free and forced convection.

UNIT - V

Boiling and condensation: Boiling curve, correlations for different regimes, Condensation: Film and Dropwise condensation, Nusselts theory of film condensation on a vertical plate, assumptions & correlations of film condensation for different geometries.

Radiation Heat Transfer: Radiant heat exchange in grey, non-grey bodies, with transmitting. Reflecting and absorbing media, specular surfaces.

Suggested Reading:

1. Heat Transfer - A basic approach- Necati Ozisik –TMH
2. Fundamentals of Heat & Mass transfer- Incropera, Dewitt, Bergman, Lavime - wiley Publication
3. Heat Transfer/ P.S. Ghoshdastidar/ Oxford Press
4. Heat Transfer-S. P. Sukhatme - Univeristies Press
5. Fundamentals of Engineering Heat Transfer-R.C. Sachdeva-New Age Science.
6. Heat Transfer/ P. K. Nag /TMH
7. Engg. Heat & Mass Transfer/ Sarit K. Das/Dhanpat Rai
8. Introduction to Heat Transfer/SK Som/PHI
9. Principals of Heat Transfer/Frank Kreith/Cengage Learning

Course Code	Course Title						Core/Elective
PE 5222 HV	**Design of Air Distribution Systems**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Learning the fundamental principles of Air conditioning systems and different methods for load calculation during summer and winter. Using ASHRAE Standards.
- Study of various outlets and its mechanism of flow through out lets. Duct design, duct construction using SMACNA.
- Study of different insulation for heated building cooled building and cooled storage.
- Understand the basic of fan and blowers and its selection on fan characteristic curve. Piping network for supply and return and pipe sizing using ASHRAE Standards.
- Study of the various air conditioning systems for Automobiles, Train, Ships, Aircraft and for some special applications.

Course Outcomes

After completing this course, the student will be able to:

1. Illustrate the fundamental principles and applications of air conditioning system and difference between summer and winter load calculation.
2. Understand diffuser types, obtain sound power level of diffuser, face area and noise level, Air duct design and duct procedure.
3. Calculate the rate of heat transfer, Presenting the properties, applications and environmental issues of different duct insulation.
4. Analyse the Fan selection, Static pressure calculation, water supply pipe sizing, fitting loses per ASHRAE Standard. Used for various applications
5. Operate and analyse the air conditioning systems.
6. Solve Air conditioning design problems using P-h, T-S and Psychometric charts

UNIT- I

Air Conditioning Systems: All-water, All-air, air-water system. Unitary System, window air conditioner, split and central air conditioning system, cooling load calculations, occupancy load, lighting load, appliance load, product load, difference between summer & winter load calculations.

UNIT- II

Air Distribution: Room Air distribution - types of supply air outlets, mechanism of flow through outlets, selection and location of outlets, general considerations. Distribution patterns of outlets, ducts, Definition and types - materials for ducts and its specification, friction loss in ducts, grills, diffusers, registers, rectangular equivalent of circular duct. Air duct designs, duct construction, duct design procedure.

UNIT- III

Thermal Insulation for A/C System: 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 building and cold storage, pipe insulation.

UNIT- IV

Air Conditioning Apparatus: Fans and blowers, types of fans, fan characteristic, centrifugal fans, axial fans, fan arrangements, filters, sources of noise and control, static pressure calculation for selection of motor

and fan. Water supply pipe sizing calculations, piping network for supply and return water line, pipe fittings, lining and insulation, piping system as per ASHRAE standards

UNIT- V

Applications: Air conditioning systems for automobiles (cars, buses, etc.), Air conditioning systems for trains, ships, & aircraft; Special applications: Computers, hospitals, cold storages, printing, textiles and leather industries.

Suggested Reading:

1. Refrigeration & Air-Conditioning by Domkundwar
2. Refrigeration &Air-Conditioning by V.K. Jain
3. Refrigeration & Air-Conditioning by C.P. Arora
4. ASHRAE Hand Book
5. Hand Book of Air Conditioning System design by Carrier

Course Code	Course Title						Core/Elective
PE 5223 HV	**Automotive Air-Conditioning**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand location of automotive air-conditioning components.
- To acquire knowledge of controlled air conditioner heating system.
- To study the different control systems.
- To provide the knowledge of servicing of AC equipment.

Course Outcomes

After completing the course, the students will able to

1. Define the fundamental principles and parts of refrigeration and air-conditioning system
2. Understand the controlled air conditioner & heating system in automotives
3. Demonstrate the knowledge of refrigeration system diagnosis, refrigerant leakage etc.
4. Analyse refrigerant flow, controlling the temperature of refrigerant as per requirement.
5. Judge the servicing of air conditioner by repairing and / or replacing of parts.
6. Design the automotive air conditioning system.

UNIT - I

Air Conditioning Fundamentals: Basic air conditioning system - location of air conditioning components in a car, schematic layout of a refrigeration system, compressor components, condenser and high pressure service ports, thermostatic expansion valve, expansion valve calibration, controlling evaporator temperature, evaporator pressure regulator, evaporator temperature regulator.

UNIT - II

Air Conditioning – Heating Systems: Automotive heaters, manually controlled air conditioner, heater system, automatically controlled air conditioner and heater systems, automatic temperature control, air conditioning protection, engine protection.

UNIT - III

Refrigerant: Containers handling refrigerants, tapping into the refrigerant container, refrigeration system diagnosis, diagnostic procedure, ambient conditions affecting system pressures.

UNIT - IV

Air Routing and Temperature Control: Objectives, evaporator airflow through the recalculating unit, automatic temperature control, duct system, controlling flow, vacuum reserve, testing the air control and handling systems.

UNIT - V

Air Conditioning Service: Air conditioner maintenance and service, servicing heater system removing and replacing components, trouble shooting of air controlling system, compressor service.

Suggested Reading:

1. William H. Crouse and Donald I. Anglin - “Automotive Air conditioning” - McGraw Hill Inc. - 1990.

2. Mitchell information Services, Inc - "Mitchell Automatic Heating and Air Conditioning Systems" - Prentice Hall Ind. - 1989.
3. Paul Weiser – "Automotive Air Conditioning" – Reston Publishing Co., Inc., - 1990.
4. MacDonald, K.I., - "Automotive Air Conditioning" – Theodore Audel series – 1978
5. Goings. L.F. – "Automotive Air Conditioning" – American Technical services – 1974.
6. Boyce H. Dwiggins – "Automotive Air Conditioning" – Delmar – 2002.
7. "Principles of Refrigeration"; Roy J Dossat: Pearson Education Inc.
8. "Refrigeration and Air Conditioning"; Arora and Damkondwar: Dhanpat Rai and Company.
9. "Refrigeration and Air Conditioning", C. P. Arora: Tata McGraw Hills Pub.

Course Code	Course Title						Core/Elective
PE 5224 HV	**Air-Conditioning Instrumentation and Control Systems**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Understand the basic principles and performance characteristics of measurement.
- Understand the principles of various measuring instruments.
- Apply the working of various measuring instruments.
- Visualize the advantages and limitations of various measuring instruments.
- Comprehend the applications of various measuring instruments.
- Apply the elements of Air Conditioning controls.

Course Outcomes

1. Identify various elements and their purpose in typical instruments
2. Understand the various errors that would occur in instruments.
3. Apply static and dynamic characteristics of instrument and should be able to determine loading response time.
4. Analyse errors so as to determine correction factors for each an instrument.
5. Evaluate an appropriate calibration methodology for instruments & control systems
6. Investigate the vibration, acceleration, pressure, flow, temperature and strain measurement.

UNIT-I

Vibration and Acceleration Measurement: Vibration and acceleration measuring instruments - linear acceleration using strain gauges, capacitive, mechanical and electronic tachometers.

