FY2024 Master program summary

Course subjects at the Graduate School of Biomedical Engineering are divided into basic medical engineering subjects, applied medical engineering subjects, and related subjects.
The number of credits required for completion of the Graduate School of Biomedical Engineering is 30 or more. Please complete at least 10 credits of basic medical engineering subjects. Then, complete at least 20 credits of applied medical engineering subjects in your course.

Basic Medical Engineering

	Lecture	Language	Credit	Requirement
Basic Engineering Subjects	Mathematics and Physics of Biomedical Engineering	JE1	2	Please complete at least 10 credits of basic medical engineering subjects. Students graduated from the Department of Health Sciences, Biology, and Pharmacy must take at least 4 credits from the following seven subjects: “Mathematics and Physics of Biomedical Engineering”, “Basic Mechanics for Biomedical Engineering”, “Medical Aspects of Electromagnetic Theory”, “Electrical and Electronic Circuits”, “Anatomy”, “Instrumental Biomolecular Analysis”, and “Fundamental Biochemistry”. Students graduated from the Department of Science and Engineering must take at least 4 credits of elective courses from Basic Medical Subjects.
	Basic Mechanics for Biomedical Engineering	JE1	2	
	Biomedical fluid Mechanics	JE2	2	
	Strength of Materials for Biomedical Engineering	JE1	2	
	Thermodynamics for Biomedical Engineering	JE1	2	
	Medical Aspects of Electromagnetic Theory	JE1	2	
	Electrical and Electronic Circuits	JE1	2	
Basic Medical Subjects	Basic Biology	JE1	2	
	Medical Molecular Biology 1	J	1	
	Physiology for Biomedical Engineering	JE1	2	
	Anatomy	JE1	2	
	Instrumental Biomolecular Analysis	JE1	2	
	Fundamental Biochemistry	JE1	2	

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Lecture Summary

・Basic Engineering Subjects

Mathematics and Physics of Biomedical Engineering
WBI-OEN501J

Tetsu Tanaka, Yuji Matsuura

Exercises on the fundamentals of mathematics and physics, focusing on calculus, differential equations, field calculus, mechanics, etc., will be provided mainly to students with non-engineering backgrounds. Students will understand the close relationship between mathematics and physics, and acquire applied skills in mathematics and physics as a basis for medical engineering.

Basic Mechanics for Biomedical Engineering
WBI-MEE502J

Mami Tanaka

In the field of biomedical engineering, for students who do not specialize in mechanical systems in the future, the curriculum begins with the fundamentals of mechanics, covering the basics and essentials of the so-called four mechanics: mechanics, heat, fluids, solids, and dynamics. This lecture serves as the foundation for applications in other fields.

Biomedical fluid Mechanics
WBI-MEE503B

Takuji Ishikawa

In this lecture, we learn functions of biological flows in terms of fluid mechanics. Flow field at the cellular scale can be regarded as Stokes flow. We learn basic characteristics and mathematical descriptions of Stokes flow. Flow generated by flagella, swimming microorganisms, motions of vesicles and cells are discussed. Rheology of biofluids is explained by introducing various constitutive laws. Flow in a human body, flying birds, swimming fish and fluid mechanics in spots are lectured. We show fluid mechanics can be a strong tool to understand biological functions.

Strength of Materials for Biomedical Engineering
WBI-MEE504J

Makoto Ohta

A review of exercises on mechanics of materials, and reviews of biomaterials and the living bodies (soft tissue, bone, blood) will be performed with focus on their material mechanical properties, friction and wear properties. Biomechanical compatibility, and

research methods will be introduced. This lecture is for review of material mechanics. The level is a bachelor.

Thermodynamics for Biomedical Engineering
WBI-MEE505J
Kazutaka Murayama

The lecture aims to help students understand the thermodynamics of life phenomena, including thermal equilibrium, thermodynamic states, equation of state of matter, equation of state of gases, first law of thermodynamics, quasi-static processes, specific heat, internal energy and enthalpy, ideal gas and reversibility, second law of thermodynamics, entropy, irreversible processes, free energy, etc. The lecture aims to help students understand the thermodynamic aspects of life phenomena.

