SCHEME :K

Name :_____
Roll No.:_____ Year : 20 ___ 20 __
Exam Seat No. :_____

LABORATORY MANUAL FOR

HEATING VENTILATION AIR CONDITIONING (315373)

MECHANICAL ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI
(Autonomous)(ISO21001:2018)(ISO/IEC27001:2013)

Maharashtra State
Board of Technical Education, Mumbai

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A Practical Manual for

Heating Ventilation Air Conditioning (315373)

Semester – V

"K- SCHEME"

Diploma in Mechanical Engineering

Maharashtra State Board of Technical Education, Mumbai

(Autonomous) (ISO 21001:2018) (ISO/IEC 27001:2013)

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

(Autonomous) (ISO 21001:2018) (ISO/IEC 27001:2013)

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MAHARASHTRA STATE
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This is to certify that Mr. / Ms .....Roll No…….of Fifth Semester of Diploma in …….of **Institute Name:** …….. (**Institute Code** :……..) has completed the term work satisfactorily in course **Heating Ventilation Air Conditioning (315373)** for the academic year 20…… to 20…..... as prescribed in the curriculum.

Place: ……. Enrollment No.: ……

Date: …..... Exam Seat No.: ……....

Course Teacher **Head of the Department** **Principal**

Seal of the Institute

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much-needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'K' Scheme curricula for engineering diploma programmes with National Education Policy 2020 (NEP-2020) and outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practical to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practical to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Knowledge of refrigeration, air conditioning, heating and ventilation with different mechanical equipments are essential in all fields of engineering.

The Practical manual development team wishes to thank MSBTE who took initiative in the development of curriculum and implementation and also acknowledge the contribution of individual course experts who have been involved in laboratory manual as well as curriculum development (K scheme) directly or indirectly.

Although all care has been taken to check for mistakes in this laboratory manual, yet it is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome.

Lab Manual Development Team

Programme Outcomes (POs) to be achieved through Practical of this Course

Following POs are expected to be achieved through the practicals of the Heating Ventilation Air Conditioning course.

PO1. Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the mechanical engineering problems.

PO2. Problem analysis: Identify and analyze well-defined mechanical engineering problems using codified standard methods.

PO3. Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs in mechanical engineering.

PO4. Engineering Tools, Experimentation and Testing: Apply modern mechanical engineering tools and appropriate technique to conduct standard tests and measurements.

PO5. Engineering practices for society, sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO6. Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well defined engineering activities in diverse and multidisciplinary fields.

PO7. Life-long learning: Ability to analyze individual needs and engage in updating in the context of technological changes in mechanical engineering.

List of Industry Relevant Skills

The following industry relevant skills of the competency in 'maintaining HVAC systems and maintaining equipment related to air handling systems in industry are expected to be developed in students by undertaking the practical of this laboratory manual.

1. Understand the different psychrometric properties of air and measure them using tools like thermometer, hygrometer, anemometer and psychrometric chart.
2. Understand different parts of unitary and central air conditioning systems, and read their specifications.
3. Understand the structure of cassette and automobile AC systems and learn how to safely dismantle and assemble them.
4. Understand cooling and heating load concepts and measure the space to calculate required AC capacity.
5. Understand how air is distributed in modern systems and compare with methods used in ancient India (IKS).

Practical- Course Outcome matrix

Course Outcomes (COs):

- CO1. Apply Psychrometric principles for HVAC applications.
- CO2. Select appropriate components for given HVAC applications.
- CO3. Select appropriate Air conditioning systems for given situation.
- CO4. Calculate cooling load for the particular situation.
- CO5. Develop proper Air distribution systems according to site requirement for the given situation.

S. No.	Laboratory Practical Titles	CO 1.	CO 2.	CO 3.	CO 4.	CO 5.
1	* Measurement of air properties.	√	-	-	-	-
2	* Identification of various components of Unitary Air conditioning system with specifications.	-	√	-	-	-
3	Dismantling and assembling of the cassette air conditioning system.	-	√	√	-	-
4	Demonstration of Central Air conditioner system.	-	√	√	-	-
5	Dismantling and assembling of the Automobile Air conditioner.	-	√	√	-	-
6	* Trail on Air conditioning system.	-	-	-	√	-
7	* Cooling and heating load calculations.	-	-	-	√	-
8	* Prepare layout of Air distribution system of given space.	-	-	-	√	√
9	Demonstration on railway HVAC system.	-	-	√	-	√
10	Air conditioning system used in ancient India. (IKS)	√	√	√	√	√

Guidelines to Teachers

1. **Teacher needs to ensure that a dated log book** for the whole semester, apart from the laboratory manual is maintained by every student which s/he has to **submit for assessment to the teacher** in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which is not mentioned in the printed practical.
3. For difficult practical if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teacher can maintain various practical related question banks for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines.

Instructions for Students:

1. For incidental writing on the day of each practical session every student should maintain a ***dated log book*** for the whole semester, apart from this laboratory manual which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning itself of each practical, student need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Technical Manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practical.

Content Page

List of Practical and Progressive Assessment Sheet

S. No.	Laboratory Practical Titles	Page No.	Date of performance	Date of submission	FA PR marks (25)	Dated sign. of teacher	Remarks (if any)
1	*Measurement of air properties.	1					
2	*Identification of various components of Unitary Air conditioning system with specifications.	7					
3	Dismantling and assembling of the cassette air conditioning system.	13					
4	Demonstration of Central Air conditioner system	20					
5	Dismantling and assembling of the Automobile Air conditioner	26					
6	*Trail on Air conditioning system	32					
7	*Cooling and heating load calculations	39					
8	*Prepare layout of Air distribution system of given space.	46					
9	Demonstration on railway HVAC system.	54					
10	Air conditioning system used in ancient India. (IKS)	60					
Total							

Note: To be transferred to Proforma of CIAAN-2023.

A suggestive list of LLOs is given in the above table. More such LLOs can be added to attain the COs and competency. A judicial mix of minimum 08 or more practical need to be performed, out of which, the practical marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.

Practical No. 1

Measurement of air properties.*

I. Practical Significance

Understanding air properties such as temperature, pressure, humidity, and density is crucial in various mechanical applications including HVAC systems, combustion engines, and pneumatic systems. Accurate measurement helps optimize performance and ensures safety.

II. Industry/Employer Expected Outcome(s)

This practical is designed to develop the ability to accurately- "Measure air properties for real-time applications.

III. Course Level Learning Outcome(s) (CO)

CO1- Apply Psychrometric principles for HVAC applications.

IV. Laboratory Learning Outcome(s)

LLO 1.1: Measure air properties using appropriate Psychrometer efficiently.
LLO 1.2: Calculate various air properties using Psychometric Chart.

V. Relative Affective Domain related Outcome(s)

- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.
- Follow safety practices.

VI. Relevant Theoretical Background with diagram (if required)

Properties of Air:

(i) Temperature (T): Degree of hotness or coldness.

(ii) Pressure (P): Force exerted per unit area.

(iii) **Relative Humidity (RH):** Ratio of actual moisture to maximum possible at a given temperature.

(iv) Density (ρ): Mass per unit volume.

(v) Psychrometric Chart: It is used to determine air properties.

VII. Experimental setup

Sling Psychrometer is a device which is used to measure both the dry bulb and wet bulb temperatures at a time. These temperatures are a measure of humidity content in air.

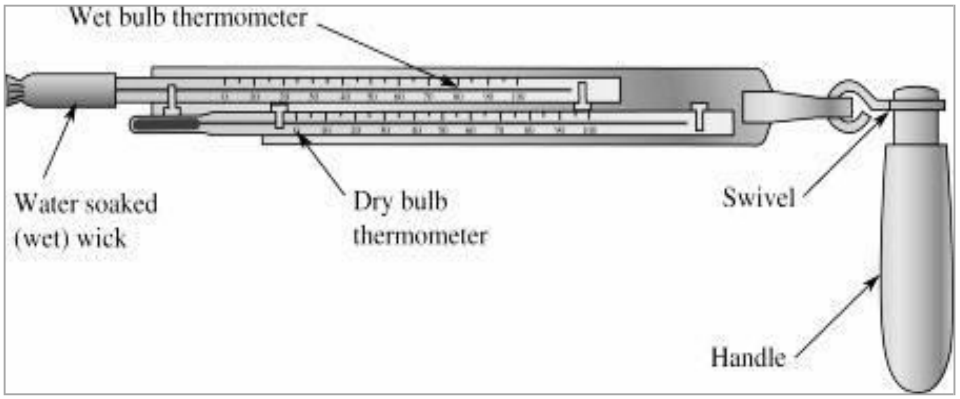


Fig. 1.1 Sling Psychrometer

VIII. Required Resources /Apparatus/Equipment with specifications

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Sling psychrometer	Measuring range -5 Deg C to 50 Deg C Material - Plastic & Glass Type - Mercury	01
2	Psychrometric chart	Psychrometric chart showing all properties American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)	01

IX. Precautions to be Followed

1. Handle glass instruments with care.
2. Avoid parallax error while reading scale.
3. Ensure all instruments are calibrated.
4. Avoid exposure of instruments to direct sunlight or drafts.

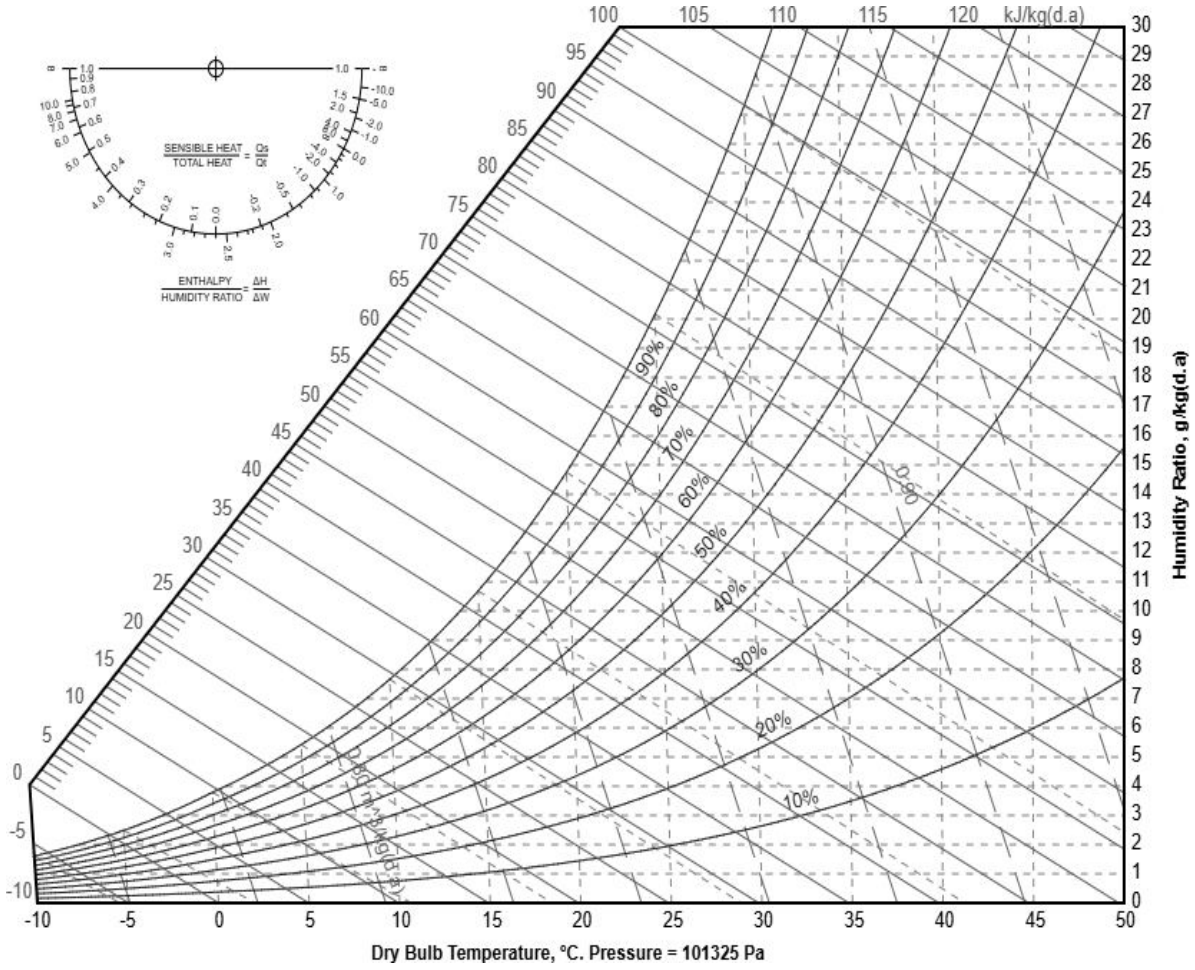
X. Procedure

1. Select the suitable psychrometer available in the laboratory.
2. Prepare the psychrometer by pouring water into the tube provided in WBT thermometer.
3. Ensure the psychrometer is in a stable, non-turbulent area for accurate readings.
4. Faculty suggests collecting different readings from various locations. Choose locations like a canteen (which may have more people and potentially higher humidity) and a classroom (which may have more consistent temperature).
5. Swirl the sling psychrometer in the air for about a minute to allow the wet-bulb to reach an equilibrium temperature.
6. Note the readings of both the dry-bulb and wet-bulb thermometers.
7. Repeat this process multiple times at each location to get a more accurate average.
8. Find the difference between the dry-bulb and wet-bulb temperatures (wet-bulb depression).
9. Once you have the dry-bulb temperature, wet-bulb temperature, and relative humidity, you can use a psychrometric chart to determine other properties like dew point, specific humidity, and enthalpy.