UNIT-II

Pressure Measurement: Resistive, magnetic, capacitive pressure transducers - Thermal conductive gauges- Mc-leod gauge, ionization gauge - pressure, measurement using strain gauges.

UNIT-III

Flow Measurements: Different types of flow transducers - Magnetic flow meters -interferometer for visualization - Rotameter other conventional types of obstruction meters.

Level Indicators: Magnetic type float gauge - Oscillator type detectors-liquid and solid level measurement by variation of capacitance.

UNIT-IV

Cryogenic Instrumentation: Low temperature measurements, measurement of micro-temperatures. Measurement of Strain: Use of resistance strain gauge in measuring different mechanical input systems.

UNIT-V

Air-Conditioning Controls: Introduction - Types, direct & reverse acting thermostats, with receiver controller - liquid valves, fail safe design, throttling range - dampers, outdoor air control – freeze protection - building up a control system, humidi stats and humidifiers- valve characteristics and selection.

Suggested Reading:

1. Instrumentation for engineering measurement /R.H. Cerrni & L.E. Foster/ wily 1982
2. Instrumentation in Scientific research/K.S, Lion/ Megravv Hill

3. Automatic process control/ D.P. Eckman /Wiley
4. Refrigeration and Air-Conditioning/W.F. Stooecker, J.W. Jone/ McGraw Hill 1982

Course Code	Course Title						Core/Elective
PE 5225 HV	**Maintenance of HVAC Equipment**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Analyse HVAC equipment and application.
- To describe Erection methodology
- To explain the Testing of Equipment and circuitry and trouble shoot of HVAC Equipment.
- Discuss the different types of preventive maintenance procedures in HVAC.
- Illustrate different maintenance schedules followed by various industries

Course Outcomes

1. Learn about the various HVAC equipment
2. Evaluate and understand Erection methodology
3. Explain ISI standards for Testing of Equipment condition monitoring
4. Discuss the principles of corrective and preventive measures
5. Analyse the problem solving techniques of preventive maintenance in HVAC
6. Investigate the maintenance problems like, leak detection, vacuumising , charging , trial run, etc.

UNIT - I

Refrigeration Equipment & Application: Elementary knowledge of refrigeration & air conditioning equipments e.g. compressors, condensers, evaporators & expansion devices, Air washers, Cooling towers & humidifying efficiency, Food preservation, cold storage, Refrigerate Freezers, Ice plant, Water coolers, Elementary knowledge of transmission and distribution of air through ducts and fans, Basic difference between comfort and industrial air conditioning.

UNIT - II

Erection of R & AC Systems: Erection methodology, foundation, padding, network analysis, critical path, interconnections; safety precautions, air handling equipments, locations in the systems, corrosion, noise, vibration monitoring and control.

UNIT III

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

UNIT IV

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

UNIT V

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

Suggested Reading:

1. Robert C. Rosciler, HVAC Maintenance, and operations Hand Book, McGraw. Hill, 1997.

2. Althouse A.D. and Turnquist C. H., Modern Refrigeration and Air conditioning, Good HeartWilcoz Co Inc., 2004.
3. ISHRAE Hand book on Refrigeration & Air conditioning, ISHRAE Bangalore, 1998.
4. Nelson C. W., Commercial and Industrial Refrigeration, McGraw-Hill, 1982.
5. Reed G. H., Refrigeration, A Practical Manual, Applied Science Publishers Ltd., London, 1982.
6. Russel E. Smithy, Electricity for Refrigeration, Heating and Air-conditioning, Duxbury Press, Massachusetts, 1980.

Course Code	Course Title						Core/Elective
PE 5226 HV	**Unconventional Refrigeration and Air-Conditioning Systems**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Illustrate the fundamentals of unconventional refrigeration & air-conditioning
- Learning of Complete vapour compression refrigeration systems
- Description, performance, analysis of Advanced vapours compression systems.
- Fundamentals of Principles and application of steam jet refrigeration system.
- Discuss the importance Properties of mixtures of refrigerants
- The concepts of Solar thermo-mechanical refrigeration system.

Course Outcomes

1. Understand the fundamentals of unconventional refrigeration & air-conditioning.
2. Explain complete vapour compression refrigeration systems
3. Applications of Advanced vapour compression systems.
4. Analyse the importance of mixtures refrigerant selection
5. Evaluate of principles and application of steam jet refrigeration system
6. Design the solar thermo-mechanical refrigeration system

UNIT-I

Introduction to refrigeration systems: methods of refrigeration, units of refrigeration, COP. Introduction to nonconventional refrigeration technologies, Thermoelectric refrigeration, magnetic refrigeration, pulse tube refrigeration, acoustic refrigeration, steam jet refrigeration, vortex tube refrigeration. Review of vapour compression refrigeration system, vapour absorption system and adsorption systems.

UNIT-II

Thermoelectric refrigeration: principle, thermoelectric properties, Seabeck effect, Peltier effect and Thompson effect. System description, performance, analysis, Applications. Advanced vapour compression systems, compound compression, multistage evaporation. Solar based refrigeration technologies, absorption and adsorption.

UNIT-III

Introduction to Magnetic refrigeration: magneto-caloric effect, magnetic materials, magnetic refrigeration near room temperature cooling, advantages over traditional refrigeration system, clean refrigeration in future, pulse tube refrigerator, principle, analysis.

UNIT-IV

Principles and application of steam jet refrigeration system: performance analysis, vortex tube refrigeration system, system description, Applications. Modern refrigerants, Need for alternative refrigerants, eco-friendly refrigerants, properties of mixtures of refrigerants, modifications required for retrofitting, safety precautions and compatibility of refrigerants with the materials.

UNIT-V

Solar thermo-mechanical refrigeration system: Carnot refrigeration cycle, solar electric compression air conditioning, simple Rankine cycle air conditioning system. Absorption refrigeration, Thermodynamic

analysis, Energy and mass balance of Lithium bromide water absorption system, Aqua-ammonia absorption system, Calculations of COP and second law efficiency. Solar desiccant dehumidification.

Suggested Reading:

1. Arora C. P Refrigeration and Air Conditioning-Tata Mc Graw Hill, 2004
2. Arora: Refrigeration and Air-conditioning, PHI, Eastern Economy Edition, 2012
3. Gosney W. B Principles of Refrigeration, Cambridge University Press, 1983
4. Stanley W Angrist Direct Energy conversions, Allyn & Bacon, 1982
5. HJ Goldsmid, Thermoelectric Refrigeration, Springer, 1st Ed. 1995

Course Code	Course Title						Core/Elective
PE 5227 HV	**Equipment Design for Thermal Systems**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Design and analyse the heat exchangers parallel flow, counter flow, multipass, and cross flow heat exchanger
- Design and analyse the Shell and tube heat exchanger
- Enable to carry out the performance of heat exchanger with the extended surfaces
- Design and analyse the cooling towers.

Course Outcomes

1. Understand the physics and the mathematical treatment of typical heat exchangers.
2. Apply LMTD and effectiveness methods in the design of heat exchangers and analyse the importance of LMTD approach over AMTD approach
3. Analyse the performance of double-pipe counter flow (hair-pin) heat exchangers
4. Design and analyse the shell and tube heat exchanger
5. Understand the fundamental, physical and mathematical aspects of boiling and condensation
6. Classify cooling towers and explain their technical features

UNIT -I

Classification of Heat Exchangers: Introduction, Recuperation & regeneration, Tabular heat exchangers, Double pipe, shell & tube heat exchanger, Plate heat Exchangers, Gasketed plate heat exchanger. Spiral plate heat exchanger, Lamella heat exchanger, Extended surface heat exchanger, Plate fin and Tabular fin.

