Physics 651: Quantum Mechanics
Syllabus - Fall 2024

CRN: 74497, F01

Lecture: **MWF 11:45-12:45, REIC 207**

Instructor: Ataur R. Chowdhury

Office: REIC 118

Office Hours: MTW 10:30-11:30 am, and any other time I am in my office.

Contact: Phone (907) 474-6109
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Prerequisites: Graduate standing or permission of instructor**.**

Text: ***Principles of Quantum Physics,*** R. Shankar, Second Edition, Plenum Publishers. (ISBN 0-306-44790-8).

Useful Resources: Undergraduate texts:
1) R. F. Feynman, et al. (The Feynman Lectures on Physics, Vol. 3);
2) S. Gasiorowics (Quantum Physics);
3) L. I. Schiff (Quantum Mechanics);
Graduate texts:
1) R. L. Liboff (Introduction to Quantum Mechanics);
2) A. Messiah (Quantum Mechanics);
3) E. Merzbacher (Quantum Mechanics);
4) J. J. Sakurai (Quantum Mechanics); and
5) G. Baym (Lectures on Quantum Mechanics).

Description: Wave-particle duality; wave packets and uncertainty relations; Schroedinger equation and probability interpretation; eigenfunctions and eigenvalues; problem involving one dimensional potentials (steps.\, barriers, harmonic oscillator, tunneling, and periodic lattice); general structure of wave mechanics; operator methods; Schroedinger equations in two dimensions; Schroedinger equations in three dimensions; spherically symmetric potentials; operator matrics, and spin; addition of angular momentua; and (time independent perturbation theory).

Schedule: Materials covered in this course will be based on chapters 1-12 of Shankar. Additional material will be provided in class as needed.

Course Objective:

1. To acquire a basic understanding of advanced concepts and formulation of quantum mechanics.

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2. To learn advanced mathematical methods that are useful trough-out physics.

3. To develop and sharpen high-level problem solving skills.

4. To be able to apply the knowledge learned in this course to real-world problems in quantum mechanics and related fields.

Student Learning Outcomes:

1. Understand the basic postulates of quantum mechanics.
2. Apply quantum formalism to solving physical problems.
3. Learn the art of Schroedinger equation, and its application to simple systems.
4. Apply Schroedinger equation to solve problems involving two and three dimensions.
4. Exploit the symmetry in quantum formalism.
5. Understand the rotational symmetry and its consequences.
6. Learn angular momentum based on symmetry.

Credits: 3 credits: 3 hr. of lecture per week.

Course Requirements/ Policies:

Class Attednence/Participation:
For a better understanding of the course material, attendance and participation in classroom activities are very important. For many of you this will be the first graduate physics course that deals with the fundamentals of advanced concepts in quantum mechanics and many of you may find this course a little difficult and mathematically intense. However, if you attend classes and work out all the assignments, you will learn and possibly master the material. This is why it is highly expected that the students will commit themselves to attend the class regularly. There will be supplemental materials for this course and the students will be held responsible for all the materials that will be brought in from outside the text. The students will be expected to participate in class activities, and take part in meaningful discussion and ask questions to better comprehend the subject material. Because of COVID-19, a regular class attendance will be recorded.

Homework:
Homework is the single most important aspect of this course. The best possible way to learn physics, and perhaps any science, is through doing problems. This is a graduate course and you may find homework challenging. However, if you find your homework difficult, please come and ask me for help. On the average, 5-8 problems will be assigned on most Fridays. The homework will be due back at the beginning of class the following Friday. NO LATE

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HOMEWORK WILL BE ACCEPTED. NO EXCEPTIONS (barring emergencies and extreme situations). The homework will be posted on the blackboard, and your solutions need to be submitted on the blackboard.
Group work is extremely effective in achieving a greater understanding of the subject material, and it is highly encouraged for solving problems. For additional help with the homework the students are most welcome to consult the instructor during the office hour or any other time by prior appointment. Any homework you submit should reflect you own best effort. **Copying of homework from your friend or any online sources is absolutely not acceptable and will result in a grade of zero for the assignment.**

Examinations:
There will be a midterm examination (October , Friday 1:00-2:00) and a final comprehensive examination (December 9, Wednesday, 11:15 am-2:15) for this course. Examinations will consist of, in most part, problems similar to those in the homework and those worked out in class. Midterm will cover the material covered in class and homework up to the date of test, and the final will be comprehensive and will include material covered during the entire semester. All exams will be held in class and solutions have to be uploaded on the blackboard.

