**Government of Karnataka**
**DEPARTMENT OF COLLEGIATE and TECHNICAL EDUCATION**

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| **Program** | **Mechanical Engineering** | **Semester** | **5** |
| **Course Code** | **20ME52I** | **Type of Course** | **L:T:P (104:52:312)** |
| **Specialization** | **Heating Ventilation and Air-Conditioning (HVAC)** | **Credits** | **24** |
| **CIE Marks** | **240** | **SEE Marks** | **160** |

**Introduction:**

Welcome to the curriculum for the Specialisation Pathway - **Heating, Ventilation and Air conditioning (HVAC)**. This specialisation course is taught in Bootcamp mode. Bootcamps are 12 weeks, intense learning sessions designed to prepare you for the practical world – ready for either industry or becoming an entrepreneur.

Human comfort plays a vital role either in industries or at home or in office or Apartment building. This is made possible through regulation of heat, airflow, ventilation, and air conditioning. Comfortable office climate increases the level of productivity and increases morale amongst the workers and employees. Studies on corporate workplace behaviour and employee motivations suggest that workers are more enticed to keep coming to work if their office is properly cooled and/or heated. Having the proper temperature at work is an added advantage for building a solid team at work.

Controlling the temperature of air inside the designated "Air Conditioned" space along with control of moisture, filtration of air and containment of air borne particles, supply of outside fresh air for control of oxygen and carbon dioxide levels in the air-conditioned space, and finally control of the movement of air or draught, is a very desirable factor. These conditions can be achieved using an HVAC system. The need for hands-on workers to implement and service that high tech HVAC systems is growing and henceforth, is the Specialization pathway - **Heating Ventilation and Air-Conditioning (HVAC)**

You will be assisted through the course, with development-based assessments to enable progressive learning. In this course, you'll learn how to Design and maintain the HVAC systems for domestic and commercial applications that are needed for today's job market.

Leading to the successful completion of this bootcamp, you shall be equipped to either do an **Internship** in an organisation working on HVAC solution or do a **Project** in the related field. After the completion of your Diploma, you shall be ready to take up roles like a MEP engineer, Utilities engineer, Maintenance engineer etc., and also can become Entrepreneur in the related field and more

This course will teach you about Thermal process, Heat transfer, Psychometry, HVAC load estimation, duct and piping design, Selection of the equipment's for HVAC system and more. Details of the curriculum is presented in the sections below

## Pre-requisite

Before the start of this specialisation course, you will have prerequisite knowledge gained in the first two years on the following subjects:

1st year -Engineering Mathematics, Communication Skills, Computer Aided Engineering Graphics, Statistics & Analysis, Basic IT Skills, Fundamentals of Electrical and Electronics Engineering, Project Management skills Engineering Materials and Mechanical Workshop

2nd year-Mechanics of Materials, Machine Tool Technology, Manufacturing Process, Fluid Power Engineering, Product Design and Development, Operations Management, CNC Machines and Elements of Industrial Automation

In this year of study, you shall be applying your previous years learning along with specialised field of study into projects and real-world applications.

**Course Cohort Owner**
A Course Cohort Owner is a faculty from the core discipline, who is fully responsible for one specialised field of study and the cohort of students who have chosen to study that specialised field of study.

**Guidelines for Cohort Owner**

1. Each Specialized field of study is restricted to a Cohort of 20 students which could include students from other relevant programs.
2. One faculty from the Core Discipline shall be the Cohort Owner, who for teaching and learning in allied disciplines can work with faculty from other disciplines or industry experts.
3. The course shall be delivered in boot camp mode spanning over 12 weeks of study, weekly developmental assessments and culminating in a mini capstone.
4. The industry session shall be addressed by industry subject experts (in contact mode/online / recorded video mode) in the discipline only.
5. The cohort owner shall be responsible to identify experts from the relevant field and organize industry session as per schedule.
6. Cohort owner shall plan and accompany the cohort for any industrial visits.
7. Cohort owner shall maintain and document industrial assignments, weekly assessments, practices and mini project.
8. The cohort owner shall coordinate with faculties across programs needed for their course to ensure seamless delivery as per time table
9. The cohort owner along with classroom sessions can augment or use supplementally teaching and learning opportunities including good quality online courses available on platforms like Karnataka LMS, Infosys Springboard, NPTEL, Unacademy, SWAYAM, etc.

**Course outcome**: A student should be able to

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| **CO1** | **Estimate the Heating and cooling Load and Air Flow for an HVAC application** |
| **CO2** | **Select Suitable equipment's for an HVAC application** |
| **CO3** | **Design the duct and piping's for an HVAC application using suitable Building information Modelling (BIM) software** |
| **CO4** | **Provide innovative HVAC solutions for green buildings** |

# Detailed course plan

| Week | C O | P O | Days | 1st session (9am to 1 pm) | L | T | P | 2ND session (1.30pm to 4.30pm) | L | T | P |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | 1 | **Introduction to HVAC**<br>Video Presentation on Application of HVAC system in – Residential buildings, Apartments, Office Space, Hotels, Auditorium, Hospitals, Automobiles, Cold storages. | | | 4 | **Thermal Principles**<br>Concepts of Heat, Sensible Heat, Latent Heat Temperature, Temperature Scale<br>Work, Power, Energy, Enthalpy, Entropy, Specific Heat, Internal energy | 3 | | |
| | 1 | | 2 | Perfect Gas – Gas Laws- Charles law, Boyles law, Characteristics Gas Equation<br><br>Laws of Thermodynamics- Zeroth Law of Thermodynamics, First Law of Thermodynamics, Second Law of Thermodynamics<br><br>Thermodynamic processes- Explain Work done, change in internal energy, heat supplied or rejected for the following processes using P-V and T-S Diagram: Constant Pressure, Constant Volume, Isothermal | 4 | | | Thermodynamic processes- Explain Work done, change in internal energy, heat supplied or rejected for the following processes using P-V and T-S Diagram<br><br>Adiabatic, Polytropic, Throttling, Free expansion | 3 | | |
| | 1 | | 3 | **Psychrometry**:<br>Psychrometric terms- Dry Air, Moist Air, Saturated Air, Degree of Saturation, Dry Bulb Temperature, Wet Bulb Temperature, Humidity, Absolute Humidity, Relative Humidity, Specific Humidity, Humidity Ratio | 4 | | | Psychrometric processes – Sensible heating, Sensible Cooling, Humidification and De-Humidification<br>Use Psychrometric chart and measure properties of air<br>Plot Psychrometric processes using Psychometric chart. | 1 | | 2 |
| | 1 | | 4 | **Human Comfort**-<br>Factors affecting human comfort, Comfort parameters, IAQ (Indoor air Quality): Causes & Sources of Indoor Air Quality, Indoor Air Pollutants | 4 | | | Demonstrate the Concepts of heat transfer – Conduction, Convection, Radiation (Lab)<br>Fourier's law of heat transfer- Thermal conductivity- Newton law of cooling - Thermal resistance (Formula's) | 1 | | 2 |