Basic Design Methods of Heat Exchanger: Introduction, Basic equations in design, Overall heat transfer coefficient, LMTD method for heat exchanger analysis, Parallel flow, Counter flow. Multipass, cross flow heat exchanger design calculations

UNIT-II

Double Pipe Heat Exchanger: Film coefficient for fluids in annulus, fouling factors, Calorific temperature, Average fluid temperature, The calculation of double pipe exchanger, Double pipe exchangers in series parallel arrangements.

Shell & Tube Heat Exchangers: Tube layouts for exchangers, Baffle heat exchangers, Calculation of shell and tube heat exchangers, Shell side film coefficients, Shell side equivalent diameter, The true temperature difference in a 1-2 heat exchanger. Influence of approach temperature on correction factor. Shell side pressure drop, Tube side pressure drop, Analysis of performance of 1-2 heat exchanger and design of shell & tube heat exchangers, Flow arrangements for increased heat recovery, the calculation of 2-4 exchangers.

UNIT-III

Condensation of Single Vapours: Calculation of horizontal condenser, Vertical condenser, DeSuper heater condenser, Vertical condenser-sub-Cooler, Horizontal Condenser-Sub cooler, Vertical reflux type condenser. Condensation of steam.

UNIT-IV

Vaporizers, Evaporators and Reboilers: Vaporizing processes, Forced circulation vaporizing exchanger, Natural circulation vaporizing exchangers, Calculations of a reboiler. Extended Surfaces: Longitudinal fins.

Weighted fin efficiency curve, Calculation of a Double pipe fin efficiency curve. Calculation of a double pipe finned exchanger, Calculation of a longitudinal fin shell and tube exchanger.

UNIT-V

Direct Contact Heat Exchanger: Cooling towers, relation between wet bulb & dew point temperatures, The Lewis number and Classification of cooling towers, Cooling tower internals and the roll of fill, Heat Balance. Heat Transfer by simultaneous diffusion and convection, Analysis of cooling tower requirements, Deign of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.

Suggested Reading:

1. Process Heat Transfer/D.Q.Kern/ TMH
2. Heat Exchanger Design/ A.P.Fraas and M N. Ozisicj/ John Wiley & sons, New York.
3. Cooling Towers / J.D. Gurney

Course Code	Course Title						Core/Elective
PE 5228 HV	**Cold Storage Technology and Systems**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- The student is able to understand the different methods of chilling the fruits and vegetables.
- The student is able to know about different methods and technologies for preservation of meat, fishery product & Processing of Meat Products.
- To impart the knowledge of milk processing, fruit juice concentrations
- To impart the knowledge of refrigerated warehouse
- The students are also learning how to refrigerate the food products during transportation

Course Outcomes

After completing this course, the student will

1. List the different methods of chilling food items
2. Understand and apply the methods of processing of Meat & fishery products
3. Apply and implement the methods of milk processing & fruit juice concentrations
4. Recognize & comply safe working practices, environment regulation and housekeeping
5. Evaluate the design & construction of refrigerated warehouse
6. Design the refrigeration system in transporting the processed food items

UNIT-I

Theories and Method of Chilling: Freezing and free de-humidification, Preparation for freezing, Freezing methods. Commercial freezing methods, Sharp, quick and air blast freezing, Freezing drying, Methods of pre-cooling fruits and vegetables, Hydro cooling, Forced air cooling and Vacuum cooling.

UNIT-II

Processing of Meat Products: Refrigeration systems for carcass chilling and holding, Chilled brine spray, Sprayed coil, Dry coil systems. Chilling and freezing variety meats, overnight chilling, quick chilling. Effect of freezing temperature on quality of meat products. Fishery Products: Icing of fish. Saltwater icing. Freezing methods, Slow freezing Blast freezing, Plate Freezing and Immersion freezing offish.

UNIT-III

Dairy Products: Milk processing, Handling, Diary plant procedure. Standardizing, Pasteurization, Homogenizing, and Container filling. Fruit Juice Concentrations: Processing and quality control selection, Grading and handling of fresh fruit, Washing, Juice extraction, Heat Treatment, Flavour fortification, Packing 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-IV

Refrigerated Warehouse: Factors affecting warehouse design, Building location, Design reduction. Shipping and receiving plant forms. Utility space, Controlled atmospheric storage rooms. Jacketed storages. Automated warehouse insulation, Cold storage doors.

UNIT-V

Refrigerated Trucks, Trailers & Containers: Temperature control methods, Body Design & construction, Auxiliary equipment, Types of refrigeration systems. Railway refrigeration cars.

Suggested Reading:

1. Refrigeration and Air-Conditioning / C. P. Arora/ Dhanpat Rai & Co.
2. Food Processing Technology: Principles and Practice / Peter Fellows / Woodhead Publishing / 3rd Edition / 2009
3. Guide and Data Book / ASHRAE.
4. Hand Book of Air-Conditioning system design/Carrier.
5. Basic Refrigeration & Air Conditioning – P.N. Ananathanarayanan – McGraw Hill
6. Principles of Refrigeration/ Dossat-Pearson

Course Code	Course Title						Core/Elective
PE 5229 HV	**Alternative Refrigerants**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of the course are to impart knowledge of the:

- Learning the Development of Vapour Compression Refrigeration Cycle from Reverse Carnot Cycle
- Discuss refrigerant selection criteria based on thermodynamic, thermophysical, environmental and economic properties
- Learning, Charging procedure and Safety rules for the preparation of refrigerant mixtures
- Assessment of Natural Refrigerants
- Learning the different procedure for servicing RAC systems

Course Outcomes

After the completion of the course, the student will be able to:

1. Understand deviations from ideal vapour compression cycle
2. Classify cascade refrigeration systems
3. Analyse the classification of Refrigerants
4. Describe the numbering system used for designating refrigerants
5. Evaluate the advantages and limitations of refrigerant mixtures.
6. Assess the application of natural refrigerants.

UNIT-I

Refrigeration Cycles – analysis: Development of Vapour Compression Refrigeration Cycle from Reverse Carnot Cycle- conditions for high COP-deviations from ideal vapour compression cycle, Multi-pressure Systems, Cascade Systems-Analysis.

UNIT-II

Refrigerants: Classification of Refrigerants, Designation of Refrigerants, Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues. Thermodynamic properties of refrigerants. Synthetic and natural refrigerants. Comparison between different refrigerants vis a vis applications. Special issues and practical implications. Montreal Protocol and the Kyoto Protocol

UNIT-III

Refrigerant Mixtures: Introduction, The Need for replacement refrigerants, Binary mixtures- composition, temperature composition, and enthalpy-concentration diagram, refrigerant mixtures, evaluation of thermodynamic properties, zeotropic and azeotropic mixtures, temperature glide. Charging procedure and Safety rules for the preparation of refrigerant mixtures. Advantages and limitations of refrigerant mixtures.

