## Module 1


**Chapter 1 : Review of Thermodynamics and Heat Transfer 1-1 to 1-29**

**1.1 Introduction ..... 1-1**
**1.2 Thermodynamics System ..... 1-1**
**1.3 Dimensions and Units ..... 1-1**
**1.4 Energy ..... 1-2**
**1.5 Ideal Gas Equation ..... 1-3**
**1.6 Enthalpy ..... 1-3**
**1.7 Specific Heats of a Gas ..... 1-3**
**1.8 First Law of Thermodynamics ..... 1-3**
**1.9 Application of 1st Law of Thermodynamics to Closed System (Non-Flow) Processes ..... 1-4**
1.9.1 A Constant Volume Process ..... 1-4
1.9.2 A Constant Pressure Process ..... 1-4
1.9.3 Constant Temperature or Isothermal Process ..... 1-5
1.9.4 Hyperbolic Process ..... 1-5
1.9.5 Reversible Adiabatic Process ..... 1-5
1.9.6 Reversible Polytropic Process ..... 1-6
1.9.7 The Combination of Polytropic Law $p \cdot V^n = C$ and Equation of State, $pV = mRT$ ..... 1-6
**1.10 Application of First Law of Thermodynamics to Steady Flow Open Systems ..... 1-6**
**1.11 Mechanical Work in a Steady Flow Process ..... 1-7**
**1.12 Second Law of Thermodynamics ..... 1-9**
**1.13 Carnot's Theorem ..... 1-9**
**1.14 Entropy ..... 1-9**
**1.15 Principle of Increase of Entropy ..... 1-9**
**1.16 Entropy Change for Ideal Gas-General Equation ..... 1-9**
**1.17 State of a Substance ..... 1-10**
**1.18 Pure Substance ..... 1-10**
**1.19 Phase Transformation at Constant Pressure-Formation of Steam ..... 1-10**
**1.20 Properties of Steam ..... 1-11**
**1.21 Steam Tables and their Uses ..... 1-12**
**1.22 Temperature – Entropy (T-S) and Enthalpy – Entropy (H-S) Diagrams for Steam ..... 1-13**
**1.23 Compressed Liquid ..... 1-14**
**1.24 Heat Transfer ..... 1-16**
**1.25 Modes of Heat Transfer ..... 1-16**
**1.26 Heat Transfer by Conduction ..... 1-16**
**1.27 Fourier's Law of Heat Conduction ..... 1-16**
1.27.1 Heat Conduction through a Thick Wall ..... 1-16
1.27.2 Analogy between Heat Conduction and Electrical System ..... 1-17
1.27.3 Composite Walls ..... 1-17
**1.28 Convection ..... 1-17**
**1.29 Overall Heat Transfer Coefficient, U ..... 1-18**
**1.30 Heat Transfer in an Infinitely Long Cylinder ..... 1-19**
**1.31 Heat Transfer through a Hollow Sphere ..... 1-20**
**1.32 Heat Transfer through A Composite Cylinder with Conduction and Convection ..... 1-20**
**1.33 Thermal Insulation ..... 1-21**
**1.34 Radiation ..... 1-21**
**1.35 Stefan - Boltzmann Law of Radiation ..... 1-21**

**Chapter 2 : Basic Concepts of Refrigeration and Refrigerants 2-1 to 2-22**


**Syllabus : Basic Knowledge :** Carnot refrigerator, Carnot heat pump, Coefficient of performance, Reversed carnot cycle and its limitation. Effect of temperature and pressure on COP of the cycle.

**Refrigerants :** Classification, Designation, Selection of refrigerant, Physical and chemical properties of refrigerants, Secondary refrigerants.