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| | | | | Indoor Air Quality Regulations, ASHRAE Guidelines and Standards | | | | | | | | |
| | | | **5** | Developmental Weekly Assessment | | | | Assessment Review and corrective action | | | | 3 |
| | | | **6** | Industry Class on Use of Psychometric Chart, parameters for Human comfort and ASHRAE standards + Industry Assignment | | | 5 | | | | | |
| 2 | 1 | | 1 | Tutorial (Peer discussion on Industrial assignment) | | 4 | | **Solar Radiation**- Radiation Heat Transfer, Overall Heat Transfer, Heat Capacity, Coefficients for Radiant Heat Transfer | 3 | | | |
| | 1 | | 2 | SOLAR ANGLES- Basic Solar Angles, Hour Angle and Apparent Solar Time, Angle of Incidence and Solar Intensity (Video Presentation)<br>Solar Radiation for a Clear Sky, Solar Radiation for a Cloudy Sky (Video Presentation)<br>Location, Weather data, Orientation Solar Radiation, U factors (For data Refer ASHRAE Standards) | 4 | | | Moisture Migration in Building Materials, Moisture Transfer from the Surface of the Building Envelope, Moisture Transfer in Building Envelopes<br>CONDENSATION IN BUILDINGS- Visible Surface Condensation, Concealed Condensation within the Building Envelope (Video Presentation) | 3 | | | |
| | 1 | | 3 | THERMAL INSULATION- Basic Materials and Thermal Properties, Moisture Content of Insulation Material, Economic Thickness, Thermal Resistance of Airspaces (Video Presentation) | 4 | | | FENESTRATION- Types of Window Glass (Glazing), Optical Properties of Sunlit Glazing (Video Presentation)<br>HEAT ADMITTED THROUGH WINDOWS- Heat Gain for Single Glazing, Heat Gain for Double Glazing (Video Presentation)<br>Selection of Glazing | 3 | | | |
| | 1 | | 4 | SHADING OF GLASS- Indoor Shading Devices, External Shading Devices, Shading from Adjacent Buildings (Video Presentation) | 4 | | | Shading Coefficients, shading coefficients of building envelopes<br>Solar Heat Gain Factors and Total Shortwave Irradiance | 3 | | | |
| | | | 5 | Developmental Weekly Assessment | | | | Assessment Review and corrective action | | | | **3** |
| | | | 6 | Industry Class on Thermal Insulation, Fenestration and Shading of Glass + Industry Assignment | | | **5** | | | | | |

| Week | C O | P O | Days | 1st session (9am to 1 pm) | L | T | P | 2ND session (1.30pm to 4.30pm) | L | T | P |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 1 | | 1 | Tutorial (Peer discussion on Industrial assignment) | | 4 | | **HVAC Load Calculation**<br>Explain – Sensible heat gain, Latent heat gain<br>Calculate sensible heat gain through building structure by conduction<br>Calculate heat gain from solar radiation<br>Calculate Solar (Sensible)heat gain through outside walls and roofs | | | 3 |
| | 1 | | 2 | Explain Sol Air temperature<br>Calculate Solar heat gain through Glass surface<br>Calculate Heat gain through Infiltration<br>Calculate heat gain through Ventilation<br>Calculate heat gain from occupants<br>Calculate Heat gain from Appliances<br>Calculate Heat gain from products | 2 | | 2 | Calculate Heat gain from lighting equipment's<br>Calculate Heat gain from power equipment's<br>Calculate Heat gain through ducts<br><br>Conversion of Tons of Refrigeration (TR) to British Thermal Units (BTU)<br><br>Conversion of Tons of Refrigeration (TR) to KW/hr<br><br>Conversion of British Thermal Units (BTU) to KW/hr | 1 | | 2 |
| | 1 | | 3 | Estimate HVAC load for a Single storey building plan using E20 or any similar forms.<br>Calculate Air flow in CFM (Supply air, Return Air, Exhaust Air, Fresh Air) | | | | | 2 | | 5 |
| | 1 | | 4 | Estimate HVAC load for an office building plan using E20 or any similar forms<br>Calculate Air flow in CFM (Supply air, Return Air, Exhaust Air, Fresh Air) | | | | | 2 | | 5 |
| | | | 5 | CIE 1– Written and practice test | | | | Assessment Review and corrective action | | | 3 |
| | | | 6 | Industry Class on HVAC load Calculation + Industry Assignment | | | 5 | | | | |
| 4 | 1 | | 1 | Tutorial (Peer discussion on Industrial assignment) | | 4 | | Estimate HVAC load for a commercial building using E20 or any similar forms<br>Calculate Air flow in CFM (Supply air, Return Air, Exhaust Air, Fresh Air) | | | 3 |

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| | 1 | | 2 | Estimate HVAC load for a commercial building using E20 or any similar forms<br>Calculate Air flow in CFM (Supply air, Return Air, Exhaust Air, Fresh Air) | | | | | | 2 | | 5 |
| | 2 | | 3 | Choosing an HVAC System - Building design, Location issues, Utilities, Availability and cost, Indoor requirements and loads, Client issues | 4 | | | **Air Conditioning systems:**<br><br>**Introduction to Split Air conditioning system (AC):**<br>Discuss types of Split AC -<br>• Wall mounted split systems<br>• Multi-head Split systems<br>• In-ceiling cassette systems.<br>• Inverter Split AC<br>Demonstrate the Parts and functions of Wall Mounted Split AC Systems<br>Demonstrate the Working of Wall Mounted Split AC Systems | 1 | | 2 |
| | 2 | | 4 | Discuss the specifications of Split AC using Company Catalogue<br>Discuss and Demonstrate Variable Refrigerant flow (VRF)/ Variable Refrigerant volume (VRV) Air Conditioning systems<br>Discuss and Demonstrate Direct Expansion (DX) Air Conditioning systems | | | 4 | Demonstrate the installation of Wall Mounted Split Air- Conditioning System | | | 3 |
| | | | 5 | Developmental Weekly Assessment | | | | Assessment Review and corrective action | | | | 3 |
| | | | 6 | Industry Class- Type of Split AC for different Application and Industry Assignment | | | 5 | | | | | |
| 5 | 2 | | 1 | Tutorial (Peer discussion on Industrial assignment) | | 4 | | **Introduction to Centralized Air Conditioning System**<br>Applications of Centralized Air Conditioning System<br>Discuss the Working of Centralized Air Conditioning System<br>**i) Refrigeration Cycle**<br>Explain the working principle of Refrigeration Cycle in a Centralized AC | 1 | | 2 |
| | 2 | | 2 | Explain and demonstrate the components of Refrigeration cycle | | | | | | | | |