Medical Aspects of Electromagnetic Theory
WBI-ELE506J
Shin Yabukami

Electro-magnetic phenomena concerning the static electric field, static magnetic field, transient electromagnetic field, an electromagnetic wave are presented. The relationship between electromagnetic field and physiological responses are explained based on the maxwell equation.

Electrical and Electronic Circuits
WBI-ELE507J
Yuji Matsuura

DC circuits, AC circuits, power supply circuits, and analog circuits including transistors and op-amps will be outlined from the perspective of medical electronic circuit design.

・Basic Medical Subjects

Basic Biology
WBI-BAM551B

Makoto Kanzaki, Kuniyasu Niizuma, Sherif Rashad, Takehiro Suzuki, Noriko Himori

This course provides students with basic knowledge of biology, mainly focusing on cellular levels, which includes the structure and function of organelles, cells, and organs, as well as the differentiation/proliferation/developmental/metabolic regulation. Students will also learn about recent advances in regenerative medicine/gene therapy/genome editing based on a cell biological point of view.

Medical Molecular Biology 1
WBI-BAM552J

Takehiro Suzuki, Graduate School of Medicine’s Teacher

This course provides students with advanced knowledge of basic molecular biology, especially of the latest findings and leading-edge techniques, and helps students understand physiological actions of molecules within living organisms, as well as the pathological condition by breakdown of molecular functions.

Physiology for Biomedical Engineering
WBI-BAM553B

Kuniyasu Niizuma

The aim of this course is to understand basic knowledge of life science from molecular, cellular, whole-body, and clinical level. This is a course for students at the School of Medicine, so it is recommended that those who do not have a medical background are required to take this class in the second year, after they have studied medicine in other classes.

In practice, students will take Basic Medicine III and Basic Medicine IV classes at the School of Medicine, and their attendance will be checked and reports will be submitted there as well.

Anatomy
WBI-BAM554B

Takaaki Abe, Hiroyasu Kanetaka, Yoshifumi Saijo, Masatoshi Saito, Kuniyasu Niizuma, Noriko Himori, Teachers of the Graduate School of Medicine

The course provides students with the knowledge of the structure and function of the human body at the molecular, cellular, tissue, organ, and organ system levels.

Following the orientation, students will learn about the motor, nervous, respiratory-circulatory, digestive, urinary, endocrine, and sensory organ systems, and so on, respectively.

Instrumental Biomolecular Analysis
WBI-BAM555B
Makoto Kanzaki, Kazutaka Murayama

Detailed analysis of biomolecules involved in diseases is important for elucidating the mechanisms and diagnosis of diseases. In this lecture, the principles of advanced analytical instruments used for biomolecular analysis will be explained, and how these instruments are used for the analysis of disease-related molecules will be discussed with actual examples. In particular, the lecture will focus on analysis at the molecular level in terms of gene analysis, protein identification, quantification, and structural analysis.

Fundamental Biochemistry
WBI-BAM556B
Makoto Kanzaki, Kazutaka Murayama

The aim of this course is to understand the structures and functions of proteins, nucleic acids, lipids, carbohydrates, and other molecules that make up living organisms at the molecular level. In the lectures, basic organic chemistry and analytical chemistry necessary for understanding molecular mechanisms will be explained, and the functions of biomolecules will be discussed from the viewpoint of chemistry. Students will deepen their understanding of the material basis of living organisms and learn about their origins and changes.

1) Basic Biomedical Engineering

Students must select at least **4 credits** from Category A.
Students must select at least **2 credits** from Category B.

Lectures of Applied Medical Engineering

Lecture	Language	Requirement	Category	Credit
Introduction to Biomedical Engineering	JE1	SR	A	2
Introduction to Coaching Communication in Biomedical Engineering	J	SR	A	2
Biomechanics	JE2	SR	A	2
Biomaterials Science	E	SR	A	1
Medical Micro/Nano Technology	J	SR	A	2
Biomedical Ultrasonics	J	SR	A	2
Measurement and Control for Biomedical Engineering	J	SR	A	2
Medical Information Measurement	J	SR	A	2
Bio-Medical Interface Fabrication	JE1	SR	A	2
Technology Related to Diagnostic Medical Imaging	J	SR	A	2
Molecurar Imaging	E	SR	A	2
Artificial Organs and Regenerative Medicine	J	S		2
Pathogenesis and Treatment of Diseases and Disorders	J	S		2
Quantum Biology	E	S		2
Socio-Biomedical Engineering	J / E	S		2
Medical and Welfare Engineering	J	S		2
Medical Device Innovation Strategy	J	S		2
Regulatory Science for Medical Device	J	S		2
Business Ecosystem for Medical Device	J	S		2

Lecture	Language	Requirement	Category	Credit
Laboratory Training in Mechanical and Electrical Engineering for Biomedical Applications	JE1	SR	B	2
Laboratory Work for Biotechnology	J	SR	B	2
Medical Device Development Practice	J	SR	B	2

Special Lecture on Biomedical Engineering A	E	S		1~2
Domestic Internship Training A	J	S		1~2
International Internship Training A	E	S		1~2
Medical Device Innovation International Internship A	E	S		1~2
Problem-Based-Learning Seminar	J	R		4
Master Course Seminar on Biomedical Engineering	J	R		6
Related lectures	Students can select lectures recognized as related by the Faculty Committee.			

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Requirement:
R = Required
SR = Selective required
S = Selective

2) Applied Biomedical Engineering

Students must select at least **20 credits** from the lectures listed below, including **10 credits** from required subjects and at least **6 credits** from elective required subjects.
A: Students must select at least **4 credits** from the following lectures.
B: Students must select at least **2 credits** from the following lectures.

Lectures of Applied Medical Engineering

Lecture	Language	Requirement	Category	Credit
Introduction to Biomedical Engineering	JE1	SR	A	2
Introduction to Coaching Communication in Biomedical Engineering	J	SR	A	2
Technology Related to Diagnostic Medical Imaging	J	SR	A	2
Molecurar Imaging	E	SR	A	2
Artificial Organs and Regenerative Medicine	J	SR	A	2
Pathogenesis and Treatment of Diseases and Disorders	J	SR	A	2
Quantum Biology	E	SR	A	2
Medical Device Innovation Strategy	J	SR	A	2
Biomechanics	JE2	S		2
Biomaterials Science	E	S		1
Medical Micro/Nano Technology	J	S		2
Biomedical Ultrasonics	J	S		2
Measurement and Control for Biomedical Engineering	J	S		2
Medical Information Measurement	J	S		2
Bio-Medical Interface Fabrication	JE1	S		2
Socio-Biomedical Engineering	J / E	S		2
Medical and Welfare Engineering	J	S		2
Regulatory Science for Medical Device	J	S		2
Business Ecosystem for Medical Device	J	S		2

Lecture	Language	Requirement	Category	Credit
Laboratory Training in Mechanical and Electrical Engineering for Biomedical Applications	JE1	SR	B	2
Laboratory Work for Biotechnology	J	SR	B	2
Medical Device Development Practice	J	SR	B	2
Special Lecture on Biomedical Engineering A	E	S		1~2
Domestic Internship Training A	J	S		1~2
International Internship Training A	E	S		1~2
Medical Device Innovation International Internship A	E	S		1~2
Problem-Based-Learning Seminar	J	R		4
Master Course Seminar on Biomedical Engineering	J	R		6
Related lectures	Students can select lectures recognized as related by the Faculty Committee.			

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3) Medical Device Innovation

Students must select at least **20 credits** from the lectures listed below, including 1**8 credits** from required subjects.

Lectures of Applied Medical Engineering

Lecture	Language	Requirement	Category	Credit
Medical Device Innovation Strategy	J	R		2
Regulatory Science for Medical Device	J	R		2
Business Ecosystem for Medical Device	J	R		2
Introduction to Biomedical Engineering	JE1	S		2
Introduction to Coaching Communication in Biomedical Engineering	J	S		2
Socio-Biomedical Engineering	J / E	S		2
Pathogenesis and Treatment of Diseases and Disorders	J	S		2
Medical and Welfare Engineering	J	S		2
Biomechanics	JE2	S		2
Biomaterials Science	E	S		1
Medical Micro/Nano Technology	J	S		2
Biomedical Ultrasonics	J	S		2
Measurement and Control for Biomedical Engineering	J	S		2
Medical Information Metrology	J	S		2
Bio-Medical Interface Fabrication	JE1	S		2
Technology Related to Diagnostic Medical Imaging	J	S		2
Molecurar Imaging	E	S		2
Artificial Organs and Regenerative Medicine	J	S		2
Quantum Biology	E	S		2

