Graduate Major in Human Centered Science and Biomedical Engineering

In recent years, the development of engineering and technology related to human healthcare, medicine and the environment conservation in academic fields of Materials and Chemical Technology, Mechanical Engineering, Electrical and Electronic Engineering, Information Technology, Life Science and Technology has been remarkable drastically. However, in present, most of disciplinary fields train students independently, and there are few examples of educational systems crossing these fields. In a globalized society, it is indispensable to learn integrated knowledge of a wide range of academic fields such as natural sciences, bioethics, the foundation of health, medical and environmental sciences, etc. for sustainable and rich human life. In addition, by utilizing these knowledge and integrating them with expertise in each field, it can be utilized more effectively and precisely to build a living infrastructure where one can develop sustainably.

In this course, all research and development of engineering and technology regarding human healthcare, medicine and environment conservation, which has been conducted in each disciplinary field, have been taken as integrated science and technology and defined as "Human Centered Science and Biomedical Engineering". The course provides the education and research to consider the correlation between human characteristics and artifact ones comprehensively based on the in-depth understanding of people and society. Thus, the goal of this course is to foster talents who have a deep understanding of human being and knowledge of natural sciences, bioethics, foundation of health, medical and environmental sciences and also learn several disciplinary fields such as Materials & Chemical Technology, Mechanical Engineering, Electrical & Electronic Engineering, Information Technology, and Life Science & Technology. That means to foster scientists and engineers who can contribute to the development of science and technology to protect people's health and realize a sustainable society. Moreover, by promoting the interaction among several disciplinary fields, we can expect to provide a new viewpoint to each field, as well as creating of new disciplines for the future.

【Master's Degree Program】

1. Outline

We foster scientists and engineers that have a deep understanding of human being by mastering natural sciences, bioethics, the foundation of health, medical and environmental sciences, and furthermore, by interdisciplinary learning academic fields of Materials and Chemical Technology, Mechanical Engineering, Electrical and Electronic Engineering, Information Technology, Life Science & Technology.

In the Master's course, students learn advanced professional knowledge of Materials & Chemical Technology, Mechanical Engineering, Electric and Electronic Engineering, Information Technology, Life Science & Technology, and acquire high intelligence and liberal arts, broad perspective and deep thought ability, comprehensive decision-making ability, solid ethical and technological view, and global thinking. Based on these abilities, they study advanced research and development, and learn task assignment skills and advanced problem-solving skills in academic research.

To be specific,

1. Systematically learn professional knowledge and skills necessary for advanced research and development in Human Centered Science and Biomedical Engineering field based on professional knowledge of a disciplinary field, which student learned in the undergraduate course.
2. Learn high level advanced professional knowledge and skills by developing professional knowledge and skills that students acquired in their undergraduate.
3. Deepen one's professional ability and creativity through lab seminar, master research planning for master thesis subjects, and master thesis research.

2. Competencies Developed

In this course, in order to achieve the above objectives, the goal of study is to acquire the following knowledge and abilities:

- Knowledge essential for Life Engineering such as Human Science, Medical & Health Science, Bioethics, and the environment in which humans are involved
- Advanced knowledge and skills of Life Engineering in each specialized field
- Basic learning ability to understand expertise in different field
- Ability to challenge the development of new areas through integration of issues and problem solving methods in each area
- Ability to set issues in relation to society and solve problems by making use of their own technology and creativity
- Leadership and communication skills that can communicate their thoughts and skills correctly and collaborate to address issues

3. Learning Goals

To acquire the skills listed in "Competencies Developed", students in this program will have the following trainings.

A) Acquiring fundamental expertise in the field of "Human Centered Science and Biomedical Engineering"

Acquiring fundamental expertise in the research field of "Human Centered Science and Biomedical Engineering" through required courses and restricted elective courses in Major Courses.

B) Acquiring advanced expertise in the field of "Human Centered Science and Biomedical Engineering"

Acquiring advanced professional knowledge and skills through Materials & Chemical Technology, Mechanical Engineering, Electrical & Electronic Engineering, Information Technology, and Life Science & Technology courses in Major Courses of "Human Centered Science and Biomedical Engineering".

C) Acquiring research-executing skills, problem-solving.

Acquiring research-executing skills and problem-solving skills through Research Seminars, Research-Related Courses as well as research working in lab by using obtained expertise.

D) Acquiring experience in relation to engineering ethics and society.

According to lectures by teachers working in industries, learning ethical and social values relevant to society and research and understanding engineering ethics.

E) Acquiring communication skills.

Learning advanced communication skills required as international professionals through discussion with researchers in the country and overseas.

F) Cultivating sophistication in relation to liberal arts and humanity.

Learning liberal arts and humanity required as researchers through Humanities and Social Science Courses, Entrepreneurship Courses.

4. IGP Completion Requirements

The following requirements must be met to complete the Master's Degree Program of this major.

1. Attain a total of 30 credits or more from 400- and 500-level courses.

2. From the courses specified in the Graduate Major in Human Centered Science and Biomedical Engineering standard curriculum, you must meet the following requirements (see Table M1 below).

- · You have acquired at least 19 credits from Major courses;
- · You have acquired 8 credits from Research Seminars;
- · You have acquired 2 credits from Research-related Courses;
- · Must acquire 4 credits from required Major Courses and 3 credits from restricted elective Major Courses;
- · Must acquire a minimum of 5 credits from Liberal Arts and Basic Science Courses (3 credits from Humanities and Social Science Courses of which 2 credits must be from 400-level courses and 1 credit from 500-level courses, and 2 credits from Entrepreneurship Courses).

3. Pass the master's thesis review and defense.

Table M1 shows course categories and the number of credits required to complete the Master's Degree Program of this major. It also shows the required minimum credits in each course category and points to be noted when selecting the required courses and electives.

