MECH 332: Thermodynamics

Catalog description: 3.0 units

Properties of substances, ideal gas equation of state, heat and work, laws of thermodynamics, steady-state analysis of closed and open systems, entropy, gas and vapor power cycles, introduction to renewable energy sources.

Prerequisites: PHYS 204A
Recommended: PHYS 204C

Course objectives: For students to learn how to

1. Identify phase and evaluate thermodynamic properties of simple, compressible substances from tables and software
2. Apply the First Law (conservation of energy principle) to closed systems and control volumes undergoing quasi-equilibrium processes involving work and heat transfer
3. Understand the limitations imposed by the Second Law and applying the property of entropy to closed systems and control volumes
4. Analyze the performance of simple vapor and gas power cycles

Course outcomes: Students shall be able to

1. Calculate work from a known *P-v* relationship
2. Identify phase of simple, compressible substances from known properties
3. Sketch thermodynamic processes on a phase diagram using *P-v*, *T-v*, and *T-s* coordinates
4. Evaluate properties from standard thermodynamic tables
5. Recognize the applicability of the ideal gas model and use it to predict pressure, volume, or temperature
6. Apply the conservation of energy principle to closed systems undergoing a process or sequence of processes
7. Apply the conservation of mass and energy principles to control volumes undergoing steady-state processes, including nozzles, diffusers, turbines, compressors, pumps, throttling valves, mixing chambers, and heat exchangers
8. Predict the maximum performance of power, refrigeration, and heat pump cycles
9. Determine the feasibility of a cycle based upon energy conservation and the Second Law
10. Analyze performance of Carnot vapor or gas power cycle
11. Calculate the entropy change of a process or sequence of processes
12. Use isentropic efficiency to calculate the performance of a steady-state turbines, compressors, pumps, and nozzles
13. Predict the performance of simple Rankine, Brayton, Otto, and Diesel power cycles

Topics covered

1. Introductory concepts and definitions: closed & open systems, equilibrium processes, cycles, state properties, dimensions & units, pressure, temperature, and measurement methods
2. Energy: kinetic, potential, internal, heat, and work; polytropic processes
3. First Law of Thermodynamics: analysis of closed systems undergoing processes and cycles, thermal efficiency for power cycles, coefficient of performance for refrigerators & heat pumps
4. Properties of simple, compressible substances: state postulate, phases of substances, phase diagrams, quality, enthalpy, ideal gas equation of state, incompressible substances, use of equation-solving and thermodynamic property software
5. Control volume energy analysis: mass & energy balances, steady-state condition, nozzles & diffusers, turbines, compressors, pumps, mixing chambers, throttling valves, and heat exchangers
6. Second Law of Thermodynamics: Kelvin-Planck & Clausius statements, thermal reservoirs, reversible & irreversible processes, Carnot corollaries, absolute temperature - heat transfer relation, maximum performance, Carnot cycle
7. Entropy: Clausius inequality, heat-entropy relationship, entropy as a property, *Tds* relations, entropy transfer & production, entropy balances for closed and open systems; computing entropy change for simple compressible substances, ideal gases, and incompressible substances; isentropic processes; isentropic efficiency for turbines, compressors, pumps, and nozzles; steady-state control volume work for internally reversible processes
8. Vapor power systems: ideal Rankine cycle, reheat, feedwater heating
9. Gas power systems: ideal Brayton cycle, reheat, regeneration, compressor intercooling, internal combustion engines, jet engines

Class/Laboratory schedule

One hundred fifty minutes of lecture per week

Contribution of course to meet the professional component

This course contributes to the student's ability to work professionally in the thermal systems area.

Relationship of course to Mechanical Engineering Program Outcomes

This course contributes principally to Program Outcome A.