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| | | | | a) Compressor – Types (Reciprocating, Centrifugal, Screw, Scroll, Hermetic), Specification from catalogue and Selection Criteria<br>b) Condenser - Types, Specification from catalogue and Selection Criteria<br>c) Evaporator - Types, Specification from catalogue and Selection Criteria<br>d) Expansion Valve - Types, Specification from catalogue and Selection Criteria<br>e) Filter drier - Types, Specification from catalogue and Selection Criteria | 1 | | 3 | Discuss Designation system for Refrigerants<br>Discuss Essential and Desirable Properties of a Refrigerant<br><br>Discuss the Criteria to Select suitable Refrigerant for the refrigeration cycle<br><br>Discuss the Effect of Refrigerant on Environment (Env Issues) | 3 | | |
| | 2 | | 3 | ii) **Chilled Water cycle**<br>Explain the working principle of Chilled Water cycle in a Centralized AC<br>Explain and demonstrate the components of Chilled Water cycle<br>a) Chillers- Demonstrate the working principle of Chillers, Discuss the types of Chillers-- Air cooled Chillers, Water cooled Chillers, Specification from catalogue and Selection Criteria<br>b) Cooling Tower- Working Principle, Types, Specification from catalogue and Selection Criteria<br>c) Condenser- Working Principle, Types, Specification from catalogue and Selection Criteria<br>d) Water Pump- Working Principle, Types, Specification from catalogue and Selection Criteria | 2 | | 2 | iii) **Air Distribution System**<br>a) Duct – Types, Material<br>b) Air Handling Unit/ Fan Coil Units - Fan, Grills, Registers, Sealing, Diffuser, Slot Diffusers, Plenum Sealings, Flexible Connectors, Equalizing Grids, Splitter dampers, Control dampers, Anti Smudge rings, Sound and sound controls, Acoustic material (its properties, selection of the same for different HVAC system), filters, VAV Boxes. | 1 | | 2 |
| | 2 | | 4 | iv) **Heating cycle**<br>a) Explain Electric Duct Heater- Types- flange type, round adapter option, Slip in Type- Calculation of Power in the heater | 1 | | 3 | b) Boiler- Oil or Gas combustion Boiler and Heat exchanger- Furnace heater<br>c) Heat pump | 1 | | 2 |

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| | | | 5 | CIE 2– Written and practice test | | | | Assessment Review and corrective action | | | 3 |
| | | | 6 | Industry Class- Centralized Air Conditioning System and Industry Assignment | | | 5 | | | | |
| 6 | 2 | | 1 | Tutorial (Peer discussion on Industrial assignment) | | 4 | | Designing Centralized AC System<br>**a) Air Distribution System-**<br>• Selection criteria for AHU<br>• Placement/Location of AHU's<br>• Fan – Fan Law, Selection Criteria, Calculation of motor power requirement | | | **3** |
| | 2 | | 2 | Demonstrate<br>• Demonstrate Zone classification- Single Zone and Multi Zone<br>• Shape of the Duct - Circular Rectangular, Square<br>• Duct Materials – Galvanized Iron, Aluminum, Stainless Steel<br>• Thickness of the Duct Sheet<br>• Aspect Ratio (Width to Height) | | | **4** | • Duct Designing method- Velocity Reduction method, Equal friction Method, Static Regain Method<br>• Pressure in Ducts- Static Pressure, Dynamic or Velocity pressure, Total pressure | | | **3** |
| | 2 | | 3 | Duct classification as per Duct Pressure<br>Design of supply and return duct using ASHRAE standards | **1** | | **3** | • Duct Seal- Class A, Class B, Class C<br>• Distribution System Plans and Symbols- Positive pressure supply, Negative pressure return<br>• Air Terminal Symbol- one way, Two-way, three-way, four -way | 3 | | |
| | 2 | | 4 | b) Designing Water Distribution System-<br>• Pipes- Piping materials and its selection<br>• Design of supply and return water pipes<br>• HVAC Piping Insulation<br>• Pumps- Types, Power requirement, Selection using Pump curve | | | **4** | • Concepts on Kitchen, Toilet, Basement Ventilation<br>• Concept on Staircase and Lift Pressurization<br>• Concept on HVAC for Clean Rooms | | | **4** |

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| | | | | c) Designing Cooling Coils-<br>• Calculate the Diameter of coil<br>• Calculate Number of Coils | | | | | | | | |
| | | | 5 | Developmental Weekly Assessment | | | • | Assessment Review and corrective action | | | | • |
| | | | 6 | Industry Class on Air and Water distribution System in AC and Industry Assignment | | | 5 • | | | | | |
| **Week** | **C O** | **P O** | **Days** | **1st session (9am to 1 pm)** | **L** | **T** | **P** | **2ND session (1.30pm to 4.30pm)** | **L** | **T** | **P** | |
| **7** | 3 | | 1 | Tutorial (Peer discussion on Industrial assignment) | | 4 | | **Working On BIM (Building Information Modelling) software for Designing an HVAC System.**<br><br>**Exploring the User Interface**<br>• Model- New<br>• Practice to Navigate the ribbon interface.<br>• Practice to Utilize user interface features.<br>• Practice to Use settings and menus<br>• Practice on Import and reuse existing drawings from other formats.<br>• Practice on Manipulating the properties of parameters | | | **3** | |
| | 3 | | 2 | HVAC Cooling and Heating Load Analysis-<br>• Creating Spaces<br>• Placing Spaces<br>• Creating a Space Properties Schedule | | | | | | | | |

