GUJARAT TECHNOLOGICAL UNIVERSITY
M.E   Semester: 1
Mechanical Engineering (Cryogenic Engineering)

Subject Name   CRYOGENIC FUNDAMENTALS

Sr.No	Course content
1.	Properties of engineering materials at cryogenic temperatures, mechanical properties ,thermal properties, electric & magnetic properties, super conducting materials ,thermo electric materials, composite materials, properties of cryogenic fluids, super fluidity of He 3 &He4.
2.	Measurement systems for low temperatures:-Temperature measurements, pressure measurements, flow measurements, liquid level measurements, fluid quality measurements.
3.	Cryogenic insulation:- various types such as expanded foams, gas filled& fibrous insulation, vacuum insulation, evacuated powder& fibrous insulation ,opacified powder insulation, multi layer insulation, comparison of performance of various insulations .
4.	Applications of cryogenic systems Super conductive devices such as bearings, motors, cryotrons, magnets, D.C. transformers, tunnel diodes, space technology, space simulation, cryogenics in biology and medicine, food preservation and industrial applications, nuclear propulsions ,chemical propulsions.
5.	Hazards:-Physical hazards, Chemical hazards, Physiological hazards, combustion hazards, oxygen hazards, , accidents in cryogenic plants & prevention
6.	Safety in handling of cryogens, care for storage of gaseous cylinders, familiarization with regulations of department of explosives.

List of Experiments:

1. Study of cryogenic properties of hydrogen and helium.
2. Study of low temperature measurement instrument.
3. Study of flow measurement and quality measurement instrument.
4. Study of liquid level measurement.
5. Study of insulation used in cryogenic equipment.
6. Study of cryogenic application (superconductivity)
7. Study of cryogenic application in space technology.
8. Study of cryogenic application in bio medical and food preservation
9. Study of safety while handling fluid.
10. To find the thermal conductivity of powder insulation by boil off calorimeter method.

Reference Books:

1. Cryogenic systems-Baron, McGraw-Hill book
2. Cryogenic fundamentals-Haselden, Academic press New York
3. Cryogenic technology –Vance
4. Advance cryogenic –bailey, plenum press
5. Cryogenic engineering –Scott

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E   Semester: 1
Mechanical Engineering (Cryogenic Engineering)

Subject Name   **VACUUM ENGINEERING**

Sr.No	Course content
1.	Equation of state for ideal gases ,real gases ,velocity and speed of gas molecules ,the mean free path ,volume occupied by gas molecules.
2.	Basic theory of pumping: Basic definitions, resistance and conductance of arbitrary vacuum pipe work, fundamental equation of vacuum technique , regions of gas flow in pipes, calculation of pump down time.
3.	Interaction of gases with solid-taking up and evolution of gases by solids, adsorption and desorption of gases.
4.	Production of vacuum: classification of vacuum pump-Calculation, operating limits of vacuum pump, their ranges, Types of vacuum pumps-oil sealed rotary, roots blower, ejector ,diffusion, turbo molecular ,sorption, getter pumps ,cold cathode &cryogenic pumps principles ,construction ,operation of pump and their salient features.
5.	Vacuum gauges: classification –ranges of vacuum gauges, McLeod, mechanical, thermal conductivity gauges, hot cathode and cold cathode ionization gauges, ionization gauges with upper range-principle, construction and salient features.
6.	Metered leak measurement. Leak hunting: Tightness of vacuum system, leak detection methods, halide leak detector, and mass spectrometer leak detector.
7.	Vacuum system components: demountable vacuum joints, electrical lead ,introduction to vacuum valves, various types, their selection.
8.	Vacuum materials:-basic requirements, metals & their alloys, non metals, pump fluids.
9.	Selection of pumping facilities –determination of intrinsic speed-matching pumps operating in series and in parallel, calculation of fire vacuum cylinders.
10.	Application of vacuum – vacuum systems for space simulation chamber,

List of Experiments:

1. Study of mechanical oil sealed double vane type vacuum pump
2. Study of simple and fractionating type oil diffusion pump
3. Study and operation of vacuum module
4. Study of vacuum gauges – Pirani and Penning gauges
5. Study of turbo molecular pump
6. Study of water ring pump
7. Study of roots blower vacuum pump
8. Study of Helium mass spectrometer leak detector.

