Dept. of Mechanical Engineering

We offer graduate programs leading to the degrees of Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) in mechanical engineering. The primary mission of the department is to promote sustainable energy research and education, for the ultimate goal of serving the environment and the global community. Our department is one of the nation's top-ranked engineering departments focusing on energy and environment. Graduate students work closely with faculty members to improve research skills and to build engineering careers. Students can join international research activities through various government- and corporate-funded projects that we offer, which will provide scholarship opportunities. Our research interests are not limited to basic topics in thermal energy and environmental engineering such as refrigeration, air-conditioning, fluid machinery and renewable energy systems, but the funded projects encompass various engineering topics in connection with micro-electro-mechanical systems, information and communication technologies, and bio-systems.

Prospective students are encouraged to contact faculty members in the department to learn about their interests and research areas. Applications and all inquiries regarding the admission should be made to the Office of Admission, which will be able to provide information about requirements, application materials, schedules, finances and other topics.

□ Courses

· **Advanced Applied Mathematics (3)**

The analytic methods to solve ordinary differential equations and partial differential equations with boundary and initial conditions are studied to apply engineering problems encountered in practice.

· **Advanced Numerical Analysis (3)**

Selected topics on numerical methods for engineering applications including interpolation, systems of linear algebraic equations, optimization, numerical differential and integration, ordinary differential equations, and partial differential equations.

· **Advanced Thermodynamics (3)**

Development and application of basic concepts in thermodynamics; system and control volume; ideal gas and real fluid; enthalpy, entropy and exergy; heat engine and heat pump; chemical reaction and equilibrium.

- **Advanced Fluid Mechanics (3)**

  Fundamental concepts and methods of fluid mechanics, inviscid flow and Bernoulli theorems, potential flow and its application, Navier-Stokes equations and constitutive theory, exact solutions of Navier-Stokes equations, boundary layer theory, introduction to turbulence.

- **Advanced Heat Transfer (3)**

  Basic theories on heat conduction, mathematical solution and simplified method for numerical solution to the 1,2D steady and 1D unsteady heat conduction problems: basic theories on heat convection and related continuity, momentum and energy equations, laminar flow heat convection: radiative heat transfer basics and shape factors.

- **Advanced Topics in Control Engineering (3)**

  Study modern control theories for the multi-inputs multi-outputs control system. Include the nonlinear control system theories. Focus on control theories and design method for real systems.

- **Experimental Methods for Engineers (3)**

  Experimental planning, variable analysis and identification, data acquisition and recording, statistical data analysis, including regression correlation, and dispersion analysis.

- **Computational Thermodynamics (3)**

  Numerical methods applied to the thermodynamic systems: modeling, analysis, simulation and optimal design: development of computer programs.

- **Advanced Thermophysical Properties (3)**

  Thermodynamic and physical properties of substances used as a working fluid of various thermo fluid system such as PVT relation, vapor pressures, latent heat, specific heat and Gibbs energy of formation: mathematical expressions and accurate correlations for the prediction of thermo-physical properties.

- **Boundary Layer Theory (3)**

  Fundamental of viscous flow and boundary layer theory: Navier-Stokes equations: laminar boundary layer (boundary layer equations, exact solutions and approximate method for the solutions, thermal boundary layers, boundary layer control, unsteady boundary layer).

- **Computational Fluid Dynamics (3)**

  This course is primarily aimed at developing a general method of prediction for heat and mass transfer, fluid flow, and related process. It includes mathematical description of physical phenomena, discretization methods, heat conduction, convection and diffusion, calculation of flow field, et al.

- **Turbulent Flow (3)**

  Fundamentals of turbulent flows, the basic equations, the origin of turbulence, turbulent production and dissipation, vorticity dynamics, turbulence scale, correlation functions and spectral dynamics, turbulence modeling.

- **Advanced Turbomachinery (3)**

  Fundamentals of energy conversion in fluid machines: principle, application and design procedure for fluid machines such as pumps and turbines: review of past developments, the current status, and future research needs in turbo-machinery fluid dynamics.

- **Computational Heat Transfer (3)**

  Numerical schemes and numerical simulation methods are studied to solve mathematical equations, which are derived from the heat transfer phenomena, such as conduction, convection, radiation, evaporation and condensation. Computational practice is carried out in parallel to approach to applied heat transfer problems.

- **Advanced Refrigeration (3)**

  Refrigeration cycles, the characteristics of each components, system performance analysis, refrigerants, control methodologies.