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| | | | | • Modifying Space Properties<br>• Creating Zones<br>• Setting Building Construction Options<br>• Area and Volume Calculations<br>• Color schemes<br>• Performing Heating and Cooling Load Analysis-Load analysis, Weather Data, Outdoor air infiltration, silver spaces<br>• Extracting and interpreting Cooling and Heating Load Report | | | | 2 | | **5** |
| | 3 | | 3 | Practice Heating and Cooling Load Analysis for building drawings using BIM | | | | 1 | | **6** |
| | 3 | | 4 | Practice Heating and Cooling Load Analysis for building drawings using BIM | | | | 1 | | **6** |
| | | | 5 | CIE 3– Written and practice test | | | Assessment Review and corrective action | | | **3** |
| | | | 6 | Industry Class on use of BIM software in a Particular Application + Industry Assignment | | 5 | | | | |
| **8** | 3 | | 1 | Tutorial (Peer discussion on Industrial assignment) | 4 | | Creating Logical Systems<br>• Create and manage air systems<br>• Configure duct connectors.<br>• Select Mechanical Equipment Components-Air Conditioning / Handling Units, VAV Boxes, Heating and Cooling Elements<br>• Select Duct types and perform Duct Routing | | | **3** |
| | 3 | | 2 | Apply/ Practice, the above concepts of logical systems for the given building drawing | | | | 1 | | **6** |
| | 3 | | 3 | Create Piping systems<br>• Adjusting Fittings and Extending the Design<br>• Selecting Fittings for Routing Preferences<br>• Choosing Pipe Materials and Sizes<br>• Adjusting the Pipe Sizing Table<br>• Perform Pipe routing<br>• Using Pipe Fitting Controls | | 3 | Apply/Practice the above concepts of piping systems for the given building drawing | | | **3** |

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| | | | | • Placing Valves<br>• Adding Piping Insulation | | | | | | | |
| | 3 | | 4 | Apply/Practice the above concepts of piping systems for the given building drawing | | | | 1 | | | **6** |
| | 3 | | 5 | Developmental Weekly Assessment | | | | Assessment Review and corrective action | | | **3** |
| | | | 6 | Industry Class on use of BIM software to design Duct and Piping's for a Particular HVAC Application+ Industry Assignment | | | **5** | | | | |
| **9** | 3 | | 1 | Tutorial (Peer discussion on Industrial assignment) | | 4 | | Design an HVAC system for a Multi storey residential building using BIM software | | | **3** |
| | 3 | | 2 | Design an HVAC system for a Commercial building using BIM software | | | | | 1 | | **6** |
| | 3 | | 3 | Design an HVAC system for an Auditorium using BIM software | | | | | 1 | | **6** |
| | 3 | | 4 | Design an HVAC system for a cold storage using BIM software | | | | | 1 | | **6** |
| | | | 5 | CIE 4– Written and practice test | | | | Assessment Review and corrective action | | | **3** |
| | | | 6 | Industry class on Safety and Maintenance of an HVAC system + Industry assignment | | | **5** | | | | |
| **10** | 3 | | 1 | Tutorial (Peer discussion on Industrial assignment) | | 4 | | Building Management System(BMS):<br>• The BMS system and its components<br>• The architecture & different levels of the BMS system<br>• The different common protocols used for BMS system and the most used protocol. | 3 | | |
| | | | 2 | • The different HVAC systems which can be controlled & monitored by the BMS system<br>• Understanding the types of I/O points and their types<br>• Define the cable types which are being used with the BMS system | 4 | | | • The BMS riser diagram and how to read it<br>• The different types of documents used with the BMS system submittal | 3 | | |
| | | | 3 | • The different benefits of using BMS system in a building | 4 | | | • Understanding the different methods to connect devices in the BMS system | 3 | | |

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| | | | | • The common field devices & sensors used with MEP systems in buildings and how to choose them from the catalogue | | | | • The BMS Schematic diagram and how to read it<br>• Understanding the Graphics of BMS | | | |
| | | | 4 | Virtual Visit on BMS + Industry Assignment | | | 4 | Virtual Visit on BMS | | | **3** |
| | | | 5 | Developmental Weekly Assessment | | | | Assessment Review and corrective action | | | **3** |
| | | | 6 | Industry Class on BMS + Industry Assignment | | | **5** | | | | |
| **Week** | **C O** | **P O** | **Days** | **1st session (9am to 1 pm)** | **L** | **T** | **P** | **2ND session (1.30pm to 4.30pm)** | **L** | **T** | **P** |
| **11** | 2 | | 1 | Tutorial (Peer discussion on Industrial assignment) | | 4 | | **Interpreting the tender Document:**<br>An organization is setting up a Multi Training Facility building in its campus. The Director invited tenders for Air conditioning work to be carried out for their building. The HVAC tender requirements for this is given in the Annexure at the end of the curriculum<br>• Analyse the tender Requirements and specifications<br>• Make cohort in to sub teams<br>• Sub team as a Vendor, wishes to participate in the tender process<br>• Sub team needs to discuss and prepare a tender Response Document<br>• Conduct Mock tender bids.<br>**Note:** For electrical estimation, use the expertise of electrical faculty. Consult Civil faculty for building drawing issues. Neglect Inspection and Testing data in the document. | | | **3** |
| | 2 | | 2 | An organization is setting up a Multi Training Facility building in its campus. The Director invited tenders for Air conditioning work to be carried out for their building. The HVAC tender requirements for this are given in the Annexure at the end of the curriculum | | | | | | | **7** |