UNIT-IV

Assessment of Natural Refrigerants: Opportunities for the application of natural refrigerants, Use of hydrocarbons as working fluids in heat pumps and refrigeration equipment, Conversion of various HCFC-22 systems to hydrocarbon, Experimental assessment of HC-290 as a substitute to HCFC-22 in a window air conditioner

UNIT-V

Tools & Servicing Practices Tools: Different Types of Refrigeration Tools, Evacuation and Charging Unit, Recovery and Recycling Unit, Vacuum Pumps. Servicing Practices: Contaminants, Moisture on condensables, Servicing RAC systems, Evacuation, Purging, Leak detection,

Suggested Reading:

1. Natural Refrigerants Sustainable Ozone- and Climate-Friendly Alternatives to HCFCs, Proklima International, 2008
2. Refrigeration & Air Conditioning Technology, By William C. Whitman, William M. Johnson, John A.
3. Refrigeration and Air Conditioning by C P Arora, McGraw-Hill edition
4. Alternatives to HCFCs in the Refrigeration and Air Conditioning Sector - Practical Guidelines and Case Studies for Equipment Conversion, Retrofit and Replacement, UNEP
5. R & AC -Manohar Prasad

Course Code	Course Title						Core/Elective
PE 5230 HV	**Renewable Energy Sources**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of the course are to impart knowledge of:

- Understand the various forms of conventional energy resources.
- Learn the present energy scenario and the need for energy conservation
- Explain the concept of various forms of renewable energy
- Outline division aspects and utilization of renewable energy sources for both domestics and industrial application
- Analyse the environmental aspects of renewable energy resources.

Course Outcomes

After the completion of the course, the student will be able to:

1. Describe the environmental aspects of non-conventional energy resources in comparison with various conventional energy systems, their prospects and limitations.
2. Know the need of renewable energy resources, historical and latest developments.
3. Understand the prospects of solar energy, geothermal energy, wind energy, bio energy and ocean energy
4. Demonstrate the need to move to environmentally friendly renewable sources of energy
5. Compare Solar, Wind and bio energy systems, their prospects, Advantages and limitations.
6. Design and recommend an alternate source of energy for various applications

UNIT - I

Introduction to renewable energy resources, Energy Scenario, Survey of energy resources. Classification and need for conventional energy resources.

Solar Energy: The Sun-sun-Earth relationship, Basic matter to waste heat energy circuit, Solar Radiation, Attention, Radiation measuring instruments.

Solar Energy Applications: Solar water heating. Space heating, Active and passive heating. Energy storage. Selective surface. Solar stills and ponds, solar refrigeration, Photovoltaic generation.

UNIT - II

Geothermal Energy: Structure of earth, Geothermal Regions, Hot springs. Hot Rocks, Hot Aquifers. Analytical methods to estimate thermal potential. Harnessing techniques, Electricity generating systems.

UNIT - III

Direct Energy Conversion: Nuclear Fusion: Fusion, Fusion reaction, P-P cycle, Carbon cycle, Deuterium cycle, Condition for controlled fusion, Fuel cells and photovoltaic. Thermionic & thermoelectric generation, MHD generator.

Hydrogen Gas as Fuel: Production methods, Fuel condition, Properties, I.C. Engines applications, Utilization strategy, Performances.

UNIT- IV

Bio-energy: Biomass energy sources. Plant productivity, Biomass wastes, aerovic and Anaerobic bioconversion processed, Raw metrical and properties of bio-gas, Bio-gas plant technology and status, the energetics and economics of biomass systems, Biomass gasification

UNIT-V

Wind Energy: Wind, Beaufort number, Characteristics, Wind energy conversion systems, Types, Betz model. Interference factor. Power coefficient, Torque coefficient and Thrust coefficient, Lift machines and Drag machines. Matching, Electricity generation.

Energy from Oceans: Tidal energy. Tides. Diurnal and semi-diurnal nature, Power from tides, Wave Energy, Waves, Theoretical energy available. Calculation of period and phase velocity of waves, Wave power systems, Submerged devices. Ocean thermal Energy, Principles, Heat exchangers, Pumping requirements, Practical considerations.

Suggested Reading:

1. Non-conventional Energy Resources – Khan – McGraw Hill
2. Energy Resources Utilization and Technologies – Y Anjaneyulu and Francis Tuluri, BS Publications
3. Solar Energy – Sukhatme & Nayak – McGraw Hill
4. Alternative Energy Sources & Systems – Steeby – Cengage Learning
5. Renewable Energy Source – Tasneem & S.A. Abbasi - PHI
6. Non-conventional Energy Resourses - Sawhney-PHI

Course Code	Course Title						Core/Elective
MC 5161 ME	**Research Methodology and IPR**						**Mandatory Course**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

To make students to

- Motivate to choose research as career
- Formulate the research problem, prepare the research design
- Identify various sources for literature review and data collection report writing
- Equip with good methods to analyse the collected data
- Know about IPR copyrights

Course Outcomes

At the end of this course, students will be able to**:**

1. Define research problem, review and asses the quality of literature from various sources
2. Improve the style and format of writing a report for technical paper/ Journal report, understand and develop various research designs
3. Collect the data by various methods: observation, interview, questionnaires
4. Analyse problem by statistical techniques: ANOVA, F-test, Chi-square
5. Understand apply for patent and copyrights

UNIT - I

Research Methodology: Objectives and Motivation of Research, Types of Research, research approaches, Significance of Research, Research Methods Verses Methodology, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Benefits to the society in general. Defining the Research Problem: Selection of Research Problem, Necessity of Defining the Problem

UNIT - II

Literature Survey and Report writing: Importance and purpose of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Need of Review, Guidelines for Review, Record of Research Review.

Report writing: Meaning of interpretation, layout of research report, Types of reports, Mechanism of writing a report. **Research Proposal Preparation**: Writing a Research Proposal and Research Report, Writing Research Grant Proposal.

UNIT - III

Research Design: Meaning of Research Design, Need of Research Design, Feature of a Good Design, Important Concepts Related to Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Steps in sample design, types of sample designs.

UNIT - IV

Data Collection and Analysis: Methods of data collection, Data organization, Methods of data grouping, Diagrammatic representation of data, Graphic representation of data. Importance of Parametric, non-parametric test, testing of variance of two normal populations, use of Chi-square, ANOVA, F-test, z-test

UNIT - V

Intellectual Property Rights: Meaning, Nature, Classification and protection of Intellectual Property, The main forms of Intellectual Property, Concept of Patent, Patent document, Invention protection, Granting of patent, Rights of a patent, Licensing, Transfer of technology.

Suggested Readings:

1. C.R Kothari, Research Methodology, Methods & Technique‖; New Age International Publishers, 2004
2. R. Ganesan, Research Methodology for Engineers‖, MJP Publishers, 2011
3. Y.P. Agarwal, Statistical Methods: Concepts, Application and Computation‖, Sterling Publications Pvt. Ltd., New Delhi, 2004
4. G.B. Reddy, Intellectual Property Rights and the Law 5th Ed. 2005 Gogia Law Agency
5. Ajit Parulekar and Sarita D'Souza, Indian Patents Law – Legal & Business Implications, Macmillan India Ltd, 2006

Course Code	Course Title						Core/Elective
OE 9101 CE	**Cost Management of Engineering Projects**						**Open Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To apply modern software packages to conduct analysis of real world data.
- To understand the technical underpinning of engineering economic analysis.
- The ability to apply the appropriate analytical techniques to a wide variety of real world problems and data sets.
- To summarize and present the analysis results in a clear and coherent manner.

Course Outcomes

At the end of this course, students will be able to**:**

1. Students should be able to learn the cost concepts in decision making
2. Student should be able to do cost planning and Marginal Costing
3. Students should be able to create a database for operational control and decision making.

UNIT-I

Introduction and Overview of the Strategic Cost Management Process: Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

UNIT-II

Project: meaning, Different types, why to manage, cost overruns centers, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

UNIT-III

Cost Behavior and Profit Planning Marginal Costing: Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis.

Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints.