- **Thermal Environmental Engineering (3)**

  Theoretical and practical topics related to indoor thermal environments such as, IAQ, psychrometrics, heating/cooling loads, air pollutants, thermal comfort, ventilation effectiveness, and airflow simulation.

- **Heat Engine (3)**

  Theoretical analysis of heat engines and related combustion processes, design of heat engine components such as boilers and steam turbines, and application in practical problems.

- **Combustion Devices (3)**

  Basic theories of thermodynamics, fluid mechanics, chemical equilibrium, and chemical reaction, and their application in systematic analysis and design of combustion devices.

- **Advanced Gas Turbine (3)**

  Advanced theories on thermal flow, reaction, structural and dynamic characteristics are studied.

· **Advanced Energy Engineering (3)**

Management for the conservative use of energy reserve and processes of alternative energy resources such as solar, tidal, and wind energy: The social and economic consideration of energy consumption based on the engineering methodology regarding the potential energy problems.

· **Vehicle HVAC System (3)**

Components, such as compressors, heat exchangers, and controller, for HVAC (Heating, Ventilation and Air Conditioning) are studied to provide comfortable environment in the cabin of vehicles. The refrigeration cycle analysis and basic design of HVAC system for vehicles are also dealt with to apply engineering problems encountered in practice.

· **Case Studies in Mechanical Engineering (3)**

Case studies of thermo fluid systems required to identify their characteristics and also to develop the modeling and analysis methods.

· **Special Topics in Mechanical Engineering (3)**

Various technologies, modeling and analysis of specific thermo fluid systems.

· **High Temperature Thermal Engineering (3)**

Thermal behavior of materials at high temperature above 1000℃ is studied. Theories on phenomena at high temperature, such as melting and solidification of mineral materials, radiative and convective heat transfer, pure oxygen combustion etc, are investigated.

· **Biomimetic Engineering (3)**

This course is intended to provide the engineering principles found in nature, which is considered a highly efficient and optimized system. It discusses newly designed man-made systems by mimicking and engineering biological phenomena regulated precisely in a tiny physical space.

· **Biomedical device (3)**

This course covers the principles of biomedical devices and related multidisciplinary technologies. Topics include liquid-handling and optical detection systems which are essential parts of various emerging tools for biomedical research and development.

· **Special Topics on Environmental Machines (3)**

Environmental machines applied for waste treatment, waste water treatment, air pollution control are studied. Thermal or cold fluid flow, heat and mass transfer, and reactions for waste incineration system, waste water treatment, various pollution control system is investigated and improve the design ability for actual system by design exercise.

- **Renewable Energy Sources (3)**

  This lecture delivers about renewable energy source, its application and management for efficient utilization such as solar, tide and wind etc. Based on the engineering theory and knowledge related with energy and global warming crisis, the efficient method in the aspect of social and economic utilization of renewable energy is treated.

- **Simulation Software (3)**

  Study various commercial simulation softwares for energy systems design and analysis.

- **Building Automation System (3)**

  Graduate students will learn principles of automatic control, control systems and applications to building energy systems. They will also acquire knowledge regarding renewable energy sources, energy system, building automation and plant engineering.

- **Research Ethics & Thesis Study (3)**

  Graduate students will develop an understanding of the nature of ethical decision-making and its role in research ethics. They will also acquire an appreciation of the reasons for conducting ethical review of research and an awareness of some of the international codes of research ethics that have been developed in response to scandals and abuses in research. Finally, they will understand the nature and definition of research ethics and an appreciation of the importance of good research.

- **Advanced HVAC System (3)**

  Main topics include air conditioning system, zoning, heat pump system and its application, load calculation, system design, and relevant HVAC equipments for a comfort living environment.

- **Measurements in Thermofluidic HVAC Systems (3)**

  Study methods of error estimation and analysis, and its propagation occurred during a measurement. Topics also include principles of temperature and flow velocity measurements such as state-of-the-art experimental techniques using thermocouple, RTD, liquid crystal, and laser Doppler velocimetry, hot wire anemometer.

- **Design of Energy Systems (3)**

Modeling and simulation of thermal systems, such as heat exchangers, refrigeration systems, manufacturing processes, power plants etc. Optimization and economic analysis of thermal systems.

- **Energy System Control (3)**

  Study the dynamic behaviors of the energy system focused on the control system design of the energy system including the HVAC system.

- **Plant EPC (3)**

  Engineering, Procurement and Construction on power plant, incineration lant, renewable energy plant, and environmental plant. Maintenance and economic feasibility analysis are also studied.

