NATURE SCIENCE FOUNDATION
Coimbatore – 641 004, Tamil Nadu

Course Title: Heating, Ventilation, and Air Conditioning (HVAC)	
Mode of Delivery: Physical Classroom Training	**Type of Learning:** Lectures, Industry Study, Case Study & Student Activity
Total Learning Hours: 60	**Total Marks:** 75

Prerequisites
Basic knowledge of thermodynamics, fluid mechanics, and electrical engineering

Learning Objectives
1. Understand and explain the working principles of HVAC systems.
2. Assess and calculate heating, cooling, and ventilation loads for buildings.
3. Design and select HVAC equipment suitable for different building types.
4. Incorporate energy-efficient practices into HVAC design and operation.
5. Analyze and solve practical problems related to HVAC systems using industry standards.

Learning Outcome
On successful completion of the course, the students will be able to attain below Learning Outcome (LO):

Learning Outcome		CL	Linked LO	Teaching Hours
LO1	Explain the fundamentals and components of HVAC systems.	**U, A**	**1,2,5,6,7,8,9,10**	**12**
LO2	Design HVAC systems for residential, commercial, and industrial applications.	**U, A**	**1,2,4,5,6,8,9,10**	**12**
LO3	Apply principles of fluid mechanics and thermodynamics in HVAC system performance.	**R, U**	**1,2,3,4,5,6,10**	**06**
LO4	Analyze energy efficiency and environmental considerations in HVAC systems.	**A, U**	**1,2,5,6,8,9,10**	**08**
LO5	Demonstrate practical knowledge of HVAC system installation and maintenance.	**U, A**	**1,2,5,6,8,9,10**	**08**
LO6	Case Study and Student Activity	**U, A**	**1,2,5,6,7,9,10**	**14**
			Total	**60**

Legends: CL = Cognitive Level, R = Remember, U= Understand, A= Apply and above levels (Bloom's Revised Taxonomy)

Learning - LO Attainment Matrix

Learning	Learning Outcomes									
	1	2	3	4	5	6	7	8	9	10
Heating, Ventilation, and Air Conditioning (HVAC)	**3**	**3**	**1**	**2**	**3**	**3**	**2**	**3**	**3**	**3**

Level 3- Highly Addressed, Level 2-Moderately Addressed, Level 1-Low Addressed.

- Method is to relate the level of LO with the number of hours devoted to the LOs which address the given LO.
- If ≥40% of classroom sessions addressing a particular LO, it is considered that LO is addressed at Level 3
- If 25 to 40% of classroom sessions addressing a particular LO, it is considered that LO is addressed at Level 2 If 5 to 25% of classroom sessions addressing a particular LO, it is considered that LO is addressed at Level 1
- If < 5% of classroom sessions addressing a particular LO, it is considered that LO is considered not-addressed.

Learning Content and Blue Print of Marks for External

Unit No	Unit Name	Hour	Questions to be set for External			Marks Weightage	Marks Weightage (%)
			R	U	A	A	
I	Introduction to HVAC and Components	**12**	5	20	10	35	24.13
II	Design and Sizing of HVAC Systems	**12**	-	20	10	30	20.68
III	Fluid Mechanics and Thermodynamics in HVAC	**06**	5	10	-	15	10.35
IV	Energy Efficiency and Environmental Impact	**08**	-	10	15	25	17.24
V	Installation and Maintenance of HVAC Systems	**08**	-	15	10	25	17.24
VI	Industry Study, Case Study & Student Activity	**14**	-	15	-	15	10.35
	Total	**60**	**10**	**90**	**45**	**145**	**100**

UNIT I: Introduction to HVAC and Components **12 Hrs**

Overview of HVAC systems, Key components: compressors, condensers, evaporators, expansion valves, Understanding Air Conditioning, Heating, and Ventilation Principles: air conditioning, heating, and ventilation, HVAC system classifications: Centralized HVAC Systems, Decentralized HVAC System, Packaged HVAC Systems, Split Systems, Applications: Residential, Commercial, Industrial, Healthcare, Datacenters, Review of HVAC design codes and standards: ASHRAE Standards, ISO Standards, Local Building Codes, Energy Efficiency Standards, Environmental Impact Regulations.

UNIT II: Design and Sizing of HVAC Systems **12 Hrs**

Load calculations for HVAC systems: Types of Loads, Factors Considered in Load Calculations, Software Tools for Load Calculation, Sizing of components like ducts, pipes, and equipment, HVAC system configuration for various applications (residential, commercial, industrial), Principles of airflow, temperature control, and humidity control, Overview of system control and automation.

UNIT III: Fluid Mechanics and Thermodynamics in HVAC **06 Hrs**

Principles of fluid flow in HVAC systems: Laminar and Turbulent Flow, Continuity Equation, Bernoulli's Principle, Frictional Losses, Thermodynamics and energy transfer: First Law of Thermodynamics (Energy Conservation) , Second Law of Thermodynamics (Heat Flow), Work and Heat Transfer, Heat Exchangers, Heat load calculations and their impact on system design: Factors Affecting Heat Load, Cooling Load Calculation, Heating Load Calculation, Impact on System Design , Refrigeration cycle and its application in HVAC systems: Compression, Condensation, Expansion, Evaporation, Application in HVAC , Study of air properties and psychometrics: Dry Bulb Temperature (DBT), Wet Bulb Temperature (WBT), Relative Humidity (RH), Enthalpy, Psychrometric Chart & Dew Point.

UNIT IV: Energy Efficiency and Environmental Impact **08 Hrs**

Energy efficiency measures in HVAC systems: Proper Sizing of Equipment, Variable Speed Drives (VSDs), Improved Insulation, Use of High-Efficiency Equipment, Smart Thermostats and Sensor, Energy Recovery Systems, Regular Maintenance and Monitoring, Sustainable HVAC solutions: Renewable Energy Integration, Green Building Practices, Environmental impact: refrigerants, emissions, and global warming potential (GWP): Refrigerants and Their Impact, Low-GWP Refrigerants, Emissions from HVAC Systems, Leakage and Maintenance, Innovations in energy-efficient HVAC systems: Variable Refrigerant Flow (VRF) System, Smart HVAC System, Demand-Response Systems, Thermal Energy Storage, Advanced Heat Pumps, Role of building energy management systems (BEMS): Real-Time Monitoring, Automated Control and Optimization, Energy Analytics and Reporting, Integration with Renewable Energy, Building Performance Optimization.

UNIT V: Installation and Maintenance of HVAC Systems **08 Hrs**

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Installation practices for HVAC systems: Site Assessment, Proper Sizing of HVAC Equipment, Ductwork Design and Installation, Refrigerant Piping and Gas Line Installation, Electrical Connections and Control Wiring, Ventilation and Airflow Considerations, Commissioning and System Testing, Training and User Instructions, Preventive and corrective maintenance techniques: Regular Inspection and Cleaning, Lubrication of Moving Parts, Checking Refrigerant Levels, Calibrating Thermostats and Sensors, Inspecting Ductwork and Insulation: Inspecting Ductwork and Insulation, Filter Replacement, Identifying and Fixing Leak, Compressor Repair or Replacement, Fan Motor and Belt Replacement, Fixing Electrical Failures, Fixing Electrical Failures, Troubleshooting common HVAC issues: System Not Cooling/Heating Properly, Strange Noises, Frequent Cycling, System Won't Start, Airflow Problems, Monitoring and testing HVAC system performance: Energy Consumption Monitoring, Airflow Measurement, Temperature and Humidity Testing, System Pressure Check, Control System Testing, Use of sensors and controllers for system efficiency: Temperature and Humidity Sensors, Occupancy Sensors, Air Quality Sensors, Pressure Sensors, Controller Integration.

UNIT VI: Industry Study, Case Study & Student Activity **14 Hrs**

Student Industry Visit: Exposure to Industry Practices, Understanding Practical Applications, Career Insights**,** Key Areas of Focus During the Industry Visit: HVAC System Design and Installation, Energy Efficiency Practices in HVAC, Sustainable and Green Building HVAC Applications, Case Studies of HVAC Systems in Commercial and Industrial Settings, Role of HVAC in Indoor Air Quality (IAQ), Technological Advancements in HVAC System, HVAC Control Systems and Automation, Challenges in HVAC System Maintenance and Troubleshooting, Career Opportunities in the HVAC Industry, Real-world Case Studies Demonstrating the Applications of HVAC – Hands-on Projects and Exercises for Implementation and Practice: HVAC System Design Project, Energy Efficiency Assessment, Smart HVAC System Implementation, HVAC System Troubleshooting and Maintenance Exercise, Environmental Impact of HVAC Systems Simulation.

References

1. *Fundamentals of HVAC Systems* by James A. McQuiston.
2. *HVAC Systems Design Handbook* by Roger W. Haines.
3. *Refrigeration and Air Conditioning* by C.P. Arora.
4. *ASHRAE Handbook – HVAC Applications* by ASHRAE.
5. *Energy Efficiency in HVAC Systems* by R. K. Shah.

Suggested list of student activities

Note: the following activities or similar activities for assessing Internal for 5 marks

1. Each student should do any one of the following type activity or any other similar activity related to the course and before conduction, get it approved from concerned learning coordinator
2. Each student should conduct different activity and no repeating should occur.

