GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch: Cryogenic Engineering

Course / Subject Code : ME01074021

Course / Subject Name : Vacuum Engineering

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PEC

Prerequisite:	Basic knowledge of physics and rotary equipments.
Rationale:	Vacuum Technology has diversified applications in different areas of science and Engineering. These include the major fields like Space-Simulation, Electronics, Chemical Processing, Food Processing, Nuclear Engineering, Electrical Engineering and Cryogenic systems. This has resulted in rapid development of many sophisticated vacuum instruments stretching till the range of 10^{-6} Torr. To keep pace with this advancement in vacuum technology the following course is designed which includes modern vacuum pumps, components, measuring systems, residual gas analyzers, leak detectors, vacuum furnaces, coating units, vacuum dryers and other applications.

Course Outcome:

On successful completion of the course, the students will be able to

No	Course Outcomes	RBT level
1	Understand basic concepts of vacuum, interaction of gases with solids and basic theory of pumping.	R/U
2	Explain various methods of producing medium and high vacuum with the help of vacuum pumps and choose suitable pump for given application.	R/U/A
3	Explain various methods of vacuum measurement, leak detection methods and design a vacuum system.	R/U/A
4	Summarize and explain various vacuum system components, vacuum joints, electrical leads, vacuum valves, vacuum materials and vacuum applications.	R/U/A

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	**Introduction to basic concepts of vacuum:** Equation of state for ideal gases and real gases, velocity and speed of gas molecules, the mean free path, transport processes, Viscosity diffusion and heat transfer in gas.	3	5
2	**Basic theory of pumping:** Basic definitions of vacuum techniques, resistance and conductance of arbitrary vacuum pipe work, fundamental equation of vacuum technique, regions of gas flow in pipes, calculation of pump down time.	4	10
3	**Interaction of gases with solids:** Taking up and evolution of gases by solids, adsorption and desorption of gases. Solubility and diffusion of gases in solids	2	5
4	**Production of vacuum:** Classification of vacuum pumps, Operating limits and ranges of vacuum pump, Types of vacuum pumps - Oil sealed rotary, roots blower, ejector, diffusion, turbo molecular, water ring, sorption, getter pumps, cryogenic pumps. Principles, construction, operation and salient features of these pumps. Baffles and traps used with pumps.	12	26
5	**Vacuum gauges:** Classification, ranges of vacuum gauges, McLeod, mechanical, thermal conductivity gauges, hot cathode and cold cathode ionization gauges. Principle, construction, working and salient features.	10	22
6	**Leak hunting:** Tightness of vacuum system, leak detection methods, halide leak detector, mass spectrometer leak detector, trouble shooting and maintenance of vacuum systems, degassing procedures,	5	10
7	**Vacuum system components:** Demountable vacuum joints, electrical lead, Vacuum valves	2	5
8	**Vacuum materials:** Basic requirements, metals & their alloys, nonmetallic materials, pump fluids.	2	5
9	**Design and calculation of vacuum system:** Gas flow in vacuum systems, conductance calculations and measurements on vacuum piping networks. Selection of pumping	2	5

Unit No.	Content	No. of Hours	% of Weightage
	facilities – determination of intrinsic speed-matching pumps operating in series and in parallel, calculation of fore vacuum cylinders.		
10	**Application of vacuum:** Vacuum Technology for semiconductor chip manufacturing, Space application, Vacuum based coating units for thin film deposition, Vacuum for Solar (Thermal and PV), Vacuum for metallurgical and pharmaceutical applications.	4	7
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	**40**	**30**	**10**	**0**	**0**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Fundamentals Of Vacuum Techniques by A Pipko
2. Modern Vacuum Practice by Harris Nigel
3. Vacuum Science & Technology- VV Rao, KL Chopra & TB Ghosh
4. Vacuum technology by A Roth
5. Vacuum technology by Andrew Gutheries
6. Modern Vacuum Physics by Austin Chambers
7. High Vacuum Technology: A Practical Guide by M.H.Hablanian

(b) Open-source software and website:

1. Vacuum Technology and Process Application – by V V Rao (NPTEL) (onlinecourses.nptel.ac.in/noc22_ge30)

Suggested Course Practical List:

1. To understand basic concepts of vacuum and interaction of gases with solids.
2. To study construction working and operating limits of a single stage and double stage mechanical oil sealed double vane type vacuum pump.
3. To study construction working and operation of simple and fractionating type oil diffusion pump.
4. To operate vacuum module to achieve 10^{-5} mbar vacuum in the given system.

5. To study construction working and application of water ring pump.
6. To study construction working of roots blower vacuum pump.
7. To study construction working and selection of turbo molecular pump.
8. Study of vacuum gauges – Pirani and Penning gauges.
9. To discuss and elaborate various applications of vacuum technology.
10. To study about various methods of leak hunting and learn about Helium mass spectrometer leak detector.
11. Industry visit to explore Application of Vacuum Technology.
12. Case study – Designing of a vacuum system for given application and requirement.

List of Laboratory/Learning Resources Required:
Vacuum module consisting of Diffusion pump, Rotary pump, vacuum gauges, baffles and traps. Turbomolecular pump along with all accessories for dry vacuum.

Suggested Project List:
Suggested Activities for Students: Students are required to download 3-5 research papers from reputed international journals on the recent advancement in the areas of vacuum engineering. They need to go through the same and prepare a review for the research papers.

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