科目名　Course Title	
電気磁気物性(Electromagnetic Materials)	
学科・専攻　Department/Program	**受講年次　Grade**
G30 Physics	3rd
授業形態　Class style	**必修・選択の別　Compulsory or Elective**
講義	* See "Remarks"
時間割コード　Registration code	**開講期・曜日・時限　Semester,Day & Period**
0680150	春学期 月：5
単位数　Credit	**科目区分　Course type**
2	

担当教員　Instructor	WOJDYLO John Andrew(WOJDYLO John Andrew)
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居室　Room	ES035

講義の目的とねらい　Course purpose

This course will be called Quantum Mechanics 3 after 2018.

This unit is the second half of a full-year course. Building on Quantum Mechanics 2, students will learn quantum mechanics at an advanced undergraduate level. The course will build physical intuition of Hilbert space and Nature on the quantum scale while improving students ’ ability to express physical intuition in mathematical terms and to solve problems. Students will learn not to be overwhelmed by mathematical symbols, and to discern the simplicity of physical principles expressed by them.

Topics include: Symmetry and conservation laws; theory of angular momentum (including addition of angular momentum); solution of rotationally invariant problems; the (spinless) hydrogen atom; Spherical tensor operators and selection rules: Wigner-Eckart Theorem; The Variational Method and WKB Approximation; Time-independent perturbation theory (non-degenerate and degenerate cases); Time-dependent perturbation theory; introduction to scattering theory.

Students will be adequately prepared with regards to their knowledge of quantum mechanics to undertake further studies in S-lab, E-lab, H-lab, R-lab, TB-lab and other, experimental labs in both the Department of Physics and Department of Applied Physics at Nagoya University. A knowledge of the principles is essential for students interested in experimental physics and theoretical physics. Students from other disciplines, such as chemistry, can also benefit from the deep treatment of quantum phenomena.

履修要件　Prerequisite

Quantum Mechanics 2 or Consent of Instructor.

• Students must have passed Quantum Mechanics 2 to take Quantum Mechanics 3.

履修取り下げについて　Course withdrawal

<可否>　Possible
<条件>
Withdraw by the official deadline in May.

成績評価　　Grading

Attendance: 5%; Weekly quizzes or other written assessment: 30%; Mid-term exam: 32.5%; Final Exam: 32.5%

不可（F）と欠席の基準　　Criteria for "Absent" &"Fail" grades

The “ Absent ” grade is reserved for students who withdraw by the official deadline in May. After that day, a letter grade will be awarded based on marks earned from all assessment during the semester.

関連する科目　　Related courses

Physics Tutorial IV. It is strongly advised that students concurrently enroll in Physics Tutorial IV.

教室　　Class room

Check the Course Timetable.

授業内容　　Content

Course Contents Shankar Chapts 11-19 (some parts omitted); parts of Cohen-Tannoudji et. al, Sakurai, Merzbacher, Gottfried. Some topics are covered in tutorials.

Lecture 1. Translational invariance and its consequences. Active and passive views. Transformation of operators. Infinitesimal translations. Finite translations. Correspondence with translations in Euclidean space. Translational invariance defined. Consequence: a certain conservation law. Translational invariance in two dimensions: importance of commutation of generators.

Lecture 2. Invariance and conservation laws cont'd. Time translation invariance; parity invariance; resultant conservation laws. Formal correspondence between generators of infinitesimal canonical transformations and generators of infinitesimal unitary transformations. Time-reversal symmetry and anti-linear operators: Wigner's Theorem.

Lecture 3. Rotational invariance and its consequences. Rotations in Euclidean space do not commute: derivation of commutation relations between generators of infinitesimal rotations in Euclidean space. Consequence: commutation relations in Hilbert space (and quantum mechanics). Conservation of angular momentum.

