* The boxes with gray background are conducted in Japanese.
* The subjects with "★" require application at Academic Affairs Section at School of Engineering (1st floor, Bld. A02 on Aobayama Campus, Email: kc-kyomu@grp.tohoku.ac.jp) before registration.

8 . Specialized Subject Description

Mathematics I 2 Credits Elective 3rd Semester	**Mathematics II** 2 Credits Elective 3rd Semester
This course teaches the fundamentals of vector calculus, ordinary differential equations, and the Laplace transform which are basic tools to analyze various phenomena in the fields of science and engineering.	The course is an introduction to partial differential equations (PDE). This course mainly analyzes initial and boundary value problems for the wave equation and the heat equation. Examples of applications come from physics and complex systems, such as shock waves, traffic flows, and chemical reactions. The course also put a focus on the Fourier series and transforms, as a tool for data processing and solving the PDEs. The goal is to examine concrete examples and develop the general theory.
Numerical Analysis 2 Credits Elective 3rd Semester	**Mechanics** 2 Credits Elective 3rd Semester
Numerical analysis is intended to be an introduction to the basis of linear algebra and numerical analysis. Applications to several engineering issues are included. 1. Vector and metric space 2. Simultaneous equation and its solution 3. Quadratic form and its application 4. Method of least squares 5. Linear programming 6. Basis of game theory	This lecture is based on the contents on the mechanics already studied in “Physics A” and “Physics B”. “Mechanics” as a specialized subject aims at acquisition of the basic knowledge for applying “Mechanics” to mechanical engineering. The main contents of this lecture are as follows: 1. Kinetics of a Particle, 2. Kinetics of a System of Particles, 3. Analytic Mechanics, 4. Vibrations of a Particle, 5. Momentum Balance of a Rigid Body, 6. Planar Kinetics of a Rigid Body.
Mechanics of Materials II 2 Credits Elective 4th Semester	**Exercises in Computer-Aided Problem Solving** 2 Credits Elective 3rd Semester
This course is intended as an introduction to mechanics of solids offered to engineering students, and presents the underlying theories and formulations for the description of stress/strain and deformations under various types of loading. Mechanics of Materials II discusses the loading mode of bending in addition to tension/compression and torsion treated in Mechanics of Materials I. The topics covered in the course include; (1) theory of beams which allows us to calculate bending/shear stresses in beams and their deflections; (2) energy methods such as Castigliano’s theorem; and (3) compression-induced failure such as buckling.	This course aims to enable students to acquire skills of solving mathematical problems using computers. In this course, students will use a popular numerical computing software. The focus is not only on learning how to use the software but more on acquiring general mathematical techniques. The course will cover not only subjects in mathematics that students have learned but those they have not learned yet, such as numerical optimization and applied statistics. Specifically, students will learn matrix calculation, linear/nonlinear equations, interpolation, numerical integration, differential equations, Monte Carlo methods, basics of machine learning, etc.
Fluid Mechanics I 2 Credits Elective 4th Semester	**Mechanics of Materials I** 2 Credits Elective 4th Semester
Basic features of fluid motions will be covered. The lecture will focus on the methods to comprehend fluid motions. 1. Physical properties of fluids 2. Static fluid mechanics 3. Basics of fluid motions 4. Momentum theory 5. Dimensional analysis and similarity rule 6. Viscous flow in pipes 7. Flow over immerse bodies	This course aims to obtain the basic knowledge of the origin of physical and chemical properties of advanced materials from the view point of the alignment of component elements. In addition, the effect of various atomic scale defects and strain on the properties is discussed. This basic theory is applied to the stable control of not only mechanical properties, but electromagnetic, optical, thermal, and electrochemical properties of various engineering materials.
Quantum Mechanics I 2 Credits Elective 4th Semester	**Mechanical Vibrations I** 2 Credits Elective 4th Semester
The study of quantum mechanics and its applications occupies an important position in modern science. The aim of this course is to give an understanding of the fundamental theories about quantum mechanics. We will learn about historical developments that led to the birth of quantum mechanics, the wave function and the uncertainty principle, Schrödinger equation, bound states in a harmonic oscillator potential, and a hydrogen-like atom.	The focus is on the acquisition of fundamental knowledge regarding dynamic problems which may arise in machinery. Systems with one, two and multiple degrees of freedom with /without damping and/or external force input are specifically discussed. Design of mechanical system based on obtained knowledge is also discussed.

Thermodynamics I 2 Credits Elective 4th Semester	**Electromagnetics I** 2 Credits Elective 5th Semester
The objectives of this course are to understand basic concepts of thermodynamics and to apply this concept to engineering problems. Thermodynamics is an important subject strongly related with environmental issues such as energy and global warming due to emission of greenhouse gases. The course includes the basic laws of thermodynamics, processes of ideal gases, conversion cycles between heat and work, phase transition, general relations among quantities of state and exergy (available energy).	Electromagnetics is the base for the development of transducers and also energy conversion machines. It is closely related with research areas of mechanical engineering. The purpose of this lecture is to learn basic knowledge and the way of thinking of electromagnetic field. Fundamentals of Maxwell equations, electro-statics, magneto-statics, and electromagnetic induction will be studied in this lecture. Taking Electromagnetics II is strongly suggested for better understanding of electromagnetics.
Mechanical Vibrations II 2 Credits Elective 4th Semester	**Thermodynamics II** 2 Credits Elective 7th Semester
The focus is on the acquisition of knowledge regarding dynamic problems which may arise in machinery. Systems with distributed mass and elasticity, rotating machinery, and reciprocating engines are specifically discussed: 1. Vibrations of string, bar, shaft, and beam 2. Dynamics of rotating machinery and reciprocating engines	This lecture teaches the chemical thermodynamics of aqueous solutions using the first and second laws of thermodynamics. Students will understand the use of thermodynamics related to chemical equilibrium and learn about the calculation of the equilibrium constant based on thermodynamic data. The knowledge of chemical thermodynamics is essential to understand environmental and biological systems and to design sensors, batteries, and medical devices. Through this lecture students learn the basis for the application of chemical thermodynamics to mechanical engineering of the environment, energy and biological systems.
Materials Science I 2 Credits Elective 4th Semester	**Materials Science II** 2 Credits Elective 5th Semester
This course will provide concise introduction to the microstructures and processing of materials and how these are related to the properties of engineering materials. In this case, although we mostly deal with metals, properties of other engineering materials will also be discussed. The goal of this course is to understand basic properties of materials, how properties are related to microstructures, how microstructures are controlled by processing, and how materials are formed and joined.	This lecture aims to understand the origin of physical and chemical of materials, which is necessary for the development of highly functional and reliable devices and equipment. The lecture will focus on the relationship between atomic alignment in materials and various properties such as 1. The origin of materials properties from a viewpoint of atomic alignment 2. Characterization methods of materials 3. Electromagnetic, thermal and optical properties of materials 4. Mechanical properties of materials 5. Electrochemical properties of oxide, ceramics
Computer Seminar I 1 Credit Required 4-5th Semester	**Mechanical and Aerospace Engineering Seminar I** 2 Credits Required 4th Semester
This course is designed to introduce undergraduate students to fundamental computer science including text editing and C programming language. The course assumes no prior knowledge about computer systems and computer programming. Students will learn about algorithms and problem solving methods.	Students will be divided based on their selected fields of research for this class. Each student will receive instruction on a research topic and then investigate their topic on their own. Students will present their results to the class and discuss them. Through this process students will increase their ability to conduct research individually, learn how to prepare and give presentations, and how to answer questions, in addition to deepening their understanding of their chosen field.
Design and Drawing I 1 Credit Required 5th Semester	**Science Technology and Industry in Japan** 1 Credits Elective 4th Semester
To design mechanical systems, several terms such as materials, stiffness and fabrication methods of the mechanical parts should be considered. Mechanical elements such as screws should also be chosen properly to satisfy the required specifications. All the related information will be transferred via drawings, and the preparation of the drawings is called “Mechanical drawings”. Several regulations are strictly determined for the mechanical drawings to correctly transfer the information. In these lectures, students are expected to learn not only how to carry out mechanical drawings but also their regulations throughout several training assignments.	This class is a newly developed multidisciplinary course that was organized by the faculties of science, engineering, and agriculture. Except for the first class, each class will feature a talk by a specialist in his/her field. The topic of each talk will be the "past, present, and future of industry, science, and technology, and their relationships and integration in Japan." Students will obtain fundamental problem-solving abilities, proactiveness, understanding of different cultures, and a multidisciplinary perspective. Registered students are expected to apply what they learn from this course in the newly developed class titled "Multidisciplinary Internship."

Control Engineering I	2 Credits Elective 5th Semester	**Control Engineering II**	2 Credits Elective 5th Semester
This course aims to obtain knowledge and understanding of feedback control systems. Starting from Laplace transform and transfer functions of systems, frequency response on Bode and Nyquist diagrams are introduced. Based on these tools, stability of feedback controlled systems is discussed. Stability test with Routh-Hurwits, root locus diagrams and rules for sketching loci are described to characterize system dynamics. Finally, design of feedback controllers with PID, pole assignment and phase lead-lag compensators are presented.		Following Control Engineering I, extensive lectures are given on modern control theories. Particularly, a focus is made on the methods for the design and analysis of linear or linearized control systems, based on state-space representation in time domain. The lectures cover the following topics: 1. State equation, state transition matrix, transfer function matrix 2. Controllability and observability 3. Realization, stability 4. State feedback and pole assignment technique 5. Observer, optimal regulator	
Quantum Mechanics II*	2 Credits Elective 5th Semester	**Electromagnetics II**	2 Credits Elective 7th Semester
Quantum mechanics is essential for an understanding of nuclear physics which is applied to a wide variety of fields, such as atomic power, nuclear fusion, analytical technology and radiology. Extending Quantum Mechanics I, this lecture provides many particle systems for atoms and nuclei, approximation methods for Schrödinger equations, scattering theories, general properties of nuclei and fundamental theories of nuclear structures and reactions.		This lecture is the extension of Electromagnetics I. Those who take this lecture must have completed Electromagnetics I. Based on the fundamental electromagnetics studied in Electromagnetics I, we give lectures on the mutual interaction of electromagnetic fields and ferromagnetic and dielectric materials, and the fundamentals of electromagnetic waves. Then we discuss analytical and numerical approaches in electromagnetic analysis. We also discuss on applications of electromagnetics in the fields of engineering which include semiconductors, superconductors, optical devices and applied electromagnetic waves.	
Kinetics in Reactions	2 Credits Elective 7th Semester	**Environmental Earth Science***	2 Credits Elective 5th Semester
Whenever the development or production of new materials, chemicals, etc. is required, chemical engineering is of fundamental importance. One key knowledge in this field is the ability to predict the motion of molecules and the outcome of reaction. In this lecture we prepare the ground for the discussion of chemical reaction rates by considering the motion of molecules in gases and liquids. Then we establish the precise meaning of the reaction rate and see how the overall rate and complex behavior of some reactions can be expressed in terms of elementary steps and atomic events that take place when molecules collide.		Students can study fundamentals of environmental Earth science on the basis of geology associating with geophysics and geochemistry. Particularly, classification of rocks, geological structure, tectonics, formation of natural resources and geochronology. Students can study several methodologies to understand formation mechanisms of rocks and geological structure, and to consider geological and environmental behaviors of the geosphere. Basic knowledge of minerals and rocks is required.	
Fluid Mechanics II	2 Credits Elective 5th Semester	**Heat Transfer**	2 Credits Elective 7th Semester
Continuing Fluid Mechanics I, lectures on fluid mechanics are given. The aim is to understand analytical methods for fluid mechanics and their mathematical descriptions through the following topics: 1. Continuity equation and equation of motion 2. Complex velocity potential 3. Potential flows 4. Vortex motions 5. Fundamental concept of exact solution for the Navier-Stokes equations 6. Boundary layer equation 7. Laminar and turbulent flows		This class provides explanations of the fundamentals of heat and mass transport phenomena. The aim of this class is to acquire fundamental knowledge of heat and mass transfer, which is useful to several engineering designs. Students firstly study the basic concept of heat transfer including conduction, convection and radiation. Then the applications of the concept to industrial designs, such as heat exchanger, boiler and condenser will be introduced. The goal of this class is to acquire the concept of heat and mass transfer.	
Heat and Mass Transfer	2 Credits Elective 8th Semester	**Transform Phenomena**	2 Credits Elective 7th Semester
Heat and mass transport phenomena are discussed from a broader viewpoint ranging from microscale to macroscale. Thermodynamic quantities are revisited with microscopic descriptions. The basic principles of statistical physics are given in order to understand the relationship between macroscopic thermodynamics and microscopic mechanics. Based on the above basics, the derivation of governing equations for mass transport phenomena, essential analogy between heat transfer and mass transfer, and application cases in the engineering are discussed.		Students will learn the basics of transport phenomena, and mathematical analogies in transport phenomena of energy, mass and momentum will be discussed. Students will understand the fundamentals of governing equations of energy, mass and momentum transport phenomena. They will also study the relationships between transport behaviors and material properties.	

Theory of Elasticity 2 Credits Elective 5th Semester	**Manufacturing Engineering and Technology I** 2 Credits Elective 5th Semester
When an elastic body is subjected to a load, it deforms and stresses are caused. The basis of continuum mechanics called elasticity which treats these phenomena mathematically is explained, where deformation is assumed to be infinitesimal. Contents are as follows: 1.Displacement, strain, equations of compatibility, 2.Stress, equations of equilibrium, 3.Strain energy, theorem of minimum potential energy, 4.Constitutive equations, isotropic body, 5.Navier's equations, Beltrami-Michell compatibility equations, and 6.Analyses of torsion, bending and some 2D problems. This lecture gives the basis of computational mechanics and solid mechanics.	Machine systems are made of numerous individual parts and from a variety of materials. Manufacturing is concerned with making the products. This subject teaches basic knowledge of production and manufacturing. Furthermore, the engineering technologies required to realize machine systems are explained.
Manufacturing Engineering and Technology II 2 Credits Elective 5th Semester	**Electrical and Electronic Circuit I** 2 Credits Elective 5th Semester
Machining is denoted as a series of material-working processes which enable the manufacturing of industrial products having various shapes and functions. In this lecture, the fundamentals of four typical material-removal machining methods, namely, cutting, grinding, polishing and non-traditional machining will be introduced systematically. The emphasis will be placed on new technologies which can improve the accuracy, quality and function of the products.	This course explains the fundamentals of electronic circuits as a linear system and their engineering applications. Topics include: 1) Linear systems and electronic circuits, 2) Resistive circuits, 3) Sinusoidal wave and impedance, 4) AC circuits, 5) Characteristics and response of linear systems, 6) Complex spectrum and frequency domain, 7) System representation.
Electrical and Electronic Circuit II 2 Credits Elective 7th Semester	**Laboratory Experiment I** 1Credit Required 7th Semester
This course teaches the operations of semiconductor devices and constructing electronic circuits. The fundamentals of analog amplifier circuits for alternating current and digital circuits for logic operations are also studied. Topics include: 1.Semiconductors and diodes 2.Transistors 3.Analog amplifier circuits (small signal low frequency analysis) 4.Digital circuits (logic gates)	Students will conduct experiments and observations of basic phenomena in the field of mechanical and aerospace engineering, and apply knowledge acquired in lectures to specific examples, in addition to acquiring basic skills needed to conduct specialized experiments. They will learn how to observe and present the results of their experiments. Students will conduct experiments under the guidance of professional instructors and produce and submit reports through discussions with these instructors.
Mechanical and Aerospace Engineering Seminar Ⅱ 1 Credit Required 5-6th Semester	**Production Process Practice** 1 Credits Required 7th Semester
Each student will study and organize documents related to their graduation research theme, and prepare an outline that sums up the documents. They will also conduct independent research and study based on the documents for presentations and discussions. Through this process they will learn about conducting document-based research, independent research, giving presentations, and responding to questions.	Manufacturing processes by machining tools are required to fabricate industrial structures. Proper machining tools should be selected according to the information in design drawings. In a series of lectures, trainings on (1) how to get information from design drawings and (2) how to use machining tools will be carried out by using the following machining tools: a. Lathe b. Ultra precision lathe c. Drilling machine d. Milling machine e. NC (Numerical control) milling machine f. RIE (Reactive-ion etching)
Computer Seminar II 1 Credits Elective 7th Semester	**Fundamentals of Information Science I** 2 Credits Elective 5th Semester
Fortran is a major programming language widely used especially in the field of scientific and technical computing. The main purpose of this course is to learn basic Fortran programming and also fundamental knowledge about numerical analysis methods by solving some specific example problems using computers.	In this course, students should be able to: (1) Know the concept of today's computers based on the history of computer development, (2) Learn data representation for computers and the mathematical foundation of computer arithmetic, and (3) Understand the concrete structure and functionality of modern computer systems through their basic components of arithmetic, memory and control units as building blocks in terms of hardware and software.

Fundamentals of Information Science II — 2 Credits Elective, 5th Semester

Scientific and engineering simulations using computers require fast and efficient programs. Application programs should also be efficient with respect to speed and memory consumption. In order to make such programs one needs to know some basics of information sciences and some programming techniques. This course provides students with basic knowledge about the following:
(1) Algorithms and data structures.
(2) Model of computation.
(3) Evaluation methods and metrics.

Space Engineering — 2 Credits Elective, 7th Semester

Basic technologies are taught for the design, development and operation of space systems such as artificial satellites, space stations and space probes. The lectures cover the following topics:
1. History of space development
2. Space environments and space systems
3. Rocket propulsion and Tsiolkovsky's equation
4. Kepler motion and orbital mechanics
5. Attitude dynamics and control of spacecraft
6. Attitude sensors, gyroscopes

Biomechanical Engineering — 2 Credits Elective, 7th Semester

Cells are the fundamental units of living organisms, and vital phenomena are induced by biochemical reactions in the cells. To understand the morphology and function of living organisms, knowledge of structure, function and evolution of cells is useful. This course aims to give students a basic understanding of the general characteristics of biology and molecular biology on the basis of cells. Biophysical properties of cells and biomechanical properties of tissues are also covered.

Introduction to Quantum Science and Energy Systems — 2 Credits, 5-6th Semester

Required :Quantum Science and Energy Engineering,

Quantum science provides the understanding of the structural units of the quantum level such as electrons, atomic nuclei and atoms. The applied technologies expand to fission and fusion energy systems, medical care, space development and environmental science. The purpose of this lecture is to obtain the basic knowledge of quantum science and energy systems through various topics.

Introduction to Energy and Environmental Technology — 2 Credits, 5-6th Semester

Required Environment and Energy Engineering

This lecture is an introductory interpretation of each discipline to study in the Course of Environment and Energy Engineering by each professor affiliated with this course. Students will receive an explanation about the purpose of education in Environment and Energy Engineering Course and build their repertoire of introductory knowledge and skills.

Multidisciplinary Internship — 1 Credit, 5th Semester

This class provides an internship or international cultural experience instructed by a supervisor. Student will obtain multilateral problem-solving abilities and practical skills.

Physical Chemistry of Interface — 2 Credits Elective, 8th Semester

Physical and chemical reactivity at the interface is quite important information for various sciences, such as environmental science and synthesis of nano materials. In this class, various physical and chemical phenomena at solid-liquid-gas interface are studied.
Including: surface energy, electric double layer, zeta potential, surface reaction, chemical potential, interface formation, surface tension, adsorption, wetting phenomena, aggregation and dispersion, etc.

Environmental Biology* — 2 Credits Elective, 6th Semester

The biosphere is the one of Earth's subsystems. Understanding the role of the biosphere is very important for challenging environmental issues all over the world. This lecture is based on the fundamentals of biology, biochemistry and ecology to study the biosphere from molecule to ecosystem. This lecture addresses substances and reactions in lives, biological functions, biological responses with environmental changes, material cycles and biological diversities.

Computational Fluid Dynamics — 2 Credits Elective, 8th Semester

The objective of this lecture is to understand numerical methods for solving partial differential equations (PDE) and incompressible Navier-Stokes equations (INSE).
This lecture first introduces the basis of PDE. Second, as typical numerical methods, the basis of finite-difference method (FDM), FDM for PDE, and FDM for INSE are covered.

Compressible Fluid Dynamics — 2 Credits Elective, 8th Semester

The purpose of this lecture is to understand the basics of compressible fluid dynamics in the inviscid limit. Under the assumption of perfect gas, the basic theories of governing equations for compressible flows, isentropic flows, normal shock waves, oblique shock waves, Prandtl-Meyer expansion waves are given in this lecture. Detailed derivations of the governing equations, isentropic flow relations, and normal/oblique shock relations are also given.

Computational Mechanics	2 Credits Elective 6th Semester
According to a revolutionary increase in computer performance, computational mechanics are becoming a powerful way to examine phenomena in place of conventional theoretical and experimental approaches. This course will introduce the basic ideas of computational mechanics with emphasis on finite element methods. The topics are as follows: 1. Role of computational mechanics 2. Finite Difference Method, FDM 3. Finite Element Method, FEM 4. Application of FEM to elastic problem 5. Other approaches, Discrete Element Method etc.	

Strength and Fracture Materials	2 Credits Elective 8th Semester
Strength and Fracture of Materials offers engineering methodologies for evaluating and ensuring the safety and reliability of machine elements and structures. This provides the academic foundation necessary for machine design in industry. This course covers the following fundamental topics; strength and fracture testing methods, yielding and fracture criteria, fracture mechanics, fracture mechanisms and properties of various materials and their application to machine design. The class then deals with brittle and ductile fractures, fatigue damage, creep deformation and fractures and environmentally assisted cracking. These are typical fracture causes in actual machine elements and structures. The mechanisms and relevant characterizing parameters for the above-mentioned deformation and fractures will be addressed along with methodologies for controlling and preventing them.	

Machine Design I	2 Credits Elective 6th Semester
In machine design, mechanisms, structures, materials and production processes are determined in this order to satisfy specifications and functions required. The selection and design of mechanisms is an upstream process of the machine design, where the basic behavior of the machine is decided. This class is based on mechanisms, which is one of fundamental subjects of mechanical engineering, and gives essential ideas about a basic methodology to topologically analyze mechanisms, the principle and classification of link mechanisms, and the design methods of representative mechanical elements including cam mechanisms, belt drive mechanisms and gear mechanisms.	

Machine Design II	2 Credits Elective 8th Semester
Machine design is intellectual work towards finding a method to achieve the purpose of design, and confirm its function. For this reason, designs must be considered from all various factors in wide view, including the fabrication, assembling of mechanical structures and the evaluation of mechanical elements etc. In this lecture, the fundamentals of machine design will be instructed such as: the accuracy, strength, reliability, function and performance of typical mechanical elements.	

Robotics I	2 Credits Elective 6th Semester
A robot is a system which is composed of mechanisms, actuators, sensors, and a computer system. The robot senses, thinks and acts as desired by itself based on control algorithms implemented in the computer system. This course introduces basics of modeling and control of a robot. You will learn a brief survey of relevant results from spatial description of a link mechanism, kinematics, inverse kinematics, statics, dynamics.	

Robotics II	2 Credits Elective 6th Semester
A robot is a system, which is composed of mechanisms, actuators, sensors, and a computer system. The robot senses, thinks and acts as desired by itself based on algorithms implemented in the computer system. This course introduces basics of configuration space, motion planning, linear and nonlinear control of manipulators and force control. Students attending this course are assumed familiar with "Robotics I".	

Measurement and Instrumentation I	2 Credits Elective 6th Semester
A wide area of measurement and instrumentation in the field of mechanical engineering will be covered. At first, basic concepts of measurement such as measurement standards, SI units of measurement, traceability, evaluation parameters for a measuring instrument, etc will be introduced. Then sensors based on mechanical, optical, electronic and magnetic principles for measurement of force, pressure, length, distance, displacement, velocity, acceleration, quantity of flow, temperature, etc., will be explained. Finally, signal and data processing, evaluation of measurement results will be presented.	

Measurement and Instrumentation II	2 Credits Elective 6th Semester
Following Measurement and Instrumentation I, basic principles and methods of precision measurement as the fundamentals of mechanical engineering will be covered. At first, the concept of precision measurement will be introduced. Then the principles of precision measurement, uncertainty evaluation and measurement standards will be explained, followed by the measurement methods for length and angle, which are the basic quantities of precision measurement. Finally, measuring instruments and technologies for measurement of dimensions, forms, surface roughness, microstructures and internal structures will be presented.	

Energy Conversion System Engineering	2 Credits Elective 7th Semester
With focus on electric power supply systems, which are one of the essential energy systems that support modern societies, this lecture aims to learn about energy conversion system engineering from social backgrounds to technical issues. In addition to existing energy conversion systems such as thermal, hydroelectric, nuclear, and geothermal power generations, renewable energies such as solar, wind power generations and fuel cells are included. Energy conversion processes, supply systems, the relationship between energy conversion systems and energy, and environmental problems will be covered.	

Laboratory Experiment II	1 Credit Required 6th Semester
Under the direct guidance of professional instructors, students will participate in specialized experiments conducted in the Mechanical & Aerospace Engineering course, and observe the environment at each of the research laboratories in various departments. They will see practical examples of knowledge obtained in specialized subjects, providing a basis for their graduation research experiments.	

Design and Drawing II 1 Credits Required 7th Semester	**Aircraft Design** 2 Credits Elective 8th Semester
Based on the fundamentals learned in Design and Drawing I, students will design several devices in view of architecture, features/performance and strength, and organize the assembly diagrams, detail drawings and design documents while considering manufacturing and assembly methods. The object of the designs will be devices intimately connected with the field of mechanical engineering.	Diverse knowledge in integrated engineering is needed for aircraft design. In this lecture, physical basics of aircraft conceptual design are described in conjunction with the basic subjects such as, wing theory stability and control, performance theory and sizing process. Topics include: 1. Aerodynamics of aircraft 2. Performance of aircraft 3. Sizing of aircraft
Nuclear Energy Physics* 2 Credits Elective 6th Semester	**Global Energy Policy*** 2 Credits Elective 6th Semester
The purpose of this lecture is to learn a basic understanding of nuclear physics and their applications in nuclear engineering, such as radiation detectors, particle accelerators, atomic power and nuclear fusion. This lecture provides the following topics based on Quantum Mechanics I and II: 1.Decay of nuclei 2.Interaction between radiation and matter 3.Radiation detectors 4.Particle accelerators 5.Atomic power and nuclear fusion	In this lecture, the global energy policy is discussed with emphasis on the use of nuclear energy. The goal of this lecture is to obtain a global perspective of world energy situation. The following topics are covered: 1.Commercial use of nuclear energy; Japan and worldwide. 2.Energy policy in Japan. 3.Design safety of nuclear power plant and lessons learned from the Fukushima accident. 4.Safety management of nuclear power plants. 5.Concept of nuclear fuel cycle and its economical evaluation.
Radiochemistry* 2 Credits Elective 6th Semester	**Neutron Transport I*** 2 Credits Elective 6th Semester
The scientific basis of nuclear phenomena is taught in the sense of chemistry for engineering applications, material science and medical science. The types of radioactive decay, their effect on chemical reactions, separation and analysis of radioactivities are provided in this class. The content of this lecture includes the chemistry field of the national qualification exam for radiation and nuclear reactor operation.	It is very important to know the behavior of neutrons in materials to understand the features of nuclear systems such as a nuclear reactors and a high-energy accelerators. The following topics are given in this lecture: (1) Interaction of neutrons with materials, (2) Chain reactions and criticality, (3) Structure of nuclear fission reactor, (4) Transport and diffusion theory of neutrons. This lecture is compulsory for students who are pursuing the license for chief engineer of reactor.
Geomechanics* 2 Credits Elective 6th Semester	**Tribology** 2 Credits Elective 7th Semester
Fundamentals for designing subsurface technologies for preserving the global environment are given, including the physical properties deformation and failure of rock and rock mass, and the mechanical properties of discontinuities. Topics covered include: 1. Geomechanics and Engineering. 2. Physical properties of rock. 3. Rock mass and classification. 4. Deformation and failure of rock under tension, compression and shear. 5. In situ tests and mechanical properties of discontinuities.	Properties of surfaces and contact interfaces in mechanical elements determine the performance and reliability of mechanical systems. The science of surface, contact, friction and wear caused at the contact interfaces and their control technologies, which are necessary to design an advanced mechanical system, are introduced and explained in this class.
Geoenvironmental Chemistry* 2 Credits Elective 7th Semester	**Surface Science and Engineering** 2 Credits Elective 7th Semester
The majority of environmental problems are caused by excessive consumption of fuels and emissions of chemical substances to the environment during transformation of natural resources. To solve the problems, quantitative understanding of geo-environment is essential. This lecture covers main topics of environmental chemistry including structure and composition of the earth, formation and distribution of underground resources, natural cycles of elements, chemistry of atmosphere and aquatic environmental chemistry.	Surface and interface are very important regions affecting the properties of solid materials. The basics of the surface, which are required to describe the properties of the surface and interface, are provided in this lecture. Interesting examples of applications related to the surfaces and interfaces are introduced, and general techniques for the surface characterization are explained in detail. The friction and wettability of material surfaces will be understood by means of microscopic view of the surface and interface.

Combustion Engineering 2 Credits Elective 7th Semester	**Introduction to Aerospace Engineering** 2 Credits Elective 5th Semester
Fundamentals of combustion which is an essential energy conversion process for human society are covered. First, classifications of fuels, relationship between enthalpy of formation of species and flame temperature, and reaction mechanism of combustion are introduced. Then, structures of laminar premixed and non-premixed flames, burning velocity, turbulent flames and detonation are explained. Finally, formation mechanisms of combustion products which have strong environmental impact, as well as the methods to reduce those products, are overviewed.	This lecture introduces basic subjects required for aerospace engineering and its applications. Then specialized topics in the field are briefly explained by each professor belonging to the aerospace course.
Neutron Transport II* 2 Credits Elective 7th Semester	**Nuclear Reactor Safety and Design*** 2 Credits Elective 7th Semester
It is very important to know the behavior of neutrons in materials to understand the features of nuclear systems such as a nuclear reactors and a high-energy accelerators. The following topics are given in this lecture: (1) Feature of delayed neutron, (2) Point kinetics equation and dynamic behavior of neutrons (3) Reactivity effect on nuclear reactor (4) Burnup characteristics of fuel This lecture is compulsory for students who are pursuing the license for chief engineer of reactor.	Mathematical methods for the safety design of power reactors are provided. Particular attention is given to the dynamic behavior of the reactor, neutron diffusion and structural integrity, by using linear ordinary differential equations, functional Fourier series and the Laplace transform.
Radiation Protection and Safety Engineering* 2 Credits Elective 7th Semester	**Fuels and Materials of Nuclear Energy Systems*** 2 Credits Elective 7th Semester
Today, radiation and radioactivity are widely used from the fundamental sciences to the medical purposes. In this course we learn the characteristics of radiation and radioisotopes including their effects on our body and their safe management. For this purpose the contents of the lecture cover physical, biological and medical aspects of the following subjects; the behavior of various radiations and interactions that determine the energy deposited in media (dose), the effect of radiation to the human body, the measurement of radiation and its protection and finally the related laws in Japan.	Nuclear fuel is energy and neutron sources for nuclear power systems. Materials of fuel cladding tubes and structural components of nuclear reactor systems are used under special conditions in reactor operation. Production and fabrication processes of the fuels and materials, their basic material properties, processes of the property changes during reactor operation caused by interaction between neutrons and materials and their degradation processes are explained. Basic concepts of fuel recycling and waste management including the fuels and materials are explained.
Introduction to Nuclear Regulation 2 Credits Elective 7th Semester	**Reservoir Engineering*** 2 Credits Elective 7th Semester
	The objectives of this course are to understand the basic equations of fluid flow in porous media, and to master the fundamentals for analyzing quantitatively mass and heat transport phenomena in underground structures containing fracturing and multiphase flow, necessary for reservoir engineering.
Material Science for Energy* 2 Credits Elective 7th Semester	**Energy and Resources*** 2 Credits Elective 7th Semester
Fundamental material science is given through various energy materials such as metallic, organic, inorganic and composite materials. Thermodynamics, phase diagram, diffusion, physical properties and structural analysis are covered. Based on basic theories, processes for energy materials and their device applications are introduced.	The objectives of this course are to study resources economy and to learn about fundamentals on engineering and environmental problems which are related to exploitation, production and utilization of energy and resources. The targets of resources are oil, gas, base metals, rare metals and elements, essential for industry.

