International Graduate Program in Science for Innovative and Quantum-expert Leaders (PSIL)

1. IGP(A) Outline

The International Graduate Program in Science for Innovative and Quantum-expert Leaders **(PSIL)** at Tokyo Institute of Technology aims to educate students from abroad through graduate degree programs in mathematics, physics, chemistry, and Earth and planetary sciences. Those who obtain a degree through this program are expected to become leaders in scientific/application research; who possesses firm knowledge on underlying principle in quantum science; who can uncover previously unknown or unresolved issues; and who can generate real and lasting innovations for the benefit of society. The work of these highly talented scientific professionals will be built on the knowledge, skills, and viewpoints obtained from each course and cutting-edge scientific research done in PSIL.

The students will be enrolled in one of the Graduate Majors listed below and educated under the Integrated Doctoral Education Program; students will be required to continuously study for up to five years in order to obtain both Master's and Doctoral degrees. Outlines of each Graduate Major are given below.

1-1. Graduate Majors available to IGP (A) (PSIL) Students

1) Graduate Major in Mathematics:

In the Major in Mathematics, cutting-edge research in algebra, geometry, and analysis is being vigorously pursued, and a variety of research results have been obtained, such as the explanation of previously unsolved problems, the creation of new mathematical concepts, and the formulation of new predictions. Thus, this Major cultivates pioneers of cutting-edge mathematics and individuals who will pursue successful careers in the public and private sectors.

2) Graduate Major in Physics:

In the natural world, there are countless mysterious phenomena that are still not completely understood, including familiar objects, microscopic objects at an elementary particle/atomic level, and large-scale astrophysical objects. Those who do a Major in Physics will conduct world-leading research with the goals of discovering the fundamental principles and laws hidden in these phenomena, deepening our understanding of the natural world, and developing basic knowledge and technology that will contribute to society.

3) Graduate Major in Chemistry:

The Major in Chemistry aims to help students acquire fundamental knowledge of matter-related phenomena and advanced specialized skills. Students in this Major will work independently on new challenges and develop their inquisitive talents, enabling them to explore the deep truths of chemistry, such as the creation of new materials and discovering the nature of various matter-related phenomena. Students will thereby be able to fully contribute to achieving a prosperous society.

4) Graduate Major in Earth and Planetary Sciences:

In the Major in Earth and Planetary Sciences, scientific research related to the Earth, planets, and space is carried out, and new research fields, such as the study of the physical and chemical conditions involved in the formation and evolution of life on Earth, are established. This Major aims to cultivate individuals who research complex natural phenomena related to the Earth, planets, and space, have insight into the essential processes involved, and quantitatively explain them.

2. Competencies Developed

PSIL focuses on the academic development of the following competencies:

- A wide range of specialized abilities required for a multi-faceted understanding of the fundamental principles in the natural sciences and mathematics.
- A thorough utilization of the fundamental principles underpinning the natural sciences and mathematics in order to approach and solve new problems hidden in nature and society.
- The ability to conduct creative research with a strong ethical compass and to initiate international leadership in a chosen field of study.

3. Learning Goals

The PSIL curriculum will help students develop the above competencies by acquiring the following skills:

A) Fundamental knowledge in their chosen field of natural science or mathematics.
B) The ability for integrating different fields of knowledge into new systems.
C) Logical communication skills.

4. IGP(A) Completion Requirements

The student enrolled in PSIL should complete both the Master and Doctoral Courses. The standard period of study is five years (two years for the Master Course and three years for the Doctoral Course), however a minimum study period of three years is also possible, depending on his/her research and academic achievements. The student should fulfill the Graduate Major requirements of their department (degree completion requirements for both the Master and Doctoral Courses) as well as those specific requirements from IGP(A). The latter requirements are indicated below and Tables M1 and D1.

Specific Requirements/Recommendations for the IGP(A) Course (PSIL)

i) Degree requirements:

A. Fundamentals in Quantum Innovation is required during the Master Course period. (1 credit)
B. Science Colloquium I is required during the Master Course period. (1 credit)
C. Science Colloquium II is required during the Doctoral Course period. (1 credit)

ii) Recommended subjects:

A. Internship-I/Internal (Project research in another laboratory within Tokyo Tech.) (4 credits)
B. Internship-II/External (Project research at a leading research facility in Japan, such as RIKEN/KEK/JAMSTEC/ IMS/JASRI/JAEA/NAOJ, or overseas, such as CERN in Switzerland/Caltech in US/CNRS in France.) (4 credits)
C. Lectures with Course number of PHY.xxx and CHM.xxx in Table M1 are selected as “Quantum Science Lectures”, and the student in PSIL are strongly encouraged to take two or more among them.