1	Understand the Different Types of HVAC Systems and Their Applications
2	Learn and Understand the Role of Thermostats in HVAC Systems
3	Explore the Working Principle of Heat Pumps in HVAC Systems
4	Compare Different Types of Air Filters Used in HVAC Systems
5	Understand the Functionality and Selection Criteria of HVAC Refrigerants.
6	Learn About Energy-Efficient HVAC Technologies and Practices
7	Study Indoor Air Quality (IAQ) and the Role of Ventilation in HVAC
8	Design a Basic HVAC System for a Residential Building
9	Explore the Integration of HVAC Systems with Smart Building Technologies
10	Quiz on HVAC Fundamentals

Case study

- Comprehensive HVAC Design for a Commercial Office Building.
- HVAC System Optimization for an Existing Building.
- Sustainable HVAC Design for a Green Building.
- HVAC Design for a Healthcare Facility (Hospitals or Clinics).
- Precision Cooling System for a Data Center.
- HVAC System Design for High-Rise Residential Buildings.
- Design and Sizing of HVAC Systems for Retail Spaces or Shopping Malls.
- HVAC Design for Hospitality Sector (Hotels and Resorts).
- Implementation of Energy-Efficient HVAC Technologies (e.g., VRF or Heat Pumps).
- Lifecycle Cost Analysis and Selection of HVAC Equipment for Industrial Facilities.
- HVAC Design and Zoning for Educational Institutions or Campus Buildings.
- Advanced Air Quality Management Systems for Public Spaces (e.g., Airports, Museums).
- Smart HVAC Systems: Integration with IoT for Energy Efficiency.
- Renewable Energy-Based HVAC System (e.g., Solar or Geothermal).
- HVAC Design for Cold Storage and Temperature-Controlled Warehousing.

Learning Assessment and Evaluation Scheme

Method	What		To whom	When/Where (Frequency in the course)	Max Marks	Evidence collected	Learning outcomes
Direct Assessment	External	Internal	Students	Three Internal tests (Average of three tests will be computed)	20	Blue books	1 to 6
				Student activities	10	Report	1 to 6
				Total	**30**		
	End Semester	End Exam		End of the Learning	70	Answer scripts	1 to 6
Indirect Assessment	Student Feedback on course		Students	Middle of the Learning		Feedback forms	1,2,3 Delivery of course
	End of Learning Survey			End of the Learning		Questionnaires	1 to 6 Effectiveness of Delivery of instructions & Assessment Methods

Note: Internal Evaluation shall be conducted for 20 marks. Average marks of three tests shall be rounded off to the next higher digit.

Questions for Internal and External will be designed to evaluate the various educational components (Bloom's taxonomy) such as:

Sl. No	Bloom's Category	%
1	Remembrance	07
2	Understanding	62
3	Application	31

Note to Internal verifier*: *The following documents to be verified by Internal verifier at the end of semester

1. Blue books (20 marks)
2. Student suggested activities report for 10 marks
3. Student feedback on learning regarding Effectiveness of Delivery of instructions & Assessment Methods.

FORMAT OF INTERNAL TEST QUESTION PAPER

Test/Date and Time	Semester/year	Course/Course Code	Max Marks
			20
	Year:		

Name of Learning coordinator : Units:_
LO's:_____

Question No	Questions	MARKS	CL	LO	LO
1					
2					
3					
4					

Note: Internal choice may be given in each LO at the same cognitive level (CL).

Format for Student Activity Assessment

DIMENSION	Unsatisfactory 1	Developing 2	Satisfactory 3	Good 4	Exemplary 5	Score
Collection of data	Does not collect any information relating to the topic	Collects very limited information; some relate to the topic	Collects some basic information ; refer to the topic	Collects relevant informati on; concerne d to the topic	Collects a great deal of information; all refer to the topic	3
Fulfill team's roles & duties	Does not perform any duties assigned to the team role	Performs very little duties	Perform s nearly all duties	Performs all duties	Performs all duties of assigned team roles with presentation	4

Shares work equally	Always relies on others to do the work	Rarely does the assigned work; often needs reminding	Usually does the assigned work; rarely needs reminding	Does the assigned job without having to be reminded.	Always does the assigned work without having to be reminded and on given time frame	3
Listen to other Team mates	Is always talking; never allows anyone else to speak	Usually does most of the talking; rarely allows others to speak	Listens, but sometimes talk too much	Listens and contributes to the relevant topic	Listens and contributes precisely to the relevant topic and exhibit leadership qualities	3
					TOTAL	**13/4=3.25=4**