Lecture	Language	Requirement	Category	Credit
Laboratory Training in Mechanical and Electrical Engineering for Biomedical Applications	JE1	S		2
Laboratory Work for Biotechnology	J	S		2
Medical Device Development Practice	J	R		2
Special Lecture on Biomedical Engineering A	J	S		1~2
Domestic Internship Training A	J	S		1~2
International Internship Training A	E	S		1~2
Medical Device Innovation International Internship A	E	S		1~2
Problem-Based-Learning Seminar	J	R		4
Master Course Seminar on Biomedical Engineering	J	R		6
Related lectures	Students can select lectures recognized as related by the Faculty Committee.			

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Lecture Summary

Introduction to Biomedical Engineering
WBI-BME601J

All faculties

This lecture will provide an overview of “Biomedical Engineering” from the perspective of its actual application and completion in the field of medicine and diagnosis. In particular, the lecture will cover the basics of (1) clinical engineering, (2) medical devices, (3) medical imaging, (4) molecular, cellular and tissue engineering, and (5) biomaterials, which are currently playing an important role in medical engineering. The lecture provides an overview of the current and future needs in medical research and treatment, with a focus on gastrointestinal diseases. Focusing on the development and application of physical methods for introducing molecules into cells, furthermore, students will learn about cells, the basic unit of life, and their functions, as well as the dynamics and imaging of molecules inside cells, chip technology, diagnosis and treatment.

Introduction to Coaching Communication in Biomedical Engineering
WBI-BME602J

Hiroyasu Kanetaka

The ability to communicate is not only a skill that companies and organizations should have in the human resources they seek, but it is also an essential skill in research activities. Coaching is used in various fields such as sports, business, education, and medical care as a form of communication that promotes the proactive behavior of others and helps them achieve their goals. The purpose of this course is to provide students with coaching skills that will be useful in their graduate school research activities and post-graduate careers.

Biomechanics
WBI-BME603B

Makoto Ohta, Kenji Kikuchi

This course provides a detailed description of the mechanical mechanisms and functions of living organisms from the standpoint of continuum mechanics. Especially, fluid mechanics of blood flow and airflow, muscles, blood vessels, and cells as soft materials, and statics and dynamics of the skeletal system as hard materials will be discussed to establish the mechanical understanding necessary for future research. Then, measurement and visualization methods of mechanical information in living organisms will be explained, and students will learn the principles of measurement of biological information and its applications.

Note: This course is offered in Japanese and English every other year.

Biomaterials Science
WBI-BME604B
Takayuki Narushima, Masaya Yamamoto, Kyosuke Ueda

In the super-aging society, expectations for biomaterials are high and various functions are required. This course covers the design, physical, mechanical, chemical, and biological properties of metallic, ceramic, and polymeric biomaterials used for biofunctional reconstruction, therapy, and diagnosis. In addition, their biological reactions with hard and soft tissues and evaluation methods are lectured. The purpose of this course is to deepen understanding of the fundamental characteristics of biomaterials.

Medical Micro/Nano Technology
WBI-BME605J
Yoichi Haga

This lecture focuses on the fundamentals and applications of microfabrication technologies that are useful for realizing small but highly functional and multifunctional medical and health care devices, especially MEMS (microelectromechanical systems) technology, which is developed from semiconductor microfabrication technology to create a batch of small mechanical elements. In addition to explaining specific elemental technologies and basic principles, specific applications to minimally invasive medical devices, implantable devices, and healthcare devices, as well as future directions will be discussed. In addition, specific methods for clinical evaluation and development of medical devices for actual clinical use will be discussed.