**2.1 Development of Refrigeration ..... 2-1**
**2.2 Definition of Refrigeration ..... 2-1**
2.2.1 Definition of Air-conditioning ..... 2-2
2.2.2 Difference between Refrigeration and Air-conditioning ..... 2-2
2.2.3 Application of Refrigeration in Food Processing ..... 2-2
**2.3 Applications of Refrigeration ..... 2-3**
**2.4 Concept of Heat Engine, Heat Pump and Refrigerating Machines ..... 2-3**

2.4.1 Performance of Heat Engine, Heat Pump and a Refrigerator ... 2-3

2.4.2 Concept of EER, SEER and IPLV ... 2-4

**2.5 BEE Star Rating ... 2-4**

**2.6 Units of Refrigeration - Tons of Refrigeration (TR) ... 2-5**

**2.7 The Carnot Refrigerator ... 2-5**

2.7.1 Limitations of Carnot Cycle with Air or Gas as Refrigerant ... 2-6

2.7.2 Carnot Refrigerator with Vapour as Refrigerant ... 2-7

**2.8 Introduction to Refrigerants ... 2-10**

2.8.1 Definition of a Refrigerant ... 2-10

2.8.2 Brief History of Refrigerants ... 2-11

**2.9 Classification of Refrigerants ... 2-11**

**2.10 Classification of Primary Refrigerants ... 2-12**

**2.11 Designation of Refrigerants ... 2-13**

**2.12 Desirable Properties of a Good Refrigerant ... 2-13**

2.12.1 Thermodynamic Properties of Refrigerants ... 2-13

2.12.2 Chemical Properties of Refrigerants ... 2-15

2.12.3 Physical Properties of Refrigerants ... 2-16

2.12.4 Other Properties of Refrigerants ... 2-16

2.12.5 Properties of an Ideal Refrigerant ... 2-16

**2.13 Properties of Important Refrigerants ... 2-17**

**2.14 Selection of a Refrigerant ... 2-18**

**2.15 Secondary Refrigerants ... 2-19**

2.15.1 Substances Used as Secondary Refrigerants ... 2-19

**Chapter 3 : Air Refrigeration System 3-1 to 3-45**

**Syllabus :** Bell Coleman cycle, Necessity of air cooling, Factors considered for the selection of air refrigeration system. Types of air refrigeration system with schematic and T-S diagram, Numerical based on simple and bootstrap air refrigeration system.

**3.1 Air Refrigeration System ... 3-1**

3.1.1 Types of Air Refrigeration System ... 3-1

3.1.2 Advantages of Closed System Over Open System ... 3-1

3.1.3 Disadvantages of Closed System Over Open System ... 3-1

**3.2 Bell-Coleman Air Refrigeration Cycle ... 3-2**

3.2.1 Advantages of Bell Coleman Cycle ... 3-3

3.2.2 Disadvantages of Bell-Coleman Cycle ... 3-3

**3.3 Application of Air Cycle Refrigeration for Aircrafts ... 3-9**

3.3.1 Advantages of Air Refrigeration System for Aircraft Cooling ... 3-9

**3.4 Methods of Air Refrigeration Systems ... 3-10**

**3.5 Simple Air Cooling System ... 3-10**

**3.6 Simple Air Evaporative Cooling System ... 3-17**

**3.7 Bootstrap Air Refrigeration System ... 3-21**

**3.8 Boot Strap Air Evaporative Cooling System ... 3-22**

**3.9 Reduced Ambient Air Cooling System ... 3-32**

**3.10 Regenerative Air Cooling System ... 3-33**

**3.11 Comparison of Various Aircraft Cooling Systems ... 3-44**

**Module 2**

**Chapter 4 : Vapour Compression Refrigeration System 4-1 to 4-33**

**Syllabus :** Simple system on P-h and T-s diagrams, analysis of the simple cycle, factors affecting the performance of the cycle, actual cycle, Numerical based on standard vapour compression system by using P-h chart and refrigerant table.

