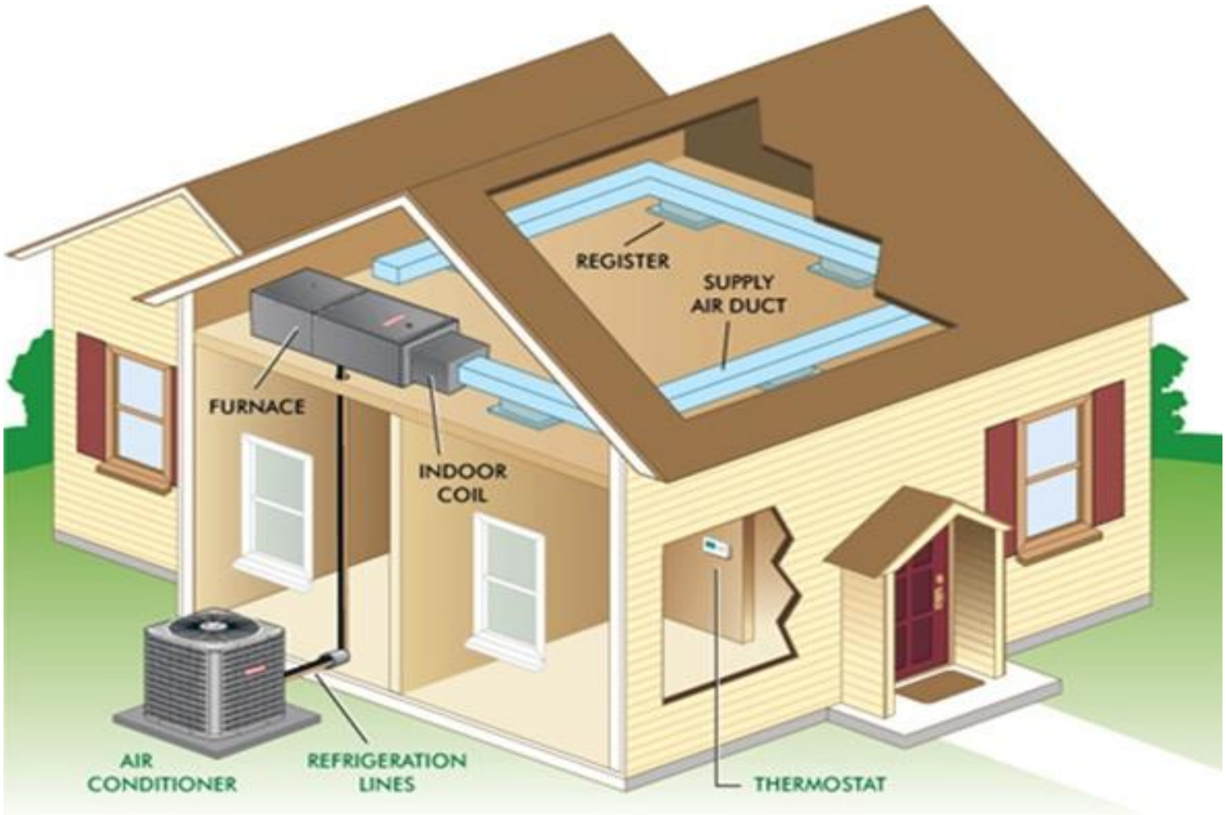
Plumbing Installation

Level IV

Based on October 2023, Curriculum Version II



Module Title: Designing, sizing and layout heating and cooling systems

Module code : EIS PLI4 M05 1023

Nominal duration: 100 Hours

Prepared by: Ministry of Labor and Skill

October 2023

Addis Ababa, Ethiopia

Tabele of content

Acknowledgment

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronym

EIS	Ethiopian industrial standard
TTLM	Training and Learning Materials
HVAC	Heating, Ventilation and Air Conditioning
QA	Quality assurance
CAD	Computer-Aided Design
BTU	British Thermal Units per Hour
OSHA	Occupational safety and health agency
PPE	Personal Protective Equipment

Introduction to the Module

Welcome to the module on designing, sizing, and layout of heating and cooling systems. In this module, we will explore the essential aspects of designing and sizing heating and cooling systems for residential and commercial buildings. We will also discuss the importance of proper layout and distribution of airflows to ensure optimal performance and comfort.

Heating and cooling systems play a crucial role in maintaining comfortable indoor environments, regardless of the external weather conditions. Designing and sizing these systems accurately is essential to ensure energy efficiency, cost-effectiveness, and occupant satisfaction.

This module covers:

- Preparing for design
- System requirements
- Design system layout

Learning Objective of the Module:

- Prepare for design.
- Identify system requirements.
- Design system layout.

Module Instruction

For effective use of this module, trainees are expected to follow the following module instruction:

1. Read the information written in each unit.
2. Accomplish the Self-checks at the end of each unit.
3. Perform Operation Sheets at the end of unit.
4. Do the "LAP test" giver at the end of each unit and
5. Read the identified reference book for Examples and exercise.

Unit One: Preparing for design

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Heating and cooling system design
- Safety and environmental requirements
- Organizing and Sequencing Work
- Tools and equipment
- work area preparation

This unit will also assist you to attain the learning outcomes stated below. Specifically, upon completion of this learning guide, trainees will be able to:

- Describe Heating and cooling system design principle
- Identify Safety and environmental requirements for designing work
- Organize and Sequence Work
- Identify Tools and equipment
- Prepare work area

1.1 Heating and cooling system design

A heating and cooling system, also known as HVAC (Heating, Ventilation, and Air Conditioning) system, is responsible for maintaining a comfortable indoor temperature and air quality in residential and commercial buildings. It consists of various components that work together to provide heating and cooling as needed.

Heating and cooling systems are related to plumbing work, as they often require plumbing connections for proper operation. Plumbing work is essential for the water supply, drainage, and piping connections in heating and cooling systems. It ensures the proper circulation of water or refrigerant, facilitates heat transfer or cooling, and contributes to the overall efficiency and functionality of these systems

1.1.1 Types of heating and cooling system

1. **Evaporative Cooling System**: An evaporative cooling system, also known as a swamp cooler, uses the natural process of evaporation to cool the air. It works by drawing in warm outside air and passing it through water-soaked pads. As the air evaporates the water, it cools down and is circulated into the living space.

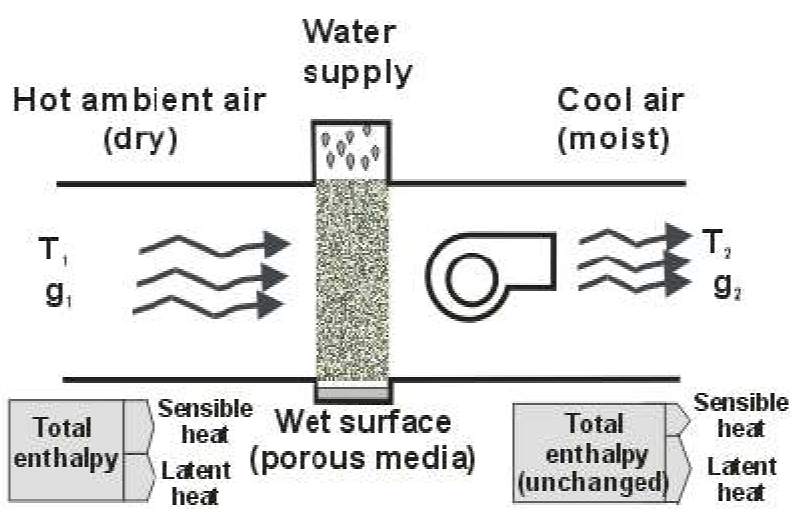


Fig 1.1: evaporative cooling system

2. **Hydronic Heating System:** A hydronic heating system uses hot water or steam to heat a building. It typically consists of a boiler that heats the water or produces steam, which is

then circulated through pipes to radiators, baseboard heaters, or radiant floor systems to provide warmth.

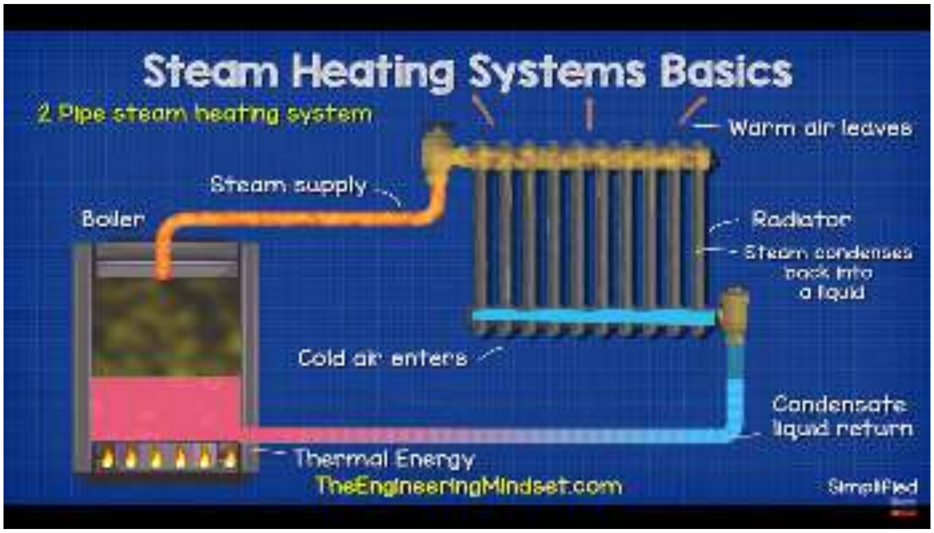


Fig 1.2: hydronic heating system radiator type

3. **Hydronic Cooling System:** A hydronic cooling system is similar to a hydronic heating system but is designed to provide cooling instead. It circulates chilled water through pipes to cooling coils or radiant cooling panels, which absorb heat from the surrounding air and provide a cooling effect.

