Dept. of Mechanical Engineering

The educational objectives of the Graduate Program in Mechanical Engineering go beyond the simple acquisition of knowledge and place a strong emphasis on cultivating the qualities required of independent researchers.

Development of independent research capability: Based on advanced specialized knowledge, students are trained to formulate their own hypotheses and solve engineering problems independently through experiments and simulations.

Cultivation of future-oriented creative and interdisciplinary talent: By integrating traditional mechanical engineering with other disciplines such as artificial intelligence, biotechnology, and energy, the program fosters creative and interdisciplinary thinking to respond to rapidly changing industrial trends.

Enhancement of global leadership and ethical awareness: Through international academic activities, students strengthen their communication skills and develop a strong sense of professional ethics as responsible engineers who understand the societal and environmental impacts of engineering technologies.

□ 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 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 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.

· **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.

· **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.

· **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.

· **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.

· **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.

· **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.

· **Advanced Heat Power (3)**

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

· **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.

· **AI Sensor Engineering (3)**

Sensor System Engineering (MS and Ph.D course): This course introduces the structure and operation principle of various sensor devices, sensor modules and sensor systems based on physics, chemistry, biotechnology, optics, etc. and application to industrial fields such as automobile, home appliances, biomedical, sports, etc.

· **Thesis Study1 (3)**

As a basic step to start research on a thesis for master's and doctoral students in engineering colleges, they are required to systematically learn research topics,

research prior research, definition of research problems, and design research methodologies. Through this, students are encouraged to specify their thesis topics and acquire basic research capabilities necessary for research.

· **Thesis Study2 (3)**

Instruct students in engineering colleges to conduct actual thesis research based on their research plans. It includes the entire process of acquiring and analyzing data (experiment, simulation, and theory), interpreting results, writing papers, and presenting academic presentations, allowing students to complete high-quality dissertations as independent researchers.

· **AI based Aerospace Guidance and Control (3)**

This course covers artificial intelligence-based guidance and control techniques used in aerospace systems. Topics include reinforcement learning-based guidance and control, and fault diagnosis using deep neural networks.

· **Intelligent Mechatronics (3)**

Intelligent Mechatronics is a course that covers technologies integrating sensors, actuators, control algorithms, and artificial intelligence techniques into mechanical systems to realize autonomous and intelligent operations.

· **Advanced Micro-Electro-Mechanical System (3)**

Nano/micro fabrication and equipments for sensor, actuator, energy harvesting device, optical/display device and functional surface applications are introduced. Topics include not only basic semiconductor fabrication process such as optical lithography, deposition, and etching, but also state of art fabrication process such as ink jet, imprint, roll-to-roll, etc.

· **Contact Mechanics (3)**

This course deals with various theories of contact stress and strain that occur between contacting surfaces, such as Hertizan contact. The course involves the effects of adhesion and friction on contact.

· **Surface Engineering (3)**

"This course introduces surface-related properties such as roughness, surface free energy, and hardness in order for students to understand the mechanical and physical properties of surfaces. This course also aims at introducing various equipment used to measure and analyze surface properties."

· **Fuel Cell Fundamentals (3)**

"Students will learn the basic principles of electrochemical energy conversion while being exposed to relevant topics in materials science, thermodynamics, and fluid mechanics."

· **Advanced Nanomaterials and Nanostructures (3)**

"Nanomaterials have been recognized as key for the realzaiton of future advanced technology. In this lecture, students will learn the diverse aspects of nanomaterials including analysis of the characteristic of nanomaterials, synthesis of nanomaterials with diverse lithography and chemical method, and distinguishing features of 0D, 1D, 2D, and inorganic-organic hybrid materials."

· **Fundamental and Applications of Laser (3)**

The basic knowledge on the principles and properties of laser is acquired, and the application studies the fine processing method using the physical-chemical reaction of laser and material, and the precision measurement method using optical interference, scattering, Moire, etc

· **Nontraditional Manufacturing (3)**

The principles, processing characteristics and application cases of material removal processes such as discharge machining, laser processing, composite machining, etc. and material attachment processes such as 3D printing are studied, and the principles and design methods are also studied for recent micro/nano processing and manufacturing methods.

· **Robot Control (3)**

By increasing the interesting and research for robots, 'Robot Control' deals with advanced control theories and control experiments.

· **Rotordynamics (3)**

Recently, household electric appliances, automobiles, aircraft, factory facilities, and plants are improving the power output and efficiency by applying high-speed rotating equipments. Therefore, in this course, we study the designs of rotating shaft, bearing, seal, and damper supporting the shaft system for the improvement of dynamic stability and reduction of power loss of high power rotating machinery and introduce design and test cases.

· **Machinery Vibration Diagnostics (3)**

Failure to diagnose the health condition of the machine results in major damage to the main part, disruption of operations, and enormous economic losses. Therefore,

for vibration-based condition diagnosis of automation machine, plant, and power plant facilities, we learn about signal processing, condition monitoring, fault analysis, facility knowledge, test evaluation method based on vibration theory and introduce diagnosis cases.

· **Intelligent CAD (3)**

Both the existing and new CAD theories are covered, together with the fundamentals and implementations of the intelligent CAD system so that the latest information technologies such as artificial intelligence, virtual reality applications, and the collaborative design theories are addressed.