UNIT-IV

Activity-Based Cost Management: Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

UNIT-V

Quantitative techniques for cost management: Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Suggested Readings:

1. Cost Accounting – A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting

Course Code	Course Title						Core/Elective
OE 9102 CS	**Business Analytics**						**Open Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Understand the role of business analytics within an organization
- Analyse data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization
- To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making
- To become familiar with processes needed to develop, report, and analyse business data
- Use decision-making tools/Operations research techniques
- Mange business process using analytical and management tools
- Analyse and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.
- Student will able to understand the basic rules of research formulation and procedure for obtaining patent rights

Course Outcomes

At the end of this course, students will be able to**:**

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

UNIT-I

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

UNIT-II

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

UNIT-III

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

UNIT-IV

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.

Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

UNIT-V

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without 8 Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Recent Trends in Embedded and collaborative business intelligence, Visual data 4 recovery, Data Storytelling and Data journalism.

Suggested Readings:

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.

Course Code	Course Title						Core/Elective
OE 9103 EC	**Embedded System Design**						**Open Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Detailed overview of important concepts of Embedded system
- Analyse PIC microcontroller, its features and programming
- Describe ARM Microcontroller architectural details and instruction set
- Understand ARM Memory management
- Learn the techniques to develop an embedded system and case studies

Course Outcomes

After completing this course, the student will be able to:

1. Understand the fundamentals of the embedded system design
2. Enumerate the instruction set of ARM Processor by studying the architecture of ARM core
3. Acquire knowledge on the serial, parallel and network communication protocols.
4. Learn the embedded system design life cycle and co-design issues.
5. List the various embedded software development tools used in the design of embedded system for various applications.

UNIT I

Introduction to Embedded Systems: Overview of Embedded System Architecture, Challenges & Trends of Embedded Systems, Hardware Architecture, Software Architecture. Application areas of Embedded Systems and Categories of Embedded Systems. Embedded System Design and Co-Design issues and Design Cycle Process

UNIT II

PIC 18: Family Overview, Architecture, Instruction Set, Addressing modes. Timers, interrupts of PIC 18, Capture/Compare and PWM modules of PIC 18

UNIT III

ARM Architecture: ARM Design Philosophy, Registers, Program Status Register, Instruction Pipeline, Interrupts and Vector Table, Architecture Revision, ARM Processor Families. Instruction Set: Data Processing Instructions, Addressing Modes, Branch, Load, Store Instructions, PSR Instructions, Conditional Instructions.

UNIT IV

ARM Thumb Instruction Set: Register Usage, Other Branch Instructions, Data Processing Instruction Single-Register and Multi Register Load-Store Instructions, Stack, Software Interrupt Instructions. Exception and interrupt handling.

ARM Memory Management: Cache Architecture, Polices, Flushing and Caches, MMU, Page Tables, Translation Access Permissions, Context Switch.

UNIT V

Embedded Software Development Tools, Host and Target Machines, Linkers/Locators for Embedded Software, Getting Embedded Software into the Target System. Debugging Techniques.

Case Studies: Design of Embedded Systems using Microcontrollers – for applications in the area of communications and automotives. (GSM/GPRS, CAN, Zigbee)

Suggested Readings:

1. Raj Kamal, Embedded Systems – Architecture, Programming and Design, 2nd Edition, TMH, 2008.
2. Andrew N. Sloss, Dominic Symes, Chris Wright, ARM Systems Developer's Guides – Designing & Optimizing System Software, Elsevier, 2008.
3. Mazidi, MCKinlay and Danny Causey, PIC Microcontrollers and Embedded Systems, Pearson Education, 2007
4. David.E. Simon, An Embedded Software Primer, 1st Edition, Pearson Education, 1999
5. Jonathan W. Valvano, Embedded Microcomputer Systems, Real Time Interfacing, Thomas Learning, 1999.

Course Code	Course Title						Core/Elective
OE 9104 EE	**Waste to Energy**						**Open Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To enable students to aware about the generation of energy from the waste.

Course Outcomes

At the end of this course, students will be able to**:**

1. Students should able to learn the Classification of waste as a fuel.
2. Students should able to learn the Manufacture of charcoal.
3. Students should able to carry out the designing of gasifiers and biomass stoves.
4. Student should able to learn the Biogas plant technology.

UNIT-I

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors. Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT-II

Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT-III

Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT-IV

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction

UNIT-V

Biochemical conversion: Anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Suggested Readings:

1. Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book, Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

Course Code	Course Title						Core/Elective
OE 9105 ME	**Industrial Safety**						**Open Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Causes for industrial accidents and preventive steps to be taken.
- Fundamental concepts of Maintenance Engineering.
- About wear and corrosion along with preventive steps to be taken
- The basic concepts and importance of fault tracing.
- The steps involved in carrying out periodic and preventive maintenance of various equipments used in industry

Course Outcomes

After completing this course, the student will be equipped with:

1. concepts of engineering systems safety
2. Identify the causes for industrial accidents and suggest preventive measures.
3. Identify the basic tools and requirements of different maintenance procedures.
4. Apply different techniques to reduce and prevent Wear and corrosion in Industry.
5. Identify different types of faults present in various equipments like machine tools, IC Engines, boilers etc.
6. Apply periodic and preventive maintenance techniques as required for industrial equipments like motors, pumps and air compressors and machine tools etc.

UNIT-I

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc., Safety colour codes. Fire prevention and firefighting, equipment and methods.

UNIT-II

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT-III

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT-IV

Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air

compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT-V

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

Suggested Readings:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, McGraw Hill Publication
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London

Course Code	Course Title						Core/Elective
AD 9001 HS	**English for Research Paper Writing**						**Audit I**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**2**	**-**	**-**	**-**	**30**	**70**	**-**

Course Objectives

- Understand that how to improve your writing skills and level of readability
- Understand the nuances of language and vocabulary in writing a Research Paper.
- Develop the content, structure and format of writing a research paper.
- Produce original research papers without plagiarism

Course Outcomes

After completing this course, the student will be able to:

1. Interpret the nuances of research paper writing.
2. Differentiate the research paper format and citation of sources.
3. To review the research papers and articles in a scientific manner.
4. Avoid plagiarism and be able to develop their writing skills in presenting the research work.
5. Create a research paper and acquire the knowledge of how and where to publish their original research papers.

UNIT - I

Academic Writing: Meaning & Definition of a research paper– Purpose of a research paper – Scope – Benefits, Limitations – outcomes.

UNIT - II

Research Paper Format: Title – Abstract – Introduction – Discussion – Findings, Conclusion – Style of Indentation – Font size/Font types – Indexing – Citation of sources.

UNIT - III

Research Methodology: Methods (Qualitative – Quantitative) Review of Literature. Criticizing, Paraphrasing & Plagiarism.

UNIT - IV

Process of Writing a research paper: Choosing a topic - Thesis Statement – Outline – Organizing notes - Language of Research – Word order, Paragraphs – Writing first draft –Revising/Editing - The final draft and proof reading.

UNIT - V

Research Paper Publication: Reputed Journals – National/International – ISSN No, No. of volumes, Scopus Index/UGC Journals – Free publications - Paid Journal publications – Advantages/Benefits

Presentation Skills: Developing Persuasive Presentations, Structure of Presentation, Presentation Slides, Presentation Delivery, role of the audience, what to search and cite, how to establish credibility.

Suggested Readings:

1. C. R Kothari, Gaurav, Garg, ―Research Methodology Methods and Techniques‖, 4/e, New Age International Publishers.
2. Day R, ―How to Write and Publish a Scientific Paper**",** Cambridge University Press, 2006
3. MLA Hand book for writers of Research Papers‖, 7/e, East West Press Pvt. Ltd, New Delhi
4. Lauri Rozakis, Schaum's, Quick Guide to Writing Great Research Papers‖, Tata McGraw Hills Pvt. Ltd, New Delhi.

