ENGINEERING THERMODYNAMICS AND HEAT TRANSFER

ENME 310

Lecture : 3 — **Year : III**
Tutorial : 1 — **Part : I**
Practical : 3/2

Course Objectives:

The objective of this course is to provide concepts of energy conservation and transfer, focusing on the laws of thermodynamics, thermodynamic cycles, and heat transfer, and exploring their applications in electrical engineering.

1 Basic Concepts (4 hours)

- 1.1 Definition and scope of engineering thermodynamics
- 1.2 Value of energy to society
- 1.3 Microscopic versus macroscopic viewpoint
- 1.4 Concepts and definitions
  - 1.4.1 Surface system, surroundings, boundary and universe; closed systems, open systems, and isolated systems
  - 1.4.2 Thermodynamic properties: Intensive, extensive and specific properties
  - 1.4.3 Thermodynamic equilibrium
  - 1.4.4 Thermodynamic state
  - 1.4.5 Thermodynamic process, cyclic process, quasi-equilibrium process, reversible and irreversible process
- 1.5 Specific volume, pressure and pressure measurement devices, temperature and temperature measurement
- 1.6 Zeroth law of thermodynamics, equality of temperature

2 Energy and Energy Transfer (3 hours)

- 2.1 Energy and its meaning
- 2.2 Stored energy and transient energy; Total energy
- 2.3 Energy transfer
  - 2.3.1 Heat transfer
  - 2.3.2 Work transfer
- 2.4 Expressions for displacement work transfer
- 2.5 Other examples of work: Electrical work and mechanical forms of work

3 Properties of Common Substances (6 hours)

- 3.1 Pure substance and state postulate
- 3.2 Ideal gas and ideal gas relations

3.3 Two phase (Liquid and vapor) systems
    3.3.1 Phase change processes: The T – v, P – v and P – T diagrams
    3.3.2 Subcooled liquid, saturated liquid, wet mixture, critical point, quality, moisture content, saturated vapor and superheated vapor
    3.3.3 Properties of two-phase mixtures
    3.3.4 Compressibility factor
3.4 Development of property data: Graphical data presentation (P-h, h-s and T-s diagrams) and tabular data presentation

4 First Law of Thermodynamics (6 hours)

4.1 First law of thermodynamics for control mass
4.2 First law of thermodynamics for control mass undergoing cyclic process
4.3 Internal energy, enthalpy and specific heats
4.4 First law of thermodynamics for control volume
4.5 Control volume analysis: Steady state analysis
4.6 Control volume steady state work and flow applications
4.7 First law of thermodynamics for an isolated system and PMM-I type

5 Second Law of Thermodynamics (6 hours)

5.1 Necessity of formulation of second law
5.2 Concepts and definitions
5.3 Two phase (Liquid and vapor) systems
    5.3.1 Thermal reservoir, heat engine, heat pump, refrigerator
    5.3.2 Reversible and irreversible processes
5.4 Kelvin-Planck and Clausius statements of the second law of thermodynamics and their equivalence
5.5 Carnot cycle and Carnot efficiency
5.6 Clausius inequality and entropy
5.7 Second law of thermodynamics for an isolated system
5.8 Entropy changes of an ideal gases, liquids and solids from Gibbs equation
5.9 Concepts of change in entropy of control mass and control volume
5.10 Isentropic processes for an ideal gases, liquids and solids
5.11 Isentropic efficiencies of steady state applications

6 Gas Power Cycles (8 hours)

6.1 Classification of cycles
6.2 Air standard assumptions
6.3 Brayton cycle
    6.3.1 Analysis of closed and open cycles
    6.3.2 Cycle with intercooling, reheating, and regeneration
    6.3.3 Gas turbine power plant layout and components
6.4 Internal combustion cycles
    6.4.1 Operation of four strokes engine

6.4.2 Air standard Otto cycle
6.4.3 Air standard diesel cycle
6.4.4 Air standard Otto and diesel cycle comparison and mean effective pressure

6.5 Diesel power plant
6.5.1 Essential components
6.5.2 Plant layout
6.5.3 Performance of I.C. Engines

7 Vapor Power Cycles and Vapor Compression Refrigeration Cycles (4 hours)

7.1 Rankine cycle
7.1.1 Ideal and actual cycle
7.1.2 Reheat cycle
7.1.3 Regenerative cycle
7.1.4 Essential components of steam power plant
7.1.5 Layout of steam power plant

7.2 Vapor compression refrigeration cycle and its performance measurement

8 Heat Transfer (8 hours)

8.1 Basic concepts and modes of heat transfer
8.2 One dimensional steady state heat conduction through a plane wall
8.3 Radial steady state heat conduction through a hollow cylinder
8.4 Heat flow through composite structures
8.4.1 Composite plane wall
8.4.2 Multilayer tubes

8.5 Critical radius of insulation for cylinders
8.6 Electrical analogy for thermal resistance
8.7 Combined heat transfers and overall heat transfer coefficient for plane and composite wall and tube
8.8 Nature of convection; Free and forced convection
8.9 Heat transfer from extended surfaces; Fins, types of fins, fin equation, fin performance, fins effectiveness, proper length of fin
8.10 Heat radiation, Stefan's law, emissivity, absorptivity, reflectivity and transmissivity; Black body, white body and gray body

Tutorial (15 hours)

1. Sample problems related to the different thermodynamic properties
2. Sample problems related to displacement work transfer
3. Sample problems related to properties and work transfer of liquid-vapor mixture system (H_2O only)
4. Sample problems related to mass and energy conservation of control mass, cyclic processes and steady state control volume systems
5. Sample problems related to entropy change and entropy generation for ideal gas, isolated system and isentropic efficiencies

6. Sample problems related to Otto, diesel and Brayton cycles and performance of I.C. engines
7. Sample problems related to Rankine cycle
8. Sample problems related to heat transfer from composite wall, cylinders, critical radius of insulation; Combined heat transfer, overall heat transfer coefficient

Practical **(22.5 hours)**

1. Temperature measurement by using different types of thermometers
2. Experiment related to first law of thermodynamics
3. Heat Pump: Coefficient of performance of heat pump/refrigerator
4. Heat Conduction: Investigate Fourier's law of linear heat conduction
5. Heat Radiation: Investigate Stefan-Boltzmann relationship
6. Effect of extended surfaces on heat transfer

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Marks distribution*
1 and 2	7	10
3	6	8
4	6	8
5	6	8
6 and 7	12	16
8	8	10
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Incropera, F.P., DeWitt, D.P. (2017). Fundamentals of heat and mass transfer. John Wiley & Sons.
2. Holman, J. P. (2010). Heat transfer. McGraw-Hill.
3. Luintel, M.C. (2016). Fundamentals of thermodynamics and heat transfer. Heritage Publishers and Distributors.
4. Moran, M.J., Shapiro, H.N. (2020). Fundamentals of engineering thermodynamics. John Wiley & Sons.
5. Rajput, R.K. (2016). A textbook of power plant engineering. Laxmi Publications.
6. Arora, S.C., Domkundwar, S., Domkundwar, A.V. (2022). A course in power plant engineering. Dhanpat Rai & Co.
7. Van Wylen, G.J., Sonntag, R.E., Borgnakke, C. (2022). Fundamentals of thermodynamics. John Wiley & Sons.
8. Cengel, Y.A., Boles, M.A. (2023). Thermodynamics: An engineering approach. McGraw-Hill.