3rd SPGC

Indian Institute of Technology, Kanpur

Proposal for a New Course

1. Course No: ME*** 651
2. Course Title: **Advanced Engineering Thermodynamics**
3. Per week Lectures: 3 (L), Tutorials: 0 (T), Laboratory: 0 (P), Additional Hours: 0(A)
4. Credits(3*L+2*T+P+A) : 9
5. Duration of Course: Full Semester
6. Proposing Department/IDP: Mechanical Engineering

   Other Department/IDP which may be interested in the proposed course: SEE, AE

   Other faculty members interested in teaching the proposed course:

   Malay Kumar Das (ME), Vaibhav Arghode (AE/SEE)
7. Proposing Instructor(s): Jishnu Bhattacharya (ME)
8. Course description

   A) Objective:

   The course is targeted to the PG students with background in mechanical engineering who are familiar with the basic UG thermodynamics course. In many cases, these students need familiarity with advanced topics in thermodynamics to apply in their inter-disciplinary research problems. The topics which are covered in material science, chemical engineering, physics or chemistry courses on thermodynamics often remain out of access for the students with mechanical engineering background. The proposed course attempts to bridge this specific gap.

B) Contents

S. No	Broad Title	Topics	No of Lectures
1	Thermodynamic Property Relations	Brief review of the first and second law as learnt in UG course, Generalized form of first and second law, Equations of state, Maxwell equation, Clapeyron equation, Clausius-Clapeyron equation,	2
2	Characteristic potentials	Euler relation, Gibbs-Duhem relation, Legendre transform, Characteristic potential and its significance in terms of equilibrium	2
3	Pure substances	Response functions, Relationships between different response functions, Joule-Thompson coefficient, Phase rule, Pure substance phase diagram	3
4	Mixtures	Partial Molar quantities, Chemical potential, Gibbs-Duhem relation, Ideal gas mixture, Real gas mixture, Fugacity	3
5	Solutions	Chemical potential of liquid, Raoult's law, Henry's law, Ideal solution, Ideal-dilute solution, Regular solution, Properties of mixing	4
6	Colligative properties	Lowering of vapour pressure, Elevation of boiling point, Depression of freezing point, Osmotic pressure, ideal solubility limit	3
7	Activities	Activity of solvent, activity of solute, activity in terms of molality, Regular solution model, activities of ions, mean activity coefficient, Debye-Huckel limiting law	3

8	Binary Phase Diagrams	Vapour pressure diagram, Vapour composition, Bubble point and Dew point, pressure-composition phase diagram, temperature-composition phase diagram, Combined VLE diagram, azeotropes, miscibility gap, spinodal, upper and lower critical points, Eutectic, Eutectoid, solid solution	5
9	Chemical Equilibrium	Reaction Gibbs free energy, Formation Gibbs energy, Reaction quotient, Equilibrium constant, Molecular interpretation, Response to pressure and temperature change, La-Chatelier principle, Van't Hoff equation	5
10	Electrochemical cells	Redox reaction, Half-cell reaction, Cell configurations, Nernst equation, Cell potential, Standard electrode potential, Standard Hydrogen electrode, Temperature coefficient, Electrochemical series	4
11	Special Topics	One or more of the following topics will be covered depending on the time available and the instructor's preference: 1. Statistical Thermodynamics: Configuration, Degeneracy, Most probable distribution, Boltzmann distribution, Partition function, Lagrange multipliers, Uniform ladder, Product of partition functions, Canonical ensemble, Mean energy, Heat capacity, Entropy, Derived functions	6

		2. Thermodynamic modelling of different systems: Atmosphere, Black body radiation, Refinery process, gas absorption and desorption, desalination etc.	

C) Pre-requisites: Undergraduate Engineering Thermodynamics (Equivalent to ESO201)

D) Short summary

The course is for the PG students with background in mechanical engineering who lack familiarity with advanced topics in thermodynamics from other streams of science which are often necessary in their inter-disciplinary research. The broad topics which will be covered in this course are as follows: Thermodynamic property relations, Characteristic potentials, Pure substance, Mixtures, Solutions, Colligative properties, Activities, Binary phase diagram, Chemical equilibrium, Electrochemical cells and Statistical thermodynamics.

9. Recommended books

a. Thermodynamics and Introduction to Thermostatistics: H.B. Cahen

b. Engineering Thermodynamics: Cengel and Boles

c. Chemical Engineering Thermodynamics: Smith, Ness and Abbott

d. Fundamentals of Classical Thermodynamics: Van Wylen, Sonntag and Borgnakke

e. Physical Chemistry: Atkins and De Paula

f. Statistical Thermodynamics: McQuarrie

g. Statistical Mechanics: David Chandler

10. Any Other remarks: Nil

Dated: 03 Dec 2024

Proposer:

(Jishnu Bhattacharya)

Dated: 03.12.2024

DPGC Convener:

Anikesh Pal

The course is approved or ~~not~~.

Chairman, SPGC

Dated: