* The subjects with ● are conducted in English.
* The subjects with ■ are conducted mainly in Japanese.
* The subjects without ●/■ are conducted only in Japanese.

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(3rd) 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(3rd) Semester	**Mechanics of Materials I** ● 2 Credits Elective 4th(3rd) 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 5(4)th 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 5(4)th 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 5(4)th 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 4th 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 4th Semester	**Control Engineering I** ● 2 Credits Elective 5th 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 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.

Control Engineering II ● 2 Credits Elective 5th Semester	**Quantum Mechanics II** 2 Credits Elective 5th Semester
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 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.
Electromagnetics II 2 Credits Elective 7(5)th Semester	**Kinetics in Reactions** 2 Credits Elective 7(5)th Semester
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.	It is one of the roles of engineering to develop various processes responsible for chemical change into useful technology for the human race's welfare. The kinetics in reactions are very important in engineering developments. In this lecture we prepare the ground for a discussion of rates of chemical reactions by considering the motion of molecules in gases and liquids. Then we establish the precise meaning of 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 meet.
Environmental Earth Science 2 Credits Elective 5th Semester	**Fluid Mechanics II** ● 2 Credits Elective 5th Semester
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.	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
Heat Transfer ● 2 Credits Elective 5th Semester	**Heat and Mass Transfer** 2 Credits Elective 5th Semester
Heat transfer is the exchange of thermal energy and it affects our everyday life. It helps us to design machines that use less energy and very importantly, it helps keep us warm or cool. We will look at three different types of heat transfer, conduction, convection, and radiation to understand physical principles and their application. The topic includes phase change such as boiling and condensation, and various types of heat exchangers.	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.
Transform Phenomena 2 Credits Elective 7(5)th Semester	**Theory of Elasticity** ● 2 Credits Elective 5th Semester
Students will learn the basics of Transport Phenomena and mathematical analogies in transport phenomena of energy, mass and momentum will be discussed. The students will understand the fundamentals of governing equations of energy, mass and momentum. They will also study the relationship between transport behaviors and material properties.	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.

Manufacturing Engineering and Technology I ● 2 Credits Elective 5th Semester	**Manufacturing Engineering and Technology II** ● 2 Credits Elective 5th Semester
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.	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.
Electrical and Electronic Circuit I ● 2 Credits Elective 5th Semester	**Electrical and Electronic Circuit II** ● 2 Credits Elective 5th Semester
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.	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)
Laboratory Experiment I ■ 1Credit Required 5th Semester	**Mechanical and Aerospace Engineering Seminar II** ■ 1 Credit Required 5th Semester
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.	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.
Production Process Practice ■ 1 Credits 5th Semester Required(Mechanical Systems, Robotics, Finemechanics, Aerospace Engineering, Mechanical/Biomedical Engineering) Elective (Quantum Science and Energy Engineering, Environment and Energy Engineering)	**Computer Seminar II** ● 1 Credits Elective 5th Semester
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)	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.
Fundamentals of Information Science I ● 2 Credits Elective 5th Semester	**Fundamentals of Information Science II** ● 2 Credits Elective 5th Semester
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.	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 5th Semester	**Biomechanical Engineering** ● 2 Credits Elective 5th 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	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 Aerospace Engineering ● 2 Credits Elective 5th Semester	**Multidisciplinary Internship** 1 Credit 5th Semester
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.	This class provides an internship or international cultural experience instructed by a supervisor. Student will obtain multilateral problem-solving abilities and practical skills.
Introduction to Quantum Science and Energy Systems 2 Credits 5th Semester Required (Quantum Science and Energy Engineering)	**Introduction to Energy and Environmental Technology** 2 Credits 5th Semester Required (Environment 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.	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.
Physical Chemistry of Interface 2 Credits Elective 8(6)th Semester	**Environmental Biology** 2 Credits Elective 6th 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.	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 6th Semester	**Compressible Fluid Dynamics** ● 2 Credits Elective 6th 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.	First, this lecture introduces the basis of partial differential equations(PDE). Second, as typical numerical methods, the basis of finite-difference method(FDM). FDM for PDE, and FDM for incompressible Navier-Stokes equations(INSE) are covered, including the following topics: 1. Basis of PDE 2. Basis of FDM 3. FDM for PDE 4. FDM for INSE

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 6th 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 6th 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, motion control and compliant motion control.

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, SLAM (Simultaneous Localization and Mapping) and control of a mobile robot. 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.

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 6th Semester

Required (Mechanical Systems, Robotics, Finemechanics, Aerospace Engineering, Mechanical/Biomedical Engineering)
Elective (Quantum Science and Energy Engineering, Environment and Energy Engineering)

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.