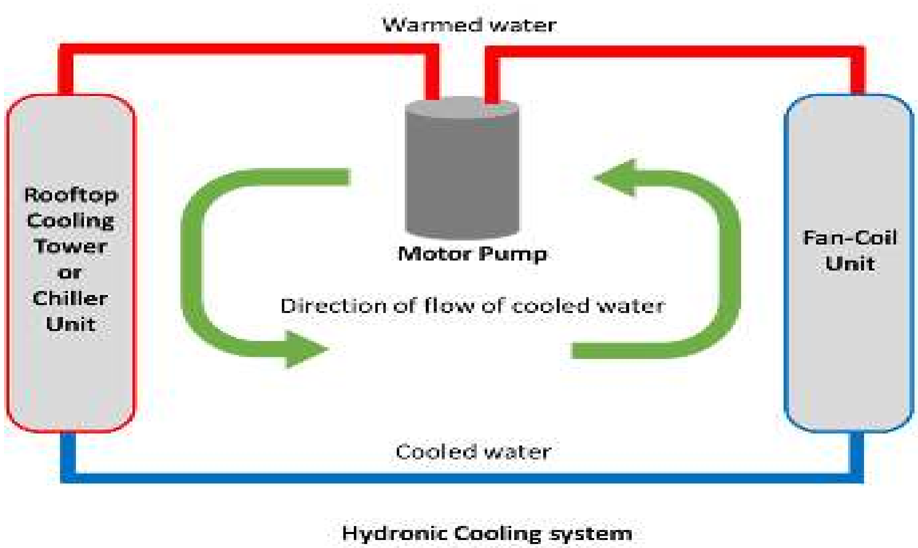


Fig 1.3: hydronic cooling system

4. **Warm Air System:** A warm air system, also known as forced air heating and cooling, uses a ***furnace*** or ***heat pump*** to heat the air. The heated air is then distributed throughout the building via ductwork and vents. In the case of cooling, the warm air system is combined with an air conditioner to cool and dehumidify the air.

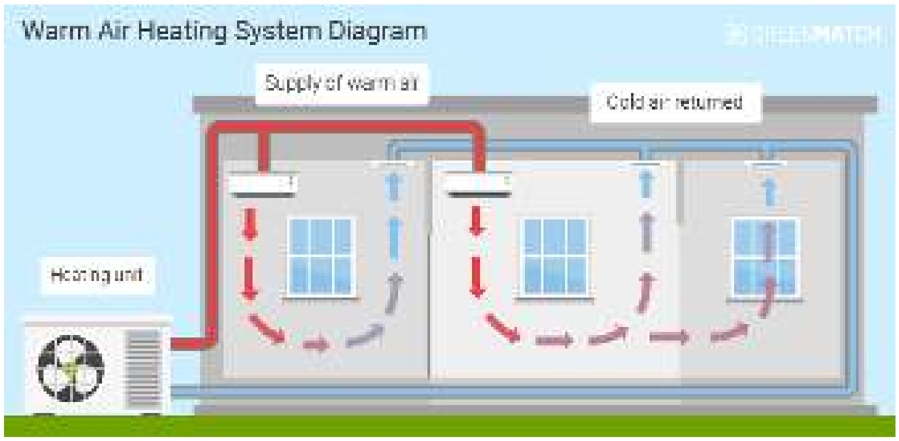


Fig 1.4: warm air system

5. **Refrigerated Air Conditioning System:** A refrigerated air conditioning system, also known as a central air conditioning system, uses a compressor and refrigerant to cool and dehumidify the air. It works by removing heat from the indoor air and releasing it outside, providing cool air through ductwork and vents.

Fig 1.5: warm air system

6. **Geothermal Heat Pump:** Geothermal heat pumps are highly efficient and environmentally friendly. They transfer heat to and from the ground instead of the outdoor air. They require burying pipes in the ground and are subject to local zoning and regulations.

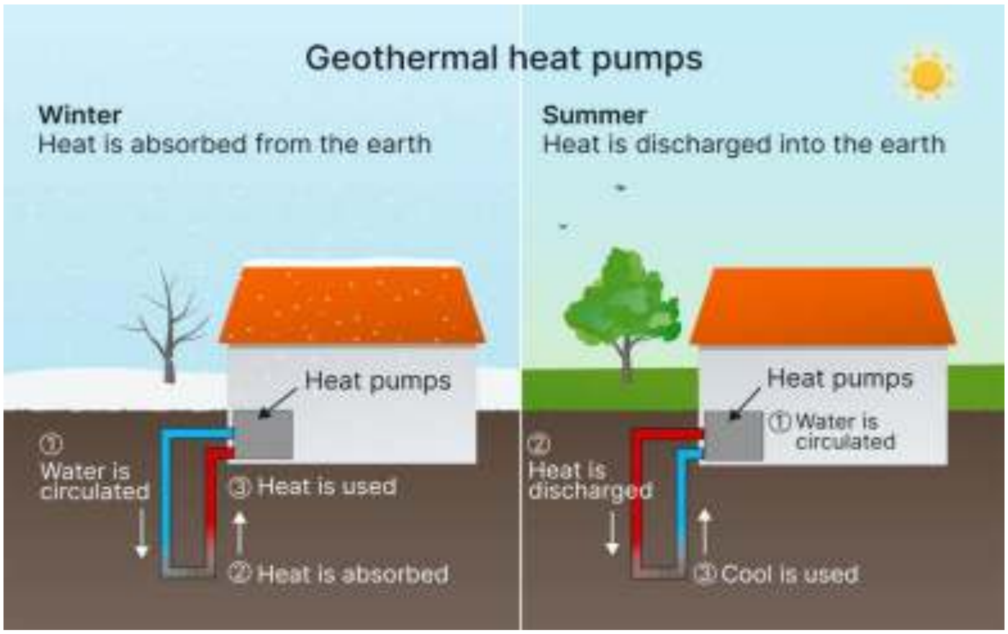


Fig 1.6: warm air system

1.1.2 Nature and scope of design

Plumber involved in the design task for Class 1 and Class 2 buildings Class 1 and 2 buildings typically refer to residential buildings such as houses, apartments, or small offices. The design of ducting and piping systems for these buildings should comply with relevant building codes and regulations, your responsibilities and the nature of the design task will primarily revolve around the plumbing systems within these residential buildings.

Nature of the heating and cooling System designing

The system involves ducting and piping systems used for air conditioning, heating, and ventilation purposes in buildings. It is designed to handle Class 1 or 2 buildings with specific maximum static pressure and velocity requirements. The system also includes heating and chilled water piping systems with maximum pressure and temperature limits. The system has a maximum output capacity and a limit on total air quantities.

Scope of heating and cooling System designing:

The system is applicable to residential and commercial sites, including both new construction projects and existing structures undergoing renovation, extension, restoration, or maintenance. The scope covers the design and installation of ducting and piping systems for air conditioning, heating, and ventilation needs within the specified limits and requirements.

Overall, the nature and scope of the system involve designing and implementing ducting and piping systems in specific building types and conditions, adhering to defined pressure, velocity, and capacity parameters.

1.2 Safety and environmental requirements

Planning, sizing, and documenting the layout of heating and cooling systems, it is essential to adhere to work health and safety (WHS) and environmental requirements consider the following safety consideration:

- **Risk Assessment**: Conduct a comprehensive risk assessment during the design process to identify potential hazards and risks associated with the project. This includes considering factors such as ergonomics, electrical safety, fire hazards, and environmental impacts.
- **Material Selection:** Designers should prioritize the use of materials that are safe, sustainable, and environmentally friendly. Consider factors such as toxicity, recyclability, and the use of renewable or low-impact materials in the design.
- **Hazard Mitigation:** Incorporate design features that mitigate identified risks and hazards. This may include incorporating safety guards, barriers, or warning signs to prevent accidents or injuries. Consider measures to minimize or eliminate exposure to hazardous substances and prevent environmental pollution.
- **Ergonomics:** Designers should consider ergonomic principles to ensure that the layout and design of workspaces minimize the risk of musculoskeletal injuries and promote the well-being of workers. This includes designing workstations, equipment, and tools that are adjustable, comfortable, and promote proper posture.
- **Personal Protective Equipment (PPE)**: Identify the need for PPE based on the risk assessment. Provide appropriate PPE, such as safety glasses, helmets, gloves, hearing protection, and respiratory protection.

1.3 Organizing and Sequencing Work

Organizing and sequencing the work for designing a heating and cooling system is essential for an efficient and well-coordinated design process. It involves prioritizing tasks, allocating resources effectively, ensuring a smooth workflow, promoting collaboration, managing risks, and enhancing client satisfaction. By structuring the design work in a logical order, it enables efficient task execution, minimizes delays and rework, and facilitates effective communication and coordination among team members. Overall, organizing and sequencing contribute to a successful and timely completion of the heating and cooling system design project.

Organizing and sequencing the design work for a heating and cooling system involves breaking down the tasks and activities into logical steps to ensure a systematic and efficient design process. The general approach to design the system:

1. **Define Project Scope and Requirements:** Begin by clearly defining the scope of the heating and cooling system design project. Identify the specific requirements, such as the desired temperature range, heating and cooling loads, energy efficiency targets, and any applicable regulations or standards.
2. **Conduct Site Assessment:** Perform a comprehensive assessment of the site where the heating and cooling system will be installed. Consider factors such as the building size, layout, orientation, insulation, windows, and existing infrastructure. Gather data on climate conditions, including temperature ranges, humidity levels, and seasonal variations.
3. **Determine System Type and Components:** Based on the project requirements and site assessment, determine the most suitable heating and cooling system type. This could include options such as central heating and cooling systems, heat pumps, radiant heating, or geothermal systems. Select the appropriate components, such as boilers, furnaces, air conditioners, heat exchangers, pumps, and ductwork.
4. **Perform Load Calculation:** Calculate the heating and cooling loads for the building to determine the capacity requirements of the system. Consider factors such as building size, insulation, occupancy, ventilation, internal heat gains, and climate conditions.
5. **Design Ductwork and Piping Layout:** Based on the load calculation and system type, design the layout for the ductwork and piping system. Determine the sizes and routes for

air ducts, supply and return vents, and piping networks. Consider factors such as air distribution, pressure drops, noise control, and accessibility for maintenance.