XI. Observations and calculations

Places	Sling Psychrometer							
	Trial	Temperature		Specific Humidity	Specific Volume (m^3/kg)	Dew Point (°C)	Specific Enthalpy	Relative Humidity
		DBT (°C)	WBT (°C)				(kJ/kg)	%
Class room	1							
	2							
Canteen	1							
	2							
	1							
	1							
	1							

XI. Results: Represent the readings obtained on the attached psychometric chart.



XII. Interpretation of Results

XIII. Conclusions and Recommendation

XIV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. List the components of a psychrometer.
2. State the significance of dry bulb temperature and wet bulb temperature.
3. List different properties available on the psychometric chart.
4. Explain the significance of the saturation curve on a psychrometric chart.
5. Use psychometric chart for determining the Specific humidity, specific volume, dew point, enthalpy, the relative humidity (in percent) given that the dry bulb temperature and wet bulb temperature are 35°C and 20°C, respectively.
6. Analyze the impact of changes in humidity and temperature on human thermal comfort using practical data. -

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=kmZ5K0XaQVI
2. https://www.youtube.com/watch?v=abt_ydjgK28
3. https://www.youtube.com/watch?v=dtNY4ejabFc&t=40s
4. https://youtu.be/MpLGmHoJfls?si=YnaZVfCdM3H_jWah
5. https://www.youtube.com/watch?v=w4Gk3Z_Pjmc
6. https://www.youtube.com/watch?v=YnSyyvRgdOk

XV. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Handling of the measuring Instruments	40%
2	Calculation of final readings	20%
Product Related (10 Marks)		**(40%)**
3	Interpretation of result	30%
4	Practical related questions	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 2

Identification of various components of Unitary Air conditioning system with specifications.*

I. Practical Significance

This practical enables student to identify the function of components in a unitary air conditioning system, such as the compressor, condenser, evaporator, expansion device, and controls. By studying their specifications, students gain insight into selection criteria, operating conditions, and compatibility within the system. This knowledge is crucial for system design, maintenance, troubleshooting, and ensuring efficient performance in residential and commercial HVAC applications.

II. Industry/Employer Expected Outcome(s)

This practical is expected to develop the skills for the industry identified competency as; "Interpret manufacturer catalogues to extract specifications, performance ratings, and selection criteria relevant to industry practices."

III. Course Level Learning Outcome (CO)

CO2 - Select appropriate components for given HVAC applications.

IV. Laboratory Learning Outcome(s)

LLO 2.1: Identify the components of a Unitary Air conditioner.

LLO 2.2: Make use of manufacturer catalogue for specifications and ratings for each component.

V. Relative Affective Domain related Outcome(s)

- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.
- Follow safety practices.

VI. Relevant Theoretical Background with diagram (if required)

A Unitary Air Conditioning System is a compact and complete system where all major components are housed within a single casing. The refrigerant absorbs heat from indoor air at the evaporator, is compressed, and then rejects heat at the condenser, completing a cycle.

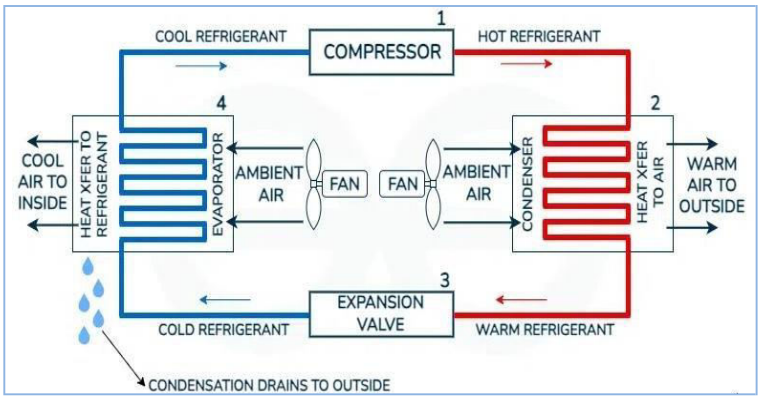


Fig. 2.1: Working Principle of Air conditioning system

VII. Experimental setup

The key elements of unitary air conditioning systems depend on whether cooling or heating only or both cooling and heating are provided. There are several types of heating systems available with unitary equipment.

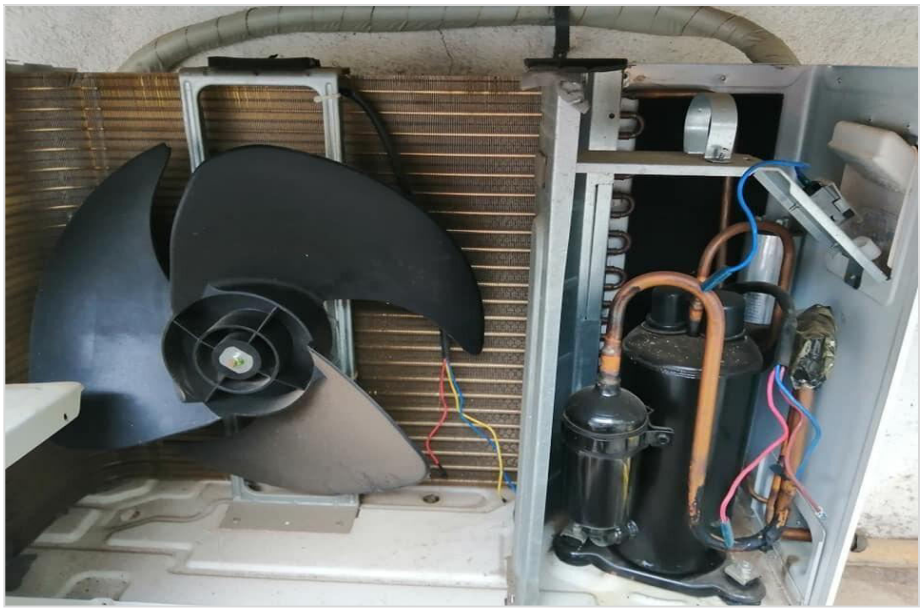


Fig. 2.2: Unitary Air Conditioner (Actual Image)

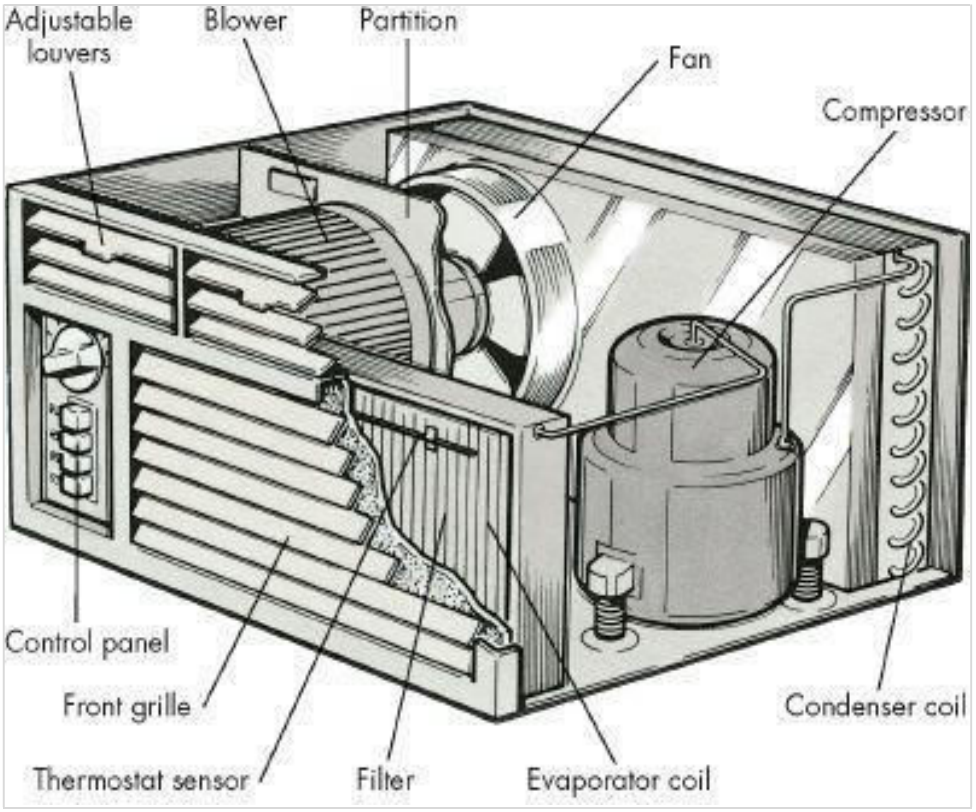


Fig. 2.3: Unitary Air Conditioner (Cut Section)

VIII. Required Resources /Apparatus/Equipment with specification

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Unitary Air Conditioner	Cut section of window air conditioner/split air conditioner capacity 1.5 TR	01

IX. Precautions to be Followed

1. Avoid improper handling of Unitary Air Conditioner set up/ Model.
2. Do not release Refrigerants (harmful substances) into the atmosphere.

X. Procedure

1. Open the unit casing to access internal components.
2. Write name of manufacturer using manufacturers catalogue with its capacity
3. Identify the main components of a Unitary Air Conditioner/.
4. Observe the working of different components of Unitary air conditioner.

XI. Observations

Type of Air conditioning system	Name the components	Specification	Remark
Unitary Air conditioning system	Compressor		
	Condenser Coil		
	Expansion Valve/ Capillary Tube		
	Evaporator Coil		
	Blower / Fan (Indoor)		
	Fan (Outdoor)		
	Air Filter		
	Thermostat		
	Butterfly Valve/ Ventilation valve		
	Overload Protector		
	Grills and Lovers		

XII. Results

Draw or paste photographs of Different components of unitary air-conditioner used for practical.

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Differentiate between the condenser and evaporator coils on basis of function, location, purpose, and state of refrigerant.
2. Draw working principle of Air Conditioning System on graph paper.
3. Write specification of Unitary Air Conditioner used in Commercial Buildings /Residential Applications.
4. Determine the evaporator coil dimensions used in system's cooling capacity.