Reference Books:

1. Fundamentals Of Vacuum Techniques-A Pipko
2. Vacuum technology: Andrew Gutheries.
3. Vacuum technology :A.roth
4. Hand book of high vacuum engg .:Steinherz.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E   Semester: 1
Mechanical Engineering (Cryogenic Engineering)

Subject Name   ADVANCED REFRIGERATION

Sr.No	Course content
1.	Balancing of vapor compression refrigeration system
2.	Dual pressure vapor compression system and its analysis.
3.	Compound compression with flash cooler and flash intercooler,
4.	multiple expansions, parallel operation, sectionalizing, booster operations, various types of cascade systems analysis
5.	Refrigerants: Ecofriendly refrigerants & their properties, secondary Refrigerants, mixture of refrigerants, azeotropics, salient characteristics of various refrigerants. Synthetic lubricating oil &their properties
6.	Absorption refrigeration: H-x charts of LiBr-H2O and NH3-H2O solutions., analysis of vapor absorption refrigeration system on H-X charts, mass concentration &equilibrium charts , heat balance, COP comparison with vapor compression refrigeration systems, two stage vapor absorption refrigeration system ,balancing of vapor absorption refrigeration systems.
7.	Air cycle refrigeration, Analysis of various cycles and their applications. Calculations of COP
8.	Steam jet refrigeration - cycle analysis, analysis on H-O charts performance, control and various applications.
9.	Thermo-electric refrigeration: Thermo-electric effects, analysis of thermo-electric cooling, COP, FOM, thermoelectric, materials.
10.	Heat pumps: Sources and sinks, refrigerant circuits, heating and cooling performance of heat pumps.
	Design of refrigeration systems for industrial &other application for transport refrigeration ,walk in coolers & cold storages for different applications.
11.	Preservation & processing of food by use of refrigeration.

List of Experiments:

1. To build up a vapour compression refrigeration system and change it with R-134a.
2. Study and testing of a steam jet refrigeration system.
3. Study and testing of forced draft cooling towers.
4. Study and testing of cascade refrigeration system.
5. Study of a mechanical heat pump system and to test it.
   - (a) On air cooled condenser mode
   - (b) On water cooled condenser mode
6. Study and testing of walk in cooler.
7. Study and testing of a short vortex tube.
8. To carry out test on reciprocating refrigerant compressor and plot. volumetric efficiency curve of a given compressor.
9. Study of NH_3 condensing plant of a cold storage.
10. Study of freeze drying machine.

Reference Books:

1. Mechanical refrigeration, sparks and dilio
2. Refrigeration and air conditioning, stocker
3. Refrigeration and air conditioning, Jordan and priester
4. Refrigeration and air conditioning, C. P. Arora
5. Ashrae hand book, refrigeration 1998
6. 6.Thermal environmental engineering-threlked 1998
7. 7.Industrial refrigeration handbook ,stoecker,1998M.E. I(MECHANICAL)

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E   Semester: 1
Mechanical Engineering (Cryogenic Engineering)

Subject Name   ELEMENTS OF CRYOGENIC ENGINEERING

Sr.No	Course content
1.	Introduction: Meaning & definition of cryogenics, Importance of cryogenics studies, properties of engineering materials at cryogenic temperatures, mechanical properties ,thermal properties, electric & magnetic properties, super conducting materials ,thermo electric materials, composite materials, properties of cryogenic fluids, super fluidity of He 3 &He4.
2.	Cryogenic Measurement systems: Temperature measurements, pressure measurements, flow measurements, liquid level measurements, fluid quality measurements.
3.	Importance of Cryogenic insulations: -Various factors for selection of insulations, various types such as expanded foams, gas filled& fibrous insulation, vacuum insulation, evacuated powder& fibrous insulation, opacified powder insulation, multi layer insulation, comparison of performance of various insulations.
4.	Salient Applications of cryogenic systems: Super conductive devices such as bearings, motors, cryotrons, magnets, space technology, space simulation chamber, cryogenics in biology and medicine, food preservation and industrial applications, nuclear propulsions ,chemical propulsions.
5.	Hazards:-Physical hazards, Chemical hazards, Physiological hazards,
6.	Combustion hazards, oxygen hazards, , accidents in cryogenic plants & prevention
7.	Safety in handling of cryogens, care for storage of gaseous cylinders, familiarization with regulations of department of explosives.