Course Code	Course Title						Core/Elective
AD 9002 CE	**Disaster Management**						**Audit I**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**2**	**-**	**-**	**-**	**30**	**70**	**-**

Course Objectives

- To impart knowledge in students about the nature, causes, consequences and mitigation measures of the various natural disasters
- To enable the students to understand risks, vulnerabilities and human errors associated with human induced disasters
- To enable the students to understand and assimilate the impacts of any disaster on the affected area depending on its position/ location, environmental conditions, demographic, etc.

Course Outcomes

At the end of this course, students will be able to**:**

1. Learn to demonstrate a critical understanding of key concepts in disaster risk reduction
2. and humanitarian response.
3. Critically evaluate disaster risk reduction and humanitarian response policy and Practice from multiple perspectives.
4. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
5. Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in**.**

UNIT-I

Introduction: Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

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, Droughts and Famines, 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

Disasters 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-IV

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

UNIT-IV

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival. Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

Suggested Readings:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies", New Royal Book Company.
2. Sahni, Pardeep (Eds.), "Disaster Mitigation Experiences and Reflections", PHI, New Delhi.
3. Goel S. L., "Disaster Administration and Management Text and Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi.

Course Code	Course Title						Core/Elective
AD 9003 HS	**Sanskrit for Technical Knowledge**						**Audit I**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**2**	**-**	**-**	**-**	**30**	**70**	**-**

Course Objectives

- To get a working knowledge in illustrious Sanskrit, the scientific language in the world
- To make the novice Learn the Sanskrit to develop the logic in mathematics, science & other subjects
- To explore the huge knowledge from ancient Indian literature

Course Outcomes

At the end of this course, students will be able to**:**

1. Develop passion towards Sanskrit language
2. Decipher the latent engineering principles from Sanskrit literature
3. Correlates the technological concepts with the ancient Sanskrit history.
4. Develop knowledge for the technological progress
5. Explore the avenue for research in engineering with aid of Sanskrit

UNIT-I

Introduction to Sanskrit Language: Sanskrit Alphabets-vowels-consonants- significance of Amarakosa-parts of Speech-Morphology-creation of new words-significance of synonyms-sandhi-samasa-sutras-active and passive Voice-Past/Present/Future Tense-Syntax-Simple Sentences (elementary treatment only)

UNIT-II

Role of Sanskrit in Basic Sciences: Brahmagupthas lemmas (second degree indeterminate equations), sum of squares of n-terms of AP- sulba, sutram or baudhayana theorem (origination of Pythagoras theorem)-value of pie-Madhava's sine and cosine theory (origination of Taylor's series).

The measurement system-time-mass-length-temp, Matter elasticity-optics-speed of light (origination of Michaelson and Morley theory).

UNIT-III

Role of Sanskrit in Engineering-I (Civil, Mechanical, Electrical and Electronics Engineering):

Building construction-soil testing-mortar-town planning-Machine definition-crucible-furnace-air blower-Generation of electricity in a cell-magnetism-Solar system-Sun: The source of energy, the earth-Pingala chandasutram (origination of digital logic system)

UNIT-IV

Role of Sanskrit in Engineering-II (Computer Science Engineering & Information Technology): Computer languages and the Sanskrit languages-computer command words and the vedic command words-analogy of pramana in memamsa with operators in computer language-sanskrit analogy of physical sequence and logical sequence, programming.

UNIT-V

Role of Sanskrit in Engineering-III (Bio-technology and Chemical Engineering): Classification of plants- plants, the living-plants have senses-classification of living creatures, Chemical laboratory location and layout- equipment-distillation vessel-kosthi yanthram

Suggested Readings:

1. M Krishnamachariar, History of Classical Sanskrit Literature, TTD Press, 1937.
2. M.R. Kale, A Higher Sanskrit Grammar: For the Use of School and College Students, Motilal Banarsidass Publishers, 2015.
3. Kapail Kapoor, Language, Linguistics and Literature: The Indian Perspective, ISBN- 10: 8171880649, 1994.
4. Pride of India, Samskrita Bharati Publisher, ISBN: 81-87276 27-4, 2007.
5. Shri Rama Verma, Vedas the source of ultimate science, Nag publishers, 2005.

Course Code	Course Title						Core/Elective
AD 9004 HS	**Value Education**						**Audit I**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**2**	**-**	**-**	**-**	**30**	**70**	**-**

Course Objectives

- Understand the need and importance of Values for self-development and for National development.
- Imbibe good human values and Morals
- Cultivate individual and National character.

Course Outcomes

After completion of the course, students will be able to:

1. Gain necessary Knowledge for self-development
2. Learn the importance of Human values and their application in day to day professional life.
3. Appreciate the need and importance of interpersonal skills for successful career and social life
4. Emphasize the role of personal and social responsibility of an individual for all-round growth.
5. Develop a perspective based on spiritual outlook and respect women, other religious practices, equality, non-violence and universal brotherhood.

UNIT-I

Human Values, Ethics and Morals: Concept of Values, Indian concept of humanism, human values; Values for self-development, Social values, individual attitudes; Work ethics, moral and non- moral behaviour, standards and principles based on religion, culture and tradition.

UNIT-II

Value Cultivation, and Self-management: Need and Importance of cultivation of values such as Sense-of Duty, Devotion to work, Self-reliance, Confidence, Concentration, Integrity & discipline, and Truthfulness.

UNIT-III

Spiritual outlook and social values: Personality and Behavior, Scientific attitude and Spiritual (soul) outlook; Cultivation of Social Values Such as Positive Thinking, Punctuality, Love & Kindness, avoiding fault finding in others, Reduction of anger, forgiveness, Dignity of labour, True friendship, Universal brotherhood and religious tolerance.

UNIT-IV

Values in Holy Books: Self-management and Good health; internal & external cleanliness, Holy books versus Blind faith, Character and Competence, Equality, Nonviolence, Humility, Role of Women.

UNIT-V

Dharma, Karma and Guna: Concept of soul; Science of Reincarnation, Character and Conduct, Concept of Dharma; Cause and Effect based Karma Theory; The qualities of Devine and Devilish; Satwic, Rajasic and Tamasic gunas.

Suggested Readings:

1. Chakroborty, S.K., Values & Ethics for organizations Theory and practice‖, Oxford University Press, New Delhi, 1998.
2. Jaya Dayal Goyandaka, Srimad Bhagavad Gita with Sanskrit Text, Word Meaning and Prose Meaning‖, Gita Press, Gorakhpur, 2017.

Course Code	Course Title						Core/Elective
AD 9011 HS	**Constitution of India and Fundamental Rights**						**Audit II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**2**	**-**	**-**	**-**	**30**	**70**	**-**

Course Objectives

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective and to address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.

Course Outcomes

At the end of this course, students will be able to**:**

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

UNIT-I

History of Making of the Indian Constitution: History, Drafting Committee, (Composition & Working) Philosophy of the Indian Constitution: Preamble, Salient Features.

UNIT-II

Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT-III

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications. Powers and Functions.

UNIT-IV

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation, Panchayat raj: Introduction, PRI: Zilla Panchayat, Elected officials and their roles, CEO Zilla Panchayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT-V

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

Suggested Readings:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Code	Course Title						Core/Elective
AD 9012 HS	**Pedagogy Studies**						**Audit II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**2**	**-**	**-**	**-**	**30**	**70**	**-**

Course Objectives

- To present the basic concepts of design and policies of pedagogy studies.
- To provide understanding of the abilities and dispositions with regard to teaching techniques, curriculum design and assessment practices.
- To familiarize various theories of learning and their connection to teaching practice.
- To create awareness about the practices followed by DFID, other agencies and other researchers.
- To provide understanding of critical evidence gaps that guides the professional development

Course Outcomes

At the end of this course, students will be able to**:**

1. Illustrate the pedagogical practices followed by teachers in developing countries both in formal and informal classrooms.
2. Examine the effectiveness of pedagogical practices.
3. Understand the concept, characteristics and types of educational research and perspectives of research.
4. Describe the role of classroom practices, curriculum and barriers to learning.
5. Understand Research gaps and learn the future directions.