The learning goals to be obtained by students through courses are listed as "associated learning goals". Prior to registering courses, students need to fully understand the course goals.

Table M1. Graduate Major in Human Centered Science and Biomedical Engineering Completion Requirements

Course category		\<Required courses\> Required credits	\<Electives\> Minimum credits required	Minimum credits required	Associated learning goals	Comments
Liberal arts and basic science courses	Humanities and social science courses		•2 credits from 400-level •1 credit from 500-level	5 credits	D, F	
	Entrepreneurship Courses		2 credits		D, F	All Graduate Attributes (GA) should be acquired. (Refer to Section 7 for the definition of GA.)
	Other courses					
Core courses	Research seminars	HCB Seminar S1 HCB Seminar F1 HCB Seminar S2 HCB Seminar F2 A total of 8 credits, 2 credits each from the above courses.		19 credits	C, E	
	Research-related courses	Research Planning for Master Thesis I Research Planning for Master Thesis II A total of 2 credits			C, E	
	Major courses	Interdisciplinary Research Fundamentals I Interdisciplinary Research Fundamentals II Interdisciplinary Research Training A total of 4 credits	3 credits from restricted electives		A, B, D, E	

Major courses and Research-related courses <u>outside</u> the Graduate Major in Human Centered Science and Biomedical Engineering standard curriculum	- 5 -					
Total required credits	**A minimum of 30 credits including those attained according to the above conditions**					
Note	**・Japanese Language and Culture Courses offered to international students can be recognized as equivalent to the Humanities and Social Science Courses of the corresponding course level.** **・For details of the Liberal Arts and Basic Science Courses, please refer to the relevant sections.**					

5. IGP Courses

Table M2 shows the Core Courses of the Master's Degree Program in this major. Graduate Majors listed in the Comments column offer core courses that are recognized as equivalent to the corresponding Major Courses or Research-related Courses in the standard curriculum of this major.

Table M2. Core Courses of the Graduate Major in Human Centered Science and Biomedical Engineering

Course category		Course number			Course title	Credits	Competencies	Learning goals	Comments
Research seminars	400 level	HCB.Z491.R	◎	★	HCB Seminar S1	0-2-0	1,3,5	C,E	
		HCB.Z492.R	◎	★	HCB Seminar F1	0-2-0	1,3,5	C,E	
	500 level	HCB.Z591.R	◎	★	HCB Seminar S2	0-2-0	1,3,5	C,E	
		HCB.Z592.R	◎	★	HCB Seminar F2	0-2-0	1,3,5	C,E	
Research-related	400 level	HCB.C471.R	◎	★	Research Planning for Master Thesis I	0-1-0	1,3,5	C,E	
	500 level	HCB.C571.R	◎	★	Research Planning for Master Thesis II	0-1-0	1,3,5	C,E	

Major courses	400 level	Code			Course Title				
		HCB.A416.L		★	Catalysis for the Environmental Issues	1-0-0	1	B	【Chemical Science and Engineering】(CAP.I416)
		HCB.A425.L		★	Advanced Biofunctional Chemistry I	1-0-0	1,4,5	B	【Chemical Science and Engineering】(CAP.A425)
		HCB.A426.L		★	Advanced Biofunctional Chemistry II	1-0-0	1,4,5	B	【Chemical Science and Engineering】(CAP.A426)
		HCB.C402.A	○		Fundamentals of Creative Design	1-1-0	3,4,5	A,C	
		HCB.C405.L			Ota City Start-up Experience Off-Campus Project	0.5-0-0.5	3,4,5	C,D,E	【Tokyo Tech Academy for Super Smart Society】(SSS.S433)
		HCB.C411.R	◎	★	Interdisciplinary Research Fundamentals I	1-0-0	1,5	A	
		HCB.C412.R	◎	★	Interdisciplinary Research Fundamentals II	1-0-0	1,5	A	
	400 level	HCB.C413.R	◎	★	Interdisciplinary Research Training	0-0-2	3,4,5	A,C	
		HCB.C421.A	○	★	Outline of Human Centered Science and Biomedical Engineering I	1-0-0	1,5	A	
		HCB.C422.A	○	★	Outline of Human Centered Science and Biomedical Engineering II	1-0-0	1,2	A	
		HCB.C423.L		★	From Data Analytics to Machine Learning	1-0-0	1,2,5	A	
		HCB.C431.A	○		Off Campus Training I	0-0-1	1,3,4,5	D	Offered in English as needed
		HCB.C441.A	○	★	Presentation for Science and Engineering I	1-0-0	2,3	E	
		HCB.C442.A	○	★	Presentation for Science and Engineering II	1-0-0	2,3	E	
		HCB.C451.L			Advanced Research Topics for Life Innovation I	1-0-0	1,2,4,5	B,D	
		HCB.C452.L			Advanced Research Topics for Life Innovation II	1-0-0	1,2,4,5	B,D	

		HCB.C461.L			Introduction to Bioethics	1-0-0	1,2,4,5	B	【Life Science and Technology】(LST.A419)
		HCB.C481.L		★	International Career Development Basics	1-1-0	2,3,4,5	A,B,C,D,E	【Life Science and Technology】(LST.B404)
		HCB.E431.L		★	Fundamentals of Light and Matter I	2-0-0	1	A	【Electrical and Electronic Engineering】(EEE.D431)
		HCB.E451.L		★	Plasma Engineering	2-0-0	1	A	【Electrical and Electronic Engineering】(EEE.P451)
		HCB.I409.L		★	Optics in Information Processing	1-0-0	1	B	【Information and Communications Engineering】(ICT.H409)
		HCB.I411.L		★	Basic Sensation Informatics	1-0-0	1,5	B	【Information and Communications Engineering】(ICT.H411)
		HCB.I422.L		★	Computational Brain	1-0-0	1	B	【Information and Communications Engineering】(ICT.H422)
		HCB.I423.L			Solving Social Issues with Cutting-Edge Technology	0-1-0	3,4,5	C,D,E	【Engineering Sciences and Design】(ESD.E407)
		HCB.L401.L		★	Molecular and Cellular Biology	2-0-0	1,4	B	【Life Science and Technology】(LST.A401)
		HCB.L405.L		★	Design of Bioactive Molecules	2-0-0	1	B	【Life Science and Technology】(LST.A405)