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| | | | | • Analyse the tender Requirements and specifications<br>• Make cohort in to sub teams<br>• Sub team as a Vendor, wishes to participate in the tender process<br>• Sub team needs to discuss and prepare a tender Response<br>• Conduct Mock tender bids.<br>**Note:** For electrical estimation, use the expertise of electrical faculty. Consult Civil faculty for building drawing issues. Neglect Inspection and Testing data in the document. | | | | | |
| | 2 | | 3 | An organization is setting up a Multi Training Facility building in its campus. The Director invited tenders for Air conditioning work to be carried out for their building. The HVAC tender requirements for this are given in the Annexure at the end of the curriculum<br>• Analyse the tender Requirements and specifications<br>• Make cohort in to sub teams<br>• Sub team as a Vendor, wishes to participate in the tender process<br>• Sub team needs to discuss and prepare a tender Response<br>• Conduct Mock tender bids.<br>**Note:** For electrical estimation, use the expertise of electrical faculty. Consult Civil faculty for building drawing issues. Neglect Inspection and Testing data in the document | | | | | **7** |
| | 2 | | 4 | An organization is setting up a Multi Training Facility building in its campus. The Director invited tenders for Air conditioning work to be carried out for their building. The HVAC tender requirements for this are given in the Annexure at the end of the curriculum<br>• Analyse the tender Requirements and specifications<br>• Make cohort in to sub teams<br>• Sub team as a Vendor, wishes to participate in the tender process<br>• Sub team needs to discuss and prepare a tender Response<br>• Conduct Mock tender bids.<br>**Note:** For electrical estimation, use the expertise of electrical faculty. Consult Civil faculty for building drawing issues. Neglect Inspection and Testing data in the document<br>Outcome of this Week is:<br>• Must be able to interpret the HVAC Drawings<br>• Understand the Specifications of the equipment.<br>• Select equipment based on Specifications and Requirements along with cost. | | | | | **7** |
| | | | 5 | CIE 5– Written and practice test | | | | Assessment Review and corrective action | | **3** |
| | | | 6 | Industry Class on Tendering process + Industry assignment | | | 5 | | | |

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| **12** | 4 | | 1 | Tutorial (Peer discussion on Industrial assignment) | | | | **Green Buildings and HVAC**<br>• Discuss Green building and its importance in sustainable Planning<br>• Characteristics of green buildings<br>• Demonstrate Life Cycle Assessment | 1 | | **2** |
| | 4 | | 2 | LEED (Leadership in Energy and Environmental Design) Certification, Requirements, Benefits<br><br>Green Building HVAC- Designing for Energy Efficiency: Through Building Simulation (Demo) | 2 | | **2** | Discuss design Measures to reduce Heat Load and increase energy efficiency of the building with techniques like<br>• Solar passive techniques<br>• Building orientation<br>• Proper Shading<br>• Window Wall Ratio<br>• Building Envelope | 3 | | |
| | 4 | | 3 | Strategies adopted in the HVAC system to meet green building requirements-<br>• Selection of Chiller<br>• Variable Speed Drives for Pumps<br>• Fans and Compressors<br>• Dedicated Outdoor Air Systems<br>• Supply Air System Control<br>• Demand Control Ventilation<br>• Air to Air Heat Recovery System<br>• Thermal Storage System for Cooling<br>• Gas Fired Chillers<br>Control cooling tower fans by sensing ambient wet bulb temperature | 3 | | **1** | **Case study on environmental benefits through energy savings in HVAC system** | 1 | | 2 |
| | 4 | | 4 | Adding intelligence to HVAC solutions-(Video's)<br>• Occupant-based thermal comfort strategies<br>• Decoupling of ventilation and heating/cooling | 2 | | 2 | **Case studies to demonstrate energy saving potentials from HVAC in Green Buildings** | | | **3** |

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| | | | | • Indirect evaporative cooling<br>**A Case Study on Energy Efficient Green Building with New Intelligent Techniques Used in HVAC to Achieve Sustainable Development Goal** | | | | | | | |
| | | | 5 | Developmental Weekly Assessment | | | | Assessment Review and corrective action | | | 3 |
| | | | 6 | Industry Class on Sustainable HVAC solutions + Industry asignment | | | 5 | | | | |
| **13** | | | 1 | **Internship**<br>**1. Secondary research on various industries and their operations to identify at least 3 companies along with the areas of work interest and develop an internship plan that clearly highlights expectations from the industry during the internship.**<br>**2. Design and develop a cover letter for an internship request to all 3 identified companies and the resume to be submitted to potential companies.**<br>**3. Prepare for an internship interview to highlight your interests, areas of study, career aspirations and personnel competence – including the areas of learning you expect to learn during internship.** | | | | **Project (Internship/Project Total = 40Hrs)**<br>**1. Identification of the problem statement (from at least 3 known problems) the students would like to work as part of the project – either as provided by faculty or as identified by the student. Document the impact the project will have from a technical, social and business perspective.**<br>**2. Design and develop the project solution or methodology to be used to solve at least one of the problems identified.**<br>**3. Prepare a project plan that will include a schedule, WBS, Budget and known risks along with strategies to mitigate them to ensure the project achieves the desired outcome.** | | | |

**References**


1. ASHRAE® HANDBOOK on Heating, Ventilating, and Air-Conditioning APPLICATIONS
2. Air Conditioning A practical introduction by David V. Chadderton
3. Air Conditioning Applications and Design by W. P. Jones
4. Air-Conditioning and Refrigeration by Shan K. Wang and Zalman Lavan
5. Air-Conditioning System Design Manual by Walter Grondzik
6. General Specifications For Heating, Ventilation & Air-Conditioning (HVAC) Works (2017) published by CPWD
7. HANDBOOK OF AIR CONDITIONING AND REFRIGERATION by Shan K. Wang

8. HVAC Equations, Data, and Rules of Thumb by Arthur A. Bell Jr., PE
9. HVAC Systems Testing, Adjusting & Balancing By Sheet Metal And Air Conditioning Contractors' National Association, Inc
10. Fundamentals of HVAC Systems by Robert McDowall, P.
11. A Text Book of Refiguration and Air conditioning by R S Kurmi and J K Gupta
12. A Text Book of Refiguration and Air conditioning by C P Arora
13. BIM handbook: A guide to building information modelling for owners, managers, designers, engineers and contractor
14. Building Information Modelling for Dummies by Stefan Mordue
15. A Practical Guide to Adopting BIM in Construction Projects by Prof Bimal Kumar

**CIE and SEE Assessment Methodologies**

| CIE Assessment | Assessment Mode | Duration In hours | Max Marks |
|---|---|---|---|
| Week 3 | CIE 1– Written and practice test | 4 | 30 |
| Week 5 | CIE 2– Written and practice test | 4 | 30 |
| Week 7 | CIE 3– Written and practice test | 4 | 30 |
| Week 9 | CIE 4– Written and practice test | 4 | 30 |
| Week 11 | CIE 5– Written and practice test | 4 | 30 |
| | On line Course work (Minimum 10 hours online course with certification from (SWAYAM/NPTEL/Infosys Springboard) | | 40 |
| | Profile building for Internship / Submission of Synopsys for project work | | 20 |
| Portfolio evaluation (Based on industrial assignments and weekly developmental assessment) * | | | 30 |
| **TOTAL CIE MARKS (A)** | | | **240** |
| **SEE 1 - Theory exam (QP from BTE) Conducted for 100 marks 3 hrs duration reduced to 60 marks** | | **3** | **60** |
| **SEE 2 – Practical** | | **3** | **100** |
| **TOTAL SEE MARKS (B)** | | | **160** |
| **TOTAL MARKS (A+B)** | | | **400** |