6. **Select Equipment and Components:** Specify and select the appropriate equipment and components for the heating and cooling system. Consider factors such as energy efficiency, performance ratings, reliability, compatibility, and budget constraints. Ensure that the selected equipment meets the required capacity and efficiency criteria.
7. **Size and Design Controls and Automation:** Determine the control strategy for the heating and cooling system. Design the control system to regulate temperature, airflow, and other parameters. Specify sensors, thermostats, controllers, and automation devices. Consider energy-saving features, zoning options, and integration with building management systems.
8. **Prepare Design Documentation:** Create detailed design documentation, including drawings, specifications, equipment schedules, and system schematics. Ensure that the documentation accurately represents the design intent and complies with relevant codes and standards.
9. **Review and Approval:** Review the design documentation with stakeholders, including clients, architects, engineers, and regulatory authorities. Address any feedback or concerns and make necessary revisions to the design. Obtain the required approvals and permits before proceeding with the installation.

In designing of heating and cooling system process include professional some types of professional such as, plumber and HVAC engineers. From the above designing process plumbers design and lay out the duct and pipe system in detail the other tasks are perform with the coordination of HVAC and electrical technician

1.4 Tools and equipment

Designing a heating and cooling system requires the use of various tools and equipment to aid in calculations, modeling, and documentation.

To design a heating and cooling system, you would typically need the following tools and equipment:

- **Computers Running CAD Software:** Computer-Aided Design (CAD) software is essential for creating detailed 2D and 3D models of the heating and cooling system. CAD software allows you to design and visualize components such as ductwork, piping, equipment, and spatial layouts. Examples of popular CAD software include AutoCAD, Revit, and Solid Works.
- **Drawing Instruments:** Traditional drawing instruments, such as pencils, pens, rulers, and drafting paper, can be useful for sketching initial design concepts, making hand-drawn calculations or diagrams, and annotating design plans. While CAD software is the primary tool for creating precise technical drawings, traditional drawing instruments can still be handy for quick sketches or calculations.
- **Calculator:** To carried out some mathematical considerations.
- **Measuring Equipment:** Various measuring instruments are used in designing heating and cooling systems to gather data and verify design parameters. These instruments help in determining factors such as temperature, airflow, pressure, and humidity. Common measuring equipment includes:
  - **Thermometers:** Digital or analog thermometers are used to measure temperatures in different locations within a building or HVAC system.
  - **Anemometers:** Anemometers measure airflow velocity, which is important for determining air distribution and sizing ductwork.
  - **Airflow Meters**: Airflow meters, such as flow hoods or hot-wires anemometers, is used to measure air volume or airflow rates in ducts or diffusers.
  - **Measuring tape:** Use to measure linear measurement to lay system component.

These tools and equipment help designers gather accurate measurements, validate design assumptions, and ensure that the heating and cooling system is properly designed and optimized for efficient performance.

1.5 Work area preparation

Preparing your work area before diving into design work is essential for creating an organized and conducive environment that promotes focus and productivity. This article outlines key considerations to help you set up an optimal work area for designing.

1. **Clean:** Start by tidying up your work area and removing any unnecessary clutter. A clean and organized workspace can help reduce distractions and create a more productive atmosphere. Clear off your desk, organize cables, and keep supplies neatly stored.
2. **Ergonomic Setup:** Ensure that your workstation is ergonomically designed to promote comfort and reduce the risk of strain or injury. Adjust your chair height, desk height, and monitor position to maintain proper posture and reduce physical discomfort during extended periods of work. Invest in a supportive chair and consider using an ergonomic keyboard and mouse.
3. **Sufficient Lighting**: Adequate lighting is crucial for accurate design work. Position your work area near a natural light source if possible, and supplement it with appropriate artificial lighting to ensure proper visibility and minimize eye strain. Avoid glare on your computer screen by adjusting blinds or using an anti-glare screen protector.
4. **Quiet Environment:** Design work often requires concentration and attention to detail. Minimize noise distractions by choosing a quiet area or using noise-cancelling headphones to create a focused work environment. Communicate with others around you to minimize interruptions during crucial design tasks.
5. **Access to Reference Materials**: Make sure you have easy access to relevant reference materials, such as building codes, design standards, product catalogs, and technical resources. Keep them organized and within reach to facilitate efficient design research and information retrieval. Consider creating a designated reference area or digital library for quick access.
6. **Proper Equipment and Tools:** Ensure that you have all the necessary equipment and tools readily available. This may include computers with the required software, drawing instruments, measuring devices, and any specialized equipment specific to your design work. Keep them organized and well-maintained to optimize efficiency.
7. **Adequate Workspace**: Ensure that you have enough physical space to accommodate your work requirements. This includes having sufficient desk space for your computer, drawing materials, and reference materials, as well as any additional space needed for laying out plans or models. Optimize your workspace layout to support your workflow.

8. **Organization and Storage:** Establish a system for organizing and storing your design files, drawings, and other project-related documents. Use physical or digital filing systems to keep track of your work and make it easier to retrieve information when needed. Consider using cloud storage solutions for easy access and backup of digital files

Self-Check 1

Part-I: Choose the correct answer

- Which cooling system uses the process of evaporation to cool the air?
  a. Evaporative Cooling System
  b. Hydronic Heating System
  c. Hydronic Cooling System
  d. Warm Air System

1. What type of heating system circulates hot water or steam through pipes to provide warmth?
   a. Evaporative Cooling System
   b. Hydronic Heating System
   c. Hydronic Cooling System
   d. Warm Air System
2. Which cooling system uses chilled water to absorb heat from the surrounding air and provide a cooling effect?
   a. Evaporative Cooling System
   b. Hydronic Heating System
   c. Hydronic Cooling System
   d. Warm Air System

Part-II: Match column A to B

Column A	Column B
1. Geothermal Heat Pump	A. Furnace or heat pump to heat the air Use fluid to operate valve
2. Warm Air System	B. Environmentally friendly system
3. Refrigerated Air Conditioning System	C. Central air conditioning system

Part-III: Answer the following questions accordingly.

1. List environmental safety requirement for designing cooling and heating system
2. List 5 tools and equipment to install design cooling and heating system
3. List the general approach to design cooling and heating system

Note: Satisfactory rating – above 75%   Unsatisfactory - below 75%
You can ask your trainer for the copy of the correct answers.

Unit Two: System requirements

This unit to provide you the necessary information regarding the following content coverage and topics:

- Information for designing heating and cooling system
- Sizing air conditioning and small bore heating system
- Sustainability principles and concepts

This guide will also assist you to attain the learning outcomes stated below. Specifically, upon completion of this learning guide, trainees will be able to:

- Obtain and confirm information for designing heating and cooling system
- Size air conditioning and small bore heating system
- Observe Sustainability principles and concepts in designing work

2.1 Information for designing heating and cooling system

Designing a heating and cooling system, it is important to obtain and confirm the necessary information and specifications. This can be done through various methods, including conducting a site inspection. Here is the information considered in designing work:

2.1.1 Load calculation

Load calculation is an essential process in designing heating and cooling systems for buildings. It involves determining the amount of heating or cooling required maintaining a comfortable indoor environment. There are various methods and factors to consider when performing load calculations.

Factors Considered in Load Calculations:

- Construction and insulation of the building, including walls, floors, and ceilings.
- Glazing and skylights, considering their performance, size, and overshadowing.
- Occupancy, including the number of people and any heat-producing devices.
- Windows and doors, as they can contribute to heat gain or loss.
- External weather conditions, such as design temperatures and extreme weather events

Heat Load Calculation Formula:

The heat load calculation formula is a basic method to estimate the heating or cooling requirements for a space.

The formula is: $Q = U \times A \times \Delta T$

Where:

- Q is the cooling load in kilowatts (kW).
- U is the overall heat transfer coefficient of the building envelope in watts per square meter per degree Celsius ($W/m^2 \cdot °C$).
- A is the total area of the building envelope in square meters (m^2).
- ΔT (Indoor temperature - Outdoor temperature)

Example:

Suppose we have a residential building with the following parameters:

- ✓ U-value (overall heat transfer coefficient): 0.3 W/(m²·°C)
- ✓ Total surface area of the building envelope: 200 m²
- ✓ Indoor temperature: 20°C
- ✓ Outdoor temperature: -5°C

Using the formula $Q = U \times A \times \Delta T$, we can calculate the heating load:

ΔT = Indoor temperature - Outdoor temperature

$\Delta T = 20°C - (-5°C)$

$\Delta T = 25°C$

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

$Q = 0.3\ W/(m^2 \cdot °C) \times 200\ m^2 \times 25°C$

$Q = 1500\ W$

So the heating load for the residential building would be 1500 watts or 1.5 kilowatts.

Cooling load calculation formula

It's the other method to is based on the heat load calculation formula, which takes into account factors such as the heat gain from the external environment and internal sources.

The formula is: Q = U x A x (external temperature – internal temperature) x 24 ÷ 1000

Where:

- Q is the cooling load in kilowatts (kW).
- U is the overall heat transfer coefficient of the building envelope in watts per square meter per degree Celsius (W/m²·°C).

- A is the total area of the building envelope in square meters (m^2).
- The external temperature is the average outdoor temperature in degrees Celsius.
- The internal temperature is the desired indoor temperature in degrees Celsius

Example:

Let's consider a case where we have a residential building with the following specifications:

- U (overall heat transfer coefficient): 40 $W/m^2 \cdot °C$
- A (total area of the building envelope): 200 m^2
- External temperature: 38°C
- Internal temperature: 24°C

Now, let's calculate the cooling load:

$Q = 40\ W/m^2 \cdot °C \times 200\ m^2 \times (38°C - 24°C) \times 24 \div 1000$

$Q = 40 \times 200 \times 14 \times 24 \div 1000$

Q = 268,800 W or 268.8 kW

Therefore, the cooling load for this residential building example is 268.8 kW.

