Dept. of Mechanics & Design

Graduate programs leading to the degrees of M.S. and Ph.D. in Mechanics and Design were established in 1987 and 1991, respectively. The joint M.S.-Ph.D. degree program is also being offered. The broad fields that are covered involve fundamental mechanics of solids, materials design for machine elements, reliability and optimization, fracture and fatigue, computer-aided design, and manufacturing. Moreover, in order to keep up with the latest trends and developments, strong emphasis is placed on the research and education in the emerging fields such as micro/nano/bio system and information technology.

□ Major Courses

· Advanced Stress Analysis (3)

Studies of stresses and strains in three-dimensional problems: failure theories and yield criteria: stress function approach to two-dimensional problems: bending of non-homogeneous asymmetric curved beams: torsion of bars with non-circular cross sections: energy methods: elastic stability, and introduction to plate theory.

· Continuum Mechanics (3)

This course is intended to provide the entering graduate students with the basic concepts of vector and tensors and the analysis of stresses and deformation at a point in a continuous medium, followed by the derivations and applications of fundamental equations of a continuous medium based on the laws of conservation of mass, linear momentum, moment of momentum, and those of thermodynamics: constitutive relations for fluids and solids. Specialization of the field equations to some boundary value problems in solid and fluid mechanics are also addressed.

· Advanced Numerical Analysis (3)

This course is designed to acquaint entering graduate students with the fundamental theory of numerical analysis that is essential in solving variety of engineering problems of practical interest. In addition to a series of lectures on the solution of systems of linear equations based on direct methods, error analysis, structured matrices, and iterative methods, the students are further introduced to the numerical solution of ordinary and partial differential equations subjected to certain boundary and initial conditions. Stability and convergence of the numerical solutions are also addressed.

· Advanced Finite Element Method (3)

This course deals with the finite element formulations such as direct stiffness method, potential energy method, Galerkin's weighted residual method, and virtual

work approach. It also introduces an isoparametric formulation with proper numerical integration rules. This course will offer the students experience in solving the boundary value problems related to solid mechanics with the educational version of finite element package. Especially, emphasis is placed on the modeling of physical problem and the interpretation of its FE solutions

· **Concurrent Engineering (3)**

This course deals with the concept and the state of the art of concurrent engineering. A systematic survey of the application and effects of the concurrent engineering design tools (DFA, DFM, DFS, DFE) through simulation and case study is studied.

· **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.

· **Advanced Composite Materials (3)**

Composites are widely used in airplanes, and automobiles. This course presents the mechanics and material aspects of deformation, stress analysis, and fracture of man-made composites as well as natural, and biological composites. Topics may include basic modeling, experimental methods, and computational techniques.

· **Advanced Theory of Elasticity (3)**

Topics covered include stress and equilibrium: deformations, strain and compatibility: constitutive equations: two dimensional problems in Cartesian and polar coordinates: application to extension, bending and torsion: introduction to three-dimensional problems using displacement potentials.

· **Computational Mechanics (3)**

Basic principles of continuum mechanics and finite element methods, with modern applications to the solution of practical problems in solid, structural, and fluid mechanics, heat and mass transfer, and other field problems, are introduced. Besides, kinematics of deformation, strain and stress measures, constitutive relations, conservation laws, virtual work, and variational principles are taught. The discretization of governing equations using finite element methods and the solution of central problems using a general purpose finite element analysis program are also covered.

· **Advanced Machine Design (3)**

The advanced topics in the field of machine design are studied: fracture theory for ductile and brittle material: design and application of beams: analysis for special springs: tribology: analysis for brake system: design and analysis for gear trains: introduction to robust engineering: and machine balancing design. The participants should research on an application as the final term project and present their results in the end of semester.

· **Topics in Mechanical Design (3)**

This course deals with problems and solutions on deformations and failures of various mechanical and automotive components. The approach emphasizes selection of materials to help with designing mechanical structures. Degradation of materials, fatigue failure by poor design, stress concentration in mechanical design and their solutions are described in this course.

· **Optimal Design (3)**

The optimization theory and practice as it applies to engineering design is studied. Topics include monotonicity analysis, numerical methods in continuous design spaces and techniques for discrete optimization, through the analytical and computer-based assignments and design exercises.

· **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.

· **Fatigue and Fracture (3)**

Composites are widely used in airplanes, and automobiles. This course presents the mechanics and material aspects of deformation, stress analysis, and fracture of man-made composites as well as natural, and biological composites. Topics may include basic modeling, experimental methods, and computational techniques.

· **Advanced Fracture Mechanics (3)**

Linear elastic and elasto-plastic models of local stress fields around the crack tips are discussed, with the introduction of concepts of stress intensity factors, strain energy release rate, strain energy density, J-integrals, and fracture resistance. Mathematical models for crack extension and fatigue crack growth are further addressed, from the standpoint of importance of maintaining the integrity of various elements and components of engineering structures.

· **Plasticity and Forming Process (3)**

This course introduces the stress and strain tensor appropriate for the analysis of large plastic deformation. This course focuses on the physical meaning of yielding, which consists of yield conditions, flow rule, and post yielding behaviour of hardening, together with its mathematical representation or constitutive equations for plastic deformation. The student will complete the term project design of actual forming processes such as rolling, forging or sheet forming.

· **Topics in Manufacturing Technology (3)**

Advanced study on the aspects of manufacturing and production technologies in a competitive environment is performed. Topics include the manufacturing processes, facilities, and systems and operation technology. Seminars involving case studies should be presented by the students.

· **Advanced Engineering Mathematics (3)**

This course covers the methodologies for solving mathematical problems which are encountered in mechanical design processes. The various practical solutions are suggested for engineering applications, i.e., boundary value problems: partial differential equations: complex integration: calculus of variations in the fields of fracture mechanics: elasticity: finite element method: and manufacturing.

