FACULTY OF ENGINEERING & TECHNOLOGY

First Year Bachelor of Engineering

Course Code: 102000214

Course Title: PROCESS ENGINEERING THERMODYNAMICS

Type of Course: Engineering Science Course

Course Objectives: The course of basic thermodynamics intends to familiarize students with various energy interactions notably heat and work transfer. It is based on certain laws of nature which are never seen to be violated. The course aims to teach the principles involved in the thermodynamic analysis of both unit operations and process equipments to provide a strong grounding required for system design and operation. It seeks to provide the necessary background so that the thermodynamic analysis of unknown systems can be approached in a logical and methodological manner. The emphasis is to make students understand the fundamentals of energy transactions in process engineering unit operations and apply these for on the field applications.

Teaching & Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)				
				Internal		External		Total
Lecture	Tutorial	Practical		Theory	J/V/P*	Theory	J/V/P*	
3	2	0	4	40 / 14	20 / 7	60 / 21	30 / 10	150 / 52

* **J**: Jury; **V**: Viva; **P**: Practical

Detailed Syllabus:

Sr.	Contents	Hours
1	Introduction, zeroth law, basic concepts Units and dimensions, Fundamental concept of thermodynamics, macroscopic versus microscopic point of view; definition of systems, processes and surrounding; concept of control volume, thermodynamic state, thermodynamic equilibrium; temperature and zeroth law; Real and ideal gases, pure substance and phase, phase rule, thermodynamic properties; comparison of heat and work; expressions for displacement work in various processes through P-V diagrams.	6
2	First law of thermodynamics First law of thermodynamics; its applications for cyclic, non-cyclic processes and control volume; concept of internal energy, enthalpy and specific heats; steady flow energy equation on unit mass and time basis, Simple application of steady flow energy equation for devices such as boiler, heat exchangers, pumps, nozzles, etc. internal energy change, enthalpy change, work done and heat transfer during the processes involving ideal gas.	8

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3	P-V-T behavior of pure substances and heat effects Definition of a pure substance, phase of a substance, triple point and critical points; P-V-T behavior of pure fluids, differences between ideal and real gases, equation of state for ideal gases and evaluation of its properties, equation of state for real gases: limiting conditions, van der Waals equation and its constants in terms of critical properties, principle of corresponding states; compressibility factor and compressibility chart; heat accompanying chemical reaction: standard heat of reaction, combustion, formation; Hess's law of constant heat summation; effect of temperature on standard heat of reaction.	**10**
4	Second law of thermodynamics Statements of the second law of thermodynamics; concept of a heat engine, heat pump, refrigerator and their equivalence, entropy; the Carnot principle; entropy changes during phase change, processes involving ideal gases, adiabatic mixing process, isothermal mixing of ideal gases and chemical reactions; Clausius inequality; principle of increase – in – entropy; entropy and irreversibility; third law of thermodynamics, absolute entropy, available and unavailable energy.	**8**
5	Applications of the laws of thermodynamics Flow processes: continuity equation, energy balance equation, flow in pipes, flow through nozzles, ejectors, throttling process (Joule – Thompson expansion), compressors; refrigeration: coefficient of performance (COP), refrigeration capacity, Carnot cycle, vapor compression cycle, choice of refrigerant, air refrigeration cycle, adsorption refrigeration, heat pumps.	
6	Thermodynamics properties of pure fluids Classification of thermodynamic properties; work function (Helmholtz free energy); Gibbs free energy; relationships among thermodynamic properties: exact differential equations, fundamental property relations, Maxwell's equations, Clapeyron equation, entropy – heat capacity relationships, effect of temperature, pressure and volume on U, H, S, CP and CV, Joule – Thomson coefficient, Gibbs – Helmholtz equation;	**10**
7	Psychometrics: Psychrometric parameters and their relationships, Psychrometric properties of air. Psychrometric Charts, Mixing of air streams, Heating and cooling processes, Humidification and dehumidification processes and their applications in chemical, food and allied process industries.	**6**

Suggested Specification table with Marks (Theory) (Revised Bloom's Taxonomy):

Distribution of Theory Marks						**R**: Remembering; **U**: Understanding; **A**: Application, **N**: Analyze; **E**: Evaluate; **C**: Create
R	**U**	**A**	**N**	**E**	**C**	
16%	20%	26%	6%	2%	0%	

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.

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Reference Books:

1	Introduction to Thermodynamics"; Y.V.C. Rao, 2nd Edition, Wiley Eastern Limited.
2	Chemical, Biochemical and Engineering Thermodynamics"; S.I. Sandler, Wiley India Edition
3	A text book of Chemical Engineering Thermodynamics"; K. V. Narayanan, Prentice-Hall of India Pvt. Ltd.
4	Chemical and Process Thermodynamics; B.G. Kyle, Prentice-Hall Inc.
5	Introduction to Chemical Engineering Thermodynamics"; J. M. Smith, H. C. Vanness, M. M. Abbott, The McGraw-Hill Companies, Inc
6	Engineering Thermodynamics by P. K. Nag (TMH)

Course Outcomes (CO):

Sr.	Course Outcome Statements	%weightage
CO-1	To develop an intuitive understanding of thermodynamics by emphasizing the physics and physical arguments	**20**
CO-2	To evaluate changes in different thermodynamic properties for pure fluids using equations of state (EOS).	**20**
CO-3	To apply the laws of thermodynamics to evaluate the performance of processes.	**15**
CO-4	To apply thermodynamic principles to the analysis of chemical processes and equipment such as turbines, compressors, heat pumps etc. Solve problems of refrigeration processes.	**20**
CO-5	To apply mass and energy balance to closed and open systems and uses of various correlation between thermodynamic properties such as U, H, G, A etc. for analyzing the thermodynamic systems.	**25**

List of Practicals / Tutorials:

Numerical / problems based on topics of each theme of content.

Supplementary learning Material:	
1	Video lectures available on the websites NPTEL.
2	CDs available with some reference books for the solution of problems.
3	Use of subject relevant software for the problems solving and analyzing the thermodynamic processes.

Curriculum Revision:	
Version:	**1**
Drafted on (Month-Year):	Apr-20
Last Reviewed on (Month-Year):	Jul-20
Next Review on (Month-Year):	Apr-22

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