Biomedical Ultrasonics
WBI-BME607B
Mototaka Arakawa

The basic concepts of elastic waves will be taught while understanding their generation, propagation, interaction with light, and their applications, especially in medical and biological applications. In this lecture, the basics and applications of linear and nonlinear propagation of longitudinal waves are first explained, then electroacoustic conversion by piezoelectric effect is explained. In addition, imaging applications, biological effects and therapeutic applications, interaction between ultrasonic waves and microbubbles, interaction between ultrasonic waves and light waves by acousto-optic effects, and operation of elastic wave application devices will be explained.

Measurement and Control for Biomedical Engineering
WBI-BME608J
Takashi Watanabe, Norihiro Sugita
This lecture covers the fundamentals and applications of measurement and control for biological systems. First, students will learn the basics of measurement of bio-electric signals and human movements. Next, students will learn the basics of PID control, neural network control, and fuzzy control, as well as application examples for motor control using functional electrical stimulation. In addition, students will learn about the identification of biological systems, and learn about the measurement and control of biological signals through exercises using Matlab.

Medical Information Measurement
WBI-BME609J
Mototaka Arakawa
The purpose of this course is to provide a systematic understanding of the fundamentals of spectral analysis methods, including their physical meanings, for the effective use of wave information in medical information measurement. For this purpose, the basics of maximum likelihood estimation, least squares, eigenvalue expansion, singular value decomposition, pattern recognition, z-transform, discrete Fourier transform, spectrum estimation using autoregressive model, estimation of transfer function and coherence function, delay time estimation, and time-frequency analysis are described.

Bio-Medical Interface Fabrication
WBI-BME610B
Masayoshi Mizutani
This lecture focuses on ultra-precision machining to achieve function creation processing aimed at creating functional interfaces. In this lecture, we will discuss ultra-precision machining technology that approaches the limit of dimensional accuracy including surface roughness, peripheral technologies such as Machine Tools, and function creation as an example of its application, which is a machining with "precision" that cannot be achieved by conventional technologies.

Technology Related to Diagnostic Medical Imaging
WBI-BME611J
Classes cancelled/undecided
In this course, students will learn the basic concepts of medical imaging and its specific applications in the field of medicine, which has become an indispensable technology for prompt, accurate and effective treatment in modern medicine. This is followed by an overview of the future development of medical engineering, which is the basis for

advancing research and development, based on basic and clinical research. In particular, students will gain a deep understanding of the basics of three-dimensional diagnostic imaging (CT, MRI) and three-dimensional analysis of various images using computers.

Molecurar Imaging

WBI-BME624E

Hiroshi Watabe

This lecture will explain imaging techniques and drug development related to molecular imaging and introduce various clinical applications using molecular imaging techniques. The objective is to systematically learn the principles and analytical techniques of PET and other medical instruments.

Artificial Organs and Regenerative Medicine

WBI-BME614J

Tomoyuki Yambe

This course provides an understanding of the structure and function of normal tissues at the level of individual cells that make up organs, which are important for artificial organs and regenerative medicine, and an understanding of the functional multifaceted nature of organs through animal experiments and perioperative ICU management. In addition, the current status of artificial organs and regenerative medicine will be explained using the digestive organs as an example, and various methods such as stem cell application, transplantation, and gene transfer will be understood.

Pathogenesis and Treatment of Diseases and Disorders

WBI-BME615J

Tetuya Kodama, Tomoyuki Yambe, Sherif Mohamed Rashad

The three leading causes of death in Japan, namely cancer, heart disease, and cerebrovascular disease, will be explained, and their prevention and treatment strategies will be taught. The course is designed to cultivate the insight to identify basic research issues from the clinical viewpoint.

Quantum Biology

WBI-BME625

Hiroshi Watabe

The application areas of synchrotron radiation (NANOTERASU) in relation to life sciences will be outlined. An overview of quantum life imaging will be given with the aim of understanding the application of quantum measurement techniques to medicine and medical care from various perspectives.

Socio-Biomedical Engineering
WBI-BME618E
Classes cancelled/undecided
Now that it has become clear that lifestyle modification is effective in preventing many chronic diseases, the need for medicine outside the hospital has increased dramatically. In this course, we will explain what health means from a medical standpoint, and learn how to assess health conditions and lifestyle habits necessary for preventive medicine, and how to utilize biological information. Note: This course is offered in English.