【For Master's degree】

【1.】IGP(A) completion Requirements

Under this program, in addition to the above-mentioned requirements, students must also fulfill the Graduate Major completion requirements of their departments (degree completion requirements). For completion requirements of your Graduate Major, please refer to the relevant Graduate Major pages in "Guide to Graduate Majors (for IGP)".

【2.】IGP(A) Courses

Table M1. Courses of IGP(A)

Course category		Course number	Course title			Credits	Competencies	Learning goals	Comments
Research-related courses	500 level	XIP.S401	◎		Fundamental in Quantum Innovation	1-0-0	1, 2, 3	A, B, C	
		XIP.S501.R	◎		Science Colloquium I	0-1-0	1, 2, 3	A, B, C	
		XIP.S502.L			Internship-I/Internal (500)	0-0-4	1, 2, 3, 4, 5	A, B, C	
		XIP.S503.L			Internship-I/External (500)	0-0-4	1, 2, 3, 4, 5	A, B, C	
Research-related courses	400 level	PHY.C439.L			Physics of Magnetic Materials	1-0-0	1, 5	A, B, C	
		PHY.C441.L			Crystal Physics	2-0-0	1, 5	A, B, C	
		PHY.C442.L			Superfluidity	1-0-0	1, 5	A, B, C	
		PHY.C443.L			Superconductivity	1-0-0	1, 5	A, B, C	
		PHY.C444.L			Quantum Transport	1-0-0	1, 5	A, B, C	
		PHY.C445.L			Surface Physics	1-0-0		A, B, C	
		PHY.C446.L			Light and Matter I	1-0-0		A, B, C	
		PHY.C447.L			Light and Matter II	1-0-0	1	A, B, C	
		PHY.C448.L			Light and Matter III	1-0-0	1	A, B, C	
		PHY.C449.L			Laser Physics	1-0-0		A, B, C	
		PHY.C450.L			Quantum Theory of Electrons in Solids	2-0-0		A, B, C	
		PHY.F430.L			Hadron Physics	2-0-0	1, 5	A, B, C	
		PHY.F431.L			Cosmology	1-0-0	1	A, B, C	
		PHY.F432.L			Astrophysics	1-0-0	1	A, B, C	
		PHY.F436.L			Advanced Particle Physics	2-0-0	1, 2	A, B, C	
		PHY.F437.L			Advanced Nuclear Physics	2-0-0	1, 4, 5	A, B, C	
		PHY.Q433.L			Field Theory I	2-0-0	1, 5	A, B, C	
		PHY.Q434.L			Field Theory II	2-0-0	1	A, B, C	
		PHY.Q435.L			Quantum Information	2-0-0		A, B, C	
		PHY.Q438.L			Quantum Mechanics of Many-Body Systems	2-0-0		A, B, C	
		PHY.S440.L			Statistical Mechanics III	2-0-0		A, B, C	
		CHM.B401.A			Basic Concepts of Inorganic Chemistry I	1-0-0	1	A, B, C	
		CHM.B402.A			Basic Concepts of Inorganic Chemistry II	1-0-0	1, 5	A, B, C	

		CHM.C401.A			Basic Concepts of Physical Chemistry I	1-0-0	1	A, B, C	
		CHM.C402.A			Basic Concepts of Physical Chemistry II	1-0-0	1	A, B, C	
		CHM.C431.B			Advanced Physical Chemistry	2-0-0	1	A, B, C	
		CHM.C432.B			Advanced Quantum Chemistry	2-0-0		A, B, C	
		CHM.D401.A			Basic Concepts of Organic Chemistry I	1-0-0	1	A, B, C	
		CHM.D402.A			Basic Concepts of Organic Chemistry II	1-0-0	1	A, B, C	

Note

• ◎：Required 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)

• The character preceding the three digits in the course number denotes the course's subdiscipline (i.e., "X" represents the subdiscipline code in the course number PHY.X400.R: C: Condensed matter physics, F: Fundamental physics, Q: Quantum mechanics and CHM.X400.R: B: Inorganic chemistry, C: Physical chemistry, D: Organic chemistry)

【For Doctoral degree】

【1.】IGP(A) completion Requirements

Under this program, in addition to the above-mentioned requirements, students must also fulfill the Graduate Major completion requirements of their departments (degree completion requirements). For completion requirements of your Graduate Major, please refer to the relevant Graduate Major pages in “Guide to Graduate Majors (for IGP)”.

【2.】IGP(A) Courses

Table D1. Courses of IGP(A)

Course category		Course number	Course title			Credits	Competencies	Learning goals	Comments
Research-related courses	**600 level**	XIP.S601.R	◎		Science Colloquium II	0-1-0	1, 2, 3	A, B, C	
		XIP.S602.L			Internship-II/Internal (600)	0-0-4	1, 2, 3, 4, 5	A, B, C	
		XIP.S603.L			Internship-II/External (600)	0-0-4		A, B, C	

Note：

• ◎：Required 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)