· **Advanced Dynamics (3)**

This course covers rigid body kinematics/kinetics, Lagrange equation, Euler equation, Hamilton Jacobi equation, gyroscopic motion, stability analysis of autonomous and non-autonomous system, and nonlinear system analysis.

· **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.

· **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.

· **Robotic 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.

· **Computational Plasticity (3)**

This course deals with the advanced level of mathematical and numerical formulation for nonlinear problems raised in various forming processes. Focuses are given to micro forming of amorphous alloys as well as the conventional forming of polycrystalline materials with damage. Students are enforced to implement the numerical formulation of the constitutive description for such nonlinear material behaviour into the given educational version of FE package.

· **Advanced Production Technology (3)**

The concept and the state of the art of advanced production technology is addressed with emphasis on H/W (CNC machine tools, industrial robot, automated guided vehicle, automatic storage and retrieval system, FMS, CIM) and S/W tools (CAD, CAM, CAPP).

· **Environmentally Conscious Design (3)**

The course is designed to learn about environmentally conscious design and manufacture, the growing national and international efforts in reducing the environmental impact of products, and how the environmental considerations affect the design's technical, economical and quality requirements.

· **CNC Machine Tool (3)**

CNC machine tools with computer are composed of part program, control systems, and machine tool itself. Therefore this subject includes the method to make part programs, the functions of control systems, and the classification of machine tools. Another topic is to understand FMS and CIM by applying the CNC machine tools to the automation which increase the productivity.

· **Intelligent Building System (3)**

The IBS is an advanced information building with a high level of information, communication, and automatic control system. We will study the concept and theory about element technologies to implement this system such as architecture,

communication, office automation, and building automation. Finally this course introduces applications for the system integration.

- **Nano Convergence Mechanical Technology (3)**

  Related to energy issues such as production, efficiency enhancement, and savement, nano convergence mechanical technology is introduced, which covers design, fabrication, and applications.

- **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.

- **Micro-Processor (3)**

  In this lecture, students understand a microprocessor and its principle. Using microprocessors, students learn ability to operate and control robotics systems.

- **Linear System (3)**

  A linear system is a mathematic model of system based on linear algebra. It is useful for system control and analysis. Through linear system, students learn fundamental knowledge for system analysis.

- **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.

· **Structural analysis and Design (3)**

This course covers topics in deformation and stress analysis in terms of structural safety. Discussed in the class are theoretical backgrounds, as well as design software tools.

• **Sensor System 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.

· **Applied Numerical Analysis (3)**

The fundamentals of modern numerical techniques for a wide range of linear and nonlinear elliptic, parabolic, and hyperbolic partial differential and integral equations are covered. Topics include finite difference, finite volume, finite element, and boundary element discretization methods: and direct and iterative solution techniques. The methodologies described form the foundation for computational approaches to engineering systems involving heat transfer, solid mechanics, fluid dynamics, and electromagnetics. Strong emphasis is given to the computer implementation of algorithms in programming assignments.

· **Applied Computational Mechanics (3)**

The computational techniques for the simulation of a large variety of engineering and engineered systems are addressed. Applications are drawn from aerospace, mechanical, electrical, and chemical engineering, biology, and materials science. Topics include mathematical formulations: network problems: sparse direct and iterative matrix solution techniques: Newton methods for nonlinear problems: discretization methods for ordinary, time?periodic and partial differential equations: fast methods for partial differential equations and integral equations.

· **Applied Finite Element Method (3)**

This course deals with the finite element formulations for the nonlinear, thermo-mechanical problems. Formulations include both explicit and implicit method to satisfy equilibrium of a body. Newton type approaches for nonlinear problem together complicated integration rules are also introduced. This course will offer the students experience in solving the boundary value problems related to nonlinear thermo mechanical stress analysis.

· **Applied Stress Analysis (3)**

Various up-to-date stress analysis techniques, including advanced strength of materials, energy methods, theory of elasticity, creep, yield and failure criteria, inelastic behavior, fracture mechanics, and fatigue crack growth analysis are studied.

· **Applied Machine Design (3)**

This course covers the theory of the practical machine design applications such as: design for strength and rigidity under both static and dynamic loads: design for the strength under Fatigue: shaft design with joints: lubrication and bearing design: finite element analysis: optimization and statistical consideration in design process. The participants should research on the application as the final term project and present their results at the end of semester.

· **Topics in Applied Mechanical Design (3)**

This course deals with subjects on the progress of advanced engineering techniques in the various fields of design, mechanics, materials, fracture, etc.

· **Applied Optimal Design (3)**

A comprehensive study of classical and modern design optimization methods is made. Students are involved in computer-based, quarter-long, group-oriented projects, the concepts of which are drawn from their student projects, other courses, and/or industry.

· **Advanced System Design (3)**

This course deals the recent system design related to manufacturing. Through the study on recent papers, high level research ability can be raised.

· **Applied CAD (3)**

This course introduces the latest technologies related the design process methods and evolutionary methods in actual designing. Reviews are made over the recent researches related to the design and manufacturing systems, by surveying the recent papers. Students will be evaluated by the oral presentation regarding the related fields.

· **Advanced Manufacturing Processes (3)**

Systematic review of the conventional and non-conventional manufacturing processes is made. Emphasis is placed on the principles, characteristics and associated economic and environmental aspects of processes, from both the theoretical and applied viewpoint.

· **Topics in Applied Manufacturing Technology (3)**

Advanced subjects related to the manufacturing technology in the new industries based on high technology (NT, BT) are covered. Topics include the processes, facilities, systems and operation technology, with seminars concerning case studies being presented by the participating students.

· **Thesis Study1 (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.

· **Thesis Study2 (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.

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