**4.1 Limitations of Air Refrigeration Cycle ... 4-1**

**4.2 The Vapour Compression Refrigeration System ... 4-1**

4.2.1 Advantages and Disadvantages of Vapour Compression System over Air Refrigeration System ... 4-2

4.2.2 System Equipment Nomenclature ... 4-2

**4.3 Pressure - Enthalpy (p-h) Chart for Refrigerants ... 4-3**

**4.4 Thermodynamic Analysis of Vapour Compression Refrigeration Cycle ..... 4-3**
4.4.1 When the Vapour is Dry-saturated at the End of Compression ..... 4-3
4.4.2 Vapour Compression Cycle when Vapour is Wet at the End of Compression ..... 4-5
4.4.3 Vapour Compression Cycle when the Vapour is Dry-saturated at Entry to Compressor ..... 4-6
4.4.4 Assumptions in Theoretical Vapour Compression Cycle ..... 4-6
**4.5 Wet Compression Vs Dry Compression ..... 4-6**
**4.6 Effect of Operating Variables on Performance of Vapour Compression Refrigeration System ..... 4-7**
4.6.1 Effect of Superheat in Suction Vapour ..... 4-7
4.6.2 Effect of Liquid Subcooling ..... 4-8
4.6.3 Effect of Change in Suction Pressure or Evaporator Pressure ..... 4-8
4.6.4 Effect of Change of High Side Pressure or Discharge Pressure or Condenser Pressure ..... 4-9
4.6.5 Representation of Sub-cooled and Super Cooled VCC ..... 4-9
**4.7 Expansion Cylinder Vs Throttle Valve ..... 4-10**
**4.8 Thermodynamic Properties of Saturated Refrigerants ..... 4-10**
**4.9 Actual Vapour Compression Refrigeration Cycle ..... 4-25**
**4.10 Methods of Improvement in Simple Saturated Vapour Compression Cycle ..... 4-26**
4.10.1 Simple Saturated Cycle with Flash Chamber ..... 4-26
4.10.2 Simple Saturated Cycle with Subcooling of Refrigerant by Vapour Refrigerant Leaving the Evaporator ..... 4-27
4.10.3 Simple Saturated Cycle with Subcooling of Liquid Refrigerant by the Liquid Refrigerant from Expansion Valve ..... 4-28
4.10.4 Simple Saturated Cycle with Accumulator ..... 4-29

**Chapter 5 : Vapour Absorption Refrigeration System 5-1 to 5-17**

**Syllabus :** Simple and practical, vapour absorption system Refrigerant-adsorbent properties, COP of ideal vapour absorption system. Domestic Electrolux refrigerator, Lithium-bromide absorption system.

**5.1 Introduction ..... 5-1**
5.1.1 Origin of the Absorption System ..... 5-1
5.1.2 Principle of Basic Liquid Absorbent System (Ammonia Water) ..... 5-2
5.1.3 Terms and Definitions ..... 5-2
**5.2 Refrigerant - Solvent Properties ..... 5-3**
5.2.1 Desirable Properties of Solvent ..... 5-3
5.2.2 Desirable Properties of Refrigerant-Solvent Combination ..... 5-3
5.2.3 Characteristics of Ammonia ..... 5-3
**5.3 Simple Ammonia-Water Vapour Absorption System ..... 5-3**
**5.4 Practical Ammonia-Water Vapour Absorption System ..... 5-4**
**5.5 Comparison between Vapour Absorption and Vapour Compression System ..... 5-5**
**5.6 COP of an Ideal Vapour Absorption System ..... 5-6**
**5.7 Domestic Electrolux ($NH_3 - H_2$) Refrigerator .. 5-9**
**5.8 Lithium Bromide Absorption Refrigeration System ..... 5-11**
5.8.1 Double - Effect Li-Br Absorption System ..... 5-13
5.8.2 Comparison between Aqua-$NH_3$ with Li Br-$H_2O$ Vapour Absorption System ..... 5-14
5.8.3 Solar Based Li Br – $H_2O$ Vapour Absorption System for Space Cooling ..... 5-14
5.8.4 Applications of Vapour Absorption System ..... 5-15
5.9 New Mixtures for Vapour Absorption System ..... 5-15

**Chapter 6 : Heat Pump 6-1 to 6-7**

**Syllabus :** Performance, Primary energy ratio, Energy efficiency Introduction, Coefficient of ratio, Heating season performance factor, Seasonal energy efficiency ratio, Classification of heat pump, Vapour compression heat pump system. Heat pump application in an industry.

