MECH 338: Heat Transfer

Catalog description: 4.0 units

Conduction, convection, and radiation heat transfer; steady-state and transient analysis methods; numerical methods applied to conduction heat transfer; design of finned arrays, heat exchangers, and systems for electronics cooling; measurement of temperature and heat rate. 3.0 hours discussion, 2.0 hours activity.

Prerequisites: CIVL 321, MECH 332
Recommended: EECE 211, MECH 306

Course objective

For students to learn to model, analyze, and design heat transfer components and systems by applying the rate equations of conduction, convection, and radiation with the principle of energy conservation.

Course outcomes: Students shall be able to

1. Identify the important heat transfer modes in a physical system
2. Write surface and control volume energy balances with the appropriate heat transfer rate equations for any physical system
3. Simplify general heat conduction equation and write boundary conditions for any well-posed conduction heat transfer problem
4. Represent steady-state, one-dimensional conduction systems as a *thermal circuit* and solve for unknown heat rates or temperatures
5. Use the *lumped capacitance method* to solve transient conduction problems
6. Understand the importance of numerical methods in conduction heat transfer and be able to use a simple finite-element software package
7. Calculate a convection heat transfer coefficient (h) or mass transfer coefficient (h_m) from an appropriate empirical correlation and use it to determine a heat transfer or mass transfer rate
8. Design/specify a fin array or heat sink to meet a temperature or heat rate requirement
9. Calculate pressure drop, fluid outlet temperatures, heat transfer rate, or required surface area for pipe flows and heat exchangers
10. Determine view factors, compute radiation heat rates and/or temperatures in an n-sided enclosure with gray, diffuse surfaces

Topics covered

1. Introduction to the three modes of heat transfer
2. Control volume and surface energy balances
3. Fourier's law, thermal conductivity, heat conduction equation, boundary conditions
4. One-dimensional steady-state conduction, thermal resistance, internal heat generation, fins
5. Two-dimensional, steady-state conduction
6. Electronics cooling: heat sink and fan selection

7. Transient conduction: lumped capacitance method, exact solutions, superposition
8. Numerical analysis: finite-difference and finite-element solution methods
9. Principles of convection: definition of convection coefficient, boundary layer equations, dimensionless parameters, turbulence, Reynolds-Colburn analogy
10. External flows: flat plate, cylinder, sphere, impinging jet
11. Internal flows: pipes, noncircular ducts
12. Natural convection in various geometries
13. Heat exchangers: analysis and design
14. Radiation properties, spectral and directional features
15. View factors, radiation exchange between surfaces, radiation shields
16. Convection and radiation, multimode heat transfer
18. Introduction to mass transfer: diffusion and convection modes

Class/Laboratory schedule

One hundred fifty minutes of lecture and one hundred minutes of activity 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 Outcomes A, C, and D.