		HCB.L407.L		★	Science of Metabolism	2-0-0	1,4,5	B	【Life Science and Technology】(LST.A407)

		Code		Mark	Course	Credits	Term	Level	Notes
		HCB.L407.L		★	Science of Metabolism	2-0-0	1,4,5	B	【Life Science and Technology】(LST.A407)
		HCB.L410.L		★	Advanced Neuroscience	2-0-0	1,5	B	【Life Science and Technology】(LST.A410)
		HCB.L411.L		★	Biomolecular Engineering	2-0-0	1,2,5	B	【Life Science and Technology】(LST.A411)
		HCB.L412.L		★	Biomaterial Science and Engineering	2-0-0	1,2,4,5	B	【Life Science and Technology】(LST.A412)
		HCB.L413.A	○	★	Advanced Biological Science and Engineering (Tsinghua University)	2-0-0	1,2,4,5	B	【Life Science and Technology】(LST.A417) (for Tokyo Tech-Tsinghua Univ. Joint Graduate program students)
		HCB.M461.L			Laboratory Training on Human Brain Functions and Their Measurements	0.5-0-0.5	1,3,5	B	
		HCB.M463.L		★ O	Introduction to Biomedical Instrumentation	1-0-0	1,2	B	O : Odd year in English This class will not be held in even years.
		HCB.M464.L		★ E	Introduction to Neural Engineering	1-0-0	1	B	E: Even year in English This class will not be held in odd years.

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		HCB.S402.L		★ O	Modeling of Discrete Systems	1-1-0	1,5	B	【Artificial Intelligence】(ART.T455) O: Odd year in English E: Even year in Japanese
		HCB.S403.L		★	Non-linear Dynamical Systems	2-0-0	1	B	【Artificial Intelligence】(ART.T456)
		HCB.S404.L		★	Complex Networks	2-0-0	1	B	【Artificial Intelligence】(ART.T462)
		HCB.T402.L		★ E	Characterization of Nanomaterials	2-0-0	1	B	【Materials Science and Engineering】(MAT.M402) a Held in 4Q O: Odd year in Japanese E: Even year in English b Held in 1～2Q (in Tsinghua University), Every year in English
		HCB.T403.L		★	Soft Materials Physics	1-0-0	1,2	B	【Materials Science and Engineering】(MAT.P403)
		HCB.T404.L		★	Soft Materials Functional Physics	1-0-0	1,3	B	【Materials Science and Engineering】(MAT.P404)
		HCB.T407.L		★ E	Advanced Course of Nano-Bionics I	1-0-0	1,2,3,5	B	【Materials Science and Engineering】(MAT.C407) E: Even year in English O: Odd year in Japanese

		HCB.T408.L		★	Soft Materials Design	1-0-0	1,5	B	【Graduate Major in Energy Science and Informatics】(ESI.J407)
		HCB.T412.L		★	Polymeric Biomaterials	2-0-0	1,5	B	【Materials Science and Engineering】(MAT.C412)
		HCB.T413.L		★	Soft Materials Functional Chemistry	1-0-0	1,5	B	【Materials Science and Engineering】(MAT.P413)
		HCB.T414.L		★ E	Reliability and Durability of Metals and Alloys	2-0-0	1,4,5	B	【Materials Science and Engineering】(MAT.M412) E: Even year in English O: Odd year in Japanese
		HCB.T417.L		★	Medical Polymers	1-0-0	1,5	B	【Materials Science and Engineering】(MAT.P417)
		HCB.T422.L		★ E	Organic Materials Design	1-0-0	1,5	B	【Materials Science and Engineering】(MAT.P422) E: Even year in English O: Odd year in Japanese
		HCB.T426.L		★	Thermal Properties of Materials	1-0-0	1,5	B	【Materials Science and Engineering】(MAT.P426)

		HCB.T431.L		★	Materials simulation	2-0-0	1,4,5	B	【Tokyo Tech Academy for Convergence of Materials and Informatics】* (TCM.A402)
		HCB.T433.L		★	Materials Informatics	2-0-0	1,4,5	B	【Tokyo Tech Academy for Convergence of Materials and Informatics】* (TCM.A404)
		HCB.T491.L			Materials Engineering and Ecology	1-0-0	3,4,5	B	【Materials Science and Engineering】 (MAT.P491)
	500 level	HCB.A532.L		★	Advanced Catalytic Reactions	1-0-0	1	B	【Chemical Science and Engineering】 (CAP.T532)
		HCB.A561.L		★	Nanobio Materials and Devices	2-0-0	1,2	B	
		HCB.C521.A	○	★	Advanced Human Centered Science and Biomedical Engineering I	1-0-0	1,2,5	A	
		HCB.C522.A	○	★	Advanced Human Centered Science and Biomedical Engineering II	1-0-0	1,4,5	A	
		HCB.C531.A	○		Off Campus Training II	0-0-2	1,3,4,5	D	Offered in English as needed
		HCB.C532.A	○		Off Campus Training III	0-0-4	1,3,4,5	D	Offered in English as needed
		HCB.C541.A	○	★	International Writing	1-0-0	2,3,4,5	E	
		HCB.C542.A	○	★	International Presentation I	0-1-0	1,2,3,4,5	E	
		HCB.C543.A	○	★	International Presentation II	0-1-0	1,2,3,4,5	E	
		HCB.C551.L			Advanced Research Topics for Life Innovation III	1-0-0	1,2,4,5	D	
		HCB.C552.L		★	Advanced Research Topics for Life Innovation IV	1-0-0	1,2,4,5	D	