Aircraft Design ● 2 Credits Elective 6th Semester

Diverse knowledge in integrated engineering is needed for aircraft design. In this lecture, a basic methodology of aircraft conceptual design is described in conjunction with the basic subjects concerning aircraft such as aerodynamics, structural dynamics, propulsion and control.
Topics include:
1. Outline of aircraft
2. Wing and airframe geometry
3. Performance of aircraft

Nuclear Energy Physics 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

Global Energy Policy 2 Credits Elective 6th Semester

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

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.

Neutron Transport I 2 Credits Elective 6th 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) 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

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.

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.

Tribology* 2 Credits Elective 7th Semester

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

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 Science and Engineering 2 Credits Elective 7th Semester

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	**Neutron Transport II** 2 Credits Elective 7th 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.	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.
Nuclear Reactor Safety and Design 2 Credits Elective 7th Semester	**Radiation Protection and Safety Engineering** 2 Credits Elective 7th Semester
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.	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.
Fuels and Materials of Nuclear Energy Systems 2 Credits Elective 7th Semester	**Reservoir Engineering** 2 Credits Elective 7th Semester
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.	In this subject, fundamentals on geo-fluid reservoirs such as the development of petroleum, natural gas, CO2 geological storage and the environmental issues of soil and groundwater contamination are studied. Students will understand the properties and characteristics of geo-fluid flow and transport phenomena including heat and mass transfer in porous media with fractures and multiphase fluid flow in reservoirs.
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.	In this subject, fundamentals of geophysical exploration, geological survey and development of energy and resources are studied to understand integrated engineering methods for the supply system of energy resources and their global environmental effects. Furthermore, energy resource security issues are discussed in the topics of sustainable development and global/local energy and resources environment in terms of energy resource exploitation.
Science Technology and Industry in Japan 1 Credits Elective 4th Semester 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."	**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	**Industrial Practice** ---Credits Elective
Required (Mechanical Systems, Robotics, Finemechanics, Aerospace Engineering, Mechanical/Biomedical Engineering) Elective (Quantum Science and Energy Engineering, Environment and Energy Engineering) 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.	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	**Special Lectures I** ---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 related to international mechanical and aerospace engineering will be given.
Special Lectures II ---Credits Elective	**Graduation Thesis** 6 Credits Required 6-9th Semester
Special lectures related to international mechanical and aerospace engineering will be given.	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.

*"Tribology" and "Energy Conversion System Engineering" will not be offered in FY 2018.
It will be offered in the 7th starting from FY2019.

3. Specialized Subjects

Dept. in which offered (*1)	Subject Subject labeled by ● will be provided in English Subject labeled by ■ will be provided in Japanese/English		Semester, IMAC-U (Japanese)	Hrs. In total	Credits	Registration restrictions apply	Subject Type (*2)	Course								Registration [For courses at left] ☆: Required ⊕: Recommended for course(*3) ○: Elective Blank: Auditable Subject
								Mechanical Systems	Finemechanics	Robotics	Aerospace Engineering	Quantum Science and Energy Engineering	Environment and Energy Engineering	Mechanical / Biomedical Engineering	International Mechanical and Aerospace Engineering Course	
En	Exercises in Mathematics and Physics I	●	2(1)	30	1	○	Common	☆	☆	☆	☆	☆	☆	☆	☆	
En	Introduction of Engineering Chemistry			30	2	○	Common	○	○	○	○	○	○	○	○	
En	Exercises in Mathematics and Physics II	●	3(2)	30	1	○	Common	☆	☆	☆	☆	☆	☆	☆	☆	
En	Practice of Information Processing	●	4(2)	30	1	○	Common	☆	☆	☆	☆	☆	☆	☆	☆	
En	Team-based Engineering Design Course	■	4(2)		1-2		Common	○	○	○	○	○	○	○	○	
M	Mathematics I	●	3	30	2	○	Basic I	○	○	○	○	○	○	○	○	[Semi-elective ①] Obtain 12 credits or more Semi-elective ① and ②
M	Mathematics II	●	3	30	2	○	Basic I	○	○	○	○	○	○	○	○	
M	Numerical Analysis	●	3	30	2	○	Basic I	○	○	○	○	○	○	○	○	
M	Mechanics	●	3	30	2	○	Basic I	○	○	○	○	○	○	○	○	
M	Mechanics of Materials II	●	4(3)	30	2	○	Basic I	○	○	○	○	○	○	○	○	
M	Exercises in Computer-Aided Problem Solving	●	3	30	2	○	Basic I	○	○	○	○	○	○	○	○	
M	Fluid Mechanics I	●	4(3)	30	2	○	Basic I	○	○	○	○	○	○	○	○	[Semi-elective ②]
M	Mechanics of Materials I	●	4(3)	30	2	○	Basic I	○	○	○	○	○	○	○	○	
M	Quantum Mechanics I	●	4	30	2	○	Basic I	○	○	○	○	○	○	○	○	[Semi-elective ③] Obtain 10 credits or more Semi-elective ② and ③
M	Mechanical Vibrations I	●	4	30	2	○	Basic I	○	○	○	○	○	○	○	○	
M	Thermodynamics I	●	4	30	2	○	Basic I	○	○	○	○	○	○	○	○	
M	Electromagnetics I	●	5(4)	30	2	○	Basic I	○	○	○	○	○	○	○	○	[Semi-elective ④] Obtain 12 credits or more Semi-elective ③ and ④
M	Mechanical Vibrations II	●	4	30	2	○	Basic I	○	○	○	○	○	○	○	○	
M	Thermodynamics II	●	5(4)	30	2	○	Basic I	○	○	○	○	○	○	○	○	
M	Materials Science I	●	4	30	2	○	Basic I	○	○	○	○	○	○	○	○	
M	Materials Science II	●	5(4)	30	2	○	Basic I	○	○	○	○	○	○	○	○	
En	Electrical Engineering Laboratory	■	4	60	1		Common	○	○	○	○	○	○	○	○	
M	Computer Seminar I	●	4	30	1		Common	☆	☆	☆	☆	☆	☆	☆	☆	
M	Seminar I	■	4	45	2		Common	☆	☆	☆	☆	☆	☆	☆	☆	
M	Design and Drawing I	●	4	30	1		Common	☆	☆	☆	☆	☆	☆	☆	☆	
M	Science Technology and Industry in Japan	●	4		1											
M	Control Engineering I	●	5	30	2	○	Basic I	○	○	○	○	○	○	○	○	[Semi-elective ③]
M	Control Engineering II	●	5	30	2	○	Basic II	○	○	○	○	○	○	○	○	[Semi-elective ⑤ and Required]
M	Quantum Mechanics II		5	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Electromagnetics II		7(5)	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Kinetics in Reactions		7(5)	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Environmental Earth Science		5	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Fluid Mechanics II	●	5	30	2	○	Basic II	○	○	○	○	○	○	○	○	