From the Ethiopian building construction and standard code some designing considerations are:

2.1.2 Ductwork and Accessories design consideration

- In designing the ductwork for an air distribution system, consideration should be given to the air velocities in ducts, choice of materials and construction of the ducts, etc.
- For the best economic solution, the duct system shall be designed at the smallest aspect ratio in co-ordination with the space available for duct installation.
- Maximum velocity for different applications shall be in accordance with table 2.1 for the pressure class shown in table

Table 2.1 Maximum Velocities for Low Pressure Ducting Systems

Application	**Velocity m/s**	
	Main duct	Branch duct
Theatres, auditorium, studios	4.0	3.0
Hotel bedrooms, conference halls, operating theaters	5.0	3.0
Private offices, libraries, cinemas, hospital wards	8.0	4.0
General offices, restaurants, department stores	7.5	5.0
Cafeteria, supermarkets, machine rooms	9.0	8.0
Factories, workshops	12.0	7.5

Table 2.2 Duct system classification

Duct pressure class	**Static pressure limit**		**Mean air velocity (m/s)**
	Positive (Pa)	**Negative (Pa)**	
Low	500	500	10
Medium	1000	750	20
High	2500	750	40

Air ducts shall be made substantially air tight throughout, and shall have no openings other than those required for proper operation and maintenance of the system. Access openings shall be provided where debris, paper or other combustible materials may accumulate in plenums and ducts. Removable grilles requiring only the loosening of catches or screws for removal may be considered as access openings.

2.1.3 Pipe work design consideration

- In designing and planning the layout of the pipe wok, due attention should be given to the choice of material, rate of flow, accessibility, protection against damage, corrosion, avoidance of airlocks, water hammer, noise transmission, unsightly arrangement, vibration and expansion of fluid, stress and strains, etc.

- Every pipe used shall be designed to have adequate strength and durability. Pipes shall be adequately supported. Hangers and brackets for supporting pipes shall be of metal.

2.1.4 Statutory and regulatory authorities' requirements

These requirements ensure that the work is carried out in compliance with relevant laws and regulations. Here are some key requirements that applicable:

1. Energy Conservation Standards:
2. Installation Codes and Standards:
4. Electrical Codes:
5. Environmental Regulations:

2.1.5 Building drawings, plans, and specifications

These documents provide crucial information about the design and layout of the building, which helps in determining the heating and cooling needs. Here are the key steps involved in determining these requirements:

1. Building Drawings: Building drawings provide a visual representation of the building's layout, including the size and shape of rooms, windows, doors, and other architectural features. These drawings help in understanding the overall structure and design of the building.
2. Plans and Specifications: Plans and specifications provide detailed information about the building materials, insulation, and construction methods used in the building. They also include information about the location and size of HVAC (Heating, Ventilation, and Air Conditioning) equipment, ductwork, and other components related to the heating and cooling systems.

This unit applies: to ducting systems for air conditioning, heating or ventilation purposes in buildings Class 1 or 2 with a maximum static pressure of 0.75kPa and a maximum velocity of 12.5 meters per second, piping systems conveying heating and chilled water operating at a maximum pressure of 700kPa or a maximum temperature of 100°C, and systems having a maximum output of 50kW and total air quantities not exceeding 950 liters per second.

2.2 Sizing air conditioning and small bore heating system

2.2.1 Air Conditioning

Air conditioning is a system that controls and regulates the temperature, humidity, and air quality in indoor spaces. It provides cooling and dehumidification, creating a comfortable environment for occupants.

Air conditioning systems typically consist of an indoor unit that contains cooling coils and an outdoor unit that houses the compressor and condenser. Refrigerant circulates between the indoor and outdoor units, absorbing heat from indoor air and releasing it outside. The conditioned air is then distributed throughout the space via ductwork or individual air handlers. Air conditioning systems are commonly used in residential, commercial, and industrial buildings to maintain a pleasant indoor climate.

2.2.2 Small Bore Heating System

A small bore heating system is a type of heating system that utilizes small-diameter pipes to distribute hot water or steam for space heating. It is often employed in residential and small-scale commercial buildings to provide efficient and comfortable heating. Small bore heating systems consist of a heat source, such as a boiler or heat pump, which heats the water or steam.

The heated water or steam is then circulated through small-diameter pipes, typically ranging from 15mm to 35mm in diameter, to radiators or other heat emitters located throughout the building. The small bore pipes offer advantages such as quicker heat-up times, improved temperature control, and reduced heat loss compared to larger diameter piping systems. Small bore heating systems are known for their energy efficiency and flexibility in zoning, allowing different areas of the building to be heated independently.

Here are the details about different types of air conditioning systems, including their advantages and disadvantages:

2.2.3 Advantage and dis advantage of air conditioning and small bore heating system

1. **Evaporative Cooling System**

   Advantages

- Energy efficient: Evaporative coolers consume less energy compared to traditional air conditioners.
- Cost-effective: They are generally less expensive to install than central air conditioners.
- Adds moisture: Evaporative coolers add moisture to the air, making them suitable for hot and dry climates
- Filters air: These systems trap dust particles, pollen, and other allergens, providing cleaner air.

Disadvantages

- Not suitable for humid areas: Evaporative coolers are less effective in humid climates.
- Maintenance: They require more frequent maintenance, and there can be a buildup of salts and mineral deposits if the area has hard water.

2. **Hydraulic Heating System**

Advantages

- Energy efficient: hydraulic heating systems can be highly efficient, as they use water to transfer.
- Zoned heating: These systems allow for individual temperature control in different areas or rooms.
- Comfortable heat: hydraulic heating provides radiant heat, which is often considered more comfortable than forced air heat.

Disadvantages

- Installation cost: The initial installation cost of a hydraulic heating system can be higher compared to other heating systems.
- Requires space: These systems require space for the installation of pipes and radiators.
- Slower heating: hydraulic heating systems may take longer to heat up compared to forced air systems.

3. **hydraulic Cooling System:**

Advantages

- Energy efficient: hydraulic cooling systems can be highly efficient, as they use water to transfer heat.
- Zoned cooling: These systems allow for individual temperature control in different areas or rooms.
- Quiet operation: Hydronic cooling systems operate quietly compared to traditional air conditioners.

Disadvantages

- Installation cost: The initial installation cost of a hydronic cooling system can be higher compared to traditional air conditioners.
- Requires space: These systems require space for the installation of pipes and cooling units.
- Slower cooling: Hydronic cooling systems may take longer to cool down compared to traditional air conditioners.

4. **Warm Air System**

Advantages

- Quick heating: Warm air systems can heat up a space quickly.
- Cost-effective: These systems can be less expensive to install compared to other heating systems.
- Can be combined with ventilation: Warm air systems can be integrated with ventilation systems to provide fresh air.

Disadvantages

- Dry air: Warm air systems can dry out the air, leading to discomfort and potential health issues.
- Inefficient distribution: These systems may have uneven heat distribution, resulting in hot and cold spots.
- Limited control: Warm air systems may have limited temperature control options.

5. **Refrigerated Air Conditioning System**

Advantages

- Effective cooling: Refrigerated air conditioning systems provide quick and efficient cooling.
- Temperature control: These systems offer precise temperature control options.
- Dehumidification: Refrigerated air conditioners can effectively remove humidity from the air.

Disadvantages

- Higher energy consumption: Refrigerated air conditioning systems tend to consume more energy compared to other cooling systems.
- Higher installation cost: The initial installation cost of a refrigerated air conditioning system can be higher.
- Maintenance: These systems may require regular maintenance to ensure optimal performance.

2.2.4 Sizing air conditioning and small bore heating system

Sizing an air conditioning system and a small bore heating system involves determining the appropriate capacity or output required to effectively cool or heat a space.

Sizing Air Conditioning System

1. Calculate the cooling load: The cooling load is determined by considering factors such as the size of the space, orientation and insulation of the building, number of occupants, heat-generating equipment, and local climate conditions.

2. Select the appropriate capacity: Once the cooling load is determined, choose an air conditioner with a capacity that matches or slightly exceeds the calculated load. Air conditioner capacity is typically measured in British Thermal Units per hour (BTU/h) or kilowatts (kW).

Sizing Small Bore Heating System

1. Calculate the heating load: The heating load is determined by considering factors such as the size of the space, insulation levels, outdoor temperature conditions, and the desired indoor temperature.

2. Determine the heat source capacity: Based on the heating load, select a heat source, such as a boiler or heat pump, with an appropriate capacity to meet the calculated load. The heat source capacity is typically measured in BTU/h or kilowatts (kW).

3. Size the small bore piping: Once the heat source capacity is determined, the size of the small bore piping can be selected. The pipe size will depend on factors such as the distance between the heat source and the heat emitters, the flow rate required, and the pressure drop limitations. Consult industry standards and guidelines to determine the appropriate pipe size.

Sizing an evaporative cooling system

1. Calculate the Cooling Load*:* Determine the cooling load of the space in kilowatts (kW) using load calculation.
2. Calculate the Required Airflow: The required airflow is typically expressed in cubic meters per hour (m^3/h) and can be calculated using the following formula:

$$\text{Airflow } (m^3/h) = (\text{Cooling Load in kW}) / (\Delta T \times 1.163)$$

Where:

- ΔT is the desired temperature difference between the outdoor air and the cooled air. A typical value is 11°C.
- 1.163 is a constant that accounts for the specific heat and density of air.

3. Select the Evaporative Cooler Capacity: Once you have determined the required airflow in m^3/h, choose an evaporative cooler with a capacity that matches or slightly exceeds the calculated airflow. The capacity of the evaporative cooler is typically specified by the manufacturer and is expressed in terms of m^3/h.