Lecture 4. Rotational invariance and angular momentum. Rotations in 2D: correspondence between those in Euclidean space and Hilbert space. Identifying the generator of infinitesimal rotations in Hilbert space. Active and passive views. Consistency checks: composition of translations and rotations in Hilbert space and Euclidean space. Lie algebra. The eigenvalue problem of L_z. Angular momentum in 3D and the eigenvalue problem of J^2 and J_z. Matrix representation: block diagonal forms and partitioning of Hilbert space.

Lecture 5. Rotational invariance and angular momentum cont'd. Finite rotation operators. Irreducible representations. Orbital angular momentum eigenfunctions in the coordinate basis. Solution of rotationally invariant problems. The free particle in spherical coordinates.

Lecture 6. Solution of rotationally invariant problems cont'd. Radial equation, reduced radial equation, boundary conditions. The (spinless) hydrogen atom in coordinate basis; quantization condition. Eigenfunctions. Also in momentum basis.

Lecture 7. The (spinless) hydrogen atom cont'd. Cause of "unexpected" degeneracy. Comparison with experiment; reasons for deviations. Fine structure corrections; hyperfine structure corrections. Spin. Mathematical representation of spin: spinors and their generalization. Response of vector field Ψ(r) under infinitesimal rotation produces two kinds of generators of infinitesimal rotations, corresponding to orbital and intrinsic angular momentum operators. Kinematics: properties of the Pauli spin matrices. Spin dynamics. Classical magnetic moment suggests form of spin magnetic moment operator. Derivation of Bohr magneton in the Coulomb gauge. Time evolution of spinors.

Lecture 8. Addition of angular momentum. Clebsch-Gordon coefficients.

Lecture 9. Spherical tensor operators and selection rules: Wigner-Eckart Theorem. Irreducible tensor operators. Explanation of "accidental" degeneracies.

Lecture 10. Addition of L and S. The Variational Method and WKB Approximation. Tunneling amplitudes; bound states.

Lecture 11. Time-independent Perturbation Theory (non-degenerate case). 1st order and 2nd order energy corrections; 1st order correction to wave function. Dipole selection rule. Example: Stark effect.

Lecture 12. Time-independent Perturbation Theory (degenerate case). Time-dependent Perturbation Theory. Transition rate. Sudden perturbation. Adiabatic perturbation.

Lecture 13. Time-dependent Perturbation Theory cont'd. Periodic perturbation. Fermi's Golden Rule. Gauge transformations, invariance of QM under gauge transformation. Photoelectric effect in the hydrogen ground state.

Lecture 14. Elementary introduction to scattering theory. Definition of scattering cross-sections. Calculation of the cross-section using probability currents. Expression for the cross-section in terms of scattering amplitude. Born series, Born approximation. Physical interpretation.

Lecture 15. Scattering theory cont ' d. Scattering from a central potential using the method of partial waves. Higher orders in perturbation theory: Schroedinger picture, Interaction picture, Heisenberg picture.

教科書　Textbook

Shankar, R., 1994, Principles of Quantum Mechanics, 2nd ed., Kluwer Academic/Plenum.

参考書　Recommended reading

1. Cohen-Tannoudji, C., Diu, B., Laloe, F., Quantum Mechanics, Wiley, 1991.
(This book complements, and at times supersedes, the treatment in Shankar.)

2. Merzbacher, E., Quantum Mechanics, 3rd Ed., Wiley, 1998.
(Merzbacher was one of the best teachers of quantum mechanics.)

3. Sakurai, J. J., Napolitano, Jim J., Modern Quantum Mechanics (2nd Ed.), Addison-Wesley, 2010.
(This book complements, and at times supersedes, the treatment in Shankar.)

4. Messiah, A., Quantum Mechanics (2 Volumes), Dover, 2015.
(Highly recommended, classic alternative reading. Cheap to buy.)

5. Gottfried, K. and Yan, T.-M., 2004, Quantum Mechanics: Fundamentals, Springer.
(Most of this book is too hard for undergraduates but several sections are at the right level and very clear. Consult this book as an authoritative reference.)

連絡方法　Contact method

その他　Remarks

*See Course List and Graduation Requirements for your program for your enrollment year.
Students must be willing to work hard to achieve a good, internationally competitive level.