		HCB.E533.L		★	Fundamentals of Light and Matter IIc	1-0-0	1	B	【Electrical and Electronic Engineering】 (EEE.D533)
		HCB.I504.L		★	Medical Image Engineering	2-0-0	1,5	B	【Information and Communications Engineering】 (ICT.H504) Students who have already taken "Medical Image Processing" (old course name) cannot take this course.
		HCB.I514.L		★	Mechanisms of Visual Perception	1-0-0	1,5	B	【Information and Communications Engineering】 (ICT.H514)
		HCB.L501.L		★	Biomolecular Analysis	2-0-0	1,5	B	【Life Science and Technology】 (LST.A501)
		HCB.L502.L		★	Science of Biological Resources	2-0-0	1,5	B	【Life Science and Technology】 (LST.A502)
		HCB.L504.L		★	Medical Biotechnology	2-0-0	1,2,5	B	【Life Science and Technology】 (LST.A504)
		HCB.M563.L		★	Micro and Nano Systems	2-0-0	1	B	【Mechanical Engineering】 (MEC.J531)
		HCB.S501.L		★	Molecular Simulation	1-1-0	1,2	B	【Artificial

							Intelligence】(ART.T545)
	HCB.S502.L	★	Design Theory in Biological Systems	2-0-0	1	B	【Artificial Intelligence】(ART.T546)
	HCB.T504.L	★	Functional Devices	2-0-0	1,2	B	【Materials Science and Engineering】(MAT.C504)
outside the Graduate Major in Human Centered Science and Biomedical Engineering standard curriculum	HCB.C403.L	△	Field Works for Creative Design	1-1-0	3,4,5	D,E	
	HCB.C404.L	★	Industrial design	1-1-0	2,3,4,5	C,E,F	
	HCB.C501.L	△	Practical Creative Design	1-2-0	3,4,5	C,D,E	
	HCB.C502.L	△	Management for Business Creation	0.6-0-0.4	1,2,3,4,5	D,E	

Note :

• ◎ : Required course, ○ : Restricted elective, ★: Course given in English, O : Odd academic years, E : Even academic years

•△ : Progressive graduate minor of "Practical-Based Entrepreneurship Education Course".

• Competencies: 1 = Specialist skills, 2 = Liberal arts skills, 3 = Communication skills, 4 = Applied skills (inquisitive thinking and/or problem-finding skills), 5 = Applied skills (practical and/or problem-solving skills)

• 【 】 Course offered by another graduate major

• The character preceding the three digits in the course number denotes the course's subdiscipline (i.e., "D" represents the subdiscipline code in the course number ABC.D400.R) : A (Applied Chemistry), C (Common Major Courses), E (Electrical and Electronic Engineering), I (Information Technology), L (Life Science and Technology), M (Material Technology), S (Artificial Intelligence), T (Materials Science and Engineering), Z (Research seminars)

6. IGP Courses That Can Be Counted as Humanities and Social Science Courses

None

7. IGP Entrepreneurship Courses and IGP Courses That Can Be Counted as Entrepreneurship Courses

In order to fulfill the completion requirements for the master's degree program, students must attain at least two credits in Entrepreneurship Courses, and should satisfy all of the Graduate Attributes (GAs) specified in Table M-1 of the "Entrepreneurship Courses" listed as "Liberal Arts and Basic Science Courses" in the Guide to Graduate Education and International Graduate Program, as well as shown below. Students will be evaluated in regards to GA achievements at the time of their degree completion. For courses with two GAs, both GAs stipulated for the courses are considered to be acquired if students attain the corresponding credits for those courses.

Entrepreneurship Courses and Major Courses that enable students to acquire GAs and are recognized as equivalent to

Entrepreneurship Courses, offered by the Graduate Major, are listed in Table M3 below. Students can also acquire GAs and credits by taking the Entrepreneurship Courses offered by the Center for Entrepreneurship Education (CEE) listed as "Liberal Arts and Basic Science Courses" in the Guide to Graduate Education and International Graduate Program.

As there are some Entrepreneurship Courses without GAs, please check carefully before registering for them.

However, it must be noted that credits attained from courses that are recognized as equivalent to Entrepreneurship Courses can be counted towards the completion requirements of the master's degree program, either for Major Courses or for Entrepreneurship Courses (not for both). Nevertheless, even in cases where credits pertaining to courses that are not considered as Entrepreneurship Courses are attained, the associated GAs may be considered by the Graduate Major to have been acquired.

For Graduate Attributes, refer to the Guide to Entrepreneurship Courses.

The Graduate Attributes of the Master's Degree Program are listed in Table M-1 as follows:

GA0M: You can clearly plan your own career and recognize the abilities necessary for realizing it while considering ethics and relevance to societal problems.

GA1M: You can acquire the knowledge, skills, ethics and entrepreneurship necessary for realizing your planned career and contribute to societal problem-solving while collaborating with other experts

Table M3. Courses of the Graduate Major in Human Centered Science and Biomedical Engineering recognized as equivalent to Entrepreneurship Courses, and Entrepreneurship Courses

Course category	Course number	Course title			Credits	GA*	Learning goals	Comments
Courses that can be counted as Entrepreneurship Courses	CAP.E422			Presentation Practice	0-1-0	GA1M	E	【Chemical Science and Engineering】
	HCB.C402.A	○		Fundamentals of Creative Design	1-1-0	GA0M /GA1 M	A,C	
	HCB.C403			Field Works for Creative Design	1-1-0	GA0M /GA1 M	D,E	outside the Graduate Major in Human Centered Science and Biomedical Engineering standard curriculum
	HCB.C431.A	○		Off Campus Training I	0-0-1	GA1M	D	Offered in English as needed
	LST.A413			Career Development Seminars	2-0-0	GA0M /GA1 M	B,D,E	【Life Science and Technology】
	LST.A419			Introduction to Bioethics	1-0-0	GA0M /GA1 M	B,E	【Life Science and Technology】