Example:

1. Calculate the Cooling Load:
   Determine the cooling load of the space using load calculation methods or by considering factors such as room size, heat-generating equipment, insulation, occupancy, and solar gain. Let's assume the cooling load is 50 kW.
2. Calculate the Required Airflow:

Use the formula: Airflow (m^3/h) = (Cooling Load in kW) / (ΔT x 1.163)

Let's assume a temperature difference (ΔT) of 10°C:

Airflow (m^3/h) = 50 kW / (10°C x 1.163)

Airflow (m^3/h) = 430.5 m^3/h

Therefore, the required airflow for the evaporative cooling system is 430.5 m^3/h.

3. Select the Appropriate Evaporative Cooler:

Based on the calculated airflow rate, choose an evaporative cooler that can deliver the required airflow. Consider factors such as the unit's airflow capacity, cooling efficiency, and manufacturer specifications.

Sizing a hydronic heating system

1. Heat Load Calculation:

The heat load (Q) of a space can be calculated using the following formula:

$$Q = \text{Area} \times \text{U-Value} \times (\text{Design Temperature Difference})$$

2. Boiler Sizing:

The boiler capacity (B) can be estimated using the following formula:

$$B = Q / (\text{Fuel Efficiency} \times \text{System Efficiency})$$

Where:

- Q is the heat load of the space in BTUs or kW.
- Fuel Efficiency is the efficiency of the boiler in converting fuel energy to heat energy.
- System Efficiency is the overall efficiency of the heating system, taking into account losses in distribution and controls.

3. Radiator Sizing:

The heat output (Q) of a radiator can be estimated using the following formula:

$$Q = V \times \Delta T \times R$$

Where:

- V is the volume of the room in cubic feet or cubic meters.
- ΔT is the desired temperature difference between the room and the radiator surface.
- R is the heat output rating of the radiator in BTU/hr or kW.

Sizing a hydronic cooling

1. Cooling Load Calculation:

$$\text{Cooling Load (Q)} = \text{Area} \times \text{U-Value} \times \text{Temperature Difference}$$

2. Chiller Sizing:

$$\text{Chiller Capacity} = \text{Cooling Load} + \text{Safety Margin}$$

3. Cooling Emitter Sizing:

$$\text{Cooling Emitter Capacity} = \text{Cooling Load per Zone} + \text{Safety Margin}$$

Select a cooling emitter (e.g., chilled beams, chilled ceilings, fan coil units) with a cooling capacity that matches or slightly exceeds the cooling load of each zone.

Sizing the pipes for cooling and heating system

The flow rate and pressure requirements to ensure proper operation and distribution of water to the cooling pads or media. Here's a general approach for sizing the pipes:

1. Determine the Flow Rate:

The flow rate is typically specified by the manufacturer and is expressed in liters per minute (LPM) or gallons per minute (GPM).

Formula:

$$q = h / (c_p * \rho * \Delta t)$$

Where:

- h = heat flow rate (kJ/s, kW)
- cp = Specific heat capacity (4.18 kj/(kg·°C)

- q = volumetric flow rate (m3/s)
- ρ = density *(kg/m3)*
- Δt = temperature difference (^{o}C)

2. Calculate the Pipe Sizing:

To calculate the pipe sizing, you need to consider the flow rate, the length of the pipe runs, and the allowable pressure drop. There are various formulas and tables available based on the pipe material and type. However, a commonly used formula for pipe sizing in HVAC systems is the Darcy-Weisbach equation:

$$\Delta P = (f * (L/D) * (\rho * V^2))/2$$

Where:

- ΔP is the pressure drop (in Pa or psi)
- f is the Darcy friction factor (dependent on pipe material, roughness, and Reynolds number)
- L is the length of the pipe run (in meters or feet)
- D is the pipe diameter (in meters or feet)
- ρ is the density of the fluid (water in this case, in kg/m^3 or lb/ft^3)
- V is the fluid velocity (in m/s or ft/s)

The goal is to determine the pipe diameter (D) that provides an acceptable pressure drop while accommodating the desired flow rate.

3. Consider Pipe Material and Local Codes:

Select a pipe material suitable for water distribution in evaporative cooling systems. Common options include PVC, copper, or polyethylene (PEX). Consider the local building codes and regulations that might dictate the approved pipe materials and sizing practices.

4. Consult Manufacturer Guidelines:

Consult the manufacturer's guidelines and recommendations for pipe sizing specific to their product , They may provide specific guidance on pipe material, diameter, and layout to ensure optimal system performance.

Sizing the duct for cooling and heating system

Sizing the ductwork for a cooling and heating system involves determining the appropriate size of the ducts to ensure efficient airflow and distribution of conditioned air throughout the building. The sizing process typically considers factors such as the airflow requirements, equipment capacity, and the layout and design of the duct system. Here's a general overview of the steps involved in duct sizing:

1. Determine the Airflow Requirements:

Calculate the required airflow for each room or zone in the building based on factors such as the cooling and heating load, room size, occupancy, and ventilation requirements. This can be done using load calculation methods or following industry standards and guidelines.

2. Select the Design Airflow Velocity:

Determine the design airflow velocity for the duct system. The recommended velocity typically falls table 2.1, in depending on the specific application and duct type.

3. Calculate the Duct Size:

Use duct sizing charts, software programs, or duct sizing equations to calculate the appropriate duct size based on the required airflow and design airflow velocity. These tools take into account factors such as the duct material, shape, length, and fittings.

Formula for duct sizing:

Formula for pressure drop in a duct system using the Darcy-Weisbach equation, expressed in metric units

- We can also determine duct size if we take recommended pressure drop 1 Pascal per meter from EBCS 11.

$$\Delta P = (f * L * \rho * V^2) / (2 * D)$$

Where:

- ΔP is the pressure drop (in Pascals)
- f is the friction factor (dimensionless)
- L is the length of the duct (in meters)
- ρ is the fluid density (in kg/m^3)
- V is the flow velocity (in meters per second)
- D is the diameter of the duct (in meters)

It's important to note that the Darcy-Weisbach equation is a general equation that can be used for various fluid flow scenarios, including duct systems.

To determine size for rectangular shape duct from diameter use the following formula:

$$D=1.3 *((a*b)^{0.625})/((a+b)^{0.25})$$

Where

- D=diameter
- a=length
- b=width

4. Consider Friction Loss and Pressure Drop:

Account for friction loss and pressure drop in the duct system due to airflow resistance, fittings, and equipment. This ensures that the system operates efficiently without excessive energy consumption or noise issues. Friction loss can be calculated using duct friction charts or software programs.

5. Account for Duct Design and Layout:

Consider the layout and design of the duct system, including the number of branches, duct lengths, bends, transitions, and fittings. Optimizing the design and minimizing obstructions can improve overall system performance and airflow distribution.

6. Validate Duct Sizing:

Review and validate the duct sizing calculations to ensure they meet the specific requirements of the HVAC equipment, local codes, and industry standards. It's recommended to consult a professional HVAC engineer or utilize specialized software to ensure accurate and reliable duct sizing.

Example:

Assuming the following parameters for design duct size for office

- Friction factor (f): 0.02
- Length of the duct (L): 20 meters
- Fluid density (ρ): 1.2 kg/m³
- Flow velocity (V): 4 meters per second
- Pressure drop (ΔP): 1 Pascal/meter

Using these values, we can calculate the duct diameter (D):

$$D = (f * L * \rho * V^2) / (2 * \Delta P)$$

$$= (0.02 * 1 * 1.2 * 4^2) / (2 * 1)$$

$$= 0.192 \text{ meters} \approx 200 \text{ mm}$$

2.3 Sustainability principles and concepts

Sustainability principles and concepts refer to a set of guiding principles and ideas that aim to promote long-term environmental, social, and economic balance and well-being. The key goal is to meet the needs of the present generation without compromising the ability of future generations to meet their own need

When it comes to cooling and heating systems, sustainability principles and concepts can be applied in several ways:

1. Efficient Design Principles:
   - Cooling and heating systems should be designed with a focus on energy efficiency to minimize resource consumption.
   - This can involve incorporating technologies such as high-efficiency heat pumps, variable-speed compressors, and smart thermostats.
   - Proper insulation and sealing of buildings can also improve the efficiency of cooling and heating systems by reducing energy loss.
2. Efficient Use of Materials:
   - Selecting materials with low environmental impact for the construction and installation of cooling and heating systems is essential.
   - This includes considering the embodied energy and emissions associated with the production and transportation of materials.
   - Using recycled or recyclable materials, as well as those with a longer lifespan, can reduce the environmental footprint of the systems.
3. Minimal Environmental Impact:
   - Cooling and heating systems should be designed and operated to minimize their environmental impact.
   - This includes reducing greenhouse gas emissions by using low carbon or renewable energy sources.
   - Implementing proper maintenance practices and regular inspections can ensure optimal performance and prevent energy waste.
4. Choice of Appropriate Components and Equipment:
   - Selecting energy-efficient components and equipment is crucial for sustainable cooling and heating systems.
   - This involves choosing appliances with high energy efficiency ratings, such as Energy Star certified products.
   - Using environmentally friendly refrigerants and considering the life cycle impacts of the components can further reduce the environmental footprint.

5. Integration with Renewable Energy Sources:
   - Sustainable cooling and heating systems can be integrated with renewable energy sources to reduce reliance on fossil fuels.
   - This can include utilizing solar thermal systems for heating and geothermal heat pumps for cooling.
   - By harnessing renewable energy, the overall environmental impact of the systems can be significantly reduced.

By incorporating these sustainability principles and concepts into the design, installation, and operation of cooling and heating systems, it is possible to achieve more energy-efficient and environmentally friendly solutions, leading to reduced carbon emissions and a more sustainable use of resources.

Self-Check 2

Part-I: Choose the correct answer.