· **Bio-Engineering (3)**

This course gives an introduction to the biomechanics and their applications in bio-mechanical engineering. It deals with design concept of biomechanical system based on material science, fluid mechanics, and solid mechanics. Main topics are biofluid mechanics such as lubrication of human synovial joints, cardiac boidynamics and mechanics of heart valves as well as biosolid mechanics such as mechanics of hard tissue, mechanics of joint articulating surface motion and contact mechanics.

· **Nano-engineering (3)**

This course describes a guide to nanotechnologies basing on nanometer scale and nano-applications in modern engineering, together with bottom-up and top-down nanofabrication technology being addressed. History and future of nanotechnology, nanoparticles, nanocoatings, micro and nano mechanics, lithography technology for semiconductor device and nanocharacterization are main topics.

· **Dynamic System Design (3)**

This course deals with a design process about dynamic systems which have kinematic chains. The kinematic and dynamic analysis of the mechanism systems are studied on and the function modeling of the mechanism systems is considered with concept of the model-based design. The modeling methodologies about the classical control and digital control are also researched on with the Simulink S/W in this course.

· **Advanced Robot Control (3)**

"This course provides an in-depth study of advanced control theories and their applications to robotic systems. Topics include nonlinear control, adaptive control, optimal control, model predictive control (MPC), and learning-based control methods such as reinforcement learning. Students will apply these methods to various robotic platforms including humanoid robots, manipulators, and autonomous mobile robots. Practical aspects such as real-time control, sensor fusion, dynamic stabilization, and interaction control are also emphasized. Through modeling,

simulation, and experimental projects, students will develop the capability to design and implement high-performance control algorithms for complex robotic systems."

- **Manufacturing Processes for Composite Materials (3)**

  This course provides a comprehensive overview of manufacturing processes for composite materials, ranging from fiber-reinforced composites to nano-composites. Topics include fabrication techniques for thermoset and thermoplastic matrix composites such as hand lay-up, vacuum bag molding, resin transfer molding (RTM), filament winding, and prepreg-autoclave processing. The course also covers dispersion and processing methods for particle- and nano-filler-based composites including nanoclay, carbon nanotube (CNT), and graphene composites. Emphasis is placed on understanding process–structure–property relationships, microstructure control, and performance enhancement strategies. Case studies and practical examples will help students develop problem-solving skills related to composite manufacturing.

- **Dynamic Control Systems (3)**

  This course covers the modeling of dynamic behaviors in various physical systems and the application of advanced control theories to achieve desired system performance. Experimental setups, including diverse laboratory equipment, are used to perform system modeling, system identification, controller design, and performance verification.

- **Advanced Guidance and Control of Aerospace systems (3)**

  In this course, students study guidance and control methods used in aerospace systems. Guidance topics focus on proportional navigation (PN) for guided missiles, while control topics include optimal control and techniques integrating artificial intelligence.

- **Advanced Robot Mechanism Design (3)**

  The lecture 'Robot Mechanism Design' covers two main topics: (1) mathematical theories to derive equations of motion of the robot mechanisms; (2) the modeling methodologies in designing the robot mechanism. The mathematical theories include the POE method, Jacobian and dynamic analysis, which is essential to derive Newtonian and Lagrangian mechanics of the robots. In addition, basic control theories, kinematic modeling of mechanism, and practice of a conventional multibody dynamics program are introduced. The term project about the robot mechanism design will be assigned for the students as a final evaluation.

□ 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.

□ AI·SW Convergence major

1) Objectives

- The AI and SW convergence major aims to systematically cultivate convergence professionals and develop and research AI and S core technologies to strengthen AI and SW convergence technology capabilities.

2) General Academic Administration

- The overall content of the convergence major follows the rules and regulations of the graduate school.
- Students in the computer engineering department, cybersecurity department, construction system engineering department, mechanical engineering department, master's program, doctoral program, and master's and doctoral program in innovative material renewable design department are recognized as completing AI and SW convergence majors if they meet the completion conditions set out in the bylaws.
- 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 AI-SW convergence major, you must apply to the computer engineering department office before the second semester.
- ※ For students who enrolled before the second semester of 2025, this regulation is retroactively applied to allow application by the second semester of 2025.

3) Program and Courses

- Mandatory Courses: Agent-type Artificial Intelligence and Creative Programming
- Core Courses: Artificial intelligence platform, AI security, intelligent robots, robotics specialties, object intelligence network, artificial intelligence leading thematic research, deep learning I, deep learning II, cryptographic algorithm, information protection protocol, artificial intelligence-based aerospace-guided control, elasticity theory, pollution problem research and smart technology, big data-based natural disaster analysis, sustainable design innovation, digital fabrication, AI modeling
- General Courses: Agent-type AI practical project, AI project 1, AI project 2, AI project 3, security implementation development methodology, subchannel attack theory, intelligent mechatronics, disaster prevention construction technology, environmental system data analysis and application, climate change complex disaster modeling and application technology, AI Renewable Design, AI Entertainment Design, AI Design Studio

4) Completion Requirement

- To complete the AI-SW convergence major, you must complete at least 9 credits of designated courses within the class period, and you must complete 3 credits of required courses and 3 credits of core courses among the credits to complete the AI-SW convergence major.