LST.B404		★	International Career Development Basics	1-1-0	GA0M /GA1 M	A,B,C,D,E	【Life Science and Technology】
CAP.E521		★	Researcher Ethics and Engineer Ethics	1-0-0	GA0M	D	【Chemical Science and Engineering】
HCB.C501			Practical Creative Design	1-2-0	GA0M /GA1 M	C,D,E	outside the Graduate Major in Human Centered Science and Biomedical Engineering standard curriculum
HCB.C502			Management for Business Creation	0.6-0-0.4	GA0M /GA1 M	D,E	outside the Graduate Major in Human Centered Science and Biomedical Engineering standard curriculum
HCB.C531.A	○		Off Campus Training II	0-0-2	GA1M	D	Offered in English as needed
HCB.C532.A	○		Off Campus Training III	0-0-4	GA1M	D	Offered in English as needed
LST.C501			MS Internship 1	0-1-0	GA1 M	D,E	【Life Science and Technology】 Offered in English as needed
LST.C502			MS Internship 2	0-2-0	GA1M	D,E	【Life Science and Technology】 Offered in English as needed
LST.C503			MS Internship 3	0-4-0	GA1M	C,D,E	【Life Science and Technology】 Offered in English as needed
LST.C504			MS Internship 4	0-6-0	GA1M	C,D,E	【Life Science and

							Technology】 Offered in English as needed
	LST.C506	★	Overseas Research Training 1 (Tsinghua University)	0-1-0	GA0M	B,E	【Life Science and Technology】 (for Tokyo Tech-Tsinghua Univ. Joint Graduate program students)
	LST.C507	★	Overseas Research Training 2 (Tsinghua University)	0-1-0	GA1M	B,E	【Life Science and Technology】 (for Tokyo Tech-Tsinghua Univ. Joint Graduate program students)
Entrepreneur ship Courses	HCB.R401.L		Masters' Recurrent Program 1-1 of HCB	0-0-1	GA0M /GA1 M	C,D,E	Entrepreneurship Course offered by the Graduate Major in Human Centered Science and Biomedical Engineering. (Cannot be counted for Major Courses)
	HCB.R402.L		Masters' Recurrent Program 1-2 of HCB	0-0-1	GA0M /GA1 M	C,D,E	Entrepreneurship Course offered by the Graduate Major in Human Centered Science and Biomedical Engineering. (Cannot be counted for Major Courses)
	HCB.R501.L		Masters' Recurrent Program 2 of HCB	0-0-2	GA0M /GA1 M	C,D,E	Entrepreneurship Course offered by the Graduate Major in Human Centered Science and Biomedical Engineering.

								(Cannot be counted for Major Courses)

○: course from this major, ★: course given in English

Credits in Entrepreneurship Courses must be attained from among the above-listed courses and those listed as such in the Liberal Arts and Basic Science Courses Guide.

＊**GA: Graduate Attributes**

The Tokyo Tech Academy for Leadership (ToTAL), WISE Programs, or Center of Data Science and Artificial Intelligence may offer courses that are recognized as equivalent to Entrepreneurship Courses in addition to those listed as such under "Liberal Arts and Basic Science Courses" in the Guide to Graduate Education and International Graduate Program. For details about available courses or completion requirements, please refer to the study guide of the academy or center that offers the relevant program.

8. Research Related to the Completion of Master's Theses

In the Master's thesis research, students experience a series of the research process and aim to improve problem-setting ability, problem-solving ability and communication skills. An example of the flow of the Master's thesis research for this is shown below. The evaluation of the academic outcome is carried out as appropriate. Students also consider the course plan as related to direction of their thesis research.

・Presentation of Research Plan and Interim presentation

It is important to conduct research systematically and check the progress to produce research results. Students conduct "Presentation of Research Plan" (Research Planning for Master Thesis I) in 4Q and "Interim presentation" (Research Planning for Master Thesis II) in 6Q to understand their research background and purpose clearly.

・Judgement criterion of the final defense of Master's Thesis

The Master's thesis and its overview must be written in Japanese or English by the student. The thesis must include the student's original consideration, and also include new findings in Human Centered Science and Biomedical Engineering field or useful research that contributes to the development of Human Centered Science and Biomedical Engineering field.

・Implementation manner of the final defense of Master's Thesis

After the preliminary review by the advisors, the final examination and evaluation will be carried out in the oral presentation of the thesis. The oral presentation must be done in Japanese or English.

1st-semester		2nd-semester		3rd-semester		4th-semester	
1Q	2Q	3Q	4Q	5Q	6Q	7Q	8Q

Orientation

Presentation of Research Plan

Interim presentation

Application of the degree

Submission of the thesis oral presentation
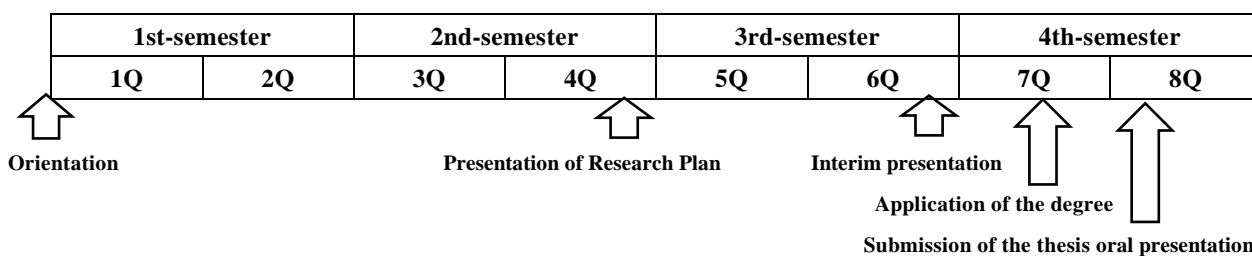
9. Seamless Transition between Degree Programs

In the graduate major of Human Centered Science and Biomedical Engineering, we foster basic academic knowledge to understand human and society deeply, expertise in science and engineering, a wide perspective, deep thought ability, comprehensive decision-making skill, ethical and technological views, internationality, and cutting-edge technological development and problem setting and solving abilities in advanced academic research and development of technology. The learning goals of this course is to acquire the following abilities.