**6.1 Introduction to Heat Pump ..... 6-1**
**6.2 Performance of Heat Pumps ..... 6-1**
6.2.1 Coefficient of Performance (COP) or Effectiveness of Heat Pump ..... 6-1
6.2.2 Energy Efficiency Ratio (EER) ..... 6-2
6.2.3 Seasonal Energy Efficiency Ratio (SEER) ..... 6-2
6.2.4 Primary Energy Ratio (PER) : ..... 6-2
6.2.5 Heating Season Performance Factor (HSPF) ..... 6-2
**6.3 Advantages and Disadvantages of Heat Pumps ..... 6-2**
6.3.1 Advantages of Heat Pump ..... 6-2
6.3.2 Disadvantages of Heat Pumps ..... 6-2
**6.4 Applications of Heat Pump ..... 6-3**
**6.5 Basics of Vapour Compression Heat Pump System ..... 6-3**
6.5.1 Vapour Compression System Both for Cooling and Heating Mode ..... 6-3
**6.6 Classification Heat Pumps ..... 6-4**
6.6.1 Air to Air Heat Pump ..... 6-4
6.6.2 Water source Heat Pump ..... 6-5
6.6.3 Ground Source Heat Pump or Geothermal Heat Pumps ..... 6-5
6.6.4 Sub Classification of Heat Pumps ..... 6-6
6.6.4.1 Solar Heat Pumps ..... 6-6
6.6.4.2 Hybrid Heat Pump ..... 6-6
6.6.4.3 Absorption or Gas Fired Heat Pumps ..... 6-6

**Module 3**

**Chapter 7 : Basic Psychrometry 7-1 to 7-43**

**Syllabus :** Psychrometry properties, relations and processes, Adiabatic air mixing process, Psychrometric chart, RSHF, GSHF, ERSHF, Bypass factor, Apparatus dew point, Numerical based on psychrometric chart and Classification of air conditioning system, relations. [Refer Chapter 8 for RSHF, GSHF, ERSHF]

**7.1 Introduction ..... 7-1**
7.1.1 Industrial Air Conditioning ..... 7-1
7.1.2 Comfort Air Conditioning ..... 7-1
7.1.3 Factors Affecting Human Comfort ..... 7-1
**7.2 Psychrometry and Psychrometric Properties ..... 7-3**
**7.3 Psychrometric Relations ..... 7-4**
7.3.1 Daltons Law of Partial Pressure ..... 7-4
7.3.2 Specific Humidity or Humidity Ratio ..... 7-5
7.3.3 Relative Humidity ($\phi$) ..... 7-5
7.3.4 Degree of Saturation ($\mu$) ..... 7-6
7.3.5 Measurement of Wet Bulb Temperature and RH by Sling Psychrometer ..... 7-6
7.3.5.1 Humidistat ..... 7-7
7.3.6 Dry Bulb Temperature (DB or $t_{db}$) ..... 7-7
7.3.7 Enthalpy of Air (h) ..... 7-7
7.3.8 Thermodynamic Wet Bulb Temperature or Adiabatic Saturation of Air ..... 7-8
7.3.9 Dew Point Temperature (DPT) ..... 7-9
7.3.10 Vapour Density or Absolute Humidity ..... 7-9
7.3.11 Specific Volume ..... 7-9
**7.4 Psychrometric Chart ..... 7-9**
**7.5 Psychrometric Processes ..... 7-10**
**7.6 Adiabatic Mixing of Air Streams ..... 7-10**
**7.7 Sensible Heating ..... 7-11**
**7.8 Sensible Cooling ..... 7-12**
**7.9 Humidification and Dehumidification of Air ..... 7-13**
**7.10 Cooling and Dehumidification ..... 7-14**
**7.11 Adiabatic Cooling or Evaporative Cooling or Cooling with Humidification Process ..... 7-15**

**7.12 Heating with Humidification ..... 7-16**
**7.13 Chemical Dehumidification or Absorbent Dehumidification (Heating with Dehumidification) ..... 7-17**
**7.14 Spray Processes ..... 7-18**

**Chapter 8 : Thermal Comfort and Cooling Load Estimations 8-1 to 8-35**

**Syllabus : Thermal Comfort Conditions :** Selection of inside design conditions, thermal comfort, heat balance equation for a human being, factors affecting thermal comfort, Effective temperature, comfort chart and factors governing effective temperature, selection of outside design conditions.