Dept. in which offered (*1)	Subject Subject labeled by ● will be provided in English Subject labeled by ■ will be provided in Japanese/English		Semester, IMAC-U (Japanese)	Hrs. In total	Credits	Registration restrictions apply	Subject Type (*2)	Course								Registration [For courses at left] ☆: Required ⊕: Recommended for course(*3) ○: Elective Blank: Auditable Subject
								Mechanical Systems	Finemechanics	Robotics	Aerospace Engineering	Quantum Science and Energy Engineering	Environment and Energy Engineering	Mechanical / Biomedical Engineering	International Mechanical and Aerospace Engineering Course	
M	Heat Transfer	●	5	30	2	○	Basic II	○	○	○	○	○	○	○	○	IMAC-U (Mechanical Systems, Finemechanics, Aerospace Engineering, Robotics, Mechanical/Biomedical Engineering): Obtain 16 credits or more in subjects at left marked with ⊕ and ○ IMAC-U (Quantum Science and Energy Engineering, Environment and Energy Engineering): Obtain 14 credits or more in subjects at left marked with ⊕ and ○
M	Heat and Mass Transfer		5	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Transform Phenomena		7(5)	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Theory of Elasticity	●	5	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Manufacturing Engineering and Technology I	●	5	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Manufacturing Engineering and Technology II	●	5	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Electrical and Electronic Circuit I	●	5	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Electrical and Electronic Circuit II	●	5	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Laboratory Experiment I	■	5	30	1		Common	☆	☆	☆	☆	☆	☆	☆	☆	
M	Seminar II	■	5	30	1		Common	☆	☆	☆	☆	☆	☆	☆	☆	
M	Production Process Practice	■	5	30	1		Common	☆	☆	☆	☆	○	○	☆	☆	
M	Computer Seminar II	●	5	30	1	○	Common	○	○	○	○	○	○	○	○	
M	Fundamentals of Information Science I	●	5	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Fundamentals of Information Science II	●	5	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Space Engineering	●	5	30	2	○	Course Elective	○	○	○	⊕	○	○	○	○	
M	Biomechanical Engineering	●	5	30	2	○	Course Elective	○	○	○	○	○	○	⊕	○	
M	Introduction to Aerospace Engineering	●	5	30	2	○	Course Elective	○	○	○	⊕	○	○	○	○	
M	Introduction to Quantum Science and Energy Systems		5	30	2	○	Course Elective					☆			☆	(Supplemental 3)
M	Introduction to Energy and Environmental Technology		5	30	2	○	Course Elective						☆		☆	(Supplemental 3)
M	Multidisciplinary Internship (Supplemental 4)		5		1											
M	Physical Chemistry of Interface		8(6)	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Environmental Biology		6	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Computational Fluid Dynamics	●	6	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Compressible Fluid Dynamics	●	6	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Computational Mechanics	●	6	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Strength and Fracture Materials	●	6	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Machine Design I	●	6	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Machine Design II	●	6	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Robotics I	●	6	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Robotics II	●	6	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Measurement and Instrumentation I	●	6	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Measurement and Instrumentation II	●	6	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Laboratory Experiment II	■	6	30	1		Common	☆	☆	☆	☆	☆	☆	☆	☆	
M	Design and Drawing II	■	6	30	1		Common	☆	☆	☆	☆	○	○	☆	☆	
M	Aircraft Design	●	6	30	2	○	Course Elective	○	○	○	⊕		○	○	○	
M	Nuclear Energy Physics		6	30	2	○	Course Elective	○	○	○	○	⊕	○	○	○	