- **Advanced Micro Thermofluids (3)**

  Control technologies of micro-physical phenomena, heat transfer and fluid flow of thermal fluid systems for their applications in next-generation technologies of BT, NT, or IT are discussed.

- **Energy convergence technology (3)**

  Based on the understanding about building energy system and energy sources including renewable energy, convergence technologies and their applications are introduced. System integration technologies for energy system are also introduced to build up engineering skills.

- **Selected Topics of Measurements in Heat Transfer and Fluid Flow (3)**

  Selected topics on thermo-fluid measurement techniques, using RTD, liquid crystal, hot-wire, LDV, PIV, and other advanced measurement techniques for heat transfer and fluid flow research.

- **Studies on the Thermodynamic Systems (3)**

  Modeling and analysis of thermodynamic systems: principles and applications of new thermodynamic cycles and various up-to-date thermofluid systems.

- **Statistical Thermodynamics (3)**

  Analysis of behavior of materials in a microscopic point of view, basic probabilities and quantum mechanics, approach of general theories in the classical thermodynamics using statistical method, statistical analysis of chemical equilibrium, ideal gas behavior and real gas behavior, non-equilibrium process and irrevisible processes.

- **Fluid Phase Equilibria (3)**

  Theories in chemical equilibrium, phase equilibrium and properties of pure substance and mixture refrigerants, application to the refrigeration cycle analysis.

· **Viscous Fluid Flow (3)**

Advanced topics and methods on analysis of viscous fluid flow.

· **Non-Newtonian Fluid Mechanics (3)**

Fundamentals of viscoelastic fluid: types and behavior of non-Newtonian fluid: governing equations for non-Newtonian fluid flow: Surface Phenomena: dielectric-behavior, pipe flow of non-Newtonian fluid.

· **Advanced Transport Phenomena (3)**

Introduction to the field of transport phenomena emphasizing on understanding basic physical principles: momentum transport (viscous flow): energy transport (heat conduction, convection and radiation): mass transport (diffusion).

· **Compressible Flow (3)**

Fundamentals of compressible flow, governing equations for compressible fluid flow, steady 1D isentropic flow, steady 1D flow with friction and heat transfer, shock and expansion waves, flow with small perturbation, method of characteristics.

· **Applied Computational Fluid Dynamic (3)**

Basic concepts of fluid flow, introduction to numerical methods, finite volume methods, solution of linear equation systems, methods for unsteady problems, solution of Navier-Stokes equations, complex geometries, turbulent flows, compressible flow.

· **Convection and Radiation Heat Transfer (3)**

Natural and turbulent convective heat transfer, The effect of fluid properties on convective heat transfer, high speed turbulent heat transfer, Radiative heat transfer phenomena in an absorptive and transparent media, Analysis of complex heat transfer.

· **Cooling of Electronics (3)**

The state of art on cooling technologies of electronic equipments are studied to pursue the compact systems. Innovative design method on cooling system of electronics is also carried out to solve practical problems.

· **Advanced Mass Transfer (3)**

Transport phenomena due to the concentration difference, property characteristics such as viscosities and diffusion coefficients: turbulent transport: molecular dynamics: heat and mass coupled transport phenomena, special problems.

· **Applied Air Conditioning (3)**

Calculation of air conditioning loads, system design, behavior of components, special problems related to air conditioning.

· **Applied Refrigeration (3)**

Analysis of various refrigeration cycles, design of the whole system and components, special problems related to refrigeration.

· **Ventilation and Air Cleaning (3)**

Theories and practices of ventilation and air cleaning, modeling and measurements of airflow and pollution concentrations, system design of ventilation and air cleaning devices to provide comfortable indoor space.

· **Cryogenic Engineering (3)**

Design and fabrication of cryogenic coolers to obtain the temperature range below -150℃ is studied. Various applications of cryogenic technology to medical, transportations, telecommunications, and industrial process are also dealt with in this course.

· **Thermal Transport in Materials Processing (3)**

Thermal transport encountered in the materials processing, such as casting, continuous casting, extrusion, molding, and heat treatment process, is studied. Design of thermal processing is carried out for the effective operation.

· **Advanced Heat Power (3)**

Advanced topics in performance characterization, analysis, design, and control of heat power systems and their components.

· **Advanced Combustion (3)**

Advanced topics in combustion engineering including analysis, design, and optimization of various combustion processes based on gaseous, liquid, and solid fuels.