・Knowledge about natural sciences, bioethics, the foundation of health, medical and environmental sciences necessary for research and development in Human Centered Science and Biomedical Engineering field.

・Ability that can set tasks in the society and solve these tasks by using one's skills and creativity.

・Communication skills that enables one to accurately communicate his or her ideas and skills to others.

・Leadership that enables one to collaborate on tasks.

In the curriculum at the doctoral course, as the 600 series, Research Planning for Doctoral Thesis I, Research Planning for Doctoral Thesis II, HCB Seminar S1~F5, Teaching methods for Human Centered Science and Biomedical Engineering, HCB International Internship, International Presentation III & IV, Research Working in Company, HCB off-campus advanced training I & II have been established, not only improvement of expertise by cutting-edge research based on curriculum from 400 series, It is an organic curriculum that can effectively improve communication skills and leadership skills.

【**Doctoral Degree Program**】

1. Outline

In the Doctoral course, we foster superior talents who will contribute to human beings' happiness and the development of science and technology by (1) having the highest degree of professional knowledge in Materials and Chemical Technology, Mechanical Engineering, Electrical and Electronic Engineering, Information Technology, and Life Science and Technology, (2) obtaining the professional knowledge in natural sciences, bioethics, the foundation of health, medical and environmental sciences, (3) having the ability to promote advanced research and development ingenious and challenging by the above professional knowledge, and (4) exhibiting creativity and international leadership capable of exploiting new fields.
To be specific,

1. Acquire advanced professional knowledge in own research field through lab seminar and research planning for doctoral thesis subjects, and cultivate a wide range of outstanding expertise and ethics in the field of Human Centered Science and Biomedical Engineering.

2. Foster leadership skills, internationality and communication skills in teaching method and international presentation subjects, and obtain career experience by conducting international internship and research working in company subjects.

3. Foster outstanding creativity, task setting ability and problem-solving skills that can lead the international community through conducting the world's highest level of research in doctoral thesis research.

2. Competencies Developed

The learning objective of this Doctoral course is to acquire the following abilities and knowledge with a higher standard than the Master's course to achieve the goals above.
・Knowledge about natural sciences, bioethics, the foundation of health, medical and environmental sciences necessary for research and development in Human Centered Science and Biomedical Engineering field.
・Advanced professional knowledge and skills related with Human Centered Science and Biomedical Engineering in each disciplinary field.
・Fundamental expertise that can understand different disciplinary knowledge.
・Ability to challenge to explore new research & development areas.
・The ability that can set tasks in the society and solve these tasks by using one's skills and creativity.
・Communication skills that enables one to accurately communicate his or her ideas and skills to others.
・Leadership that enables one to collaborate on tasks.

3. Learning Goals

To acquire the skills listed in "Competencies Developed", students in this program will have the following trainings.

A) Acquiring fundamental expertise in the field of "Human Centered Science and Biomedical Engineering"

Acquiring fundamental expertise in the research field of "Human Centered Science and Biomedical Engineering" through required courses and restricted elective courses in Major Courses.

B) Acquiring advanced expertise in the field of "Human Centered Science and Biomedical Engineering"

Acquiring advanced professional knowledge and skills through Materials & Chemical Technology, Mechanical

Engineering, Electrical & Electronic Engineering, Information Technology, and Life Science & Technology courses in Major Courses of "Human Centered Science and Biomedical Engineering".

C) Acquiring research-executing skills, problem-solving.

Acquiring research-executing skills and problem-solving skills through Research Seminars, Research-Related Courses as well as research working in lab by using obtained expertise.

D) Acquiring experience in relation to engineering ethics and society.

According to lectures by teachers working in industries, learning ethical and social values relevant to society and research and understanding engineering ethics.

E) Acquiring communication skills.

Learning advanced communication skills required as international professionals through discussion with researchers in the country and overseas.

F) Cultivating sophistication in relation to liberal arts and humanity.

Learning liberal arts and humanity required as researchers through Humanities and Social Science Courses, Entrepreneurship Courses.

4. IGP Completion Requirements

The following requirements must be met to complete the Doctoral Degree Program of this major.

1. Attain a total of 24 credits or more from 600-level courses.

2. From the courses specified in the Graduate Major in Human Centered Science and Biomedical Engineering standard curriculum, you must meet the following requirements (see Table D1 below):

・ You have acquired 12 credits from Research Seminars;

・ You have acquired 4 credits from Research-related Courses;

・ Must acquire a minimum of 2 credits from restricted elective Major Courses;

・ Must acquire a minimum of 6 credits from Liberal Arts and Basic Science Courses (2 credits from Humanities and Social Science Courses, and 4 credits from Entrepreneurship Courses).

3. Pass the doctoral dissertation review and defense.

Table D1 shows course categories and the number of credits required to complete the Doctoral Degree Program of this major. It also shows the required minimum credits in each course category and points to be noted when selecting the required courses and electives.

The learning goals to be obtained by students through courses are listed as "associated learning goals". Prior to registering courses, students need to fully understand the course goals.