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							Mechanical Systems	Finemechanics	Robotics	Aerospace Engineering	Quantum Science and Energy Engineering	Environment and Energy Engineering	Mechanical / Biomedical Engineering	International Mechanical and Aerospace Engineering Course	
M	Global Energy Policy	6	30	1	○	Course Elective	○	○	○	○	⊕	○	○	○	
M	Radiochemistry	6	30	2	○	Course Elective	○	○	○	○	⊕	○	○	○	
M	Neutron Transport I	6	30	2	○	Course Elective	○	○	○	○	⊕	○	○	○	
M	Geomechanics	6	30	2	○	Course Elective	○	○	○	○	○	⊕	○	○	
M	Energy Conversion System Engineering*	7	30	2	○	Basic II	○	○	○	○	○	○	○	○	[Elective ⑥ and Required]
M	Tribology*	7	30	2	○	Basic II	○	○	○	○	○	○	○	○	
M	Geoenvironmental Chemistry	7	30	2	○	Common	○	○	○	○	○	○	○	○	
En	Introduction to Electronic Engineering	7	30	2	○	Common	○	○	○	○	○	○	○	○	
En	Introduction to Materials Science	7	30	2	○	Common	○	○	○	○	○	○	○	○	
En	Introduction to Environmental Engineering	7	30	2	○	Common	○	○	○	○	○	○	○	○	
En	Introduction to Intellectual Property Right	7	15	1	○	Common	○	○	○	○	○	○	○	○	
En	Introduction to Biomedical Engineering	7	30	2	○	Common	○	○	○	○	○	○	○	○	
En	Engineering Ethics	7	15	1	○	Common	○	○	○	○	○	○	○	○	
En	English Communications in Technology II	7	30	2	○	Common	○	○	○	○	○	○	○	○	
M	Surface Science and Engineering	7	30	2	○	Course Elective	○	○	⊕	○	○	○	○	○	
M	Combustion Engineering	7	30	2	○	Course Elective	○	○	○	⊕	○	○	○	○	
M	Neutron Transport II	7	30	2	○	Course Elective	○	○	○	○	⊕	○	○	○	
M	Nuclear Reactor Safety and Design	7	30	2	○	Course Elective	○	○	○	○	⊕	○	○	○	
M	Radiation Protection and Safety Engineering	7	30	2	○	Course Elective	○	○	○	○	⊕	○	○	○	
M	Fuels and Materials of Nuclear Energy Systems	7	30	2	○	Course Elective	○	○	○	○	⊕	○	○	○	
M	Reservoir Engineering	7	30	2	○	Course Elective	○	○	○	○	○	⊕	○	○	
M	Material Science for Energy	7	30	2	○	Course Elective	○	○	○	○	○	⊕	○	○	
M	Energy and Resources	7	30	2	○	Course Elective	○	○	○	○	○	⊕	○	○	
M	Nuclear Chemical & Environment Engineering	8	30	2	○	Course Elective	○	○	○		⊕	○	○	○	
M	Plant Visit (Supplemental 1)					Common	☆	☆	☆	☆	○	○	☆	○	
M	Industrial Practice					Common					○	○		○	
M	Special Seminar and Practice					Common	○	○	○	○	○	○	○	○	
M	Special Lectures I (Supplemental 2)					Common	○	○	○	○	○	○	○	○	
M	Special Lectures II					Common	○	○	○	○	○	○	○	○	
En	English in Technology I		30	1		Common	○	○	○	○	○	○	○	○	
En	Overseas Study I ~ IV					Common									
En	Institute of Engineering Education Special Lectures					Common	○	○	○	○	○	○	○	○	
M	Graduation Thesis	6 7 8 9		6		Common	☆	☆	☆	☆	☆	☆	☆	☆	

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