Nuclear Chemical & Environment Engineering* 2 Credits Elective 8th Semester

Radioactive materials generated by the utilization of nuclear energy must be safely managed. This class summarizes the nuclear fuel cycle and focuses on the fundamentals of both the reprocessing of spent fuel and the disposal of radioactive wastes, from the view of chemical & environmental engineering.

Plant Visit ---Credits Elective

Students will deepen their awareness of the connection between academic knowledge of the mechanical and aerospace engineering and society by visiting facilities at various businesses and institutions. They will also observe how mechanical and aerospace engineering functions within actual production processes. These extracurricular field trips are meant to provide students a point of reference for their post-graduation career activities.

Industrial Practice ---Credits Elective

This class aims to provide students with practical knowledge and skills that cannot be obtained through classroom lectures, experiments, and training, and to contribute significantly to the students' subsequent individual studies. The class is held during summer vacation, so students wishing to take it should consult with the course instructor and complete the necessary procedures. At the end of the course, each student will submit a report. If this report is deemed sufficient, the student will receive a number of credits commensurate with the activities performed.

Special Seminar and Practice ---Credits Elective

This course aims to give students the experience of mechanical engineering through practical activities or training. It also includes an internship in one of many Japanese companies.

Special Lectures I ---Credits Elective

Special lectures related to international mechanical and aerospace engineering will be given.

Special Lectures II ---Credits Elective

Special lectures related to international mechanical and aerospace engineering will be given.

Graduation Thesis 6 Credits Required 6-9th Semester

A graduation thesis is a vital component of the requirements for students seeking to graduate. The students will carry out research and write a graduation thesis. Working within the research laboratory they chose at the beginning of their 3rd year, students shall organize their research on a topic proposed by their academic adviser. They shall develop problem-solving abilities through document-based research, experimentation and calculation, in addition to learning how to organize and present the results of their research.