1. Which component of an air conditioning system is responsible for absorbing heat from indoor air and releasing it outside?

   a) Compressor
   b) Condenser
   c) Cooling coils
   d) Refrigerant

2. What is the main purpose of an air conditioning system?

   a) Regulate humidity levels
   b) Control indoor air quality
   c) Provide cooling and dehumidification
   d) Maintain a comfortable environment

3. What is a key advantage of small bore heating systems compared to larger diameter piping systems?

   a) Quicker heat-up times
   b) Improved temperature control
   c) Reduced heat loss
   d) Energy efficiency and flexibility in zoning

Part-III: Say true for right statement and false for wrong one

1. Evaporative cooling systems are more effective in humid climates.
2. Hydronic heating systems use water to transfer heat.
3. Hydronic cooling systems operate quietly compared to traditional air conditioners.
4. Warm air systems can provide quick heating.
5. Refrigerated air conditioning systems consume less energy compared to other cooling systems.

Part-III: Answer the following questions accordingly.

1. What factors are considered when sizing pipes for a cooling and heating system?
2. A cooling system requires a heat flow rate of 20 kW to properly cool the space. The specific heat capacity of water is 4.18 kJ/(kg•°C), and the density of water is 1000 kg/m³. If the desired temperature difference is 10°C, calculate the volumetric flow rate (q) of water needed for the cooling system. Round your answer to two decimal places.
3. How can sustainability principles be applied to cooling and heating systems.

Note: Satisfactory rating – above 75%   Unsatisfactory - below 75%
You can ask your trainer for the copy of the correct answer.

Operation sheet 2.1: Determine pipe size

Operation title: Determining pipe size for heating and cooling system

Purpose*:* To know the size of pipe for cooling and heating system

Equipment, Tools and Materials:

- Specification
- Pen/pencil
- Paper
- Calculator

Steps in doing the task:

Step 1: Gather Required Data

- Cooling or heating load (in kW), take 50
- Specific heat capacity of the fluid (in kJ/kgoC)
- Density of the fluid (in kg/m3)
- Temperature difference (ΔT) between the fluid inlet and outlet (in oC)
- Maximum allowable flow velocity (Vmax) based on system requirements and fluid properties (in m/s).
- Roughness f

For water-based cooling and heating systems, the maximum flow velocity is typically recommended to be within the range of ***1 to 3*** meters per second (m/s).

Step 2: Calculate Volumetric Flow Rate (q)

q = Cooling or heating load / (Specific heat capacity * Density * ΔT)

Step 3: Determine Pipe Size

3.1: Calculate Cross-Sectional Area (A)

A = Volumetric Flow Rate (q) / Maximum allowable flow velocity (Vmax)

3.2: Select a Pipe Diameter (D)

Based on the calculated cross-sectional area (A), select a suitable pipe diameter (D) from standard pipe size charts or catalogs.

Step 4: Verify Pressure Drop

To verify pressure drop, additional information such as pipe length, pipe roughness, and system configuration is required. With this information, the Darcy-Weisbach equation or other appropriate pressure drop formulas can be used to calculate the pressure drop and ensure it falls within acceptable limits.

The recommended pressure drop is typically limited to a range of 0.05 to 0.25 bar per100 meters of pipe length.

Use the following formula to check recommended pressure drop

$\Delta P = (f * (L/D) * (\rho * V^2))/2$

Quality Criteria: Assured performing of all the activities according to the procedures.

Precautions: Use proper safety requirement

Operation sheet 2.2: Determine duct size

Operation title: determining duct size for heating and cooling system

Purpose*:* To know the size of duct for cooling and heating system

Equipment, Tools and Materials:

- Specification
- Pen/pencil
- Paper
- Calculator

Steps in doing the task:

Step 1: Gather Required Data

- Cooling load (in kW)
- Airflow rate (in cubic meters per second, m^3/s,)
- Desired air velocity (in meters per second, m/s,)
- Friction loss factor (F) based on the type of duct and fittings (obtained from duct design charts or tables)
- Duct shape and dimensions (if known)

Step 2: Calculate Cross-Sectional Area (A)

- A = Airflow rate (Q) / Air velocity (V)

Step 3: Calculate Equivalent Diameter (D)

- If the duct shape is known and it is circular:

$$D = 2 * \sqrt{(A / \pi)}$$

- If the duct shape is known and it is rectangular:

$$D = 2 * \sqrt{[(L * W) / (L + W)]}$$

Step 4: Select Duct Size

- Based on the calculated equivalent diameter (D), select a suitable duct size from standard duct size charts or catalogs. The selected duct size should be the closest match to the calculated D value.

Step 5: Verify Pressure Drop

- After selecting the duct size, it is important to verify that the pressure drop in the system is within acceptable limits.

Quality Criteria: Assured performing of all the activities according to the procedures. **Precautions:** Use proper safety requirement

Lab Test 1

Instructions: Perform the following activity as required standard

Task 1: Collect necessary material and equipment for your work.

Task 2: Determine heat and cool load for given case.

Task 3: Determine pipe size

Task 4: Determine duct size

Task 5: Finalize your work

Unit Three: Design system layout

This unit to provide you the necessary information regarding the following content coverage and topics:

- Heating and cooling lay out designing
- Specifying and optimizing materials
- Recording plans
- Work area restoring

This guide will also assist you to attain the learning outcomes stated below. Specifically, upon completion of this learning guide, trainees will be able to:

- Design Heating and cooling lay out.
- Specify and optimize materials.
- Record plans
- Restore work area

3.1 Heating and cooling lay out designing

Designing the layout for a heating and cooling is done after determining the size and the system, it is important to consider factors such as the size and layout of the building, the desired temperature zones, and the type of HVAC equipment being used.

Guide line for creating a heating and cooling system layout:

1. **Determine the heating and cooling load**: Calculate the heating and cooling load for each area of the building to determine the capacity required for the HVAC system. This can be done using software programs or by consulting with an HVAC engineer.
2. **Divide the building into zones:** Divide the building into different zones based on the heating and cooling requirements. Each zone should have its own thermostat to control the temperature independently.

- Consider Thermal Boundaries: Take into account the thermal boundaries within the building. These boundaries can be defined by walls, doors, windows, or other architectural features that affect heat transfer and temperature control. Aim to create zones that are separated by these boundaries to minimize heat transfer between areas.
- Identify Occupancy Patterns: Analyze the occupancy patterns within the building. Determine areas that are frequently occupied, such as offices, conference rooms, or common areas, and areas that are rarely occupied, such as storage rooms or mechanical spaces. This information will help in allocating zones based on usage requirements.
- Evaluate Temperature Requirements: Consider the different temperature requirements of various zones. Some areas may require warmer temperatures, like living spaces or work areas, while others may need cooler temperatures, like server rooms or equipment rooms. Group areas with similar temperature needs into separate zones.
- Utilize Building Function and Usage: Take into account the specific functions and usage of different areas within the building. For example, areas with high heat-generating equipment, such as computer server rooms or kitchens, may require dedicated zones to manage their unique cooling requirements.

3. **Determine the location of HVAC equipment:** Decide where the heating and cooling equipment will be located. This can include the placement of the furnace, air conditioner, heat pump, or other HVAC units. Factors to consider when deciding on the location:
   - Accessibility: Choose a location that provides easy access for installation, maintenance, and repairs. The HVAC equipment should be placed in an area that allows technicians to reach it without obstacles or tight spaces. Sufficient clearance around the equipment is necessary for safe and convenient servicing.
   - Airflow and Ventilation: HVAC equipment requires proper airflow and ventilation for optimal performance. Ensure that the location allows for adequate air circulation around the equipment, especially for air-cooled systems. Avoid placing the equipment in confined spaces or areas with restricted airflow that can hinder heat dissipation or impede the intake of fresh air.
   - Noise Considerations: HVAC equipment can generate noise during operation. Select a location that minimizes noise transmission to occupied spaces, such as offices or living areas. Consider placing the equipment in mechanical rooms, equipment yards, or on the roof to reduce noise disturbance. Install sound insulation or barrier systems if necessary.
   - Space Availability: Assess the available space within the building to accommodate the HVAC equipment. Consider the size and dimensions of the equipment, as well as any necessary clearances for installation, maintenance, and airflow requirements. Ensure that the selected location provides enough space for the equipment and related components, such as ductwork or piping connections.
   - Structural Support: HVAC equipment can be heavy, especially larger units like chillers or rooftop units. Verify that the chosen location can provide adequate structural support to accommodate the weight of the equipment. Consider factors such as floor loading capacity or roof load-bearing capacity, and consult with structural engineers if needed.
   - Serviceability: Plan for the ease of maintenance and equipment serviceability. Choose a location that allows for convenient access to filters, coils, motors, and other components that require regular maintenance or replacement. Ensure that there is sufficient space for technicians to perform routine service tasks and equipment inspections.

- Building Codes and Regulations: Check local building codes, regulations, and fire safety requirements that may affect the placement of HVAC equipment. Some jurisdictions have specific guidelines regarding equipment locations, clearances, or fire suppression measures that must be followed to ensure compliance.
- Integration with Building Systems: Consider how the HVAC equipment will integrate with other building systems. Evaluate the proximity to electrical panels, plumbing connections, gas lines, or fuel supplies, depending on the specific equipment requirements. Ensure that the location facilitates easy connections and coordination with other building services.
- Aesthetics: While functionality is crucial, consider the visual impact of the HVAC equipment location. If the equipment is visible to building occupants or the public, design considerations may be necessary to minimize the visual impact or integrate the equipment with the architectural design.

4. **Design the ductwork:** Plan the layout of the ductwork system to distribute heated or cooled air throughout the building. Consider the size and shape of the ducts, as well as the location of supply and return vents. Ensure that the ductwork is properly sized to deliver the required airflow to each zone.

- Identify Supply and Return Air Locations: Determine the locations for supply air outlets (registers or diffusers) and return air grilles. Consider factors such as room size, occupancy, and airflow requirements. Place supply outlets strategically to ensure even air distribution and sufficient airflow to each room.
- Design the Main Trunk Lines: Start by designing the main trunk lines that will carry conditioned air from the HVAC equipment to various zones or areas within the building. These trunk lines are typically larger in size and branch out to smaller ducts leading to individual rooms.
- Design Branch Ducts: Design the branch ducts that connect the main trunk lines to individual supply outlets in each room. Ensure that the branch ducts are properly sized to deliver the required airflow to each space while maintaining proper air velocity and pressure.