Medical and Welfare Engineering
WBI-BME619J
Mami Tanaka
This paper discusses the technologies required in the field of medical and welfare engineering from an engineering perspective, and discusses the creation of new sensors and actuators, information processing technologies, systemization, and their development as the basis for the development of medical and welfare engineering.

Medical Device Innovation Strategy
WBI-BME621J
Yoshifumi Saijo
In order to learn the basics for understanding and developing medical devices, students will learn the definition and current status of medical devices, as well as the mechanism and usage of individual medical devices such as CT, MRI, ultrasound, and endoscopes. Students will also learn about the current status of medical device development in companies.

Regulatory Science for Medical Device
WBI-BME622J
Makoto Ohta, Koji Ikeda
In order to implement advanced technology in society, it is necessary to harmonize it with people and society. This course examines regulatory science, which is the basis of this concept, from the perspective of medical device development, to understand the concept.

Business Ecosystem for Medical Device
WBI-BME623J
Shin Yabukam, Michi Fukushima, Tsuyoshi Kato
In order for a new medical device to be commercialized and used in the medical field, it is necessary to go through research and development and clinical trials, and at the

same time, it is necessary to commercialize the procurement of materials, manufacturing, sales and after-sales care, and to establish it as a business. In some cases, a single company will commercialize the product, while in other cases, multiple companies will cooperate. Cooperation with the research and development system is also essential. This series of processes is called the business ecosystem for medical devices. This process varies depending on the healthcare system based on the healthcare policy of the country where the product will be commercialized. The purpose of this course is to provide students with an overview of their position and role when they are involved in the commercialization of medical devices in the future.

Laboratory Training in Mechanical and Electrical Engineering for Biomedical Applications
WBI-BME671J
Tetsu Tanaka, Mami Tanaka, Yoichi Haga, Takuji Ishikawa, Yuji Matsuura, Tatsuo Yoshinobu, Takashi Watanabe, Ayumi Hirano, Makoto Yoshizawa, Shin Yabukam

Students acquire knowledge and skills in mechanical and electrical engineering necessary for research and development of devices in medical engineering through practical training.

Laboratory Work for Biotechnology
WBI-BME673J
Tetsuya Kodama, Takaaki Abe, Hiroyasu Kanetaka, Kazutaka Murayama, Makoto Kanzaki, Keiko Numayama

The purpose of this course is to systematically learn the molecular biological analysis methods essential for medical engineering research. This course consists of gene sequencing, vector design, gene cloning, gene transfer, fluorescence observation, and protein analysis.

Medical Device Development Practice
WBI-BME674J
Yoshifumi Saijo, Takaaki Abe, Kuniyasu Niizuma, Yukio Katori, Tomoyuki Yamube, Shinji Kamakura, Noriko Himori

After exploring and quantitatively evaluating clinical issues by observing clinical sites and interviewing medical professionals, students will create ideas for medical devices to solve these issues and fabricate prototypes.

Special Lecture on Biomedical Engineering A
WBI-BME691J
All faculties

This is a special lecture on the latest academic research in the field of medical

engineering, or on the creation and development of studies related to the field of medical engineering.

Domestic Internship Training A
WBI-BME692J
All faculties
Conduct research and development activities outside the university for one week to one month during the Master's or Doctoral course. Through this training, students will learn how to put their daily university research into practice in the field of research and development.

International Internship Training A
WBI-BME693E
All faculties
Short- to medium-term visits to overseas research facilities, including partner universities, to build an international cooperative system and gain basic experience to understand the global development of medical engineering.

Medical Device Innovation International Internship A
WBI-BME696E
All faculties
Short- to medium-term visits to overseas research facilities to understand the latest international information related to medical devices and to gain basic experience in building international cooperative systems.

Problem-Based-Learning Seminar
WBI-BME694J
All faculties
PBL (Problem-Based Learning) education by multiple instructors from different fields, which fosters the ability to set problems as a medical engineering engineer through the systematization and synthesis of high-level specialized knowledge.

Master Course Seminar on Biomedical Engineering
WBI-BME695J
All faculties
Experiments and exercises, including research presentations and discussions, will be conducted in each specialized field of medical engineering.