UNIT-I

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions, Overview of methodology and Searching.

UNIT-II

Thematic Overview: Pedagogical practices followed by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education

UNIT-III

Evidence on the Effectiveness of Pedagogical Practices: Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and Practicum) and the school curriculum and guidance material best support effective pedagogy? - Theory of change - Strength and nature of the 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 - Support from the head teacher and the community – Curriculum and assessment - Barriers to learning: Limited resources and large class sizes.

UNIT-V

Research Gaps and Future Directions: Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment – Dissemination and research impact.

Suggested Readings:

1. Ackers J, Hardman F, Classroom Interaction in Kenyan Primary Schools, Compare‖, 31 (2): 245 – 261, 2001.
2. Agarwal M, Curricular Reform in Schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361 – 379, 2004.
3. Akyeampong K, Teacher Training in Ghana – does it count? Multisite teacher education research project (MUSTER), Country Report 1. London: DFID, 2003.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J, Improving teaching and learning of Basic Maths and Reading in Africa: Does teacher Preparation count? International Journal Educational Development, 33 (3): 272- 282, 2013.
5. Alexander R J, Culture and Pedagogy: International Comparisons in Primary Education, Oxford and Boston: Blackwell, 2001.
6. Chavan M, Read India: A mass scale, rapid, learning to read campaign, 2003.

Course Code	Course Title						Core/Elective
AD 9013 HS	**Stress Management by Yoga**						**Audit II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**2**	**-**	**-**	**-**	**30**	**70**	**-**

Course Objectives

The Course will introduce the students to

- Creating awareness about different types of stress and the role of yoga in the management of stress.
- Promotion of positive health and overall wellbeing (Physical, mental, emotional, social and spiritual).
- Prevention of stress related health problems by yoga practice.

Course Outcomes

After successful completion of the course, the students will be able to:

1. Understand yoga and its benefits.
2. Enhance Physical strength and flexibility.
3. Learn to relax and focus.
4. Relieve physical and mental tension through asanas.
5. Improve work performance and efficiency.

UNIT - I

Meaning and Definition of Yoga - Historical perspective of Yoga - Principles of Astanga Yoga by Patanjali.

UNIT - II

Meaning and Definition of Stress - Types of stress - Eustress and Distress. Anticipatory Anxiety and Intense Anxiety and depression. Meaning of Management- Stress Management.

UNIT - III

Concept of Stress According to Yoga - Stress assessment methods - Role of Asana, Pranayama and Meditation in the management of stress

UNIT - IV

Asanas- (5 Asanas in each posture) - Warm up - Standing Asanas - Sitting Asanas - Prone Asanas - Supine asanas - Surya Namaskar.

UNIT - V

Pranayama- Anulom and Vilom Pranayama - Nadishudhi Pranayama - Kapalabhati Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama.

Meditation Techniques: Om Meditation - Cyclic meditation: Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT)

Suggested Readings:

1. "Yogic Asanas for Group Training - Part-I", Janardhan Swami Yogabhyasi Mandal, Nagpur.
2. Swami Vivekananda, "Rajayoga or Conquering the Internal Nature", Advaita Ashrama (Publication Department), Kolkata.
3. Nagendra H.R and Nagaratna R, "Yoga Perspective in Stress Management", Swami Vivekananda Yoga Prakashan, Bangalore.

Course Code	Course Title						Core/Elective
AD 9014 HS	**Personality Development Through Life Enlightenment Skills**						**Audit II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**2**	**-**	**-**	**-**	**30**	**70**	**-**

Course Objectives

- 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

At the end of this course, students will be able to**:**

1. Develop their personality and achieve their highest goal of life.
2. Lead the nation and mankind to peace and prosperity.
3. Practice emotional self-regulation.
4. Develop a positive approach to work and duties.
5. Develop a versatile personality.

UNIT - I

Neetisatakam – Holistic Development of Personality - Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)

UNIT - II

Neetisatakam – Holistic Development of Personality (cont'd) - Verses 52, 53, 59 (don'ts) - Verses 71,73,75 & 78 (do's) - Approach to day to day works and duties.

UNIT - III

Introduction to Bhagavadgeetha for Personality Development - Shrimad Bhagavadgeetha: Chapter 2 – Verses 41, 47, 48 - Chapter 3 – Verses 13,21,27,35 - Chapter 6 – Verses 5,13,17,23,35 - Chapter 18 –Verses 45, 46, 48 Chapter – 6: Verses 5, 13, 17, 23, 35; Chapter – 18: Verses 45, 46, 48

UNIT - IV

Statements of Basic Knowledge - Shrimad Bhagavadgeetha: Chapter 2- Verses 56, 62,68 - Chapter 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad Bhagawat Geeta.

UNIT - V

Role of Bhagavadgeetha in the Present Scenario - Chapter 2 – Verses 17 - Chapter 3 – Verses 36, 37, 42 - Chapter 4 – Verses 18, 38, 39 - Chapter 18 – Verses 37, 38, 63.

Suggested Readings:

1. Srimad Bhagavad Gita, Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya), P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi

Online Resources: NTPEL: http://nptel.ac.in/downloads/109104115/

Course Code	Course Title						Core/Elective
PC 5251 HV	**Refrigeration Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To familiarize with the fundamentals of refrigeration cycles
- To calculate the COPs of refrigeration cycles
- To comprehend the performance of cooling towers, ice plant, expansion devices
- To analyse the performance of vortex tube, heat pump, air-conditioning law limit
- To understand the pull down characteristics of domestic refrigerator
- To understand the working of ventilation systems

Course Outcomes

After completing this course, the student will be able to:

1. Define and explain the refrigeration cycles
2. Explain the working of ventilation systems
3. Calculate the COPs of refrigeration cycles
4. Comprehend the performance of cooling towers, ice plant, expansion devices
5. Analyse the performance of heat pump
6. To understand the pull down characteristics of domestic refrigerator

List of Experiments:

1. Study and Performance of Vapour Compression Refrigeration Cycle
2. To find performance of Refrigeration Test Rig by using different Expansion Devices
3. To find performance parameters of an Ice Plant
4. To find performance parameters of Vapour Absorption Refrigeration system
5. Performance analysis of Mechanical Heat Pump
6. Study of pull down characteristics of Domestic Refrigerator

Course Code	Course Title						Core/Elective
PC 5252 HV	**Air-Conditioning Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To familiarize with the working of air conditioning systems
- To calculate the COPs of air conditioners
- To comprehend the performance of cooling towers, ice plant, expansion devices
- To analyse the performance of vortex tube, air-conditioning law limit
- To understand the pull down characteristics of domestic refrigerator
- To understand the working of ventilation systems

Course Outcomes

After the completion of the course, the student will be able to:

1. State the basic concepts and principles of air-conditioning
2. Obtain cooling capacity and coefficient of performance by conducting test on air-conditioning test rig
3. Comprehend the performance of Ventilation Trainer
4. Analyse the performance of vortex tube, air-conditioning law limit
5. Calculate the efficiency of air washer
6. Investigate the pull down characteristics of domestic refrigerator

List of Experiments:

1. Find out the COP and Cooling Capacity of window Air Conditioning System
2. Find out the efficiency of air washer test rig
3. Find out the Humidified efficiency and overall efficiency of the experimental Cooling tower
4. Find the COP, Cooling Capacity and bypass factor of the Air Condition test rig
5. COP of miniature centralized AC unit
6. Performance analysis of Vortex Tube Apparatus
7. Study of performance parameters using Ventilation Trainer