Paper:
For most graduate courses, it is customary that a paper is required to explore the field a little more than it is done in classroom setting. Quantum mechanics is continuously evolving and is being employed in many other fields outside physics. To explore its contemporary development, you will be required to write a paper that adds something outside the scope of this course. You can delve into some exciting development of quantum mechanics in medicine, in biotechnology, in nanotechnology, computer computing, etc., and pick your topic. You could also choose an advanced topic in quantum mechanics or any related field. This paper does not have to original piece of work, but has to be part of some work that ongoing or some work that has been published in reputable scientific journals. The paper should be limited to 5-6 pages (not including references) pages, and the format of this paper should follow the format of any published article in a reputable journal. The paper will graded mainly on merit of its physics (70%), clarity of its concept (20%), and its style (10%) of presentation. An outline for this paper is due on September 5, 2020, and the written paper is due on November 20, 2020. The outline and paper need to be submitted on the blackboard.

University AI Policy:
UAF does not have yet a central university policy for AI to be abided by. Depending how you use this, this could be very useful tool for learning. But please make sure you are using AI to cheat and copy things out of online sources of any kind. The university takes cheating seriously and it reserves the right to take lawful actions.

Grading Policy:

Homework	30%
Participation	5%

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Paper	10%
Midterm	20%
Final	35%
Total	100%

The final grading for this course will be based on a curve. For a given score, your letter grade will not be lower than what it would be expected based on standard grading scale (90-100 = A, 80-90 = B, etc.). Allowed grades are limited to letter grades A,B,C,D,F,I,BN, and no plus-minus grades will be given for this course.

Incomplete Grade Policy: "The letter "I" (Incomplete) is a temporary grade used to indicate that the student has satisfactorily completed (C or better) the majority of work in a course but for personal reasons beyond the student's control, such as sickness, has not been able to complete the course during the regular semester. Negligence or indifference are not acceptable reasons for an "I" grade."

Syllabus Addendum (Revised 8/22/2022)

COVID-19 statement: Students should keep up-to-date on the university's policies, practices, and mandates related to COVID-19 by regularly checking this website:
https://sites.google.com/alaska.edu/coronavirus/uaf?authuser=0
Further, students are expected to adhere to the university's policies, practices, and mandates and are subject to disciplinary actions if they do not comply.

Student protections statement: UAF embraces and grows a culture of respect, diversity, inclusion, and caring. Students at this university are protected against sexual harassment and discrimination (Title IX). Faculty members are designated as responsible employees which means they are required to report sexual misconduct. Graduate teaching assistants do not share the same reporting obligations. For more information on your rights as a student and the resources available to you to resolve problems, please go to the following site: https://catalog.uaf.edu/academics-regulations/students-rights-responsibilities/.

Disability services statement: I will work with the Office of Disability Services to provide reasonable accommodation to students with disabilities.

ASUAF advocacy statement: The Associated Students of the University of Alaska Fairbanks, the student government of UAF, offers advocacy services to students who feel they are facing issues with staff, faculty, and/or other students specifically if these issues are hindering the ability of the student to succeed in their academics or go about their lives at the university. Students who wish to utilize

these services can contact the Student Advocacy Director by visiting the ASUAF office or emailing asuaf.office@alaska.edu.