[Space for Answer]

XVI. References/Suggestions for Further Reading

1. https://www.youtube.com/watch?v=-zYIYizSycI
2. https://www.youtube.com/watch?v=lUGM6FG3yMA
3. https://www.youtube.com/watch?v=GzEMdQk1QTk

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (5 Marks)		**(20%)**
1	Observation of the different components.	20%
Product Related (20 Marks)		**(80%)**
2	Interpretation of result	30%
3	Conclusions	30%
4	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (5)	**Product Related (20)**	**Total (25)**	

Practical No. 3

Dismantling and assembling of the Cassette air conditioning system

I. Practical Significance

This practical develops hands-on skills in dismantling and assembling cassette air conditioners, helping students to study internal components, installation procedures, and maintenance practices commonly required in commercial HVAC applications.

II. Industry/Employer Expected Outcome(s)

This practical is expected to develop the skills for the industry identified competency as; "Perform basic maintenance and troubleshooting tasks as expected in HVAC servicing and installation roles."

III. Course Level Learning Outcome (CO)

CO2 - Select appropriate components for given HVAC applications.
CO3 - Select appropriate Air conditioning systems for given situation

IV. Laboratory Learning Outcome(s)

LLO 3.1: List the different components of a Cassette air conditioner.
LLO 3.2: Select the proper tools for dismantling and assembling.
LLO 3.3: Inspect condition of components.

V. Relative Affective Domain related Outcome(s)

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Relevant Theoretical Background with diagram (if required)

Cassette air conditioners are ceiling-mounted units, offering a space-saving and discrete alternative to traditional air conditioning systems. They are typically used in large commercial or residential spaces where a central cooling system is needed, according to several sources.

Key features of Cassette air conditioner-

1. **Ceiling-mounted design:** The indoor unit is installed in the ceiling, leaving wall space free for other purposes.
2. **Compact and discreet:** They blend well with interior decor and don't take up valuable floor space.
3. **Efficient cooling:** Cassette units are designed to distribute air evenly throughout the room, providing efficient cooling and heating.
4. **Ideal for large spaces:** They are well-suited for large, open-plan spaces, commercial buildings, and homes where central AC is needed.

VII. Experimental setup

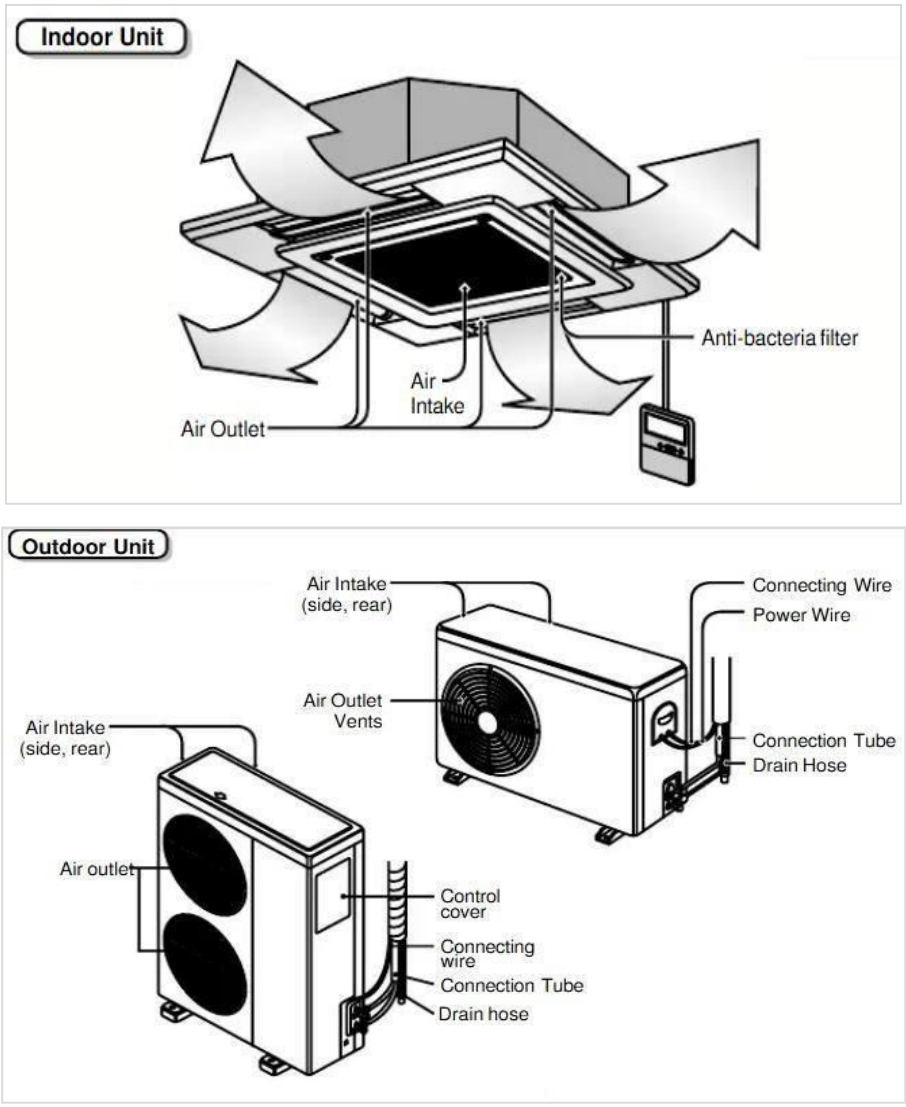


Fig. 3.1 Components of Cassette air conditioner

Fig. 3.2 Cassette Air Conditioner

VIII. Required Resources /Apparatus/Equipment with specification

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Cassette Air Conditioner	Actual set up/ Model of Unitary Air conditioning system showing all important parts. (Minimum 5 TR or above)	01

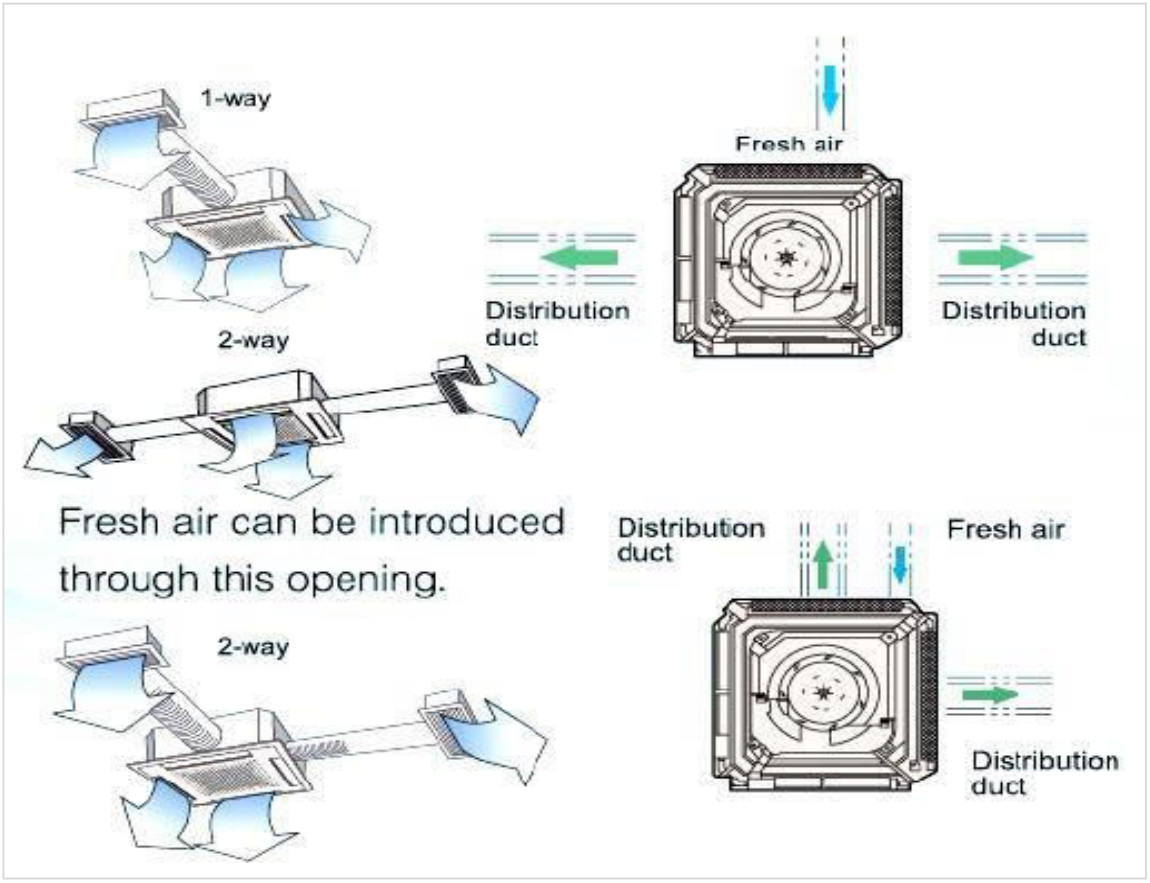


Fig. 3.3: Duct system Cassette air conditioner

IX. Precautions to be Followed

1. Avoid improper handling of Cassette Air Conditioner set up/ Model.
2. Do not release Refrigerants (harmful substances) into the atmosphere.
3. Use special and recommended HVAC Tool Box.

X. Procedure

1. Open the unit with duct system to access internal components.
2. Observe different internal components.
3. Observe duct layout.
4. Indentify duct layout system.
5. Draw air movement diagram.
6. Inspect electrical wiring and components.

XI. Observations and calculations

S. No.	Particulars	Remark
1	Compressor	Capacity-
		Make-
		Type-
2	Condenser	Capacity-
		Type-
		No. of coils-
3	Expansion valve	Name-
		Type-
4	Evaporator	Make-
		Type-
		No. of coils-
5	Blower	Type-
6	Fan Motor	Capacity-
		Type-
7	Duct	Type (cross section)-
		Material of duct-
		Insulation material-

XII. Results

Draw or paste photographs of Different components of Cassette air-conditioner used for practical.

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Enlist common faults in cassette air conditioning system.
2. Collect at least 2 manufacturers catalogue of unitary air conditioning.
3. Compare Cassette and Split air conditioner on the basis of capacity, initial cost, operating cost, applications.

[Space for Answer]

XIII. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=Brlyov7F220
2. https://www.youtube.com/watch?v=hfKa5YQCyn0

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (05 Marks)		**(20%)**
1	Handling of the measuring Instruments	20%
Product Related (20 Marks)		**(80%)**
2	Interpretation of result	30%
3	Conclusions	30%
4	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (5)	**Product Related (20)**	**Total (25)**	

Practical No. 4

Demonstration on Central Air Conditioner system.

I. Practical Significance

The demonstration on the Central Air Conditioner system helps students to get knowledge about its components, working, and real-world applications, while developing basic skills in system design, operation, and maintenance relevant to HVAC industries.

II. Industry/Employer Expected Outcome(s)

This practical is expected to develop the skills for the industry identified competency as "Apply basic maintenance and troubleshooting skills meeting industry expectations for entry-level HVAC technicians and support roles in building management and climate control systems."

III. Course Level Learning Outcome (CO)

CO2 - Select appropriate components for given HVAC applications.
CO3- Select appropriate Air conditioning systems for given situation

IV. Laboratory Learning Outcome(s)

LLO 4.1: Identify the components of central air conditioning system.
LLO 4.2: Demonstrate the central air conditioning system.

V. Relative Affective Domain related Outcome(s)

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background with diagram (if required)

1. Know the construction and working of central air conditioner system.
2. Identify various sub-assemblies of central air conditioner system.
3. Identify recommended tools.

The central air conditioner system can be divided into three parts,

1. Plant room, which includes compressor, condenser and motor
2. Air handling unit room (AHU room)
3. Air distribution system (Ducting)

The plant room is located away from room to be air conditioned. Other components are grouped together in a AHU and conditioned air is circulated through air distribution system i.e. ducting with the help of fan or blower to the room to be air conditioned. As shown in Fig. 4.1, the air, which is to be conditioned, is directly allowed to flow over the evaporator coil. Low pressure and low temperature refrigerant passing through evaporator coil absorbs heat from the air. Thus, the air gets cooled.

