THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

Irreversible Thermodynamics and Transport of Charge, Heat, and Spin

MECHENG 8603

Credit Hours:
3.00 - 3.00

Course Levels:
Graduate (5000-8000 level)

Course Components:
Lecture

Course Description:
Ohm?s, Fourier and Fick?s laws, which relate linearly the transport of electrical charge, heat and matter to voltages, temperatures and concentrations gradients, are generalized in the framework of irreversible thermodynamics. The microscopic mechanisms of transport of heat, electrical charge and magnetization by elemental excitations (electrons, phonons and magnons) are explained.

Prerequisites and Co-requisites:
Prereq: 8503 or statistical mechanics, and permission of instructor.

Course Goals / Objectives:

- Learn the basics of irreversible thermodynamics: how to treat thermodynamic systems that are slightly out of thermodynamic equilibrium, using linear perturbation theory.
- Learn the concept of fluxes and flow of matter, heat, electrical charge, and magnetization or spin. Learn about thermodynamic driving forces, pressure differences, temperature differences, voltage, magnetization differences.
- The Onsager relations relate fluxes to forces that are not directly related: a voltage can drive flow of matter (electrophoresis), a temperature difference a flow of electricity (thermoelectrics) or of matter (thermal diffusion) or of magnetization.
- Review of the properties of the three types of elemental excitations that carry electricity, heat, and magnetization are electrons, phonons (lattice waves) and magnons (spin waves) in solids.
- The microscopic theory of the transport of charge (electrical conductivity, thermoelectric effects) in solids
- The microscopic theory of the transport of heat (phonon, electron and magnon thermal conductivity) in solids
- The microscopic theory of the transport of spin (magnons, electrons and also phonons) in solids
- Interactions between electrons, phonons and magnons, and corrections to the transport theory due to these interactions, such as phonon-drag, magnon-drag and the spin-Seebeck effect.

Course Topics:

- Review classical thermodynamics and introduction to transport
- The Onsager relations
- Diffusive electron transport in crystalline solids
- Corrections to electron transport
- Diffusive phonon transport in crystalline solids
- Corrections to phonon transport
- Magnons and magnon thermal conductivity
- Interactions and mixed effects
- Applications

Designation:

Elective