Student Academic Support:

- Speaking Center (907-474-5470, uaf-speakingcenter@alaska.edu, Gruening 507)
- Writing Center (907-474-5314, uaf-writing-center@alaska.edu, Gruening 8th floor)
- UAF Math Services, uaf-traccloud@alaska.edu, Chapman Building (for math fee paying students only)
- Developmental Math Lab, Gruening 406
- The Debbie Moses Learning Center at CTC (907-455-2860, 604 Barnette St, Room 120, https://www.ctc.uaf.edu/student-services/student-success-center/)
- For more information and resources, please see the Academic Advising Resource List (https://www.uaf.edu/advising/lr/SKM_364e19011717281.pdf)

Student Resources:

- Disability Services (907-474-5655, uaf-disability-services@alaska.edu, Whitaker 208)
- Student Health & Counseling **[6 free counseling sessions]** (907-474-7043, https://www.uaf.edu/chc/appointments.php, Gruening 215)
- Center for Student Rights and Responsibilities (907-474-7317, uaf-studentrights@alaska.edu, Eielson 110)
- Associated Students of the University of Alaska Fairbanks (ASUAF) or ASUAF Student Government (907-474-7355, asuaf.office@alaska.edu, Wood Center 119)

Nondiscrimination statement: The University of Alaska is an affirmative action/equal opportunity employer and educational institution. The University of Alaska does not discriminate on the basis of race, religion, color, national origin, citizenship, age, sex, physical or mental disability, status as a protected veteran, marital status, changes in marital status, pregnancy, childbirth or related medical conditions, parenthood, sexual orientation, gender identity, political affiliation or belief, genetic information, or other legally protected status. The University's commitment to nondiscrimination, including against sex discrimination, applies to students, employees, and applicants for admission and employment. Contact information, applicable laws, and complaint procedures are included on UA's statement of nondiscrimination available at www.alaska.edu/nondiscrimination. For more information, contact:
UAF Department of Equity and Compliance
1692 Tok Lane, 3rd floor, Constitution Hall, Fairbanks, AK 99775
907-474-7300
uaf-deo@alaska.edu

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Additional syllabi statement for courses including off-campus programs and research activities:

University Sponsored Off-Campus Programs and Research Activities

We want you to know that:

1. UA is an AA/EO employer and educational institution and prohibits illegal discrimination against any individual: www.alaska.edu/nondiscrimination.
2. Incidents can be reported to your university's Equity and Compliance office (listed below) or online reporting portal. University of Alaska takes immediate, effective, and appropriate action to respond to reported acts of discrimination and harassment.
3. There are supportive measures available to individuals that may have experienced discrimination.
4. University of Alaska's Board of Regents' Policy & University Regulations (UA BoR P&R) 01.02.020 Nondiscrimination and 01.04 Sex and Gender-Based Discrimination Under Title IX, go to: http://alaska.edu/bor/policy-regulations/.
5. UA BoR P&R apply at all university owned or operated sites, university sanctioned events, clinical sites and during all academic or research related travel that are university sponsored.

For further information on your rights and resources click here.

Tentative Schedule

Lecture, Reading, Paper and Exam

Week	Date	Topics	Reading Assignment
1	8/26-8/30	classical vs. quantum, wave-particle duality	Shankar chapter 3
2	9/2-9/6	wave packet and uncertainty relations **Labor Day 9/7**	Shankar chapter 3 Shankar chapter 9
3	9/7-9/11	Hermitian operator, vector and operators, Dirac representation	Shankar chapter 1
4	/14-9/18	postulates of QM,	Shankar chapter 4

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		measurement in QM	
5	9/21-9/25	Schroedinger equation, infinite square well potential	Shankar chapter 5
6	9/28-10/2	delta potential, scattering, step potential, tunneling	Shankar chapter 5
7	10/5-10/9	harmonic oscillator **Outline for paper due Monday**	Shankar chapter 7
8	10/12-10/16	classical limit: Ehrenfest theorem	Shankar chapter 6
9	10/19-10/23	Feynman's path integral **Midterm Friday 10/23**	Shankar chapter 8
10	10/26-10/30	many particle system, identical particles	Shankar chapter 10
11	11/2-11/6	symmetry consideration in QM, translational invariance	Shankar chapter 11
12	11/9-11/13	time translation, parity, time reversal symmetry	Shankar chapter 11
13	11/16-11/20	rotational invariance and angular momentum **Paper due this Friday**	Shankar chapter 12
14	11/23-11/27	eigenvalue problems of angular of angular momentum **Thanksgiving Break Nov. 25-29**	Shankar chapter 12
15	11/30-12/4	angular momentum in two and Three dimensions	Shankar chapter 12
16	12/13	**FINAL**: 10:15-12:15 …….All the best…	