VII. Experimental setup

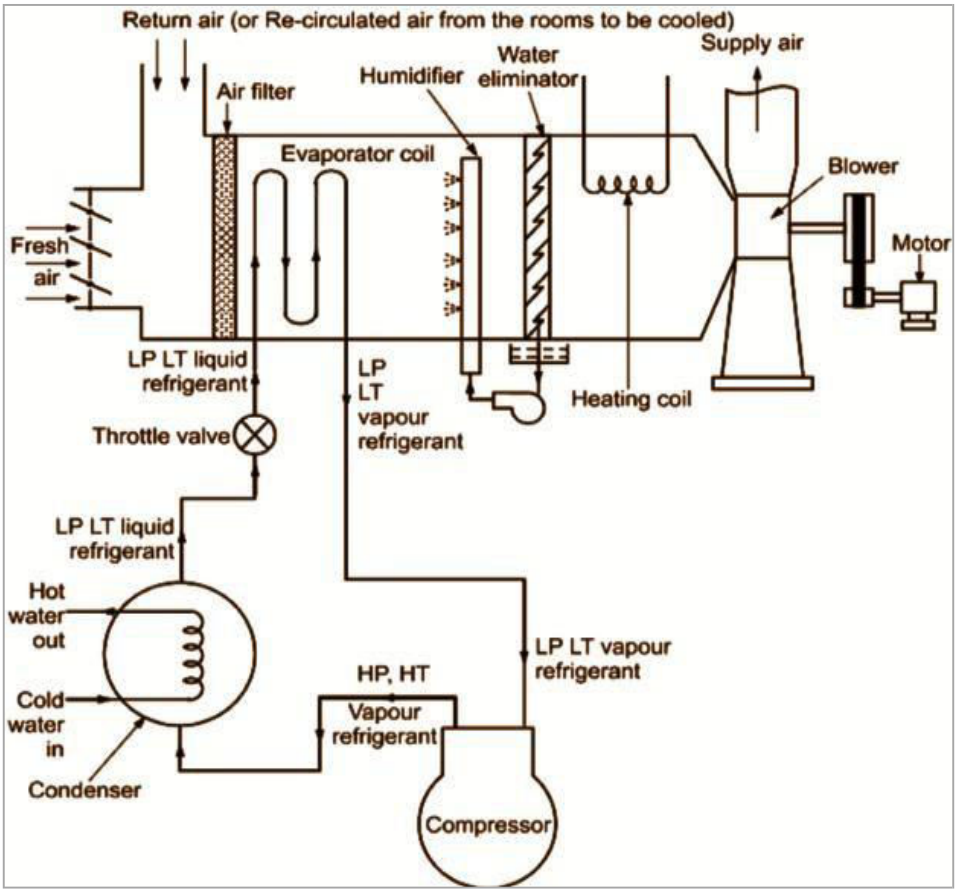


Fig. 4.1: Components of Central Air Conditioner system

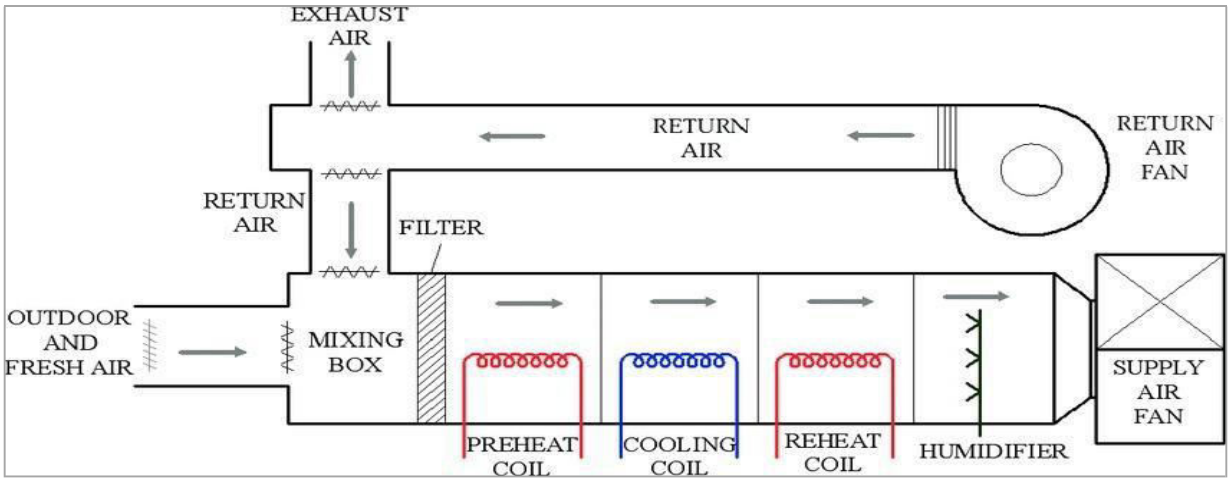


Fig. 4.2: Layout of Central Air Conditioner system

VIII. Required Resources /Apparatus/Equipment with specification

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Central Air Conditioner	Use charts of Central Air Conditioner. Use Videos for demonstration.	01

IX. Precautions to be Followed

1. Avoid improper handling of Central Air Conditioner set up/ Model.
2. Do not release Refrigerants (harmful substances) into the atmosphere.

X. Procedure

1. Identify the different components of central air conditioners through demonstration.
2. Make the list of different components.
3. Write specification.
4. Observe the Air distribution system.

XI. Observations

S. No.	Particulars	Remark
1	Compressor	Type-
		Make-
2	Chiller	Type-
3	Refrigerants used	Primary –
		Secondary –
4	Duct system	Cross-section –
		Material-
		Layout –
5	Air Handling Unit	Position
		Make up duct

XII. Results

Draw or paste photographs of Different components of Central air-conditioner.

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Draw a layout of Central Air Conditioner.
2. Differentiate between Central Air Conditioning system and Unitary Air Conditioning system on the basis of: (a) Area required (b) Capacity (c) Space temperature control (d) Equipment life (f) Maintenance (g) Initial cost (h) Plant room (i) Installation.
3. List out common problems associated with central air conditioning system.

[Space for Answer]

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XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=h5wQoA15OnQ
2. https://www.youtube.com/watch?v=L5jQqmaFKOE
3. https://www.youtube.com/watch?v=TPabv9iDENc

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (05 Marks)		**(20%)**
1	Handling of the Models/set up	20%
Product Related (20 Marks)		**(80%)**
2	Interpretation of result	30%
3	Conclusions	30%
4	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (05)	**Product Related (20)**	**Total (25)**	

Practical No. 5

Dismantling and Assembling of Automobile Air conditioner.

I. Practical Significance

The practical helps students develop hands-on skills in identifying, dismantling, and assembling components of an automobile air conditioning system, preparing them for diagnostics, servicing, and maintenance tasks in the automotive HVAC industry.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the skills for the industry identified competency as; "Apply basic maintenance and troubleshooting skills meeting industry expectations for entry-level HVAC technicians and demonstrating practical skills in system servicing, fault diagnosis, and maintenance"

III. Course Level Learning Outcome (CO)

CO2 - Select appropriate components for given HVAC applications.
CO3- Select appropriate Air conditioning systems for given situation

IV. Laboratory Learning Outcome(s)

LLO 5.1: Select the proper tools for dismantling and assembling.
LLO 5.2: Inspect condition of components.

V. Relative Affective Domain related Outcome(s)

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

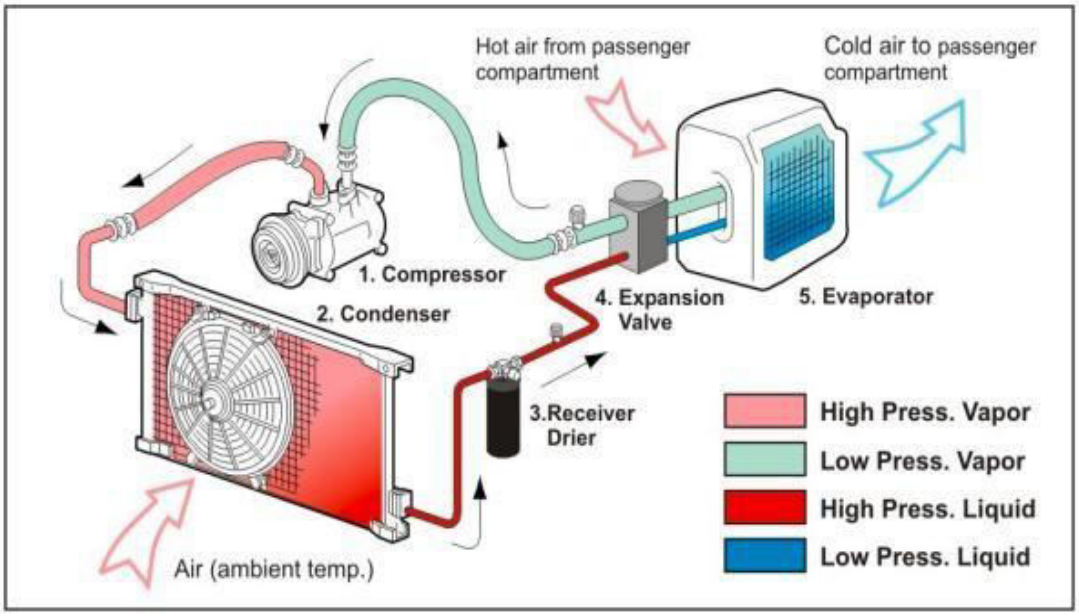
VI. Relevant Theoretical Background with diagram (if required)

1. Know the construction and working of Automobile Air Conditioner system.
2. Identify various subassemblies Automobile Air Conditioner system.
3. Identify recommended tools.
4. Know the procedure of dismantling and assembly

Automobile air conditioning is a necessity for both comfort and safety, particularly in hot weather or high humidity. It provides a comfortable environment for occupants, reduces the risk of heatstroke and dehydration, and can improve driving conditions by preventing fogged-up windows. Additionally, a properly functioning AC can improve fuel efficiency by reducing the need to open windows, which creates drag.

An Automobile air conditioning system consists of a compact version of the components of the normal air conditioner that are evaporator, compressor, condenser, expansion device and a fan which are fitted in a car to provide air condition inside the passenger's compartment.

VII. Experimental setup



.Fig. 4.1: Components of Automobile Air Conditioner system

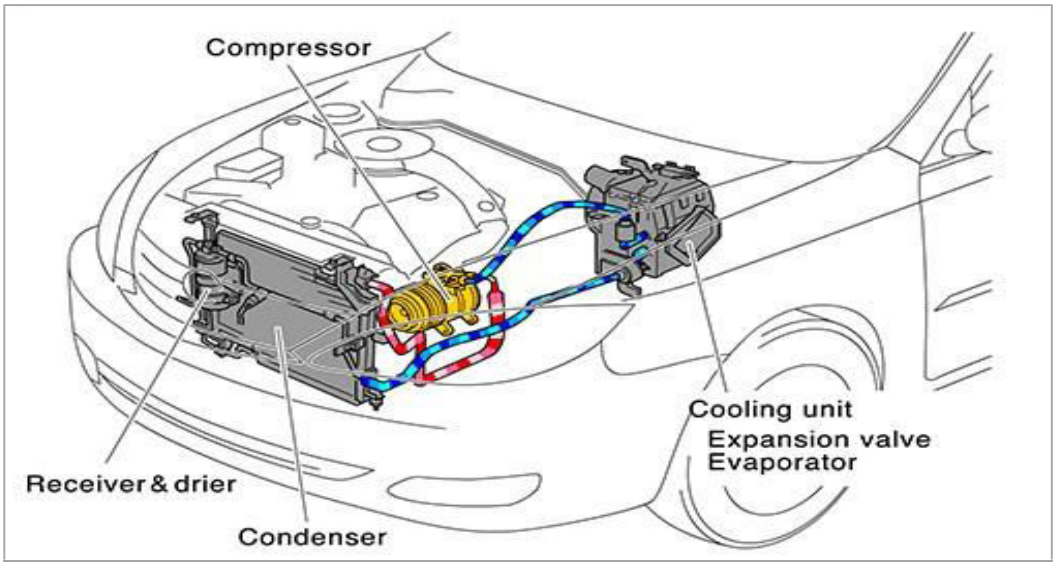


Fig. 4.2: Automobile Air Conditioner Systems

VIII. Required Resources /Apparatus/Equipment with specification

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Automobile Air Conditioner	Demonstration model of Automobile Air Conditioner: Automobile AC Compressor, Capacity: 10-1000 CFM or more. Use charts and Videos for demonstration	01

IV. Precautions to be Followed

1. Recover refrigerant before dismantling to avoid harmful gas release.
2. Label and store parts systematically to ease reassembly.
3. Use special and recommended tools for assembly and dismantling of automobile air conditioning system.