**Cooling Load Estimation : RSHF, ERSHF and GSHF**

Introduction, Components of cooling load Different heat sources Various load Estimation. Design of air conditioning system. Building survey and economic aspect used in design.

**8.1 Introduction ..... 8-1**
**8.2 Inside Design Condition ..... 8-1**
8.2.1 Industrial Application ..... 8-2
8.2.2 Comfort Applications (Thermal Analysis of Human Body) ..... 8-2
8.2.2.1 Factors Affecting Human Comfort ..... 8-2
8.2.3 Effect of Extremes of Hot and Cold ..... 8-2
8.2.4 Effective Temperature ..... 8-3
8.2.5 Human Comfort Chart ..... 8-3
**8.3 Outside Design Conditions ..... 8-4**
**8.4 Design of Air Conditioning System ..... 8-4**
**8.5 Sources of Heat Load ..... 8-5**
**8.6 Heat Gain through Glass ..... 8-5**
8.6.1 Factors Affecting Solar Radiation at a Place ..... 8-6
8.6.2 Factors Affecting Solar Radiation Entering the Room ..... 8-6
8.6.3 Method of Estimation ..... 8-6
**8.7 Heat Load through Opaque Surface ..... 8-7**
8.7.1 Overall Heat Transfer Coefficient ..... 8-7
8.7.2 Surface Area ..... 8-7
8.7.3 Temperature Difference ..... 8-7
**8.8 Infiltration ..... 8-9**
**8.9 Ventilation ..... 8-9**
**8.10 Outside Air Load ..... 8-9**
**8.11 Occupancy Heat Load ..... 8-10**
**8.12 Lighting ..... 8-10**
**8.13 Equipment ..... 8-10**
**8.14 Product Brought in ..... 8-10**
**8.15 System Heat Gain ..... 8-10**
**8.16 Equipment Selection ..... 8-11**
**8.17 RSHF, ERSHF, GSHF ..... 8-11**
**8.18 Psychrometric Analysis ..... 8-12**
**8.19 Psychrometric Analysis of Uncommon Load Patterns ..... 8-13**
**8.20 Partial Load Analysis ..... 8-14**
8.20.1 Air Flow Control ..... 8-14
8.20.2 Return Air Bypass ..... 8-14
8.20.3 Reheating ..... 8-14
8.20.4 Capacity Control of Compressor ..... 8-15
**8.21 Winter Air Conditioning ..... 8-15**
8.21.1 Heat Load/Loss Estimate ..... 8-15
8.21.2 Psychrometric Analysis ..... 8-15
**8.22 Green Building ..... 8-16**

**Module 4**

**Chapter 9 : Air Distribution System and Ducts Design 9-1 to 9-26**

**Syllabus : Duct :** Classification of ducts, duct material, pressure in ducts, flow through duct, pressure losses in duct Air flow through simple duct system, Equivalent diameter, Methods of duct system design

**Air Handling Unit :** Introduction to Fan coil unit, Types of fans used air conditioning applications, Fan laws, Filters supply and return grills, Sensors.

**9.1 Introduction ..... 9-1**
**9.2 Supply Air Duct ..... 9-1**
9.2.1 Material ..... 9-1
9.2.2 Classification of Duct ..... 9-1
9.2.3 Shape of Duct ..... 9-2
9.2.4 Size of Duct ..... 9-2
9.2.5 Obstruction ..... 9-2
9.2.6 Bends, Tees and Branch Take Offs ..... 9-3
9.2.7 Fire Dampers ..... 9-3
**9.3 Flow Through Duct ..... 9-3**
**9.4 Pressure Losses in the Duct ..... 9-4**

