4th SPRC

Department of Sustainable Energy Engineering
Indian Institute of Technology Kanpur

Proposal for Course Modification

Course title	: Thermodynamics of Energy Systems
Number	: SEE604
Credits (L-T-P [C])	: 3-0-0-9
Departments proposing the course	: Sustainable Energy Engineering
Name of the proposer	: Aakash Chand Rai
Offered for	: UG/PG Students of SEE/other departments.
Status of the course	: UG/PG Elective
Prerequisite(s) for the course	: Should **not** have taken ESO201 or an equivalent course at IITK.
At Faculty members interested in teaching	: Laltu Chandra and Lalit Pant.
Other departments/programs whose students are expected to take up the course	: ME, ChE, MSE.

Course objectives

This course provides the necessary background of engineering thermodynamics to postgraduate students who did not get adequate exposure to the subject at the undergraduate level. The course will cover the basic principles of thermodynamics and prepare the student to effectively use thermodynamics in the field of sustainable energy engineering. The course will also lay the foundations for subsequent studies in fluid mechanics, heat transfer, and statistical thermodynamics.

Existing course outline

Course outline

Open and closed systems, first and second laws, concept of characteristic potential and entropy, control volume analysis, properties of pure substance, chemical potential, phase equilibrium, binary solutions, chemical reaction, Air standard cycles, Rankine cycle, reheat and regenerative Rankine cycles, Vapour compression refrigeration cycle, Heat pump, vapour absorption cycle (qualitative analysis only), properties of moist air, Psychrometric chart, air-conditioning processes, Solar intensity on a tilted plane, flat plate collector, concentration limit, parabolic trough and parabolic dish collector, central receiver tower, thermal storage system, Basics of electrochemistry, equilibrium electrochemistry, kinetics, fundamentals of a battery, fundamentals of a fuel cell

Revised Course outline

1. Introduction and basic principles: Introduction, units and dimensions, thermodynamic systems, properties and states, process and cycle, energy, pressure, specific volume, temperature, and the zeroth law.
2. Pure substance behavior: Pure substance, phase equilibrium, independent properties, thermodynamic tables, thermodynamic surfaces, the ideal gas equation and deviation from the ideal-gas behavior, and

other equations of state.

3. Energy transfers: Work and heat transfer processes.
4. Energy analysis for a control mass: The first law of thermodynamics and its applications for a control mass; internal energy, enthalpy, and specific heats; and the first law as a rate equation.
5. Mass and energy analysis for a control volume: Conservation of mass, the first law of thermodynamics for a control volume, and energy analysis of steady-state and transient process.
6. The second law of thermodynamics: Heat engines and refrigerators, the second law of thermodynamics, reversible and irreversible processes, Carnot cycle, and the thermodynamic and ideal-gas temperature scales.
7. Entropy: The Clausis inequality; entropy- a system property; entropy of a pure substance; entropy change in reversible processes; the Gibbs equations; entropy changes of solids, liquids, and ideal gases; entropy generation and the increase of entropy principle; and entropy as a rate equation.
8. Entropy analysis for a control volume: The second law of thermodynamics for a control volume and its application to steady-state and transient processes, the steady-state single-flow process, and isentropic efficiencies.
9. Irreversibility and availability: Available energy, reversible work, and irreversibility; availability and second-law efficiency; and the exergy balance equation.
10. Thermodynamic property relations: The Maxwell relations and the Clapeyron equation.

Existing lecture-wise breakup

Lecture wise breakup

S. N.	Broad Title	Topics	No. of Lectures
1.	Basics of thermodynamics	Open and closed systems, first and second laws, concept of characteristic potential and entropy, control volume analysis, properties of pure substance, chemical potential, phase equilibrium, binary solutions, chemical reaction	15
2.	Power and Refrigeration cycles, Air conditioning	Air standard cycles (Otto, Diesel, Dual and Brayton), Rankine cycle, reheat and regenerative Rankine cycles, Reverse Rankine refrigeration cycle, Heat pump, vapour absorption cycle (qualitative analysis only), properties of moist air, Psychrometric chart, air-conditioning processes	7
3.	Solar thermal conversion	Intensity on a tilted plane, flat plate collector, concentration limit, parabolic trough and parabolic dish collectors, central receiver tower, thermal storage system	9
4.	Electrochemical Conversion	Basics of electrochemistry, equilibrium electrochemistry, kinetics, fundamentals of battery, fundamentals of fuel cell	9

Revised lecture-wise breakup

Topics	Number of lectures (approximate)
1. Introduction and basic principles	3
2. Pure substance behavior	6
3. Energy transfers	3
4. Energy analysis for a control mass	5
5. Mass and energy analysis for a control volume	4
6. The second law of thermodynamics	4

7. Entropy	6
8. Entropy analysis for a control volume	4
9. Irreversibility and availability	3
10. Thermodynamic property relations	2
Total	**40**

Textbooks, reference books, suggested readings, and any other references

- Thermodynamics – an engineering approach by Yunus Cengel and Micheal Boles
- Fundamentals of thermodynamics by Claus Borgnakke and Richard Sonntag
- Engineering thermodynamics by P K Nag.

Course proposed by	**Recommended/Not recommended**	**This course is approved/~~not approved~~**
(Aakash Chand Rai)	Convener, DPGC (SEE)	Chairman, SPGC