List of Experiments:

1. Study of cryogenic properties of hydrogen and helium.
2. Study of low temperature measurement instrument.
3. Study of flow measurement and quality measurement instrument.
4. Study of liquid level measurement.
5. Study of insulation used in cryogenic equipment.
6. Study of cryogenic application (superconductivity)
7. Study of cryogenic application in space technology.
8. Study of cryogenic application in bio medical and food preservation
9. Study of safety while handling fluid.
10. To find the thermal conductivity of powder insulation by boil off calorimeter method.

Reference Books:

1. Cryogenic systems-Baron, McGraw-Hill book
2. Cryogenic fundamentals-Haselden, Academic press New York
3. Cryogenic technology –Vance
4. Advance cryogenic –bailey, plenum press
5. Cryogenic engineering -Scott
6. Cryogenic Engineering & Gas Applications – By Dr. P.K.Bose.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E   Semester: 1
Mechanical Engineering (Cryogenic Engineering)

Subject Name   ADVANCED HEAT & MASS TRANSFER

Sr.No	Course content
1.	Conduction: Factors affecting thermal conductivity of solids, liquids & gases. General three dimensional heat conduction equation in Cartesian, cylindrical & spherical coordinates. Initial condition and various boundary conditions. Heat sources systems, Critical thickness of insulation. Different types of fins & their analysis. Two dimensional steady state conduction. Transient heat conduction.
2.	Convection: Free & forced convection, Similarity & simulation of convection heat transfer, Boundary layer theory, Turbulent flow heat transfer. Analogy between momentum & heat transfer. Heat transfer with liquid metals. Recent developments in the theory of turbulent heat transfer. Natural convection under different situations. Empirical relations in convection heat transfer.
3.	Two phase flow & heat transfer: Boiling- Introduction to boiling heat transfer, regimes of boiling heat transfer, pool boiling, flow boiling. Condensation- Heat transfer in condensation, Drop wise & film wise condensation. Empirical equations.
4.	Radiation: Laws of thermal radiation. Shape factors. Radiation heat transfer between black, diffuse & gray surface.
5.	Design of Heat Exchanger: LMTD Methods, importance of fouling factor, Overall heat transfer co-efficient, NTU- effectiveness method, Analysis of compact heat exchanger—plate-fin heat exchangers, regenerative type heat exchanger. Optimization & simulation of heat exchangers.
6.	Basic aspects of heat transfer in porous media.
7.	Mass Transfer: Modes of mass transfer, comparison between heat & mass transfer, Frick's law of diffusion, general mass diffusion equation, diffusion through stagnant gas, convective mass transfer, dimensionless parameters & dimensional analysis of convective mass transfer, Evaporation of water in air.

List of Experiments:

1. Thermal conductivity of metallic rod
2. Thermal conductivity of insulating powder
3. Thermal conductivity of composite wall
4. Natural convection experiment
5. Forced convection
6. Heat transfer in pin-fin
7. Stefan Boltzmann's constant
8. Measurement of emissivity of test surface
9. Effectiveness of heat exchanger

10. Critical heat flux
11. Heat pipe
12. Calibration of thermo couple with the help of the test rig
13. To find the diffusivity of volatile liquid
14. Comparison of filmwise and dropwise condensation.