Table D1. Graduate Major in Human Centered Science and Biomedical Engineering Completion Requirements

Course category		\<Required courses\> Required credits	\<Electives\> Minimum credits required	Minimum credits required	Associated learning goals	Comments
Liberal arts and basic science courses	Humanities and social science courses		2 credits	6 credits	D, F	All Graduate Attributes (GA) should be acquired. (Refer to Section 7 for the definition of GA.)
	Entrepreneurship Courses		4 credits		D, F	
	Other courses					
Core courses	Research seminars	HCB Seminar S3 HCB Seminar F3 HCB Seminar S4 HCB Seminar F4 HCB Seminar S5 HCB Seminar F5 A total of 12 credits, 2 credits each from the above courses.		18 credits	C, E	
	Research-related courses	Research Planning for Doctoral Thesis I Research Planning for Doctoral Thesis II A total of 4 credits			C, E	
	Major courses		2 credits		A, B, D, E	

	Major Courses and Research-related courses <u>outside</u> the Graduate Major in Human Centered Science and Biomedical Engineering standard curriculum								
Total required credits		**A minimum of 24 credits including those attained according to the above conditions**							
Note		**・Japanese Language and Culture Courses offered to international students can be recognized as equivalent to the Humanities and Social Science Courses of the corresponding course level.** **・For details of the Liberal Arts and Basic Science Courses, please refer to the relevant sections.**							

5. IGP Courses

Table D2 shows the Core Courses of the Doctoral Degree Program of this major. Graduate Majors listed in the Comments column offer core courses that are recognized as equivalent to the corresponding Major Courses or Research-related Courses in the standard curriculum of this major.

Table D2. Core Courses of the Graduate Major in Human Centered Science and Biomedical Engineering

Course category		Course number			Course title	Credits	Competencies	Learning goals	Comments
Research seminars	600 level	HCB.Z691.R	◎	★	HCB Seminar S3	0-2-0	1,3,5	C,E	
		HCB.Z692.R	◎	★	HCB Seminar F3	0-2-0	1,3,5	C,E	
		HCB.Z693.R	◎	★	HCB Seminar S4	0-2-0	1,3,5	C,E	
		HCB.Z694.R	◎	★	HCB Seminar F4	0-2-0	1,3,5	C,E	
		HCB.Z695.R	◎	★	HCB Seminar S5	0-2-0	1,3,5	C,E	
		HCB.Z696.R	◎	★	HCB Seminar F5	0-2-0	1,3,5	C,E	
Research-	600 level	HCB.C671.R	◎	★	Research Planning for Doctoral Thesis I	0-2-0	1,2,3,4,5	C,E	

		HCB.C672.R	◎	★	Research Planning for Doctoral Thesis II	0-2-0	1,2,3,4, 5	C,E	
Major courses	600 level	HCB.C601.A	○		Teaching methods for Human Centered Science and Biomedical Engineering	1-0-1	1,3,4,5	C,E	Offered in English as needed
		HCB.C631.A	○	★	HCB International Internship	0-0-4	1,2,3,4, 5	B,C,D	
		HCB.C632.A	○		Research Working in Company	0-2-2	1,5	B,C,D	
		HCB.C633.A	○		HCB off-Campus advanced training 1	0-0-1	1,2,3,4, 5	B,C,D	Offered in English as needed
		HCB.C634.A	○		HCB off-Campus advanced training 2	0-0-2	1,2,3,4, 5	B,C,D	Offered in English as needed
		HCB.C635.L			Cooperative Education through Research Internships of (HCB course)	0-0-4	1,3,4,5	B,C,D	
		HCB.C641.A	○	★	International Presentation III	0-1-0	1,2,3,4, 5	E	
		HCB.C642.A	○	★	International Presentation IV	0-1-0	1,2,3,4, 5	E	
		HCB.C681.A	○	★	International Career Development Advanced	1-1-0	1,2,3,4, 5	A,B,C,D,E	【Life Science and Technology】 (LST.B605)

Note：

• ◎：Required course，　○：Restricted elective，　★：Course given in English

• Competencies: 1 = Specialist skills,　2 = Liberal arts skills,　3 = Communication skills, 4 = Applied skills (inquisitive thinking and/or problem-finding skills), 5 = Applied skills (practical and/or problem-solving skills)

• The character preceding the three digits in the course number denotes the course's subdiscipline (i.e., "D" represents the subdiscipline code in the course number ABC.D600.R): C (Common Major Course), Z (Research seminars)

6. IGP Courses That Can Be Counted as Humanities and Social Science Courses

None

7. IGP Entrepreneurship Courses and IGP Courses That Can Be Counted as Entrepreneurship Courses

In order to fulfill the completion requirements for the doctoral degree program, students must attain at least four credits in Entrepreneurship Courses, and should satisfy all of the Graduate Attributes (GAs) specified in Table D-1 of the "Entrepreneurship Courses" listed as "Liberal Arts and Basic Science Courses" in the Guide to Graduate Education and International Graduate Program, as well as shown below. Students will be evaluated in regards to GA achievements at the time of their degree completion. For courses with two GAs, both GAs stipulated for the courses are considered to be acquired if students attain the corresponding credits for those courses.

Entrepreneurship Courses and Major Courses that enable students to acquire GAs and are recognized as equivalent to Entrepreneurship Courses, offered by the Graduate Major, are listed in Table D3 below. Students can also acquire GAs and credits by taking the Entrepreneurship Courses offered by the Center for Entrepreneurship Education (CEE) listed as "Liberal Arts and Basic Science Courses" in the Guide to Graduate Education and International Graduate Program.

As there are some Entrepreneurship Courses without GAs, please check carefully before registering for them.

However, it must be noted that credits attained from courses that are recognized as Entrepreneurship Courses can be counted towards the completion requirements of the doctoral degree program, either for Major Courses or for Entrepreneurship Courses (not for both). Nevertheless, even in cases where credits pertaining to courses that are not considered as Entrepreneurship Courses are attained, the associated GAs may be considered by the Graduate Major to have been acquired.