Engineering Common Subject Description

Exercises in Mathematics and Physics I 1 Credit Required 2nd Semester	**Exercises in Mathematics and Physics II** 1 Credit Required 3rd Semester
This course aims to bridge the gap between the relevant mathematical knowledge necessary in physics and its late appearance in mathematic courses for the freshmen of the School of Engineering. It emphasizes developing students' abilities of calculating, problem- solving and applying mathematics into physics and specific subjects, so as to help students to progress naturally to college physics and engineering subjects where calculus is the basic language. The course covers: differential, integral, series, partial differentials, multiple integrals, vector calculus, ordinary differential equations, laws of motion, and work and energy.	This is the continuation of Exercises in Mathematics and Physics I. It emphasizes developing students' abilities of calculating, problem-solving and applying mathematics into physics and specific subjects, so as to help students to progress naturally to college physics and engineering subjects where calculus is the basic language. The course covers: vector integral theorem, high order differential equations, fourier analysis, momentum and angular momentum, vibration, relative motion, mechanics of system of particles, rigid bodies, fluid mechanics, elastic mechanic and waves.
Practice of Information Processing 1 Credit Required 4th Semester	**Team-based Engineering Design Course** 2 Credits Elective 6th Semester
This course aims to help students acquire basic programming skills for information processing. Students will experience writing, compiling, executing programs under the Unix environment to deeply understand the basic grammar of the C programming language. Basic Information B is a prerequisite. Students are recommended to review Basic Information B, particularly the basic grammar of the C programming language and usage of computer systems in the class rooms. To acquire programming skills, it is necessary to write several codes by yourself. So it is important for students to prepare and review this course not only during the class hours but also outside of the hours.	Students will apply their own ideas and creativity to find solutions to assigned or student-created, problems, and study methods and tools for realizing their solutions. This course puts particular emphasis on the process of performing these tasks. Group study will be performed with advice from the instructor, providing an excellent opportunity for students to experience the pleasures of communication, teamwork, discovery, and creativity. It also provides a chance for students to broaden their knowledge, as they are free to choose problems not related to their field of study. Some topics are jointly implemented with the University of Science and Technology Beijing (China). We hope that many students will take this course.
Introduction to Industrial Chemistry 2 Credits Elective 7th Semester	**Introduction to Electronic Engineering** 2 Credits Elective 7th Semester
While chemistry is a field that investigates the principles of material transformation, industrial chemistry is an academic discipline aimed at applying these principles to engineering. This course will systematically outline the basic knowledge required by engineers in the field industrial chemistry, including:. 1. Organic chemical reactions and their applications 2. Basics and applications of inorganic chemistry and physical chemistry 3. Basics and applications of chemical engineering	This course will outline the basic knowledge required by engineers in the fields of electrical, electronic, communications, and information engineering, then address the latest topics of these fields. 1. Electrical power systems and energy conversion. 2. Semiconductor integrated circuits and ultrafine processing technology. 3. Medical ultrasound engineering and life sciences. 4. Multimedia and communication formats.
Introduction to Materials Science 2 Credits Elective 7th Semester	**Introduction to Environmental Engineering** 2 Credits Elective 7th Semester
Human culture developed rapidly once it began using metals. However, not many people know what metals actually are. Through the use of standard diagrams utilized in the field of materials science, this course will provide simple explanations of metal manufacturing principles and processes, crystalline structures of pure and alloy metals, the relation between formation mechanisms and composition of strength and viscosity, the relation between defects and deformation mechanisms and changes in mechanical properties due to thermal treatment, etc.	This course will outline phenomena and principles found in the living, local, and global environments and the relationship between nature and humans. In addition, the course will explain the role of engineering, focusing on the protection and restoration of the environment, environmental cycles, and coexistence.
Introduction to Intellectual Property Right 1 Credit Elective 7th Semester	**Introduction to Biomedical Engineering** 2 Credits Elective 7th Semester
This course aims to explain both patents and intellectual property in general, which have come under scrutiny due to the recent growth of the internet and advances in biotechnology. Specific case studies from highly experienced EU and US businesspeople, lawyers, and patent agents will be used, so even students with no legal background will be able to see how intellectual property rights are reflected in corporate technology development strategies.	The field of biomedical engineering contributes to the development and improvement of medicine, health care, and welfare by applying engineering technology to medical problems. This course will begin by giving an basic outline of medical and healthcare instruments. Next, it will explain in omnibus style how the various diagnostic/therapeutic devices and equipments are used in modern health care, and their basic principles.

Engineering Ethics 1 Credit Elective 7th Semester	**English Communications in Technology II** 2 Credits Elective 7th Semester
This course aims to provide engineering students with a sense of responsibility and awareness towards society, and an understanding regarding the social and environmental effects and value of engineering solutions. We hope to teach students that the ultimate goal of engineering is human welfare, but that in fact a lack of ethics in engineering personnel is causing large problems in society and the global environment. Students will study the process of making ethical value judgments using actual case studies related to engineering.	This lecture aims at training students' ability of English communication as a scientist and engineer. The focus is the presentation skill, while various relevant aspects such as scientific papers searching, reading, abstracting, contents organizing and discussion will be also practiced. Lectures are processed in small classes. After being given lectures on basic knowledge of English presentation, each student will have chance to give one or two 10-minute presentations on selected topics by themselves based on papers in the world leading scientific journals or in their own research fields. Questioning and answering will be carried out after each presentation, teacher's advice is followed. All lectures are given in English. The grades will be assigned according to attendance, performance in presentations and final reports.
Overseas Study I ~ IV --- Credits Elective --- Semester	**Institute of Engineering Education Special lectures** 1 Credits Elective 2nd Semester
Credits of these lectures are approved according to a Study abroad experience that is organized by Tohoku University or partner universities. 0.5 credit is approved to a study abroad experience less than 10 days, while 1 credit is approved to an experience from 10 days to 3 months. Whether the credit can be counted in the graduation criterion of not depends on the department. Please check the notice board and ask the department when you have any question.	**(Marvels of Life and Nature)** This course fosters a deep compassion and cultivates a keen sensitivity to the many mysteries in nature and life.
Institute of Engineering Education Special lectures 1 Credit Elective 5th /6th Semester	**Institute of Engineering Education Special lectures** 1Credit Elective 2nd Semester
(Special Lecture by Top Leaders) Internationally-prominent figures provide opportunities for students to develop a comprehensive view of the global state of affairs and issues at hand while cultivating a highly-critical mind, broad perspective, and long-term outlook.	**(Design and Engineering)** Through a special course on problem and project-based learning and an advanced creative engineering training program, this course helps students develop a sense of purpose and fosters a broad perspective, imagination, and teamwork.
Institute of Engineering Education Special lectures ---Credits Elective 5th/7th Semester	**Institute of Engineering Education Special lectures** 2 Credits Elective 5/7th Semester
(History of Science and Its Journey from Failure to Success) How has science and engineering gotten where it is now? Students will learn through case studies about how scientists and engineers strove and toiled to achieve success after much trial and error.	**(Introduction to Project Management)** Offered in conjunction with the Innovative Leaders Center, this course provides a strategic approach to development through special classes on project management and an introduction to sociotechnical systems.