* The industrial assignment shall be based on peer-to-peer assessment for a total of 10 marks (on a scale of 1 to 10) and in the event of a group assignment the marks awarded will be the same for the entire group, the developmental assessment will be for a total of 20 marks and based on MCQ/case study/demonstration and such other assignment methods

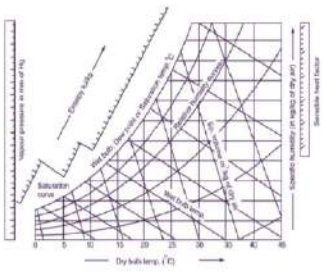
**Assessment framework for CIE (1 to 5)**

**Note: Theory to be conducted for 1 hour and practice for 3 hours, total duration of exam – 4 hours**

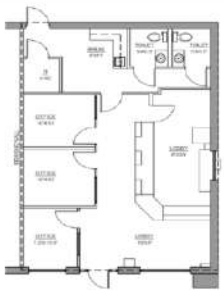
**CIE 1 - Model Question Paper**

| **Programme** | **Mechanical Engineering** | **Semester** | **V** |
|---|---|---|---|
| **Course** | **Heating, Ventilation and Air-Conditioning (HVAC)** | **Max Marks** | **30** |
| **Course Code** | **20ME52I** | **Duration** | **4 hours** |
| **Name of the course coordinator** | | | |

Note: Answer one full question from each section.

| **Qn.No** | **Question** | **CL L3/L4** | **CO** | **PO** | **Marks** |
|---|---|---|---|---|---|
| | **Section-1 (Theory) – 10 marks** | | | | |
| 1.a) | What does these lines represent on a Psychometric chart<br>i) Vertical and uniform space lines<br>ii) Curved line<br>iii) Non-Uniformly spaced inclined straight lines<br>iv) Non-Uniformly spaced horizontal lines<br>v) Uniformly spaced inclined straight lines<br>vi) Shading a portion of the psychrometric chart<br>  | L3 | 1 | | 03 |
| b) | Rajasthan has a unique weather, though the deserts of Rajasthan have shrunk drastically still the Ganganagar district of Rajasthan has similar weather:<br>1. Sand storms, which brings a lot of heat and dust.<br>2. Strong Sunlight, which causes extreme day temperature.<br>3. Colder nights, vast difference in the day and night temperature.<br>4. Lots of insects and flies. | L4 | 1 | | 07 |

| | | | | | |
|---|---|---|---|---|---|
| | Analyse different Glazing methods and suggest a suitable solution to the above problem | | | | |
| 2.a) | Indicate the following Psychometric processes on a Psychometric chart<br>i) Sensible heating<br>ii) Sensible cooling<br>iii) Humidification and dehumidification | L4 | 1 | | 03 |
| b) | Energy efficiency of buildings is attracting significant attention from the research community as the world is moving towards sustainable buildings design. Shading influences the solar energy on a window and the conveyed energy within the room through the window. Discuss shading phenomenon and its effect in heat load calculations? | L3 | 1 | | 07 |
| | **Section-2 (Practical) - 20 marks** | | | | |
| 3) | Estimate HVAC load for a building plan given using E20 or any similar forms<br>Also, Calculate Air flow in CFM. The conditions are as follows<br>Inside conditions: 25°C dry bulb, 50 percent RH, Wi = 0.00992 kg water/kg air<br>Outside conditions: 43°C dry bulb, 24°C wet bulb, Wo = 0.0105 kg water/kg air<br>U-value for wall: 1.75 W/m² K<br>U-value for roof: 1.33 W/m^2 K<br>U-value for floor: 1.3 W/m^2K<br>Effective Temp. Difference (ETD) for wall: 22°C<br>Effective Temp. Difference (ETD) for roof: 26°C<br>U-value for glass: 2.9 W/m² K<br>Solar Heat Gain (SHG) of glass: 275 W/m^2<br>Internal Shading Coefficient (SC) of glass: 0.8<br>Occupancy: 6 (100 W sensible heat/person) (50 W latent heat/person)<br>Lighting load: 50 W/m^2 of floor area<br>Appliance load: 650 W (Sensible) + 310W(latent)<br>Infiltration: 0.4 Air Changes per Hour<br>Barometric pressure: 101 kPa Note: hfg of water = 2501 kJ/kg. | L4 | 1 | | 20 |

| | | | | | |
|---|---|---|---|---|---|
| |  | | | | |
| 4) | Estimate HVAC load for a building plan given using E20 or any similar forms<br>Also, Calculate Air flow in CFM. The conditions are as follows<br>Outside conditions 43 C dry bulb, 24 °C wet bulb, density of dry air 1,095 kg/m3<br>U-value for wall 1.78 W/m² K<br>U-value for floor 12 W/m² K<br>U-value for glass 3.12 W/m² K<br>Cooling load temperature difference (CLTD) for wall 25° C<br>Cooling load temperature difference (CLTD) for roof 30 °C<br>Solar Heat Gain (SHGFmax) of glass 300 W/m2<br>Internal Shading Coefficient (SC) of glass 0.86<br>Cooling load factor (CLF) 1.0<br>Occupancy 4 people (90 W sensible heat/person) (40 W latent heat person)<br>Lighting load 33 W/m2 of floor area<br>Appliance load 600 W (Sensible) 300 W (latent)<br>Infiltration rate 8.2125 x 109k/Hr<br>Barometric pressure 101 kPa<br>Specific heat of moist air (Cpm) 1.0216 kJ/kgK<br>Specific enthalpy of vaporization 2501 kJ/kg | L4 | | | 20 |

| | | | | | |
|---|---|---|---|---|---|
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**Note : Theory questions shall be aligned to practical questions**