Reference Books:

1. 1. J.P. Holman, "Heat Transfer", McGraw Hill Book Co. 9th edition, 2008.
2. Roshenow, W. Hartnell, J. Ganic, "Hand Book of Heat Transfer", Vol. 1 & 2, Mcgraw Hill, 2005.
3. Incropera & Hewitt, "Fundanentals of Heat & Mass Transfer", John Willey, 2005.
4. Engineering heat & mass transfer by **Mahesh M. Rathore**.
5. S.P.Sukhatme "Heat Transfer " University Press
6. Eckert and Drake. Heat and Mass transfer. McGraw Hill
7. Collier, J.B. and Thome, J.R., *Convective boiling and condensation*, Oxford   Science Publications, 1994.
8. L S Tong and Y S Tang. *Boiling Heat Transfer and Two-Phase Flow*.   Taylor and Francis, 1997.
9. P.B Whalley. *Boiling, Condensation and Gas-Liquid Flow.* Oxford   University Press, 1987.
10. Louis C Burmeister, *Convective Heat Transfer*, John Wiley and Sons, 1993.
11. Adrian Bejan, *Convective Heat Transfer*, John Wiley and Sons, 1995.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E   Semester: 1
Mechanical Engineering (Cryogenic Engineering)

Subject Name   CRYOGENIC HEAT EXCHANGERS

Sr.No	Course content
1.	Advanced heat transfer: steady state conduction with two and three dimension with heat generation, solution of problem by numerical ,finite difference and graphical methods, matrix ,finite element methods, transient heat conduction and solution by analytical correlation for convective heat transfer for natural and forced convection ,transition flow, flow outside of duets, boiling heat transfer coefficients .pressure drop in two phase flow, frost formulation ,condensation ,heat transfer coefficient during condensation.
2.	Shell & tube type heat exchangers-design
3.	Fin effectiveness , surface effectiveness and overall coefficients of heat transfer. Overall pressure drop, effectiveness- NTU approach solution by equations and graphical methods,. Effect of heat-exchanger effect of various specific on exchanger performance.
4.	Design of regenerative type heat exchanger for single and multi stage, Philips, Gifford single volume, double volume, Vuilleumier, magnetic cry refrigerators.
5.	Design of heat exchangers for liquefaction systems ,single tube ,double tube Linde heat exchangers three channel heat exchangers ,multiple tube type ,Giaque Hampton and Collins type heat exchangers.
6.	Finned tube and plate type heat exchangers, different configuration heat transfer coefficients and friction coefficient for various configuration.
7.	Single tube Linde exchanger, double tube type, three channel heat exchanger. Linde multiple tube type , Giauque Hampson, Collin's,
8.	Plate fin heat exchanger ,different fin configuration, heat transfer coefficients , and friction factors for various configurations.
9.	Testing of heat exchangers as per standards.

List of Experiments:

1. Thermal aspects of heat exchanger design
2. Design of double pipe Heat exchange
3. Timkers model & TEMA standards
4. Bell Deware's method for shell and tube type heat exchange design
5. Design of Reboilers and estimation of loss of energy in the pipe
6. Analysis and design regenerative heat exchanger
7. Design of compact heat exchanger
8. Design of plate type heat exchanger
9. Heat exchange networking

Reference Books:

1. Saunders, E.A.D., "Heat exchange – selection design and construction", Longmann Scientific and Technical, N.Y.2001.
2. Kays, V.A and London,A.L., "Compact Heat Exchangers", McGraw Hill, 2002
3. Holger Martin , "Heat Exchanger" Hemisphere Publ.Corp., Washington,2001
4. Kuppan,T., "Heat Exchangert Design Handbook", Macel Dekker, Inc., N.Y.,2000
5. Seikan Ishigai, "Steam Power Engineering, Thermal and Hydraulic Design Principles", Cambridge Univ. Press,2001

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E   Semester: 2
Mechanical Engineering (Cryogenic Engineering)