X. Procedure

1. Select the vehicle/model for practical.
2. Visually inspect unit.
3. Select the proper tools for dismantling and assembling.
4. Identify the components.
5. Inspect the condition of components.

XI. Observations and calculations

S. No.	Particulars	Remark
1	Compressor	Type-
		Location of Compressor-
2	Condenser	Type-
		Location of Condenser-
3	Expansion valve	Type-
		Location of Expansion valve-
4	Evaporator	Type-
		Location of Evaporator
5	Receiver and Drier	
6	Air filter	

XII. Results

Draw or paste photographs of Different components of automobile air-conditioner.

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. List the tools required for dismantling and assembling an automobile AC system.
2. List the common issues found in automobile AC systems during servicing
3. Draw layout of Automobile air conditioning system
4. List refrigerants used in automobile air conditioner.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=ODYEyAl8ztE
2. https://www.youtube.com/watch?v=74StaGd6ORo
3. https://www.youtube.com/watch?v=WCTVydZ1ohg

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Handling of the Models/set up	40%
2	Observations of models/set up	20%
Product Related (10 Marks)		**(40%)**
3	Interpretation of result	20%
4	Conclusions	10%
5	Practical related questions	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 6

Trial on Air conditioning system.*

I. Practical Significance

This practical helps student to study performance evaluation of an air conditioning system through real time measurements of parameters. It enables them to calculate performance indicators. Analyzing system behavior under different operating conditions, students develop diagnostic and energy efficiency assessment skills, which are essential for HVAC system design, optimization, and maintenance in industrial and commercial settings.

II. Industry/Employer Expected Outcome(s)

This practical is expected to develop the skills for the industry identified competency as; "Evaluate the performance of an air conditioning system."

III. Course Level Learning Outcome (CO)

CO3 - Select appropriate Air conditioning systems for given situation.
CO4 - Calculate cooling load for a particular situation.

IV. Laboratory Learning Outcome(s)

LLO 6.1: Conduct performance test on Air Conditioning Test rig to evaluate the cooling effect.
LLO 6.2 Measure and record parameters such as supply air temperature return air temperature, outdoor air temperature and humidity levels.

V. Relative Affective Domain Related Outcome(s)

- Demonstrate working as a leader/ team member.
- Maintain tools and equipment.
- Follow ethical Practices.
- Follow safety practices.

VI. Relevant Theoretical Background (with Diagram)

The Air Conditioning Test Rig works on the vapor compression refrigeration cycle, which is used in most air conditioners. In this cycle, a refrigerant absorbs heat from the air and removes it from the space to be cooled.

The Vapor Compression Refrigeration (VCR) Cycle has four main components:

1. **Compressor –** Increases refrigerant pressure and temperature.
2. **Condenser –** Releases heat to the outside air and turns the gas into a liquid.
3. **Expansion Valve –** Reduces pressure and cools the liquid refrigerant.
4. **Evaporator –** Absorbs heat from indoor air; refrigerant evaporates and cools the room.

This process cools the air, which is then blown into the room. The rig allows measurement of temperatures, humidity, airflow, pressure, and power, helping students understand cooling performance and energy efficiency.

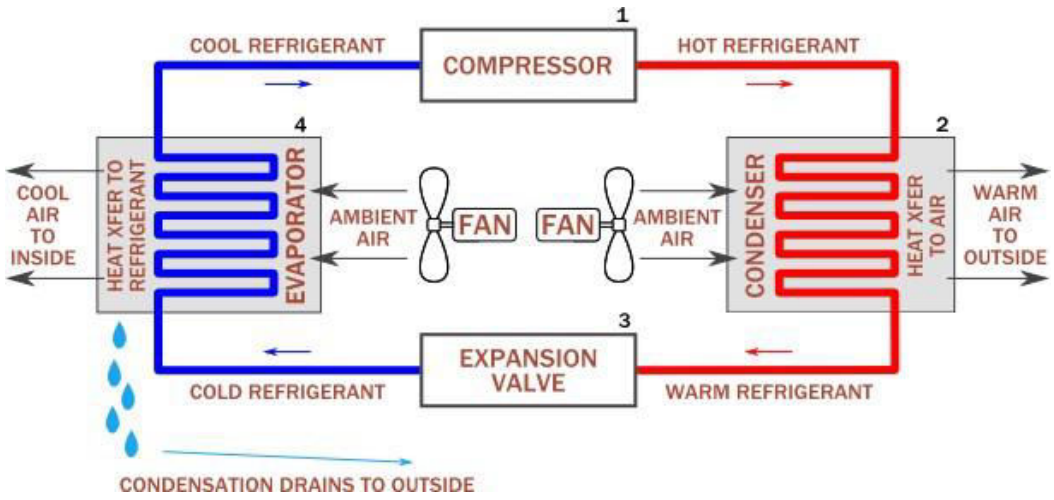


Fig. 6.1: components of air conditioner

VII. Experimental Setup

- An Air Conditioning Test Rig is a lab setup that shows how a basic cooling system works using a vapor compression cycle. Or
- Working model of Split or Window type AC at least 1TR capacity with test panel required.

Fig. 6.2 Air conditioning test rig

VIII. Required Resources / Apparatus / Equipment

Equipment	Suggested broad Specification	Quantity
AC Test Rig	An Air Conditioning Test Rig is a lab setup that shows how a basic cooling system works using a vapor compression cycle. Working model of Split or Window type AC at least 1TR capacity with test panel.	1
Thermometers/Sensors	-10°C to 150°C For measuring return and supply air temps	1
Hygrometer	Humidity: 0% RH to 100% RH For humidity measurement	1
Wattmeter	**Voltage:** 0 to 250 V AC (single-phase) or 0 to 440 V AC (three-phase) For power consumption measurement	1
Anemometer (optional)	**Velocity:** 0.2 m/s to 30 m/s (vane type) For air velocity measurement	1
Stopwatch	Digital Stopwatch For time control	1
Psychrometric chart	For calculating humidity-related values of ASHRAE	1

IX. Precautions to be followed

1. Avoid improper handling of all instruments.
2. Record readings properly only after system reaches steady condition.
3. Turn off the system immediately in case of abnormal noise
4. After the experiment, switch off main power.

X. Procedure

1. Switch ON the AC test rig and allow it to run for 10–15 minutes to reach steady state.
2. Measure and record the following:
    a) Supply air temperature (after cooling coil)
    b) Return air temperature (before cooling coil)
    c) Outdoor air temperature
    d) Indoor and outdoor humidity
3. Record power consumption using wattmeter.

XI. Observations and Calculations

S. No.	Parameter	Value	Unit
1.	Supply air temperature- Temperature of air after it passes through the cooling coil		°C
2.	Return air temperature- Temperature of air returning from the conditioned space back to the system		°C
3.	Dry Bulb Temperature (DBT): Before the coil (°C)		°C
4.	Dry Bulb Temperature (DBT): After the coil (°C)		°C
5.	Wet Bulb Temperature (WBT): Before the coil (°C)		°C

S. No.	Parameter	Value	Unit
6.	Wet Bulb Temperature (WBT): After the coil (°C)		°C
7.	Outdoor Relative Humidity		%
8.	Air Flow Rate (Qv)=A·V		m³/min
9.	Power Input (W)		kW
10.	Cooling Effect (Q)		kW
11.	Coefficient of Performance (COP)		Unit less

Calculations:

1. The setup includes an **Air Conditioning Test Rig** with measuring instruments. It simulates real AC operation and lets us measure:
   a) Return and supply air temperatures
   b) Indoor and outdoor humidity
   c) Power used by the AC unit
2. This helps to understand how much cooling the AC provides and how efficiently it works.
   Cooling Effect (Q) is calculated as:

$$\mathbf{Q = \dot{m} * Cp * (T_{return} - T_{supply})}$$

Where:

$\dot{m}$: mass flow rate of air (kg/s)

Cp: specific heat of air (~1.005 kJ/kg·K)

T_{return} - T_{supply} : air temperatures before and after cooling

To calculate the mass flow rate,

$$\mathbf{\dot{m} = \rho * A * V}$$

Where,

ρ = density of air (typically ~1.2 kg/m³ at room temperature)

A = cross-sectional area of the duct (m²)

V = velocity of air in the duct (m/s)

COP (Coefficient of Performance): COP=Q/W

Where, W is the electrical power consumed.

1. Determine Enthalpy using Psychrometric Chart or Table:

Use DBT and WBT to get specific enthalpies:

h_1 = Enthalpy of air entering the evaporator (kJ/kg)

h_2 = Enthalpy of air leaving the evaporator (kJ/kg)

2. Cooling Capacity (Refrigeration Effect):

$$Q = \dot{m} * (h_1 - h_2) \text{ (kJ/min)}$$

Convert to kW: $Q_{kW} = Q/60$

3. Compressor Power Input:

P=Wattmeter Reading (in kW) =

4. Coefficient of Performance (COP):

$COP=Q_{kW}/P$

XII. Results

S. No.	Parameters	Measured Value
1	Cooling Effect of the system	kW
2	Power consumed	kW
3	COP of the system	

XIII. Interpretation of Results

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XIV. Conclusions and Recommendation

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XV. Practical Related Questions:

Note: Below given are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Name refrigerant commonly used in the test rig.
2. Calculate the coefficient of performance (COP) if cooling capacity is 2 kW and power input is 0.5 kW.
3. List the parameters of comfort air conditioning along with their values.
4. List the factors that influence the efficiency of an air conditioning system.

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XVI. References / Suggestions for Further Reading

1. Test on AC Test Rig: https://youtu.be/lJRvx8pYsNU?si=rrW-Tra_06jvbC4M
2. AC Test Rig: https://youtu.be/5dgRgBuWDZw?si=B16HfyJG8GEIqOzE
3. Trial on AC Test Rig: https://youtu.be/UVH-WNDaDiA?si=bHIubRtmh5CMDzKU

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Handling of the Measuring Instruments	20%
2	Taking readings of required parameters	20%
3	Calculation of Final Readings	20%
Product Related (10 Marks)		**(40%)**
4	Interpretation of result	20%
5	Conclusions	10%
6	Practical related questions	10%
	Total	100 %

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 7

Cooling and Heating Load Calculations.*

I. Practical Significance

This practical helps student to estimate the amount of heat energy that must be added or removed from a space to maintain desired indoor conditions. It involves identifying heat gain or loss due to factors like solar radiation, occupancy, lighting, equipment, and ventilation. Performing these calculations, students gain skills essential for designing and selecting appropriate HVAC systems, ensuring energy efficiency, occupant comfort, and cost-effective operation in residential, commercial, and industrial buildings.

II. Industry/Employer Expected Outcome

This practical is expected to develop the skills for the industry identified competency as; "Calculate cooling and heating loads for different types of given room or buildings, enabling them to design and select suitable HVAC systems".

III. Course Level Learning Outcome (CO)

CO4 - Calculate cooling load for the particular situation.