5. **Consider zoning and control systems**: If the building has multiple zones, consider using zoning systems and control panels to regulate the temperature in each zone independently. This allows for more efficient operation and personalized comfort.
6. **Plan for ventilation:** Incorporate ventilation systems to ensure a constant supply of fresh air. This can include the use of air handlers, exhaust fans, and outdoor air intakes.
7. **Consider energy efficiency:** Design the system with energy efficiency in mind. This can include the use of high-efficiency HVAC equipment, insulation, and proper sealing of ductwork to minimize air leakage.
8. **Ensure compliance with building codes and regulations**: Make sure the heating and cooling system layout complies with local building codes and regulations. This may include requirements for equipment placement, ventilation rates, and energy efficiency standards.

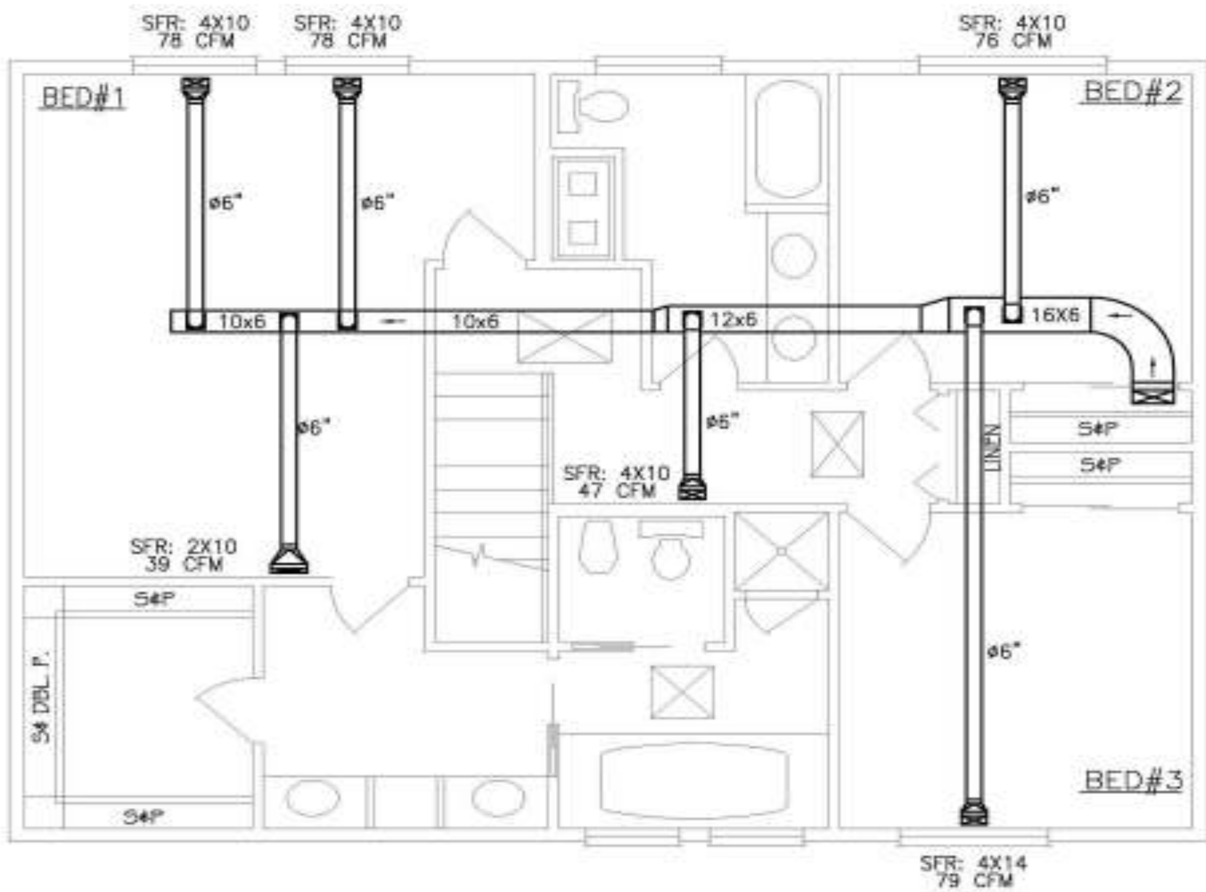


Fig 3.1 .Main and Branch duct lay out

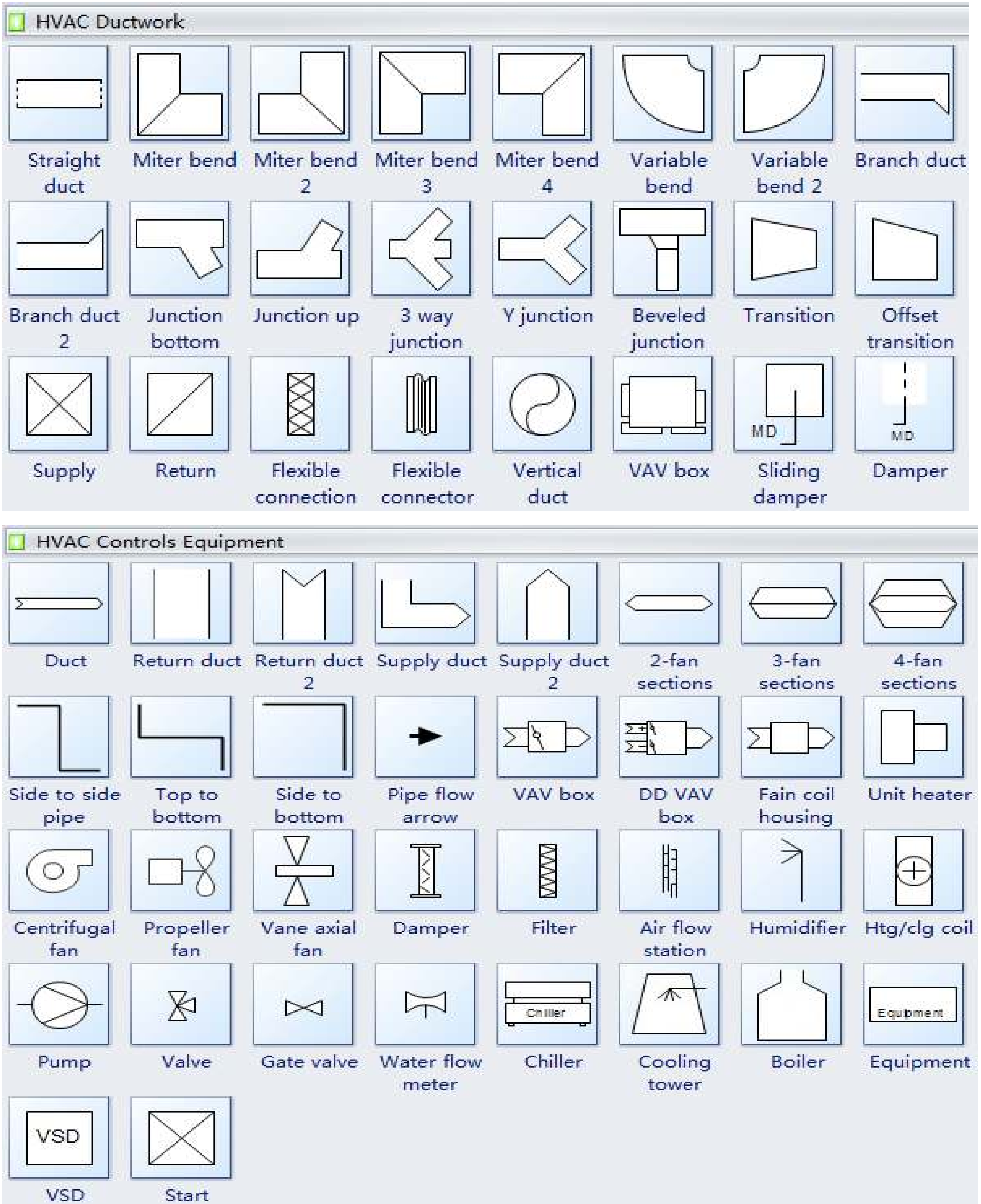


Fig 3.2 HAVC work symbol

3.2 Specifying and optimizing materials

Specifying and optimizing materials according to standards from the proposed design, it's essential to have the appropriate drafting materials, equipment, and access to relevant structure plans and specifications.

3.2.1 Materials Specification and Optimization:

- Design Standards and Codes: Familiarize yourself with the applicable design standards, building codes, and regulations that govern material selection. These standards provide guidelines for material properties, performance requirements, and safety considerations.
- Performance Requirements: Identify the performance requirements for the materials based on the design specifications. Consider factors such as strength, durability, fire resistance, thermal insulation, acoustics, and sustainability.
- Research Material Options: Research and evaluate different materials that meet the performance requirements and comply with the relevant standards. Consider factors such as material properties, composition, availability, cost-effectiveness, environmental impact, and compatibility with other building components.
- Material Testing and Certification: Verify that the selected materials have undergone appropriate testing and have the necessary certifications to demonstrate compliance with the relevant standards. Look for materials with recognized third-party certifications or approvals.
- Sustainability Considerations: Optimize material selection by considering sustainability factors. Look for materials with recycled content, renewable resources, low embodied carbon, and minimal environmental impact.

3.2.2 Drafting Materials and Equipment:

- Drawing Paper: High-quality drawing paper for manual sketches and drawings.
- Drafting Board or Table: A smooth and stable surface for placing the drawing paper.
- Drafting Pencils: Different hardness graphite pencils for drawing lines of varying thickness and darkness.
- Erasers: Soft erasers for correcting mistakes or removing unwanted lines.
- Scale Ruler: A specialized ruler with different scales for accurate measurements and scaled drawings.