Subject Name   CRYOGENIC SYSTEMS

Sr.No	Course content
1	Cryogenic Refrigeration System: Ideal isothermal and reversible isobaric source refrigeration cycles, Joule Thomson system, cascade or pre-cooled joule–Thomson refrigeration systems, expansion engine and cold gas refrigeration systems, Philips refrigerators, Importance of regenerator effectiveness for the Philips refrigerators, Gifford single volume refrigerator, Gifford double volume refrigerators analysis, COP,FOM ,regenerators ,pulse tube refrigerators , various types of pulse tube refrigerator
2	Refrigerators using solids as working media: Magnetic cooling, magnetic refrigeration systems, thermal; valves, nuclear demagnetization
3	Gas liquefaction systems: Introduction, thermodynamically ideal systems ,joule Thomson effect, liquefaction systems such as Lnde Hampton ,precooled Linde Hampson ,linde dual pressure ,cascade, Claude ,Kapitza ,Heyland systems using expanders, comparison of liquefaction systems .liquefaction systems for neon ,hydrogen & helium
4	Adsorbents: various adsorbents, salient features – properties, determination of mass of absorbents for the adsorption of gases
5	Adsorption processes Physical principles of adsorption , BET equation for single and multiple layer , Use of sorption process in cryogenics static and dynamic arrangement for the sorption processes , Adsorption columns , PSA and VSA adsorption systems, isotherms, reactivisation

List of Experiments:

1. Study and analysis of cryo refrigeration system. – isothermal source system, isobaric source system.
2. Study and analysis of Philips refrigeration system.
3. Study and analysis of precooked cycle of refrigeration
4. Study and analysis of GM refrigerator.
5. Study and analysis of Vuilleumier and Solvay refrigerators.
6. Study and analysis of magnetic refrigerator and thermal valves.
7. Study and analysis of dilution refrigerator.
8. Study of ideal liquefaction system.
9. Study of Linde dual pressure system.
10. Study of hydrogen liquefaction system.
11. Study of pulse tube refrigeration system.

Reference Books:

1. Cryogenic Systems, **Barron, McGraw Hill Book Co**.
2. Theory and design of cryogenic systems : **A.Arkherov**
3. Cryogenic process engineering **Timmerchand & Flynn**

4. **"**Theory and design of cryogenic systems", **Mikulin,** MIR Publication, 2002

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E Semester: 2
Mechanical Engineering (Cryogenic Engineering)

Subject Name   CRYOGENIC PLANTS AND EQUIPMENTS

Sr.No	Course content
1	Gas separation and gas purification system : Thermodynamically Ideal separation system, general characteristics of mixtures , temperature composition diagram for cryogenic gas mixtures , fugacity , enthalpy composition diagrams, Simple condensation and evaporation, principles of rectification, theoretical plate calculations for columns, Mecabe – Thiele method for theoretical plate calculation , types of rectification columns
2	Air separation and purification systems: Linde single column, double column, Linde-Frank1 and Heylandt systems, argon, xenon and krypton. 'L' Air liquede systems fir hydrogen, hydrogen – deuterium in separation systems, helium separation system, separation of helium isotopes , purification of helium.
3	Modern air liquefaction , liquid nitrogen and oxygen plants.
4	Dewars, classification of Dewars, static and chassis mounted cryogenic liquid storage and transport tanks LNG storage tanks, construction Liquid and vapour shielded vessels, cryogenic liquid transfer pumps, liquid transfer lines their design, vacuum insulated line joints, and cryogenic valves liquid transfer systems.
5.	Design of cryostat. Various types of cryostats, construction, their salient features.
7.	Fabrications and jointing techniques, flanged and bolted joints , joining of dissimilar metals , welding of stainless steel and alloy steels

List of Experiments:

1. Study of cryogenic storage vessels.
2. Study of separation system for O_2 and N_2.
   a. Linde single column system
   b. Linde double column system
   c. Linde Frankle system
   d. Heylandt system
3. Study and design of rectification column.
4. Study of cryogenic fluid transfer line vacuum insulated line joints.
5. Cryogenic valves & design of transfer line.
6. Study of the various fabrication techniques applied to cryogenic plant & equipments.
7. To study of Philips LN2 plant.
8. To study the salient design feature of a cryostat & its construction & equipments.
9. Study of separation system for H2 & He.