IV. Laboratory Learning Outcome(s)

LLO 7.1: Analyze the specific thermal loads and environmental conditions of a specific space.

LLO 7.2: Calculate heat gains and losses.

V. Relative Affective Domain Related Outcome(s)

- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.
- Practice energy conservation.

VI. Relevant Theoretical Background (with Simple Diagram):

Cooling Load is the total heat a room gains and needs to be removed to keep the temperature comfortable.

Heating Load is the total heat a room loses and needs to be added to maintain warmth.

Types of Loads:

1. External Load: Sunlight, outdoor temperature (through walls, roof, windows).
2. Internal Load: People, lights, machines inside the room.

Formula (simplified):

Total Load $\mathbf{Q=U\cdot A\cdot \Delta T}$

Where:

Q= Heat gain/loss (W)

U = Heat transfer coefficient ($W/m^2 \cdot K$)

A = Area of wall/window (m^2)

ΔT = Temperature difference between inside and outside (°C)

A = Area of wall/window (m^2)

ΔT = Temperature difference between inside and outside (°C)

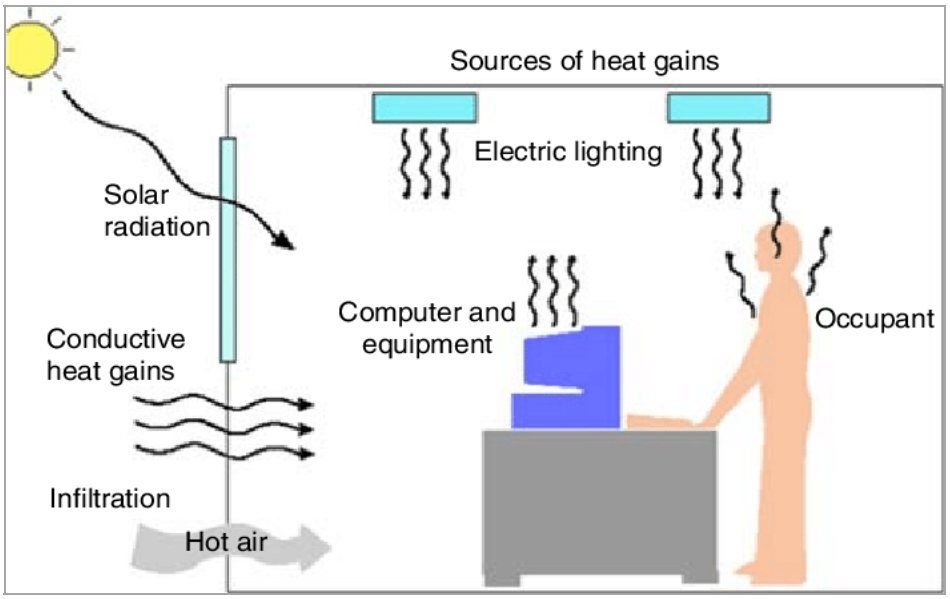

Fig. 7.1: Heating load components

VII. Experimental Setup

You need to choose a sample room or use a model house/lab setup. You'll collect data about:

1. Room size (length, width, height)
2. Type and area of walls, windows, doors
3. Number of people and appliances inside
4. Indoor and outdoor temperatures

VIII. Required Resources / Apparatus / Equipment

Item	Specification/Description	Quantity
1. Measuring tape	For room dimensions	1
2. Thermometer	For indoor and outdoor temperatures	1
3. Hygrometer (optional)	To measure humidity	1
4. Calculator	For load calculations	1
5. Data sheets or templates	For noting wall/window areas, materials, etc.	1
6. Psychrometric chart (optional)	For accurate humidity-based analysis	1

IX. Precautions to be Followed

- Avoid improper handling of all instruments.
- Use correct room measurements
- Avoid wrong assumptions
- Record all data clearly
- Close doors and windows

X. Procedure:

1. Measure the room size (length × width × height).
2. List all external walls, windows, and doors with area and material (e.g., brick, glass).
3. List number of occupants inside room.
4. Note indoor and outdoor temperatures.
5. Calculate heat gain/loss through each wall/window using the formula:

$$Q=U*A*\Delta T$$

(Use U-values from standard tables, e.g., 0.8 W/m²·K for brick walls, 5.5 W/m²·K for single glass).

6. Add internal heat gains from:
   - People (~100 W/person)
   - Lights (~10 W/bulb)
   - Equipment (as per rating)
7. Add all values to get total cooling or heating load in watts or kilowatts.

XI. Observations and Calculations:

Observation Table:

Element	Area (m²)	U-value (W/m²·K)	ΔT (°C)	Q (W)
Walls				
Windows				
Doors				
Occupants (. . nos.)				
Lights (....nos.)				
Total Load				

Calculations:

Measure Room Size:

Length (L): ____ m

Width (W): ____ m

Height (H): ____ m

Volume = L × W × H

List All External Components:

For each wall, window, and door – note:

Area (A): ____ m²

Material: e.g., Brick, Glass

U-Value: Use standard (e.g.,

Brick Wall = 0.8 W/m²·K

Glass Window = 5.5 W/m²·K)

Note Temperatures:

Indoor Temperature (Ti): ____ °C

Outdoor Temperature (To): ____ °C

ΔT = |To - Ti|

Calculate Heat Transfer for Each Surface:

Use formula:

Q = U × A × ΔT (in watts).

Add Internal Heat Gains:

People: 100 W × No. of persons = ____ W

Lights: 10 W × No. of bulbs = ____ W

Equipment: Use power rating = ____ W

Calculate Total Load:

Total Heat Gain/Loss = Sum of all Q values

Express in **watts (W)** or **kilowatts (kW)**

XII. Result:

Total Cooling Load =..... W

(This is the capacity your AC must handle for this room to stay cool.)

XIII. Interpretation of Results:

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XIV. Conclusions and Recommendation:

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XV. Practical Related Questions:

Note: Below given are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. State the necessity of cooling load calculation
2. Name sensible heat gain sources in a room.
3. List the factors affecting cooling load in a building.
4. Write the effect of infiltration on cooling load.

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XVI. References / Suggestions for Further Reading

1. Cooling & Heating Load Calculations: https://youtu.be/2Z3Q32CG9xQ
2. Cooling Load Calculation: Cold Room hvac- https://youtu.be/0gv2tJf7nwo
3. Heat Load Calculation HVAC: https://youtu.be/9-K9Y5b8M5c
4. (Load Calculation) Overview: https://youtu.be/aCIrbSFWD20

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Handling of the Measuring Instruments	20%
2	Taking readings of required parameters	20%
3	Calculation of Final Readings	20%
Product Related (10 Marks)		**(40%)**
4	Interpretation of result	20%
5	Conclusions	10%
6	Practical related questions	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 8

Prepare Layout of Air Distribution System for a Given Space.*

I. Practical Significance

This practical enables student to design an efficient air distribution layout by considering factors such as room dimensions, occupancy, equipment load, and air flow requirements. It develops skills in selecting and positioning ducts, diffusers, and air handling units to ensure uniform temperature distribution, adequate ventilation, and occupant comfort. The exercise prepares students for real-world applications in HVAC system design, contributing to energy-efficient, safe, and functional indoor environments in residential, commercial, and industrial settings.

II. Industry/Employer Expected Outcome

This practical is expected to develop the skills for the industry identified competency as; "Design an effective air distribution system layout, ensuring proper ventilation, comfort, and energy efficiency in various indoor spaces, preparing them for real-world HVAC applications".

III. Course Level Learning Outcome (CO)

CO4- Calculate cooling load for particular situation.

CO5- Develop proper Air distribution systems according to site requirement for the given situation.

IV. Laboratory Learning Outcome(s)

LLO 8.1: Prepare Air distribution system layout.

LLO 8.2: Create schematic layouts by using Auto-CAD that illustrates the proposed duct routes, sizes, and connections.

V. Relative Affective Domain-related Outcome(s)-

- Demonstrate working as a leader/ team member.
- Maintain tools and equipment.
- Follow ethical Practices.
- Practice good housekeeping.

VI. Relevant Theoretical Background (with Diagram):

Air Distribution System includes:

1. **Ducts:** Pathways for air to travel from the air handling unit (AHU) to rooms.
2. **Diffusers/Grilles:** End-points of ducts where air enters or exits the space.
3. **Return Air Paths:** For bringing used air back to the AHU.

Design Factors:

1. Room size and shape
2. Air flow rate needed
3. Number and location of diffusers

- Duct size and layout (main duct, branches)

Duct Sizing Formula (based on flow rate and velocity):

$$Q = A \times V$$

Where; Q = Air flow rate (m^3/s)

A = Duct cross-sectional area (m^2)

V = Velocity of air (m/s)

VII. Experimental Setup

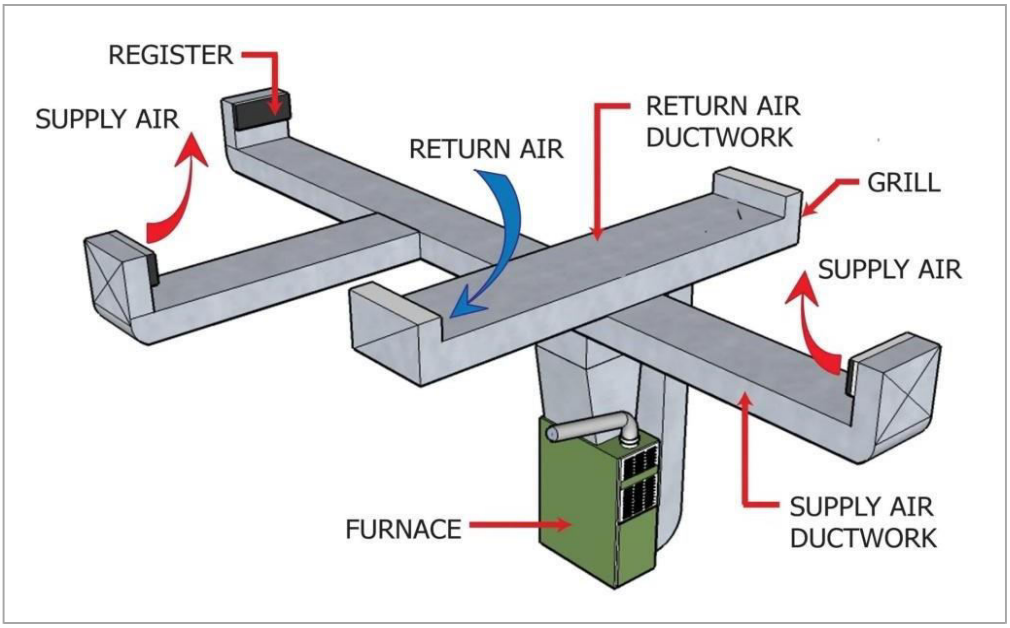

Fig. 8.1: Air Distribution System

Use a given room layout (e.g., classroom, office space) and perform:

1. Load calculation to estimate airflow
2. Decide number and location of outlets
3. Design main and branch duct routes
4. Create schematic layout using AutoCAD

AutoCAD Layout Instructions:

1. Open AutoCAD and set units to meters or millimeters.
2. Import or draw the room layout.
3. Draw supply ducts as polylines or rectangles.
4. Mark diffuser positions with symbols.
5. Label all duct sizes and air flow values.
6. Add return ducts and AHU location.
7. Use layering (e.g., DUCT-SUPPLY, DUCT-RETURN) for clarity.
8. Save and print the layout.