**9.5 Loss of Pressure Due to Friction ..... 9-4**
9.5.1 Friction Factor 'f' ..... 9-4
**9.6 Equivalent Diameter of a Circular Duct or a Rectangular Duct ..... 9-4**
**9.7 Friction Chart for Circular Ducts ..... 9-5**
**9.8 Dynamic Losses in duct ..... 9-5**
9.8.1 Pressure Loss due to Enlargement ..... 9-5
9.8.2 Pressure Loss Due to Contraction ..... 9-6
9.8.3 Pressure Loss at Entry or Exit from Duct ..... 9-6
9.8.4 Pressure Loss in Bends, Tees, and Branch Offs ..... 9-6
9.8.5 Equivalent Lengths of Fittings ..... 9-6
**9.9 Methods of Duct Design ..... 9-6**
9.9.1 Velocity Reduction Method ..... 9-7
9.9.2 Equal Friction Method ..... 9-7
9.9.3 Static Regain Method ..... 9-7
9.9.4 Design of Duct by Equal Friction Method ..... 9-8
**9.10 Pressure Drop in Ducts ..... 9-9**
**9.11 Air Conditioning Equipments ..... 9-14**
**9.12 Air Cleaners ..... 9-14**
9.12.1 Choice of the Filter ..... 9-14
9.12.2 Types of Filters ..... 9-15
9.12.3 Installation and Maintenance of Filters ..... 9-16
**9.13 Cooling Coil ..... 9-16**
**9.14 Heating Device ..... 9-17**
**9.15 Humidifier ..... 9-18**
**9.16 Fans ..... 9-18**
9.16.1 Introduction ..... 9-18
9.16.2 Axial Fans ..... 9-19
9.16.3 Centrifugal Fans ..... 9-19
9.16.4 Fan Classification ..... 9-20
9.16.5 Fan Laws ..... 9-20
9.16.6 System Balance ..... 9-20
9.16.7 Selection of Fan ..... 9-21
9.16.8 Fan Control ..... 9-21
**9.17 Noise and its Control ..... 9-22**
9.17.1 Noise Generation and Transmission in AC System ..... 9-22
9.17.2 Noise Attenuation and Control ..... 9-22
**9.18 Room Air Distribution ..... 9-23**
**9.19 Types of Outlets ..... 9-24**
**9.20 Location of Outlet ..... 9-24**
**9.21 Return Air System ..... 9-25**


**Module 5**


**Chapter 10 : Components of HVACR Systems 10-1 to 10-27**


**Syllabus : HVACR and Components :** Working of reciprocating, screw and scroll compressors, working of air cooled and water cooled and evaporative condensers, Working of DX, Flooded and Forced feed evaporators, Expansion devices Capillary tube, TXV, EXV, Type of insulation materials.


**10.1 Introduction ..... 10-1**
**10.2 Compressor ..... 10-1**
**10.3 Reciprocating Compressor ..... 10-2**
10.3.1 Construction and Working ..... 10-2
10.3.2 Performance of Reciprocating Compressors ..... 10-2
10.3.3 Parts of Reciprocating Compressors ..... 10-4
10.3.4 Lubrication ..... 10-5
10.3.5 Capacity Control ..... 10-6
**10.4 Rotary Compressor ..... 10-7**
**10.5 Centrifugal Compressor ..... 10-7**
**10.6 Screw Compressor ..... 10-8**
**10.7 Scroll Compressor ..... 10-8**
10.7.1 Comparison and Selection of Compressor ..... 10-9
**10.8 Hermetically Sealed Compressor ..... 10-10**
**10.9 Condensers ..... 10-10**
10.9.1 Air Cooled Condensers ..... 10-10
10.9.2 Water Cooled Condensers ..... 10-11
10.9.3 Water Cooling Devices ..... 10-12
10.9.3.1 Spray ponds ..... 10-12
10.9.3.2 Cooling Towers ..... 10-12
10.9.3.3 Selection of Cooling Towers ..... 10-14
10.9.4 Evaporative Condenser ..... 10-14
10.9.5 Comparison of Air Cooled and Water Cooled Condensers ..... 10-14
**10.10 Expansion and Flow Control Devices ..... 10-14**
10.10.1 Float Valve ..... 10-15
10.10.2 Automatic Expansion Valve (AXV) ..... 10-15
10.10.3 Thermostatic Expansion Valve (TXV) ..... 10-15
10.10.4 Capillary Tube ..... 10-17