Reference Books:

1. Cryogenic Systems, **Barron, McGraw Hill Book Co**.
2. Theory and design of cryogenic systems : **A.Arkherov**
3. Cryogenic process engineering **Timmerchand & Flynn**

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E   Semester: 2
Mechanical Engineering (Cryogenic Engineering)

Subject Name   ADVANCED AIR CONDITIONING

Sr.No	Course content
1.	Psychometric charts : ASHRE and CARRIER charts ,their differences ,application of corrections of different charts Applied psychrometry : Combinations of different processes and their representation on psychrometric charts, psychrometric calculations for cooling and dehumidification .High latent heat load ,dehumidified air quantities based on total and effective room loads ,GSHF and ESHF ,effect of fan and duct heat gain or dehumidified air quantity ,effective surface temperature ,effect of bypass factor on on GSHF ,analysis for using all outside air ,psychrometric of partial load control
2.	Cooling tower: Different types ,construction working performance ,testing different types of desert coolers ,testing of desert coolers as per BIS,Air washer, different types, construction performance.
3.	Heat gain calculations : choices of supply conditions . Solar heat gain: Terminology calculation different solar angles ,relation between different angles ,calculation of the intensity of direct ,diffused and ground radiation , solar air temperature ,empirical methods to evaluate heat transfer through walls, and roofs, TETD and its determination by calculation and tables ,Heat gain through glass ,Solar heat gain factor, use of equations and tables ,shading of glass ,solar chart and its use .shading of glass ,solar chart and its use, shading devices and its selection ,load due to other sources, stack effect ,different methods of calculating cooling load as per ASHRE-some brief idea(other than TETD methods)
4.	Duct Design : Types of ducts ,duct construction ,factors affecting duct construction ,friction charts and other correction factors ,losses ,design velocity and its selection ,duct heat gain or loss ,duct insulation ,duct layouts, duct sizing methods ,equal friction static regains and T-method design simple idea .Noise and their isolation ,duct materials and their accessories
5.	Air Distribution: Terminology ,outlet performance ,types of outlets ,location of outlets ,factors affecting grill performance ,selection of outlets using nomographs ,tables and line charts ,room air diffusions,performance index (ADPI)and its use in outlet selection ,use of different equations.
6.	Air conditioning systems :Factors affecting the selection of the systems ,classification ,systems ,design procedure ,system features ,psychrometric analysis ,controls of all air ,air water ,all water ,DX ,VAV and dual duct systems basic idea of cold air distributions systems and dessicant cooling systems

7.	Thermal effects :-Human thermo regulation, different equations governing thermal exchanges ,factors affecting comforts, environmental indices, AQ and its importance –Human comfort and health.
8.	Air conditioning controls : Characteristics of HVAC noise ,Acoustical rating systems and criteria ,RC ,NC, and NR criteria for noise rating ,noise control methods for VAV units ,cooling towers ,air devices roof top units ,chillers ,pumps ,AHU rooms, compressors.
9.	Air handling systems : Fans ,types ,construction performance characteristics ,fan laws ,testing as per BS ,IS and AMCA standards, fan selection with the help of tables charts and curves, fan drive arrangements and discharge from fans,duct design fan selection etc.

List of Experiments:

1. To study various instruments used in air conditioning
2. Study of clean room and to plot time v/s temperature curve.
3. Study of air conditioning test rig and to plot various processes.
4. Study of different types of fans used in air conditioning.
5. To find out performance characteristics of a forward curved blade fan.
6. To find out the capacity of a FCB centrifugal fan from suction side. Also determine average velocity of a fan from discharge side and calculate C_d of a given fan
7. To determine the capacity of a given fan using ten point method.
8. Study of 15 TON water chilling plant.
9. Study and testing of ductable split A / C plant of a conference hall of main building of LDCE A'bad.
10. Industrial visit of multiplex / cinema halls / auditorium / Malls etc.

Reference Books:

1. Air Conditioning Engineering -By Jones 5th 2001
2. Thermal Environmental Engineering, Threlkeld
3. Hand book of air conditioning systems design :carrier corporation 1965
4. Air conditioning principles and systems –pita
5. HVAC testing adjusting and balancing manual :Gladstone 3 rd 1997
   Ashrae Data Book, (1) Fundamentals (2001) (2) application (1999) (3)System and equipments (2000)
6. Hand book of air conditioning and refrigeration : wang 2 (1993
7. Air conditioning application and design by jones 2nd 1997
8. Air conditioning system design manual : lorach1993
9. Fan handbook :bleier 1998

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E   Semester: 2
Mechanical Engineering (Cryogenic Engineering)