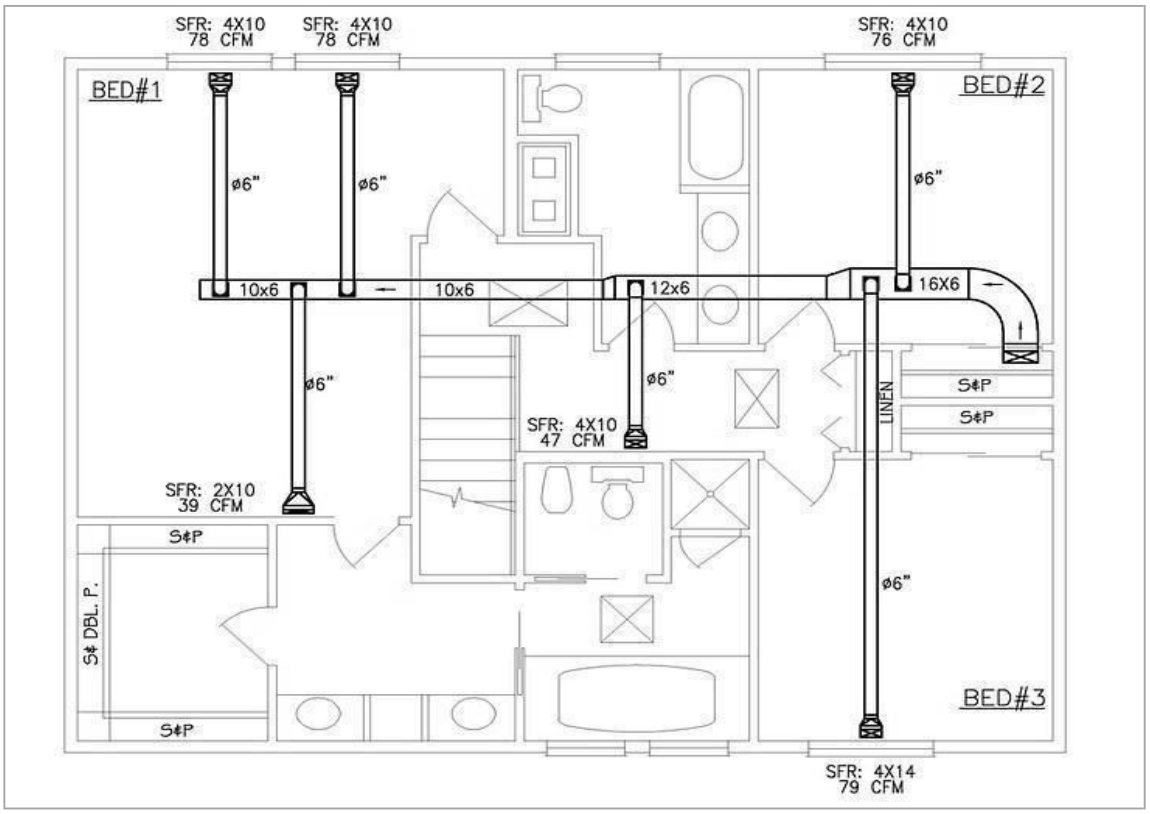

Fig. 8.2: Sample AutoCAD drawing of Air Distribution System

VIII. Required Resources / Apparatus / Equipment

Equipment/Software	Specification / Use	Quantity
Room plan or blueprint	Physical or digital layout of the space	1
Measuring tape	For room dimensions (if actual space used)	1
Calculator	For airflow and sizing calculations	1
Duct sizing charts	For standard duct sizes and velocity ranges	1
AutoCAD software	For preparing schematic layout	1
Computer with AutoCAD	With HVAC template (if available)	1

IX. Precautions to be Followed

1. Handle drawing instruments carefully
2. Follow safety rules while handling measuring tools.
3. Keep duct runs as short as possible to reduce pressure loss.
4. Maintain proper spacing between supply and return outlets.
5. Use correct symbols and scale in the layout drawing.

X. Procedure:

1. **Study the room layout**
   – Measure or note the room dimensions (length × width × height) and count number of occupants.
2. **Estimate required airflow**
   – Use comfort load guideline: approx. 10 L/s per person (e.g., 4 people × 10 L/s = 40 L/s = 0.04 m^3/s).
3. **Decide number of supply air outlets**
   – Use 1 outlet per 10–15 m^2 of floor area for uniform air distribution.
4. **Select duct layout type**
   – Choose branch layout or trunk & branch based on room shape and obstacles.
5. **Keep ducts short and straight**
   – Minimize bends and length to reduce frictional losses.
6. **Calculate duct size using formula**
   – Use **Q = A × V** where:
   Q = Air flow rate (m^3/s)
   A = Duct area (m^2)
   V = Velocity (assume 5–7 m/s)
7. **Draw layout in AutoCAD (or manually)**
   – Prepare a **single-line duct layout** showing:
   - Air handler location
   - Main ducts and branches
   - Supply diffusers and return grilles
   - Duct sizes and labels
8. **Ensure proper return air placement**
   Place return grille opposite to supply outlets to ensure complete circulation.
9. **Add standard HVAC symbols and legend**
   Use conventional symbols for diffusers, grilles, ducts, dampers, etc.
10. **Review and finalize**
    Recheck dimensions, labels, airflow path, and neatness before submission.

XI. Observations and Calculations:

Consider your departmental laboratories for layout.

S. No.	Parameter	Value	Unit
1	Room area:		m^2
2	Number of Occupants		Unit less
3	Required Air Flow per Person (As per comfort guideline)		L/s
4	Total Required Air Flow (Q)		m^3/s

S. No.	Parameter	Value	Unit
5	Number of Supply Outlets (Based on 1 per - 12 m^2)		outlets
6	Air Flow per Outlet: (Q / No. of outlets)		m^3/s
7	Duct Area: (A = Q/V) per Outlet		m^2
8	Diameter of Circular Duct (per outlet)		mm

Calculations:

Calculate Room Area

Room area: ….. m × …… m = ……. m^2

Calculate Required Air Flow (Q): Using comfort load guideline:

Air flow per person= ……..L / s = ……. m^3 / s

For 4 persons: Q = 4 × Air flow per person = ……. m^3 / s

Decide Number of Supply Outlets

Using 1 outlet per 10–15 m^2:

Number of outlets = Room area / 12 =.....outlets

Calculate Air Flow per Outlet

$Q_{per\ outlet}$ = Q / number of outlets =..... m^3 / s

Calculate Duct Size for Each Outlet

Assuming velocity V = 5 to 10 m/s

Using formula Q = A × V

Where A = cross-sectional area of duct

A=Q / V= .....m^2

Convert Area to Diameter for Circular Duct

Area of circle: $A=\pi \times (d/2)^2$

Rearranged for diameter d:

$$d = 2 \times \sqrt{(A/\pi)}$$

= …….m

= …….mm

So, use **duct diameter =**..... **mm** (nearest standard size).

XII. Result:

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XIII. Interpretation of Results:

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XIV. Conclusions and Recommendation:

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XV. Practical Related Questions:

Note: Below given are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. State the purpose of an air distribution system in HVAC.
2. Name commonly used duct materials in air distribution.
3. List the major components of an air distribution system.
4. Draw different duct sections usually used in HVAC system.

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XVI. References / Suggestions for Further Reading

1. Function & Benefits of HVAC: https://youtube/tRB9gyXitGk?si=R6EwN1M50ZhDyl5A
2. Air Distribution System: https://youtu.be/gRcgUfeAHl4?si=V30WMYuP77gq3T1j
3. Air Distribution System Design: https://youtu.be/fNzekzchskY?si=9GSPoBeiTv4_J2GD
4. Introduction to Air Distribution: https://youtu.be/AajG6-X5xZY?si=hGvBQMF8AZbFwmNf

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Preparation of Schematic Layout	40%
2	Preparation of Layout using AutoCAD	20%
Product Related (10 Marks)		**(40%)**
3	Interpretation of result	20%
4	Conclusions	10%
5	Practical related questions	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 9
Demonstration on Railway HVAC System.

I. Practical Significance

This practical enables student to gain foundational knowledge of HVAC systems used in railway coaches, including their components, working principles, and control mechanisms. They will be able to identify system parts, study air distribution and temperature regulation specific to mobile environments, and recognize maintenance needs. This prepares them for roles in railway HVAC servicing, maintenance, and system integration, meeting the industry's demand for skilled technicians in transportation climate control systems.

II. Industry/Employer Expected Outcome

This practical is expected to develop the skills for the industry identified competency as; "Prepare air distribution system layout"

III. Course Level Learning Outcome (s)

CO3 – Select appropriate Air conditioning system for given situation.

CO5 - Develop proper Air distribution systems according to site requirement for the given situation.

IV. Laboratory Learning Outcome(s)

LLO 9.1: Identify the components of a railway HVAC System.

LLO 9.2: Prepare Air distribution system layout.

LLO 9.3: Create schematic layouts by using Auto-CAD that illustrates the proposed duct routes, sizes, and connections.

V. Relative Affective Domain-related Outcome(s)

- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.
- Follow safety practices.

VI. Relevant Theoretical Background (with Diagram)

Railway HVAC systems usually use the Vapor Compression Refrigeration Cycle to cool air, and electric or hot water-based systems to heat air in winters. They are compact and mounted on coach roofs or under frames.

Main Components:

- **Compressor:** Pressurizes refrigerant.
- **Condenser:** Releases heat to outside air.
- **Expansion valve:** Reduces pressure of refrigerant.
- **Evaporator:** Absorbs heat from cabin air to cool it.
- **Blowers/Fans:** Circulate air through ducts inside the coach.
- **Filters:** Clean dust and dirt from air.

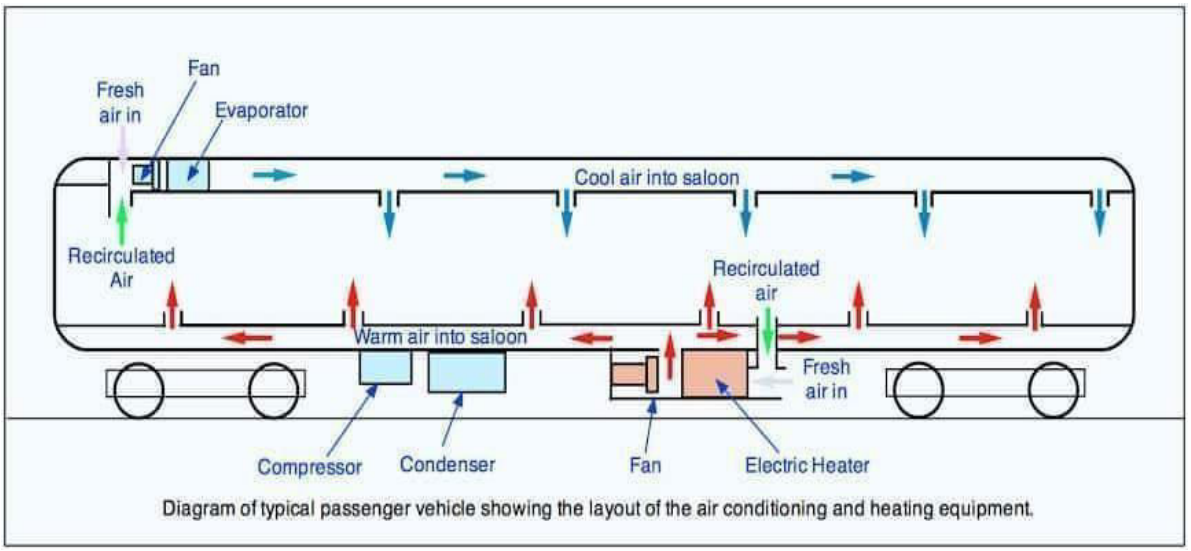

Fig. 9.1: Layout of Railway HVAC System

VII. Experimental Setup

The demonstration is typically done using:

1. A cutaway model or animation/video that shows working components of Railway HVAC system.
2. Charts of Railway HVAC system.
3. Measurement tools to observe temperature, air velocity, and power use.

VIII. Required Resources / Apparatus / Equipment

Equipment	Specification / Use	Quantity
Railway Coach HVAC unit	Cut way model	1
Coach layout drawing	For air duct design reference	1
Video/Animation (if physical unit not available)	To demonstrate component functions use following link: https://youtu.be/FlPGoFcKyeg?si=mOGuKt2UF-lhjrvG. (*Subject teacher should refer other convenient link also*)	1

IX. Precautions to be followed (Safety instructions/Rules/Standards)

1. Follow the instructions given by Teacher at all times.
2. Do not operate controls without permission.
3. Handle tools and gauges with care and proper grip.