**10.11 Evaporator....10-17**
10.11.1 Air Cooling Evaporators....10-17
10.11.2 Liquid Chilling Evaporator....10-18
10.11.3 DX and Flooded Evaporators....10-18
10.11.4 Defrosting....10-19
**10.12 Accessories....10-20**
10.12.1 Oil Separator....10-20
10.12.2 Receiver....10-20
10.12.3 Dryer....10-20
10.12.4 Strainer....10-21
10.12.5 Sight Glass....10-21
**10.13 Controls....10-21**
10.13.1 Thermostat....10-21
10.13.2 Low Pressure Cutout....10-22
10.13.3 High Pressure Cutout....10-22
10.13.4 Oil Failure Cutout....10-22
**10.14 Piping in Refrigeration System....10-22**
**10.15 Insulation in Refrigeration....10-23**
10.15.1 Desirable Properties of Insulating Materials....10-23
10.15.2 Classification of Insulation....10-23
10.15.3 Insulating Materials used in Refrigeration Equipment....10-24
**10.16 Services Operations....10-24**
10.16.1 Small Domestic Plant....10-24
10.16.2 Large Plants....10-25

**Module 6**

**Chapter 11 : Applications of HVAC and R Systems 11-1 to 11-21**

**Syllabus :** Ice plant, Food storage plants, dairy and food processing plants, freeze drying, A/c in textile, Printing pharmaceutical industry and Hospitals, cold chain Technology, Transport air conditioning, Solar refrigeration.

**11.1 Introduction....11-1**
**11.2 Refrigerators....11-1**
11.2.1 Components of Refrigeration System....11-2
11.2.2 Precautions During Usage of Refrigerator : (Thermodynamic Significance)....11-3
11.2.3 Defrosting....11-3
**11.3 Water Coolers....11-4**
**11.4 Deep Freezers....11-4**
**11.5 Ice Making Plant....11-4**
11.5.1 Block or Can Ice Plant....11-5
11.5.2 Flake Ice Plant....11-5
11.5.3 Cube Ice Plants....11-5
**11.6 Preservation of Food....11-5**
11.6.1 Spoilage Agents....11-6
11.6.2 Enzymes....11-6
11.6.3 Microorganism....11-6
11.6.4 Methods of Preservation of Food....11-7
11.6.5 Preservation of Food by Refrigeration....11-8
11.6.6 Storage Conditions....11-9
11.6.7 Frozen Storage....11-10
**11.7 Cooling Load Calculation....11-10**
**11.8 Types of Cold Storage....11-11**
11.8.1 Controlled Atmosphere / Modified Atmosphere Storage (CA/MA storage )....11-12
**11.9 Milk Chilling Plant for Dairy....11-13**
**11.10 Hospital Air-conditioning System....11-13**
**11.11 Industrial Air-conditioning : Textile, Printing, Pharmaceutical....11-14**
11.11.1 Textile Industry....11-14
11.11.2 Printing Industry....11-14
11.11.3 Pharmaceutical Industry....11-14
11.11.4 Sources of Cooling Load for a Restaurant....11-15
**11.12 Automotive /Transport Conditioning....11-15**
**11.13 Air Conditioning of Multiplexes....11-16**
11.13.1 Multiplexes....11-16
**11.14 Cold Chain Technology....11-16**
**11.15 Solar Based Refrigeration System (Li Br – H2O Vapour Absorption System)....11-17**
**11.16 Deep Sea Water Airconditioning (SWAC)....11-18**
**11.17 Variable Refrigerant Flow (VRF) System....11-19**
**11.18 Variable Air Flow (VAV) System....11-19**
- **Appendix A....A-1 to A-9**
- **Appendix B....B-1 to B-14**

❑❑❑