· **Advanced Design of Thermal Equipments (3)**

Modeling of thermal equipments including heat exchangers, turbo machinery, piping and duct systems, simulations and design optimization of thermal systems, economic considerations.

· **Optimal Control (3)**

Study optimal control theories based on linear control theories. Emphasize practical applications of control theories to read systems. Include topics for the dynamic programming, the Pontryagin minimum principle, and optimal control design methods.

· **Application of Advanced Control Engineering (3)**

Study adaptive control theories. Emphasize practical applications of control theories to real systems. Include topics for self-tuning regulators and model? reference adaptive controllers.

· **Process Control (3)**

Study the process control of mechanical systems. Emphasize closed-loop system dynamics and design methods for multi-variable processes. Include topics for the control valve sizing and the control system structure design.

· **Special Studies on Mechanical Engineering (3)**

Methods of modeling and analysis of specific thermofluid systems.

· **Seminar in Mechanical Engineering (3)**

Studies of thermofluid systems to survey the current trend of research and development on them.

· **Multi-phase Flow (3)**

This course covers the current status in estimating the important engineering parameters and physical phenomena in multi-phase flow to cases where more than two phases are present. Adiabatic two-phase flow is not only concerned in this course, but convective boiling and condensation, which is great importance of heat and mass transfer between phases, is also lectured. This course focuses on two-phase flow notation and flow patterns, the basic governing equations of two-phase flow, empirical treatment of two-phase flow, pool and convective boiling, subcooled and saturated boiling heat transfer, critical heat flux, condensation, etc.

· **Smart Convergence Technology (3)**

This subject introduces information technology (IT) for energy engineering including the heating and cooling systems to maximize the efficiency with minimum cost. The subject also introduces new technologies such as biotechnology(BT) and nanotechnology (NT), which are aapplied to core elements of energy systems.

· **Independent Study I (3)**

Selecting a research topic in mechanical engineering that interests the student and conducting the research intensively under the guidance of the advisor.

· **Independent Study II (3)**

Selecting a research topic in mechanical engineering that interests the student and conducting the research intensively under the guidance of the advisor.

· **Independent Study III (3)**

Selecting a research topic in mechanical engineering that interests the student and conducting the research intensively under the guidance of the advisor.

· **Independent Study IV (3)**

Selecting a research topic in mechanical engineering that interests the student and conducting the research intensively under the guidance of the advisor.

□ Climate Disaster Convergence Major

1) Objectives

- The Climate Disaster Convergence Major aims to systematically cultivate interdisciplinary experts who can enhance adaptive technology capabilities for climate disasters, and to develop and research core technologies for climate disaster adaptation.

2) General Academic Administration

- The overall content of the convergence major follows the rules and regulations of the graduate school.
- Students in the master's, Ph.D,, and integrated Ph.D. programs of the Department of Civil and Environmental Engineering, Department of Economics, Department of International Trade, and Department of Mechanical Engineering are recognized as having completed the Climate Disaster Convergence Major if they meet the completion requirements stipulated in the internal regulations.
- The completion and degree conferment for the first major follows the internal regulations of the first major and the rules and regulations of the general graduate school.
- To participate in the Climate Disaster Convergence Major, students must apply to the Civil and Environmental Engineering office by the second semester.
  ※ For students who enrolled before the first semester of 2025, this regulation is retroactively applied to allow application by the first semester of 2025.

3) Program and Courses

- Mandatory Courses: Advanced Topics in Interdisciplinary Climate Disaster Adaptation Technologies and Policies (725560a)
- Core Courses: Climate Change and Response Policies (725570a), Climate Change and Alternative Water Resources (725580a), Modeling and Adaptation Technologies for Compound Disasters Due to Climate Change (725590a), Modeling Urban Heatwaves and Thermal Energy Analysis in Climate Change (725600a), Global Climate Adaptation

Policy (725070a)

- General Courses: Advanced Hydrology (635480a), Environmental Impact Assessment (635820a), Aanlysis and Application of Environment System Data (7209901), Bigdata Analysis for Natural Disaster Modeling (635450b), (Renewable Energy Sources (667300a), Statistical Analysis for International Commerce (6mc081b), International Trade Theory (6mc151a)

4) Completion Requirement

- To complete the Climate Disaster Convergence Major, students must complete at least 9 credits of designated courses within the duration of their studies, including at least 3 credits of mandatory courses and 3 credits of core courses.

□ Faculty Members

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