Course Code	Course Title						Core/Elective
PC 5253 HV	**HVAC Systems Design Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To calculate the building heating & cooling loads using appropriate software
- To calculate the duct sizes and cooling tower & chilled water pipe sizes
- To identify and select appropriate air terminal outlets
- To assess Indoor Air Quality using appropriate software
- To prepare the 2D design and working drawings of HVAC systems

Course Outcomes

After completing this course, the student will be able to:

1. List the various software used in the field of HVAC
2. Select appropriate air terminal outlets
3. Use an appropriate software to calculate heating & cooling loads of a building
4. Analyse the various duct sizes and cooling tower / chilled water pipe sizes
5. Assess Indoor Air Quality using appropriate software
6. Design and draft the 2D design and working drawings of HVAC systems

List of Experiments:

1. Understanding the various psychrometric processes on psychrometric chart
2. Simple Heating & Cooling Load Calculations using related software
3. Designing of ducts sizing using related software
4. Chilled water air-conditioning system pipe sizing using related software
5. Selection of air terminal outlets using related software
6. Indoor Air Quality assessment using related software
7. HVAC design and 2D drafting using AutoCAD software
8. Demonstration of the following HVAC design features in Commercial, Residential, & Industrial projects:
    a. Duct design
    b. Coordination with MEP services
    c. Plant room design
    d. Mechanical room design

Course Code	Course Title						Core/Elective
PC 5254 HV	**Seminar**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**50**	**-**	**1**

Course Outcomes

At the end of this course, students will be able to**:**

1. Develop the habit of referring the journals for literature review.
2. Understand the gist of the research paper.
3. Identify the potential for further scope.
4. Present the work in an efficient manner.
5. Write the documentation in standard format.

Seminar topics may be chosen by the students with advice from the faculty members and the student shall read further relevant articles in the domain.

The seminar must be clearly structured and the power point presentation shall include following aspects:

1. Introduction to the field
2. Literature survey
3. Consolidation of available information
4. Summary and Conclusions
5. References

Each student is required to:

1. Deliver the seminar for a maximum duration of 30 minutes, where the presentation should be for 20 minutes in PowerPoint, followed by Question and Answers session for 10 minutes.
2. Submit the detailed report of the seminar in spiral bound in a précised format as suggested by the Department.

Guidelines for awarding marks		
S. No.	**Description**	**Max. Marks**
1	Contents and relevance	10
2	Presentation skills	10
3	Preparation of PPT slides	05
4	Questions and answers	05
5	Report in a prescribed format	20

Note:

1. The seminar presentation should be a gist of at least five research papers from **Peer-reviewed** or **UGC recognised** journals.
2. **The seminar report should be in the following order:** Background of work, literature review, techniques used, prospective deliverables, discussion on results, conclusions, critical appraisal and reference.
3. At least two faculty members will be associated with the seminar presentation to evaluate and award marks.
4. Attendance of all the students for weekly seminar presentations is compulsory. If the student fails to secure minimum attendance as per O.U. rules, the marks awarded in the seminar presentation shall remain void.

Course Code	Course Title						Core/Elective
PC 5255 HV	**Mini Project with Seminar**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**4**	**50**	**-**	**2**

Course Outcomes

At the end of this course, students will be able to**:**

1. Formulate a specific problem and give solution
2. Develop model/models either theoretical/practical/numerical form
3. Solve, interpret/correlate the results and discussions
4. Conclude the results obtained
5. Write the documentation in standard format

Guidelines:

- As part of the curriculum in the II- semester of the programme each student shall do a mini project, generally comprising about three to four weeks of prior reading, twelve weeks of active research, and finally a presentation of their work for assessment.
- Each student will be allotted to a faculty supervisor for mentoring.
- Mini projects should present students with an accessible challenge on which to demonstrate competence in research techniques, plus the opportunity to contribute something more original.
- Mini projects shall have inter-disciplinary/ industry relevance.
- The students can select a mathematical modeling based/Experimental investigations or Numerical modeling
- All the investigations should be clearly stated and documented with the reasons/explanations.
- The mini-project shall contain a clear statement of the research objectives, background of work, literature review, techniques used, prospective deliverables, and detailed discussion on results, conclusions and reference

Departmental committee: Supervisor and a minimum of two faculty members

Guidelines for awarding marks in CIE (Continuous Internal Evaluation): Max. Marks: 50		
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
Supervisor	20	Progress and Review
	05	Report
Departmental Committee	05	Relevance of the Topic
	05	PPT Preparation
	05	Presentation
	05	Question and Answers
	05	Report Preparation

Course Code	Course Title						Core/Elective
PC 5256 HV	**Major Project Phase – I**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**20**	**100**	**-**	**10**

Course Outcomes

At the end of this course, students will be able to:

1. Exposed to self-learning various topics.
2. Learn to survey the literature such asbooks, journals and contact resource persons for the selected topic of research.
3. Learn to write technical reports.
4. Develop oral and written communication skills to present.
5. Defend their work in front of technically qualified audience

Guidelines:

- The Project work will preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution.
- Seminar should be based on the area in which the candidate has undertaken the dissertation work.
- The CIE shall include reviews and the preparation of report consisting of a detailed problem statement and a literature review.
- The preliminary results (if available) of the problem may also be discussed in the report.
- The work has to be presented in front of the committee consists of Chairperson-BoS, Osmania University and Head, Supervisor & Project coordinator from the respective Department of the Institute.
- The candidate has to be in regular contact with his supervisor and the topic of dissertation must be mutually decided by the guide and student.

Guidelines for awarding marks in CIE (Continuous Internal Evaluation): Max. Marks: 100		
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
Supervisor	30	Project Status / Review(s)
	20	Report
Departmental Committee (Chairperson BoS, Osmania University and Head, Supervisor & Project coordinator from the respective department of the institution)	10	Relevance of the Topic
	10	PPT Preparation
	10	Presentation
	10	Question and Answers
	10	Report Preparation

Note: The Supervisor has to assess the progress of the student regularly.

Course Code	Course Title						Core/Elective
PC 5257 HV	**Major Project Phase – II (Dissertation)**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**32**	**-**	**200**	**16**

Course Outcomes

At the end of this course, students will be able to:

1. Use different experimental techniques and will be able to use different software/ computational /analytical tools.
2. Design and develop an experimental set up/ equipment/test rig.
3. Conduct tests on existing set ups/equipments and draw logical conclusions from the results after analysing them.
4. Either work in a research environment or in an industrial environment.
5. Conversant with technical report writing and will be able to present and convince their topic of study to the engineering community.

Guidelines:

- It is a continuation of Major Project Phase – I started in semester - III.
- The student has to submit the report in prescribed format and also present a seminar.
- The dissertation should be presented in standard format as provided by the department.
- The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion.
- The report must bring out the conclusions of the work and future scope for the study. The work has to be presented in front of the examiners panel consisting of an approved external examiner and Chairperson BoS, & Head, Osmania University and Supervisor from the Institute.
- The candidate has to be in regular contact with his/her Supervisor / Co- Supervisor

Guidelines for awarding marks in SEE (Semester End Examination): Max. Marks: 200		
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
Supervisor	10	Regularity and Punctuality
	10	Work Progress
	30	Quality of the work which may lead to publications
	10	Analytical / Programming / Experimental Skills Preparation
	10	Report preparation in a standard format
External Examiner and Chairperson, BoS & Head, Osmania University (All together)	20	Power Point Presentation
	60	Quality of thesis and evaluation
	30	Innovations, application to society and Scope for future study
	20	Viva-Voce