**Scheme of Evaluation for Practical question- Section 2**

| Sl. No | Description | Marks: 20 |
|---|---|---|
| 1 | Analyze the given Problem Statement | 03 |
| 2 | Calculate Heat Load for the given drawing using E20 or other forms | 10 |
| 3 | Tabulate the result and provide inference | 03 |
| 4 | Suggest one way to reduce the heating load with justification | 04 |
| | **Total** | **20** |

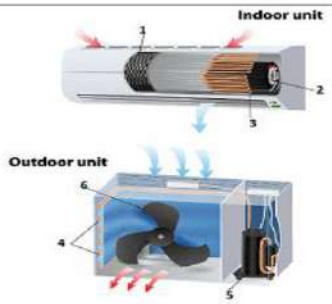
**Assessment framework for SEE 1 (Theory)**

| | | |
|---|---|---|
| **Programme :** | **Mechanical Engineering** | **Semester: V** |
| **Course :** | **Heating, Ventilation and Air-Conditioning (HVAC )** | **Max Marks: 100 Marks** |
| **Course Code :** | **20ME52I** | **Duration: 3 Hrs** |

**Instruction to the Candidate:** Answer one full question from each section.

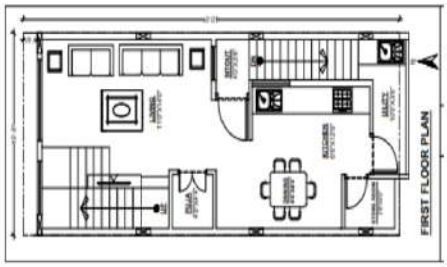
| Q.No | Question | CL (L3/L4) | CO | Marks |
|---|---|---|---|---|
| | **Section-1** | | | |
| 1.a) | According to statistics, major percentage of the overall business operating cost is spent on staff cost including medical benefit paid for employee. Therefore, promoting health and wellbeing at work not only contributes to employees' active engagement and improved productivity, but also leads to remarkable savings in operating cost for employers. For these reasons, an acceptable indoor environmental quality plays a key role. What comfort parameters need to be considered for maintaining indoor air quality? Discuss. | L4 | 1 | 08 |
| b) | An air-conditioned room that stands on a well-ventilated basement measures 3 m wide, 4 m high and 8 m deep. The two 8 m walls contain a double-glazed glass window of size 1.2 m by 1.3 m, mounted flush with the wall with no external shading. There are no heat gains through the other walls other than the ones with windows. Calculate the total latent heat and the total heat from the walls only using E20 or other forms<br>Inside conditions: 25°C dry bulb, 50 percent RH, Wi = 0.00992 kg water/kg air<br>Outside conditions: 43°C dry bulb, 24°C wet bulb, Wo = 0.0105 kg water/kg air<br>U-value for wall: 1.75 W/m² K<br>U-value for roof: 1.33 W/m^2 K<br>U-value for floor: 1.3 W/m^2K<br>Effective Temp. Difference (ETD) for wall: 22°C<br>Effective Temp. Difference (ETD) for roof: 26°C<br>U-value for glass: 2.9 W/m² K<br>Solar Heat Gain (SHG) of glass: 275 W/m^2<br>Internal Shading Coefficient (SC) of glass: 0.8<br>Occupancy: 3 (100 W sensible heat/person) (50 W latent heat/person) | L3 | | 12 |

| | | | | |
|---|---|---|---|---|
| | Lighting load: 30 W/m^2 of floor area<br>Appliance load: 550 W (Sensible) + 280 W(latent)<br>Infiltration: 0.4 Air Changes per Hour<br>Barometric pressure: 101 kPa Note: hfg of water = 2501 kJ/kg. | | | |
| 2.a) | Building energy efficiency is an important matter for energy policy at the regional, national and international levels. Several technological techniques and designs for high performance are based on central concepts such as space conditioning, ventilation, daylighting, and solar heat gain control. Does the techniques of Glazing and Shading affect energy efficiency? Justify | L4 | | 08 |
| b) | An air-conditioned room that stands on a well-ventilated basement measures 3 m wide, 3 m high and 6 m deep One of the two 3 m walls faces west and contains a double-glazed glass window of size 1.5 m by 1.5 m, mounted flush with the wall with no external shading. There are no heat gains through the walls other than the one facing east. From the following information<br>Inside conditions 25 °C dry bulb, 50% relative humidity<br>Outside conditions 43 C dry bulb, 24 °C wet bulb, density of dry air 1,095 kg/m3<br>U-value for wall 1.78 W/m² K<br>U-value for floor 12 W/m² K<br>U-value for glass 3.12 W/m² K<br>Cooling load temperature difference (CLTD) for wall 25° C<br>Cooling load temperature difference (CLTD) for roof 30 °C<br>Solar Heat Gain (SHGFmax) of glass 300 W/m2<br>Internal Shading Coefficient (SC) of glass 0.86<br>Cooling load factor (CLF) 1.0<br>Occupancy 4 people (90 W sensible heat/person) (40 W latent heat person)<br>Lighting load 33 W/m2 of floor area<br>Appliance load 600 W (Sensible) 300 W (latent)<br>Infiltration rate 8.2125 x 109k/Hr<br>Barometric pressure 101 kPa<br>Specific heat of moist air (Cpm) 1.0216 kJ/kgK<br>Specific enthalpy of vaporization 2501 kJ/kg<br>Since the room stands on a well-ventilated basement, assume the conditions in the basement to be the same as that of the outside. Also, since the floor is not exposed to solar radiation assume the Cooling load temperature difference for the floor as the temperature difference between the outdoor and indoor.<br>Calculate the sensible, latent and total heat gains using E20 or other forms | L3 | | 12 |
| **Section-2** | | | | |