X. Procedure

1. Watch a video/model of a train coach with an HVAC system.
2. Identify all components: compressor, evaporator, condenser, ducts, and blower.
3. Observe the air flow path from intake to return.

XI. Observations

Parameter	Value	Unit
1. Supply air temperature		°C
2. Return air temperature		°C
3. Cabin air temperature change		°C per min
4. Air velocity at outlet		m/s
5. Power consumed (if measurable)		kW

XII. Result

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XIII. Interpretation of Results

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XIV. Conclusions and Recommendation

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XV. Practical Related Questions:

Note: Below given are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Name air conditioning system used in railway coaches.
2. Name refrigerant commonly used in railway HVAC systems.
3. State the effect of poor HVAC maintenance on passenger comfort.
4. List common problems and maintenance issues associated with railway HVAC systems.
5. Explain working of Railway HVAC system.

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XVI. References / Suggestions for Further Reading

1. Working of Metro Train HVAC: https://youtu.be/FlPGoFcKyeg?si=mOGuKt2UF-lhjrvG
2. AC Unit of Train: https://youtu.be/wQ1Q7cLWdDs?si=TM3wMvCGorn355Z3
3. HVAC System in Train: https://youtu.be/IXoTOvv7TGk?si=Zhocx7yCiylLKqY5
4. Study of a Railway AC System: https://youtu.be/Y8yZbUBmpWY?si=oIT_QfkoB-CqYKEl
5. Nose/Vibration issues in railway AC: https://youtu.be/bbm09LLtLrI?si=1iYvaB9pYKsMUm7Y

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Observations of the models/setup	40%
Product Related (15 Marks)		**(60%)**
2	Interpretation of result	10%
3	Conclusions	10%
4	Practical related questions	40%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (10)	**Product Related (15)**	**Total (25)**	

Practical No. 10

Air conditioning system used in ancient India (IKS).

I. Practical Significance

This practical introduces students to traditional cooling techniques used in ancient India, such as passive cooling, use of water bodies, ventilation strategies, and architectural designs like thick walls, courtyards, and wind catchers. It helps students to study the principles of natural ventilation and thermal comfort without mechanical systems. The practical encourages sustainable thinking and inspires the integration of eco-friendly, low-energy cooling methods into modern HVAC design, aligning with green building and energy conservation practices.

II. Industry / Employer Expected Outcome

This practical is expected to develop the skills for the industry identified competency as; "Develop modern HVAC systems by integrating eco-friendly, low-energy cooling methods through sustainable thinking."

III. Course Level Learning Outcome (CO)

CO1 - Apply Psychrometric principles for HVAC applications.
CO2 - Select appropriate components for HVAC applications.
CO3 - Select appropriate Air conditioning system for given situation.
CO4 - Calculate cooling load for a particular situation.
CO5 - Develop proper air distribution systems according to site requirement for given situation.

IV. Laboratory Learning Outcome(s)

LLO 10.1: Identify the components of Air conditioning system used in ancient India.
LLO 10.2: Prepare a report on Air conditioning system used in ancient India.

V. Relative Affective Domain Related Outcome(s)

- Demonstrate working as a leader/a team member.
- Follow ethical Practices.
- Practice energy conservation.
- Practice good housekeeping

VI. Relevant Theoretical Background (with Diagram)

Following are different methods used for cooling purposes in ancient India.

1. Grass Curtains method: Curtains made from *khus* grass were hung in windows and doorways. Water was regularly sprinkled on them. As air passed through the wet grass, it cooled due to evaporation and entered the house as cool air. Provided a refreshing scent and reduced indoor temperatures.

2. Use of Earthen Pots (Matkas): For Cooling Water and Air - Water stored in *matkas* (porous earthen pots) remained cool as water slowly evaporated through the pot walls. The evaporation process cooled the pot and the surrounding air slightly. Provided cool drinking water and helped cool small spaces.

3. Hanging Wet Cloth over Windows: Wet cotton sheets or towels were hung on window grills or doorways. Functioned like an evaporative cooler, as wind passing through cooled the air. Low-cost, reusable, and quick.

4. Use of Charpai (Woven Cot) for Sleeping - Instead of mattresses, people slept on *charpais* made of jute or cotton ropes. Allowed airflow underneath the body, helping sweat to evaporate and cool the body. Comfortable in hot and humid climates, especially when placed outdoors at night.

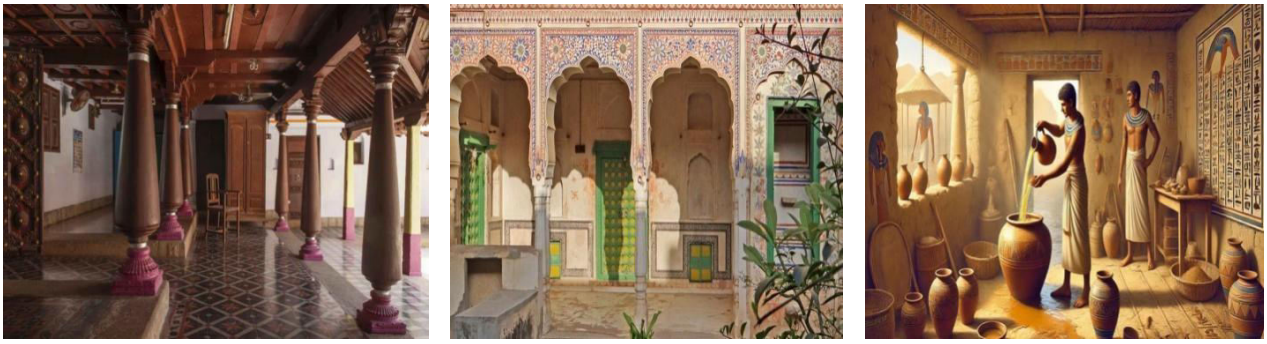
5. Use of Cow Dung Plaster - Walls and floors were sometimes coated with cow dung mixed with mud, a traditional antibacterial and insulating material. Provided thermal insulation and kept interiors naturally cool. Eco-friendly, sustainable, and hygienic.

6. Thick Mud or Stone Walls - Houses were built using mud bricks, clay, or stone, with thick walls (often over 1 foot thick). These materials absorbed heat slowly during the day and released it slowly at night, maintaining a cooler indoor temperature. Natural insulation; very effective in hot and dry regions like Rajasthan.

7. Use of Wind Catchers - In certain regions, structures like wind catchers or high vents were used to trap cool breezes. These directed wind into living spaces while pushing out warm air. Functioned like a natural air conditioner in desert homes.

VII. Experimental Setup

Below is a simple illustration of an **ancient India Air-cooling system** with water pots, wet cloth ventilation openings:



(a) **(b)** **(c)**

Photograph 10.1: (a) Chettinad Mansions of Tamil Nadu: The houses designed with high ceilings and thick walls, which help keep the interiors cool. (b) A haveli of Rajasthan: The central courtyard helps in keeping the house cool by allowing hot air to rise and escape. (c) Natural insulation: Materials like straw, clay, and mud were used to insulate homes, keeping interiors cooler.

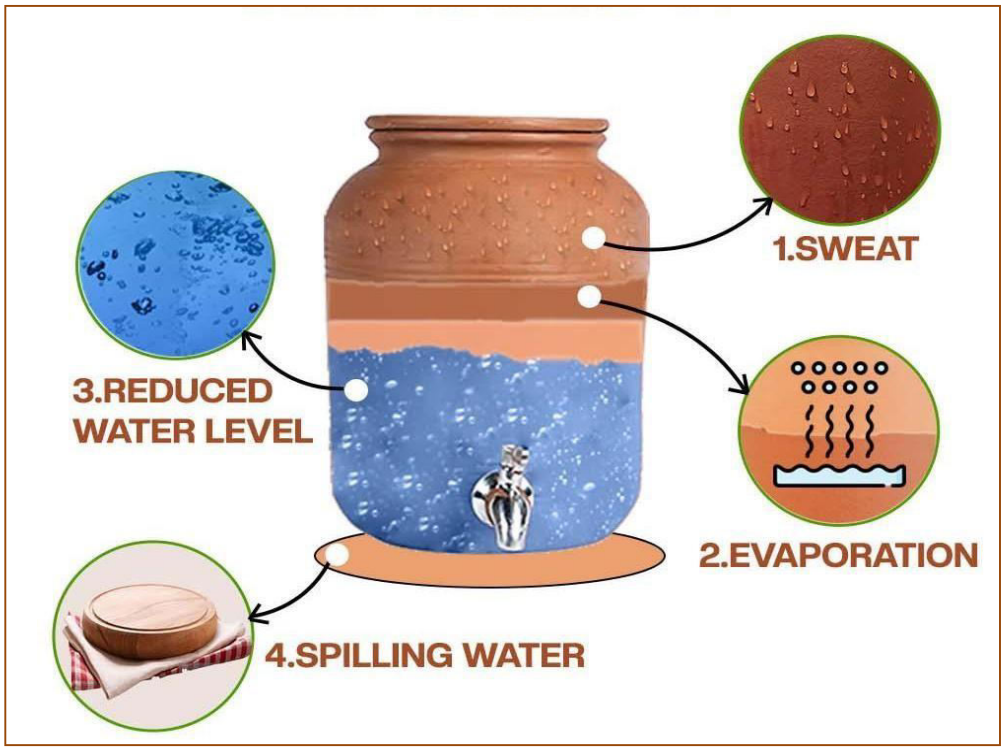


Fig.10.2: Natural cooling clay water pot

VIII. Required Resources/Apparatus/Equipment

S. No.	Item	Purpose / Description
1	Earthen Pots (Matka)	Demonstrate evaporative cooling by natural porous surfaces.
2	Khus (Vetiver) Grass Mats	Traditional cooling screens; soaked and hung in air paths to cool incoming air.
3	Water Supply (Bucket/Tank / Spray)	Used to keep the khus mats moist and maintain evaporative action.
4	Thermometer (DBT/WBT)	Measuring temperature before and after the cooling setup.
5	Hygrometer	Measuring relative humidity.
6	Jute Curtains / Cotton Drapes	Natural insulating and cooling material used in homes.
7	Psychrometric Chart	Analyzing changes in air properties.

IX. Precautions to be followed (Safety instructions/Rules/Standards)

1. Follow instructions given by faculty.
2. Use all instruments properly required during practical.
3. Prepare relevant report as per instructions given by faculty.

X. Procedure:

- Students have to understand different cooling methods used in ancient India.
- Students have to verify the usefulness of these techniques during practical sessions.
- Prepare a report on different methods used for cooling purposes in ancient India.
- Consider the different cooling techniques while preparing a report.
- The report should be detailed with appropriate diagrams/figures/charts.

XI. Observations

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XII. Result

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XIII. Interpretation of Results

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XIV. Conclusions and Recommendation

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XV. Practical Related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Name cooling technique used in traditional Indian stepwells.
2. Write the benefit of using earthen pots for cooling water.
3. Mention the scientific principle behind cooling in stepwells and courtyards.
4. Mention one reason why mud walls were effective in temperature control.

[Space for Answer]

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XVI. References / Suggestions for Further Reading

1. Ancient cooling techniques: https://youtu.be/Nk-CbiP16Og?si=PKP_YAFPnjFtP5lj
2. Earthen Pot cooling in summer days: https://youtu.be/RfJVd5_ZpM4?si=6HB8Az-wSqb1jilS

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Observations of the measuring instruments	20%
2	Handling of the measuring Instruments	20%
Product Related (15 Marks)		**(60%)**
3	Report Preparation	40%
4	Conclusion	10%
5	Practical related questions	10%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (10)	**Product Related (15)**	**Total (25)**	