Subject Name   RADIANT HEATING & COOLING SYSTEM

Sr.No	Course content
1.	INTRODUCTION TO RADIANT SYSTEMS-- Radiant phenomenon, Natural thermal environment, Application of Natural principals
2.	ADVANTAGES OF USING RADIANT SYSTEMS-- Occupant thermal comfort, radiant characteristics and applications, radiant energy and operating cost,
3.	THE ENERGY BALANCE---Concept of control volume and associated thermodynamic principles, internal energy and enthalpy, conservation of energy equation. Transient conduction in soil and Newton's law of cooling.
4.	RADIATION HEAT TRANSFER---Wavelengths and electromagnetic spectrum of radiations, absolute temperature scales. Radiative intensity, the basic building block of radiative heat transfer, and its application in the built environment. Planck's law, blackbody radiation, Wien's displacement law, Stefan-Boltzmann equation. emissivity, absorptivity, and transmissivity characteristics building material surfaces in a radiant environment. Thermophysical properties of matter encountered in the built environment. View factor calculations, Radiative resistance network approach, radiant heating systems, spherical harmonics method, Monte Carlo method, and discrete ordinates modeling.
5.	THERMAL COMFORT AND THERMAL COMFORT MODELS --Concept of Thermal Comfort, and it looks at the effects of thermal distribution systems. The Rohles-Nevin studies, the Fanger and Gagge models, and improvements to the Fanger and Gagge models. Thermal comfort design methodology, concept of The Mean Radiant Temperature, the performance capabilities of radiant heating and cooling systems in comparison to convection. Concept of The Operative Temperature., thermal comfort, measurement techniques, calculations and procedures for thermal comfort calculations.
6.	RADIANT HEATING SYSTEMS --Electric radiant heating panels, high temperature heaters radiant hydronic heating systems, Radiant Heating and Cooling Hybrid Systems, Convective Systems with Radiant Panels, optimization of system combination. Ventilation with Radiant Heating and Cooling systems.

7.	CONTROLS FOR RADIANT HEATING AND COOLING SYSTEMS--A low- or line voltage thermostat, single low-voltage control, over-temperature limit sensor or temperature control, supportive flow and temperature control sensors and valves that interact in response to the master control. Slave or independent area controls zone control, outdoor reset control, interior controls, motorized mixing valves, safety controls, downstream flow control, and temperature valves of mechanical and electronic equipments.

List of Experiments:

1. Study of different thermal comfort models and practice.
2. Determination of mean radiant temperature for the given built environment.
3. Study of different sizing and load estimation methods.
4. To develop the models of the building comfort analysis methodology.
5. Study of different radiant heating systems.
6. Study of different radiant cooling systems.
7. Study of different controls of radiant systems.
8. Study of computer aided design tools for radiant systems.
9. Study Hybrid heating and cooling demonstration projects.
10. Case Studies.

Reference Books:

1.   Radiant Heating and Cooling by Richard D. Watson and Kirby S. Chapman.
2.   Radiant floor heating by R. Dodge Woodson
3.   Radiant Heating and cooling manual by John Siegenthaler and Lawrence Drake.
4.   Heating and Cooling of Buildings: Design for Efficiency by Kreider J. F., Rabl A. and Curtiss Peter

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E   Semester: 2
Mechanical Engineering (Cryogenic Engineering)

Subject Name   COMPUTATIONAL FLUID DYNAMICS

Sr.No	Course content
1.	Introduction & Basic concepts: Introduction of CFD, Types of fluids and basic equations of flow, Conservation of mass, Newton's Second law of Motion, Governing equations of fluid flow, Navier-Stokes equations, Boundary layer equations, Expanded form of N-S equations, Conservation of energy principle, Special form of N-S equations, Classification of second order partial differential equations, Initial and boundary conditions, Governing equations in generalized coordinates. Review of essentials of fluid dynamics.
2.	Differential Equations & Discretization: Elementary Finite Difference Equations, Basic aspects of Finite Difference Equations, Errors and Stability Analysis, Discretization , Application to heat conduction and convection, Problems on 1-D and 2-D steady state and unsteady state conduction, Problem on Advection phenomenon, Incorporation of Advection scheme.
3.	Introduction to Finite Element Philosophy: Basics of finite element method, stiffness matrix, isoperimetric elements, formulation of finite elements for flow & hear transfer problems.
4.	Introduction to Finite Volume Philosophy: Integral approach, discretization & higher order schemes, Application to Complex Geometry.
5.	Introduction to solutions of viscous incompressible flows using MAC and

