

Physics 652: Quantum Mechanics Syllabus - Spring 2021

CRN: 34945, F01

Lecture: MWF 1:00-2:00 PM, REIC 207

Instructor: Ataur R. Chowdhury

Office: REIC 118

Office Hours: MW 4:00-5:30 pm, and any other time I am in my office.

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Prerequisites: PHYS 651 or the equivalent 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: Schrodinger's equations, operator formalism, correspondence principle, central force problems, perturbation theory, quantum statistical mechanics, and applications of quantum mechanics to collision problems, radiation and spectroscopy.

Course Objective:

1. To acquire a basic understanding of advanced concepts and formulation of quantum mechanics.
2. To learn advanced mathematical methods that are useful through-out physics.
3. To develop and sharpen high-level problem solving skills.

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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 Schrodinger equation, and its application to simple systems.
4. Apply Schrodinger 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.
7. Learn approximation methods of solving quantum problems.
8. Understand the physics of particle scattering.
9. Learn rudimentary theory of EM radiation.

Instructional methods: Interactive lecture based instruction

Mode of Instruction: Face-to face live lectures in class

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

Course Requirements/ Policies:

Class Attendance/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 second 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

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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 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 your 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 (February 19, Friday 1:00-2:00 PM) and a final comprehensive examination (April 27, Wednesday, 1:30 -4:00 PM) 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 submitted on papers.

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 be an original piece of work, but has to be part of some work that is 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 be 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 February 8, 2021, and the written paper is due on April 9, 2021. The outline and paper need to be submitted on the blackboard.

Grading Policy:

Homework	35%
Participation	5%
Paper	10%
Midterm	20%
<u>Final</u>	<u>30%</u>

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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.”

Academic Honesty

UAF expects and requires academic honesty from all members of the University community, and takes any act of plagiarism and cheating seriously. It is expected that all assignments, including homework and reports, that are turned in for this course must be the original work of the individual student. Failure to comply with this policy will result in penalty as stipulated under UAF regulations.

Student Protections and Services:

COVID-19 Essentials: Because of COVID-19, University has put in place some mandatory procedures to adhere to. All student are encouraged to observe these rules to ensure a safe environment for all of us for a successful fall semester. I request all of you to do the following:

- 1) Wear mask during class,
- 2) Maintain social distancing in class,
- 3) Use designated doors for entering and exiting,
- 4) Try to sit at the same place in class (for tracing),
- 5) Check updates about COVID-19 on the website listed below on a regular basis.

<https://sites.google.com/alaska.edu/coronavirus/uaf/uaf-students?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.

Protection: Every qualified student is welcome in my classroom. Students at this university are protected against sexual harassment and discrimination (Title IX), and minors have additional protections. As required, if I notice or am informed of certain types of misconduct, then I am required to report it to the appropriate authorities. For more information on your rights as a student and the resources available to you to resolve problems, please go the following site: www.uaf.edu/handbook

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UA is an AA/EO employer and educational institution and prohibits illegal discrimination against any individual: alaska.edu/nondiscrimination.

Services: As needed, I am happy to work with you, disability services, veterans' services, rural student services, etc to find reasonable accommodations.

Effective communication: Students who have difficulties with oral presentations and/or writing are strongly encouraged to get help from the UAF Department of Communication's Speaking Center (907-474-5470, speak@uaf.edu) and the UAF English's Department's Writing Center (907-474-5314, Gruening 8th floor), and/or CTC's Learning Center (604 Barnette st, 907-455-2860).

Disabilities Services

The UAF Office of Disability Services implements the Americans with Disabilities Act (ADA), and insures that UAF students have equal access to the campus and course materials. Any student who may need assistance with disabilities, should feel free to contact the instructor or directly to the Office of Disabilities Services (208 WHIT) by calling 907- 474-5655, or through email: uaf-disability-service@alaska.edu.

General Remarks

"Physics is just the refinement of everyday thinking," A. Einstein

Physics is the subject that requires you to think and ponder. Physics is not mathematics, but it does require mathematics to make it useful. In order for you to succeed in this course you may pay heed to the following suggestions.

1. Read the chapter before it is discussed in class so that you know the material and know what questions to ask for clarification.
2. Start your homework on day one so that you have ample time to think about the questions and get the help you need.
3. Think the problems through and follow the logical sequence to get the result.
4. Do not hesitate to ask for help. We wish all of you to excel and we are here to help.

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Tentative Schedule

Lecture, Reading, Paper and Exam

<u>Week</u>	<u>Date</u>	<u>Topics</u>	<u>Reading Assignment</u>
1	1/11-1/15	angular momentum in two and three dimensions	Shankar chapter 12
2	1/18-1/22	Hydrogen atom, comparison with experiments Civil Rights Day 1/18 (no class)	Shankar chapter 13 Shankar chapter 13
3	1/25-1/29	many electron atoms, periodic table	Shankar chapter 13
4	2/1-2/5	kinematics of spin, rotational operators	Shankar chapter 14
5	2/8-2/12	spin dynamics, EPR, Stern-Gerlach experiment Outline for paper due Monday	Shankar chapter 14
6	2/15-2/19	addition of angular momenta, Clebsch_Gordon coefficients, Midterm Friday 2/19	Shankar chapter 15
7	2/22-2/26	Approximation methods, variational principle,	Shankar chapter 16
8	3/1-3/5	WKB approximation, Time-independent perturbation	Shankar chapter 16 Shankar chapter 17
9	3/8-3/12	degenerate perturbation with examples	Shankar chapter 17
10	3/15-3/19	time-dependent perturbation, first order approximation	Shankar chapter 18
11	3/22-3/26	higher order perturbations, EM radiation	Shankar chapter 18

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12	3/29-4/2	one dimensional scattering, time-dependent Born approximation	Shankar chapter 19
13	4/5-4/9	time-independent Born approximation, partial wave expansion Paper due this Friday	Shankar chapter 19
14	4/12-4/16	free particle Dirac equation	Shankar chapter 20
15	4/19-4/23	EM interaction of Dirac particles, spin	Shankar chapter 20
16	4/26	students' project presentation	
	4/27	FINAL: 1:30-4:00All the best...	
