GUJARAT TECHNOLOGICAL UNIVERSITY

MECHANICAL ENGINEERING
CRYOGENIC ENGINEERING
SUBJECT CODE: 2181917
B.E. 8TH SEMESTER

Type of course: Elective

Prerequisite: Thermodynamics, Refrigeration and Air conditioning

Rationale: The course is designed to give fundamental knowledge of types of cryogenic fluids, behaviour of materials and properties at low temperature, cryogenic refrigeration, requirement of low temperature, gas separation, purification and measuring instruments

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE(E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Introduction**: Cryogenic engineering, properties of cryogenic fluids like Oxygen, Nitrogen, Argon, Neon, Florin, Helium, Hydrogen, Properties of material at cryogenic temperature- mechanical, thermal, and electrical-Super conductivity, application of cryogenic systems in space, medical, industries, biological etc.	6	14
2	**Cryogenic refrigeration:** Principle and Methods of production of low temperature and their analysis: Joule Thomson Expansion, Cascade processes, Ortho and para hydrogen conversion, cold gas refrigerators, Linde -Hampson cycles, Claude and cascaded systems, magnetic cooling, Stirling Cycle Cryocoolers, Philips refrigerators, Gifford single volume refrigerator, Pulse tube refrigerators	10	25
3	**Cryogenic requirements:** Cryogenics Heat Exchangers, Compressors, Expanders, Effect of various parameters in performance and system optimization. Various insulations (expanded foams, gas filled, fibrous, vacuum, multi-layer etc.) and Storage equipment for cryogenic fluids, industrial storage and transfer of cryogenic fluids	7	16
4	**Gas separation and purification:** Ideal gas, mixture characteristics composition diagrams, gas separation, principle of rectification, plate calculation, flash calculation rectification column analysis, separation of air, hydrogen and helium, gas purification methods	7	16
5	**Cryogenic instrumentation and safety:** Properties and characteristics of instrumentation, strain displacement, pressure, flow, liquid level, density and temperature measurement in cryogenic range. Safety in cryogenic fluid handling, storage and use. Safety against cryogen hazards like burns, frostbite, asphyxiation, hypothermia etc.	6	14
6	**Applications:** 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	6	15

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	10	15	15	15	5

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table

Reference Books:

1. Randal F. Barron, Cryogenic Systems, Oxford University Press, New York, 1999
2. T.M Flynn, Cryogenic Engineering, Maxwell Dekker, 1997.
3. Scoot, Cryogenic Engineering, Van Nostrand Co. Inc. 1985.
4. R W Yance and WM Duke, *Applied Cryogenic Engineering,* John Willey.
5. Klaus D. Timmerhaus, Richard Palmer Reed, Cryogenic Engineering: 50 years of progress, Springer, 2007.

Course Outcome:

After learning the course the students should be able to:

- Possess basic knowledge of cryogenics.
- Design cryogenic systems.
- Find applications of cryogenics
- Demonstrate the knowledge of cryogenic instrumentation

List of Experiments: (Any 10 of the following experiments)

1. Study and analysis of isothermal source cryo-refrigeration system
2. Study of cryogenic properties of hydrogen and helium.
3. Study of low temperature measurement instrument.
4. Study of flow measurement and quality measurement instrument.
5. Study of cryogenic application (superconductivity)
6. Study of cryogenic application in space technology.
7. Study of cryogenic application in bio medical and food preservation
8. Study and testing of cascade refrigeration system.
9. Study of ideal liquefaction system.
10. Study of hydrogen liquefaction system
11. Study of helium liquefaction system

Design based Problems (DP)/Open Ended Problem:

1. Calculation of number of plates required in rectification column
2. Design cascade system to obtain low temperature

Major Equipment:

1. Model of rectification column
2. Measuring instruments
3. Dewar flask

List of Open Source Software/learning website:

1. http://nptel.ac.in/
2. www.learnerstv.com

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.