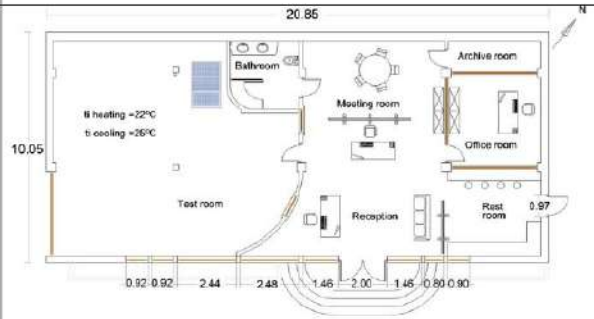
| | | | | | |
|---|---|---|---|---|---|
| 3.a) |  Fig (a) | A Split Airconditioning system is shown in Fig (a). Identify the components indicated by numbers. What are the functions of these components? How is Air conditioned happening in this system? | L3 | 2 | 08 |
| b) | Homeowners were looking for more comfort than they were getting from window air conditioners in the summer, and they were tired of having to install and store the heavy, bulky units every year. They needed ductless HVAC system to solve their problem. Compare different ductless air-conditioning systems available and suggest a suitable one for this case with justification: | | L4 | | 12 |
| 4.a) | HVAC systems are provided with Cooling towers and Condensers. What is the role played by these components? How do they work in an Air-Conditioning system? | | L3 | | 08 |
| b) | You have been approached by Walthamstow Academy as they have recognised the need for an integrated air conditioning solution for their flagship school. The requirement was to provide the most efficient method of cooling mixed-use rooms including offices, classrooms, laboratories and IT Suites over three floors and a 12,000 square feet footprint. Compare different Air-Conditioners and suggest a suitable one to solve their problem with justification: | | L4 | | 12 |
| | **Section- 3** | | | | |
| 5. | Heating and Cooling Load is required to be analysed for the building drawing shown in Fig (a)for the following conditions<br>Inside conditions: 25°C dry bulb, 50 percent RH, Wi = 0.00992 kg water/kg air<br>Outside conditions: 43°C dry bulb, 24°C wet bulb, Wo = 0.0105 kg water/kg air<br>U-value for wall: 1.75 W/m² K<br>U-value for roof: 1.33 W/m^2 K<br>U-value for floor: 1.3 W/m^2K<br>Effective Temp. Difference (ETD) for wall: 22°C | | L4 | 1 | 20 |

| | | | | |
|---|---|---|---|---|
| | Effective Temp. Difference (ETD) for roof: 26°C<br>U-value for glass: 2.9 W/m² K<br>Solar Heat Gain (SHG) of glass: 275 W/m^2<br>Internal Shading Coefficient (SC) of glass: 0.8<br>Occupancy: 6 (100 W sensible heat/person) (50 W latent heat/person)<br>Lighting load: 50 W/m^2 of floor area<br>Appliance load: 650 W (Sensible) + 310W(latent)<br>Infiltration: 0.4 Air Changes per Hour<br>Barometric pressure: 101 kPa Note: hfg of water = 2501 kJ/kg.<br>  <br>Fig(a) | | | |
| 6 | Three thousand lug boxes of apples are stored at 35° F in a storage cooler 50 ft x 40 ft x 10 ft. The apples enter the cooler at a temperature of 90° F and at the rate of 200 lugs per day each day for the 15 day harvesting period. The walls including floor and ceiling are constructed of 1 in. boards on both sides of 2x4 studs and are insulated with $3\frac{5}{8}$ in. of rock wool. All of the walls are shaded and the ambient temperature is 85° F. The average weight of apples per lug box is 59 lb. The lug boxes have an average weight of 4.5 lb and a specific heat value of0.60 Btu/lb/° F. Determine the average hourly cooling load based on 16 hr operating time for the equipment. | L4 | | 20 |
| | **Section-4** | | | |
| 7.a) | The green building is an eco-friendly segment, since it depends on the essential principles - "REDUCE, REUSE and RECYCLE. Does sustainable planning help in adopting these principles? Justify with illustrations. | L3 | 4 | 10 |

| | | | | |
|---|---|---|---|---|
| b) | Green Building movement has been driving the HVAC community for now about a decade to look at innovative solutions for reducing the energy cost and better IEQ (Indoor Environment Quality). The ventilation and air conditioning system which is a key component in green building design is on the verge of a paradigm shift. This shift is providing designers opportunities to explore energy efficient designs. The new initiatives such as intelligent HVAC systems are aimed at improving health, comfort and productivity. Discuss with comparison various intelligent HVAC methods that are available and suggest suitable that can be adopted to reduce the energy consumption. Illustrate with examples. | L4 | | 10 |
| 8.a) | LEED (Leadership in energy and Environmental Design) is the most widely used green building rating system in the world. LEED certification is a globally recognized symbol of sustainability achievement and leadership. What requirement should the building satisfy to obtain LEED certificate? How does this certificate help HVAC in green buildings? | L3 | | 10 |
| b) | In a study conducted by Howarth, it was found that energy consumption (EC) in Saudi Arabia is very different in summer and winter. Taking into account 60 GW for summer and 23 GW for winter, it is clear that owing to using AC throughout the country, the summer electricity consumption is 2.6 times that of winter. Adopt suitable techniques to reduce heat load and improve the energy efficiency of the building by comparing the various techniques and hence provide solutions to this problem. | L4 | | 10 |
| | **Section-5** | | | |
| 9.a) | A two-story house; with the living room, kitchen, and hallway located on the ground floor, while 3 bedrooms, and a smaller living room are located upstairs. The upper portion of the house is mostly occupied during the night only. It makes sense then to establish zones in such a situation. Suggest suitable zoning for the above case to provide solution by comparing the zoning methods adopted in HVAC systems. | L4 | 2 | 10 |
| b) | Piping's play a critical role in HVAC systems. While designing Piping system, losses in pipes are to be considered. Discuss various losses in pipe and methods to overcome these losses? | L3 | | 10 |
| 10.a) | Ductwork is an essential part of the HVAC system. There are so many ducts material options in the market, and each serves a different purpose. The option you choose may be decided based on needs such as insulation, noise reduction, moisture and condensation, and build-up. Discuss different Duct materials for HAVC system and their application. | L3 | | 10 |

| | | | | | |
|---|---|---|---|---|---|
| b) |   | Analyse the given drawing and select suitable Air distribution system and justify. | L4 | | 10 |

## Scheme of Evaluation for SEE 2

| Sl. No | Description | | Marks |
|---|---|---|---|
| **Problem statement** |   | **Design an HVAC system for the given office space using suitable BIM software**<br>**Note:** Necessary Psychometric, building data and location must be provided by the examiner | **100** |
| 1 | Heating and cooling load calculation using E20 forms or any other forms | | 20 |

| | | |
|---|---|---|
| 2 | Apply logical systems for the given office space drawing | 30 |
| 3 | Apply piping systems for the given office space drawing | 30 |
| 4 | Innovating methods to reduce the Heating and cooling Load | 20 |
| **Total** | | **100** |