- Compass: Used for drawing arcs and circles of various sizes.
- Templates: Pre-made shapes and symbols for consistent and efficient drawing.
- T-Square: A straightedge with a perpendicular crossbar for drawing horizontal and vertical lines.
- French curve: A flexible template for drawing smooth curves and irregular shapes.
- CAD Software and Equipment: Computer-Aided Design (CAD) software and hardware for digital drafting and design, including computers, printers, and scanners.

3.2.3 Relevant Structure Plans and Specifications:

- Architectural Plans: Detailed drawings that illustrate the layout, dimensions, materials, and features of the building or structure.
- Engineering Plans: Drawings that show the structural components, systems, and details of the building or structure.
- Electrical Plans: Diagrams that illustrate the electrical layout, wiring, and connections within the building.
- Plumbing Plans: Drawings that show the layout and connections of the plumbing system in the building.
- Mechanical Plans: Detailed drawings that depict the HVAC systems and equipment.

By optimizing material selection and using appropriate drafting materials, equipment, and access to structure plans and specifications, you can ensure that your designs meet the required standards, regulations, and performance criteria of the proposed project.

3.3 Recording plans

Recording plans involves creating accurate and detailed documentation of design and construction plans. Here's a brief explanation of the steps:

1. Gather and organize design documents: Collect all relevant plans and specifications.

2. Choose a recording method: Decide whether to use paper-based, digital, or a combination of both methods to document the plans.

3. Implement version control: Establish a system to track changes and updates to the plans, ensuring everyone has access to the most recent information.

4. Include supporting documentation: Supplement the plans with additional information, such as design narratives or material schedules, to provide context and clarity.

5. Index and cross-reference documents: Create an index or table of contents to help navigate and relate different sections of the plan record.

6. Store plans securely: Store physical copies in a controlled environment or use reliable backup systems and security measures for digital formats.

7. Document revisions and updates: Clearly record any changes made to the plans, including the reasons, responsible parties, and dates of revisions.

8. Communicate and share plans: Make the recorded plans accessible to relevant stakeholders, facilitating effective communication and coordination.

Following these steps will help create a comprehensive plan record, ensuring accurate documentation and smooth project execution.

3.4 Work area restoring

Restoring the work area in lay outing and designing work involves organizing and cleaning up the workspace to maintain an efficient and productive environment.

Steps to restore the work area:

1. Clear the Workspace: Remove any unnecessary items, tools, or materials from the workspace. Return them to their designated storage areas or dispose of them properly.

2. Organize Tools and Equipment: Ensure that all tools and equipment are properly organized and stored. Use toolboxes, shelves, or drawers to keep items easily accessible and in their designated places.

3. Clean Surfaces: Wipe down work surfaces, such as desks, drafting tables, or computer screens, to remove dust, dirt, or debris. Use appropriate cleaning agents and tools suitable for the surface materials.

4. Arrange Reference Materials: Organize reference materials, such as design manuals, catalogs, or samples, in a neat and accessible manner. Use shelves, folders, or holders to keep them organized and easily retrievable.

5. Manage Cables and Wires: Tidy up cables and wires by using cable management solutions such as cable clips, ties, or cable trays. This helps prevent tangling and tripping hazards.

6. Dispose of Waste: Properly dispose of any waste materials, such as scrap paper, packaging, or other non-reusable items. Use designated waste bins or recycling containers as appropriate.

7. Update Layouts and Drawings: If you have created layouts or drawings during the design process, ensure that they are properly organized and stored. Update them as necessary and file them in a logical order for easy reference.

8. Clean Work Tools: Clean and maintain your work tools regularly to ensure they are in good working condition. This includes cleaning brushes, pens, drafting tools, or any other equipment used in the design process.

9. Maintain a Clutter-Free Environment: Regularly DE clutter the work area to remove any unnecessary items or debris that may accumulate over time. Encourage a habit of tidiness and cleanliness to maintain an organized workspace.

Self-Check 3

Part-I: Choose the correct answer.

1. When creating a heating and cooling system layout, which factor is important to consider regarding the building's zones?
   a) The number of windows in each zone b) The desired temperature in each zone
   c) The location of the building's entrance d) The type of flooring used in each zone
2. What is the purpose of designing the ductwork in a heating and cooling system layout?
   a) To determine the number of HVAC units required
   b) To distribute heated or cooled air throughout the building
   c) To provide a pathway for water supply to the HVAC equipment
   d) To create a decorative element in the building's interior
3. How can zoning systems and control panels contribute to a heating and cooling system layout?
   a) They regulate the temperature in each zone independently
   b) They provide additional lighting in each zone
   c) They control the building's security system
   d) They monitor the water consumption of the HVAC equipment

Part-II: Answer the following questions accordingly.

1. What are some factors to consider during materials specification and optimization?
2. What are some essential drafting materials and equipment?
3. What are some relevant structure plans and specifications?
4. What are the steps involved in recording plans?
5. What are the steps to restore the work area in lay outing and designing work?.

Note: Satisfactory rating – above 75% Unsatisfactory - below 75%
You can ask your trainer for the copy of the correct answers.

Operation sheet 3.1: Design system layout

Operation title: designing system lay out

Purpose*:* To determine the positions of components in the house or office

Equipment, Tools and Materials:

- Pencil
- Paper
- Drawing board
- Eraser
- Cad
- Computer with cad software

Steps in doing the task:

1. Gather information:
   - Determine the heating and cooling requirements for the space, including the desired temperature range and any specific needs or constraints.
   - Identify the available energy sources, such as electricity, gas, or oil, and consider their availability and cost.
   - Assess the space layout and dimensions, including the number of rooms, their sizes, and any architectural features that may affect the system design.

2. Create a rough sketch:
   - Start by drawing a rough outline of the space, including walls, windows, doors, and any other relevant features.
   - Indicate the location of the heating and cooling equipment, such as furnaces, air conditioners, or heat pumps.
   - Consider the placement of vents, registers, and ductwork to ensure proper air distribution throughout the space.
   - Include any additional components, such as thermostats, filters, or dampers.

3. Determine equipment and duct sizing:

   - Calculate the heating and cooling loads for each room based on factors like insulation, occupancy, and equipment.

- Select appropriate heating and cooling equipment based on the calculated loads and the available energy sources.
- Determine the required duct sizes based on the airflow requirements and the distance between the equipment and the vents.

4. Design the ductwork layout:

- Sketch the ductwork layout, indicating the main trunk lines, branch lines, and individual supply and return ducts.
- Consider the most efficient and practical routing of the ductwork, taking into accounts any obstacles or space limitations.
- Ensure proper sizing and balancing of the ductwork to achieve even air distribution and minimize pressure losses.

5. Review and refine the sketch:

- Carefully review the sketch to ensure accuracy and feasibility.
- Make any necessary adjustments or refinements to optimize the system layout and performance.

Quality Criteria: Assured performing of all the activities according to the procedures.

Precautions: Use proper safety requirement.

Lab Test 2

Instructions: Perform the following activity as required standard

Task 1: Collect necessary material and equipment for your work.

Task 2: Create a rough sketch

Task 3: Determine equipment and duct sizing

Task 4: Design the ductwork layout.

Task 5: Review and refine the sketch

Task 6: Finalize your work

Reference

Books

1. EBCS 11(Ethiopian building code standard 11)
2. HVAC Equations, Data, and Rules of Thumb by Larsen Angel and Arthur Bell
3. HVAC Systems Design Handbook, Fifth Edition by Roger Haines and Michael Myers
4. Modern Refrigeration and Air Conditioning by Andrew Althouse, Alfred Bracciano, Daniel Bracciano, Gloria Bracciano, and Carl Turnquist
5. Refrigeration and Air Conditioning Technology by Bill Johnson, Jason Obrzut, Eugene Silberstein, John Tomczyk, and Bill Whitman
6. Residential Construction Academy HVAC by Eugene Silberstein
7. System Diagnostics and Troubleshooting Procedures by John Tomczyk 6. The Guide to the NATE-ICE Certification Exams)

URLs

https://www.conceptdraw.com/solution-park/AREA_BUILDING_PLANS

https://www.stoutmep.com/electromechanical-ethos-blog/commonly-used-hvac-symbols

https://www.engineeringtoolbox.com/cooling-heating-equations-d_747.html

https://www.intechopen.com/chapters/62059

https://www.nfpa.org/Public-Education/Staying-safe/Safety-equipment/Smoke-alarms/Installing-and-maintaining-smoke-alarms

https://www.youtube.com/watch?v=5y_VBiTiuAY

https://www.youtube.com/@EngineeringMindset

https://www.youtube.com/watch?v=1pGx6XmGEnE

https://www.youtube.com/watch?v=pAyVGT0SM70&list=PLPU58tWB1sVudP4EpIJOaBzda-r_aYB-f

TTLM Developer's Profile

No	Name	Qualification (Level)	Field of Study	Organization/ Institution	Mobile number	E-mail
1	Esmael Mohamed	BSC	Water Work construction technology	Kombolcha PTC	0915543225	bad9565@gmail.com
2	Abebe Endalew	BSC	Civil Engineering	Misrak PTC	0933007757	abebe aware09@gmail.com
3	Bamlaku Endalamaw	BSC	Building construction technology	Adis Ketema In/PTC	0934971363	ethio.markoss@gmail.com
4	Dawit Tefera	BSC	Construction Technology	Harar PTC	0912357591	dawit9575@gmail .com
5	Solomon Fentaw	MSC	Water And Sanitation	W/ro shien PTC	0921043646	fentawsolomon40@yahoo.com
6	Solomon Tadesse	BSC	Construction Technology	G/winget PTC	0921414347	soletadss@gmail.com
7	Tariku Wondimagen	MSC	Construction Management	Dilla PTC	0916512167	Mamush572@gmail.com
8	Teketel Sufebo	BSC	Hydraulics & water resource engineering	Butajira	0936726026	teketelsufebo22@gmail.com
9	Yitagesu Negesse	BSC	Civil Engineering	Tegbared PTC	0921132723	yate@gmail.com