For Graduate Attributes, refer to the Guide to Entrepreneurship Courses.

The Graduate Attributes of the Doctoral Degree Program are listed in Table D-1 as follows:

GA0D: You can clearly design your own career and contribute to realizing scientific, technological, or social innovation through a comprehensive understanding of the knowledge, skills, social responsibilities and ethics required to become an active member of academia and/or industry.

GA1D: You can lead in realizing scientific, technological, or social innovation by acquiring advanced leadership skills, entrepreneurship, knowledge and expertise, and by developing social responsibility necessary for materializing your designed career.

Table D3. Courses of the Graduate Major in Human Centered Science and Biomedical Engineering recognized as equivalent to Career Development , and Entrepreneurship Courses

Course category	Course number	Course title			Credits	GA*	Learning goals	Comments
Courses that can be counted as Entrepreneurship Courses	HCB.C631.A	○	★	HCB International Internship	0-0-4	GA1D	B,C,D	
	HCB.C632.A	○		Research Working in Company	0-2-2	GA1D	B,C,D	for Graduate Program for Working Adults students
	HCB.C633.A	○		HCB off-Campus advanced training 1	0-0-1	GA1D	B,C,D	Offered in English as needed
	HCB.C634.A	○		HCB off-Campus advanced training 2	0-0-2	GA1D	B,C,D	Offered in English as needed

	HCB.C635.L			Cooperative Education through Research Internships of (HCB course)	0-0-4	GA0D/ GA1D	B,C,D	
	LST.B605	A ○	★	International Career Development Advanced	1-1-0	GA0D/ GA1D	A,B,C,D,E	【Life Science and Technology】
	LST.C601			PhD Internship 1	0-1-0	GA1D	A,C,E	【Life Science and Technology】 Offered in English as needed
	LST.C602			PhD Internship 2	0-2-0	GA1D	A,C,E	【Life Science and Technology】 Offered in English as needed
	LST.C603			PhD Internship 3	0-4-0	GA1D	A,B,C,E	【Life Science and Technology】 Offered in English as needed
	LST.C604			PhD Internship 4	0-6-0	GA1D	A,B,C,E	【Life Science and Technology】 Offered in English as needed
Entrepreneur ship Courses	HCB.R601			Doctoral Recurrent Program 1 of HCB	0-0-1	GA0D /GA1 D	C,D,E	Entrepreneurship Course offered by the Graduate Major in Human Centered Science and Biomedical Engineering. (Cannot be counted for Major Courses)
	HCB.R602			Doctoral Recurrent Program 2-1 of HCB	0-0-2	GA0D /GA1 D	C,D,E	Entrepreneurship Course offered by the Graduate Major in Human Centered Science and Biomedical Engineering. (Cannot be counted for Major Courses)

	HCB.R603			Doctoral Recurrent Program 2-2 of HCB	0-0-2	GA0D /GA1 D	C,D,E	Entrepreneurship Course offered by the Graduate Major in Human Centered Science and Biomedical Engineering. (Cannot be counted for Major Courses)
	HCB.R604			Doctoral Recurrent Program 3 of HCB	0-0-3	GA0D /GA1 D	C,D,E	Entrepreneurship Course offered by the Graduate Major in Human Centered Science and Biomedical Engineering. (Cannot be counted for Major Courses)
	HCB.R605			Doctoral Recurrent Program 4 of HCB	0-0-4	GA0D /GA1 D	C,D,E	Entrepreneurship Course offered by the Graduate Major in Human Centered Science and Biomedical Engineering. (Cannot be counted for Major Courses)

○: course from this major, ★: course given in English

Credits in Entrepreneurship Courses must be attained from among the above-listed courses and those listed as such in the Liberal Arts and Basic Science Courses Guide.

＊**GA: Graduate Attributes**

The Tokyo Tech Academy for Leadership (ToTAL), WISE Programs, or Center of Data Science and Artificial Intelligence may offer courses that are recognized as equivalent to Entrepreneurship Courses in addition to those listed as such under "Liberal Arts and Basic Science Courses" in the Guide to Graduate Education and International Graduate Program. For details about available courses or completion requirements, please refer to the study guide of the academy or center that offers the relevant program.

8. Research Related to the Completion of Doctoral Theses

In the doctoral thesis research, in addition to problem-solving skills, we foster problem setting ability and improvement of communication skills in English. These are acquired in the process of setting and evaluating the results of the studies. An example of the flow of the doctoral thesis is shown below.

・Interim presentation

It is important to conduct research systematically and check the progress to produce research results. Thus, student conduct Research Planning for Doctoral Thesis I in 4Q, and Research Planning for Doctoral Thesis II in 9Q-11Q.

・Judgement criterion of the final defense of doctoral thesis

Those who wish to make the final defense of their doctoral thesis must undergo prior examination at Research Planning for Doctoral Thesis II and obtain the approval to apply for it.

The doctoral thesis must be written in Japanese or English by the student. The content of the thesis must have novelty, creativity, and sufficient academic value in the field of Human Centered Science and Biomedical Engineering, and also major parts of the content must be published in international academic journals or the same level as the contents in international journals.

・Implementation manner of the final defense of doctoral thesis

After students pass the interim interview, they will submit their thesis and then perform the oral presentation.　A final examination and evaluation will be carried out via a preliminary review by the advisors. In the final examination, their understanding abilities (including English ability) of the relevant research field will be confirmed. The oral presentation must be done in Japanese or English.

Research Planning for Doctoral Thesis I

Research Planning for Doctoral Thesis II

1-semester		2-semester		3-semester		4-semester		5-semester		6-semester	
1Q	2Q	3Q	4Q	5Q	6Q	7Q	8Q	9Q	10Q	11Q	12Q

Orientation

Application of the degree

Submission of the thesis, oral presentation

Final examination