Note: This is only an example. Appropriate rubrics/criteria may be devised by the concerned Learning Coordinator for assessing the given activity

MODEL QUESTION BANK

Course Title: Heating, Ventilation, and Air Conditioning (HVAC)

LO	Question	CL	Marks
I	What does HVAC stand for?	R	05
	List the primary components of an HVAC system.	A	
	What is the function of a compressor in an HVAC system?	U	
	How does a condenser work in an HVAC system?	U	
	Describe the role of an evaporator in an HVAC system.	U	
	What is the purpose of an expansion valve in an HVAC system?	U	
	How does an HVAC system provide heating and cooling?	U	
	What is meant by the term 'air handling unit' in an HVAC system?	U	
	What is the importance of a duct system in HVAC?	U	
	Explain the role of refrigerant in HVAC systems.	R	
	How do filters contribute to the efficiency of an HVAC system?	A	10
	What is the function of the thermostat in HVAC systems?	A	
	Define ventilation in the context of HVAC.	U	
	What are the basic types of HVAC systems?	U	
	How does the principle of heat transfer apply to HVAC systems?	U	
	What factors are considered when designing an HVAC system?	A	
	What is the purpose of load calculation in HVAC system design?	A	

II	Define cooling load in the context of HVAC design.	A	5
	What is a heating load, and how is it calculated for HVAC systems?	A	
	Explain the significance of airflow rate in HVAC system design.	A	
	What are the different types of air distribution systems used in HVAC designs?	U	
	What is the role of duct sizing in HVAC design?	A	10
	How do you calculate the required capacity of an HVAC unit?	A	
	Explain the concept of ventilation rate in HVAC system design.	U	
	What is the difference between sensible and latent heat in HVAC design?	A	
	How does insulation affect HVAC system sizing?	A	
	What factors are considered when designing an HVAC system?	A	
III	**What is Bernoulli's equation, and how is it applied in HVAC systems?**	U	5
	Explain the concept of pressure drop in HVAC fluid flow systems.	R	
	What is the difference between laminar and turbulent flow in HVAC ducts?	R	
	How does the first law of thermodynamics apply to HVAC systems?	U	
	What is the role of specific heat in HVAC systems?	U	
	Define enthalpy and its importance in the operation of HVAC systems.	U	
	What is the significance of the Reynolds number in fluid flow within HVAC systems?	U	
	How does the second law of thermodynamics relate to the efficiency of an	U	
IV	What is the COP (Coefficient of Performance) in HVAC systems, and how does it relate to energy efficiency?	U	5
	Explain the significance of SEER (Seasonal Energy Efficiency Ratio) in air conditioning systems.	A	
	How does proper insulation contribute to energy efficiency in HVAC systems?	A	
	What are the key factors influencing the environmental impact of HVAC systems?	A	
	What is the role of refrigerants in HVAC systems, and how do they impact the environment?	U	
	Explain how variable-speed drives (VSDs) improve the energy efficiency of HVAC systems.	U	10
	What is the difference between renewable and non-renewable energy sources in HVAC applications?	A	
	How can energy recovery ventilators (ERVs) help reduce the environmental impact of HVAC systems?	A	
	What are the environmental benefits of using smart thermostats in HVAC systems?	A	
	What are the essential steps involved in the installation of an HVAC system?	U	5
	Explain the importance of proper duct design during HVAC system installation.	A	

V	What are common challenges faced during HVAC installation and how can they be avoided?	**A**	
	What routine maintenance tasks should be performed on HVAC systems to ensure optimal performance?	**U**	
	Why is it important to clean or replace air filters regularly in HVAC systems?	**U**	
	How does refrigerant leakage affect the efficiency and performance of HVAC systems?	**U**	
	What is the role of commissioning in HVAC installation and why is it necessary?	**A**	**10**
	Explain the importance of checking refrigerant charge during HVAC system maintenance.	**U**	
VI	What are the key challenges faced by the HVAC industry in meeting energy efficiency standards?	**U**	**5**
	Describe a case study where a specific HVAC system was implemented to reduce energy consumption in a commercial building.	**U**	
	How does the integration of smart HVAC systems improve operational efficiency in large industrial facilities?	**A**	
	Explain the impact of climate change on HVAC system design and operation.	**A**	
	In your opinion, how can HVAC systems in the healthcare industry be improved for better indoor air quality and patient comfort?	**U**	
	What is the role of IoT in modern HVAC systems and how does it enhance system performance and maintenance?	**U**	
	How do HVAC systems in large retail stores or malls differ from those in residential buildings? Discuss with an example.	**U**	**10**
	Discuss a real-life example where poor HVAC system maintenance led to a major failure or inefficiency. What steps could have been taken to prevent it?	**A**	