3．電気電子情報工学系　Electrical, Electronics and Computer Engineering Field			**EEC-F5**
授業科目名 Course Title	量子力学と量子計算・量子暗号 Quantum Mechanics, Quantum Computation and Quantum Cryptography	単位数 Credit	**2**
担当教員 Instructor	山田　徳史　YAMADA Norifumi 山上　智幸　YAMAKAMI Tomoyuki	開講学期 Semester	春学期 Spring
キーワード Keywords	wave-particle duality, wave function, Schrödinger equation, tunneling effect,	曜日/時限 Day & Time	

授業概要　Course summary

量子力学は我々の世界の基本法則です。ここ数十年に渡り、量子力学の計算機科学（特に量子計算と量子暗号）への応用が進んできました。本授業は量子計算と量子暗号の基礎について学びます。授業の前半では量子力学の基礎について学び、後半では量子計算と量子暗号について学びます。

Quantum mechanics is believed to govern our world and it is worth exploring its basic nature and promoting our understandings of this physics principle. In the past few decades, researchers have sought its application to computer science, particularly, quantum computation and quantum cryptography. This course aims at providing a basic knowledge on quantum computation and quantum cryptography, which have been developed solely on quantum mechanics. The lecture begins with exploring basics of quantum mechanics, which is a core concept of this course. Based on this concept, the lecture will move to an introduction of two important applications: the theories of quantum computational complexity and quantum cryptography.

Selected topics include:

(1) basic principles of quantum mechanics;

(2) quantum decoherence, quantum information;

(3) quantum Turing machines, quantum one-way functions, quantum hardcore, quantum list-decoding.

到達目標　Course goal

・understand the basic concepts of quantum mechanics
・understand the relationship between the time dependent and the time independent Schrödinger equations
・able to solve the time independent Schrödinger equation for simple potentials
・a better understanding of quantum computation and cryptography
・a better understanding of classical computational complexity theory

授業内容　Course description

1. particle and wave nature of quantum mechanical particle (double slit experiment)
2. wave function and its probabilistic interpretation
3. time dependent Schrödinger equation
4. time independent Schrödinger equation
5. eigenfunction expansion of time dependent wave functions
6. example of energy eigenstates (1)
7. example of energy eigenstates (2)
8. classical complexity theory I
9. classical complexity theory II
10. quantum information basics
11. quantum finite automata

12. quantum state complexity
13. quantum interactive proof systems
14. quantum list decoding
15. quantum cryptography

準備学習（予習・復習）等　Preparation / Review

Preparation: Check the meaning of the following words/terms before the class begins.
1. wave-particle duality, double-slit experiment
2. wave function, probability interpretation of wave function
3. Einstein's light quanta hypothesis, De Broglie's hypothesis
4. energy eigenstates
5. orthogonality and completeness of energy eigenstates
6. method for solving the second order ordinary differential equations
7. tunneling effect
8. classical complexity theory I
9. classical complexity theory II
10. quantum information basics
11. quantum finite automata
12. quantum state complexity
13. quantum interactive proof systems
14. quantum list decoding
15. quantum cryptography

Review: Make a summary of the class content soon after the class ends. Submit the reports when required.

授業形式　Class style

教科書、プリント、あるいはその他参考資料を用いた授業です。講義とペアになる演習はありません。
The lectures will be given weekly based on the textbook, printout, or other references provided or specified by each lecturer. There is no special exercise classes that supplement the lectures.

成績評価の方法・基準　Method of evaluation

期末試験により評価します。講義で扱った内容の６０％以上を理解していると認められるときに単位を認定します（60%～70%が可、70%～80%が良、80%～90%が優、90%～100%が秀）。
The progress of each student will be measured by oracle examinations after the end of the course. If his/her understandings exceed more than 60% of what the whole lectures cover, then he/she will pass the course.
S(Excellent):90%-100%, A(Very Good):80%-90%, B(Good):70-80%, C(Fair):60-70%, F(Fail):Below 60%

教科書・参考書等　Textbook and material

前半では教科書は指定しません（参考となる web ページを紹介します)。
In the first part of the class, no textbooks are specified (helpful web pages will be shown instead).

受講要件・予備知識　Prerequisite

微分積分と線形代数の基礎知識と計算力、ならびにチューリングマシンなどの計算機科学に関する基礎知識を有すること。それらの有無を試験によって判断することもあります。試験の結果によっては、受講できないことがあります。
Those who want to take this course must have skills of calculus（differentiation and integration）, linear algebra, and a basic understanding of “computation” (Turing machines etc.). There might be a qualification exam to check basic knowledge on these subjects. If the score is low, the student is not qualified to take this course.
この授業は対面で行います（コロナの感染状況が落ち着いている限り）。
This is a face-to-face class unless the status of COVID-19 requires a shift to online learning.

その他の注意事項　Note
このシラバスの内容は、担当者が学生に事前に周知した上で変更されることがあります。 This syllabus is subject to revision with prior notification to the students by the instructors.