	simple algorithm.
6.	Solutions of viscous incompressible flows by stream function, vorticity formulation. Two dimensional incompressible viscous flow, estimation of discretization error, applications to curvilinear geometries, derivation of surface pressure & drag.

Experiment list:

1. Exercise on pin-fin analysis

2. Exercise on 1-D steady state heat conduction

3. Exercise on 1-D unsteady state heat conduction

4. Exercise on 2-D steady state heat conduction

5. Exercise on 2-D unsteady state heat conduction

6. Exercise on   heat transfer by convection

7. Exercise on fluid flow

8. Exercise on irregular geometry

Reference Books:

1. Anderson D.A., Tannehil j.c.Pletcher R.H." Computational fluid mechanics & heat transfer" Hemisphere publishing corporation,. Newyork, U.S.A2004.
2. Anker S.V., "Numerical heat transfer & flow" Hemisphere corporation,2001
3. H.K.verstag & W.Malalsekra," An introduction to computational fluid dynamics" Longman-2000
4. Carnahan B, "Applied numerical method" John Wiley & Sons-2001.
5. Patankar, " Numerical heat transfer & Fluid Flow", Mc.GrawHill.,2002
6. Murlidhar K., Sunderrajan T., "Computational Fluid Mechanics and Heat Transfer", Narosa Publishing House.
7. Date A. W., "Introduction to Computational Fluid Dynamics", Cambrige Uni. Press, 2005.
8. Ferziger J. H., Peric M., "Computational Methods for Fluid Dynamics", Springer, 2002.

GUJARAT TECHNOLOGICAL UNIVERSITY
M.E   Semester: 2
Mechanical Engineering (Cryogenic Engineering)

Subject Name   CRYOENIC APPLICATIONS

Sr.No	Course content
1.	Cryogenic properties of materials: thermal properties, electrical properties, superconductivity, super fluidity.
2.	Space applications: Missile launching, propellant pressurizing systems, vehicle cooling, cryopropollents, space simulators
3.	Biological applications: semen preservation, blood preservation, bone morrow preservation, tissue and micro organism preservation,
4.	Medical Application: cryosurgery, skin disease treatment
5.	Electronic applications: MASER, LASER, infrared detectors, photomultipliers.
6.	Superconductive devices: Superconducting bearings, magnets, motors gyroscope and switches, cryotrons, MRI.
7.	Nuclear applications: bubble chambers, radioactive waste disposal.
8.	Metal fabrication applications: cold stretching, cryoforming, metal stress reliving, annealing.
9.	Food handling applications: food freezing, food shipment and handling.
10	Low temperature preservation of tissues: harvesting of tissues, processing of tissues, preservation and storage of tissue, deep freezing, freeze drying.
11.	Agriculture applications: fisheries, animal science

12.	Genetic applications, embryo freezing
13.	Miscellaneous applications

List of Experiments:

1. Analysing mechanical & thermal properties of metals at cryogenic temperatures.

2. Understanding superconductivity and Meissener Effect.

3. Study of various types of cryogenic engines.

4. To understand various methods of blood preservation.

5. Study of Cryogenic application in MRI.

6. Study of various applications super conductivity in electrical and electronic devices.

7. Study of construction & working of a space simulation chamber.

8. Study of various types of cryogenic surgery probes.

9. Study of effect of cryogenic temperatures on fabrication technology.

Reference Books:

1. Cryogenics research and applications – Marshall Sittig & Stephen Kidd
2. Advances in Cryogenics – Proceedings of International Conference on Cryogenics, Calcutta, December 6-10, 1988.
3. Cryogenic Engineering & Gas Applications – By Dr. P.K.Bose.
4. Cryogenic technology and Applications – By A. R. Jha.