

Mathematical Methods in Quantum Mechanics (MATH 5399)

Instructor: Răzvan Gelca

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Time of class: Tuesday and Thursday: 2:00-3:30

Office Hours: By appointment, maybe by Zoom.

Text book: Lecture notes will be posted on instructor's web page. The course will use input from the books *Quantum Theory for Mathematicians*, by Brian C. Hall (Springer), *Lectures on Quantum Mechanics for Mathematics Students*, by L.D. Faddeev and O.A. Yakubovskii (AMS), and *Theta Functions and Knots* by Răzvan Gelca, but will not follow these books closely. The instructor will develop his OWN lecture notes.

Description of the course: The instructor intends to make the material accessible to students with various backgrounds. For this reason the course will start with a short overview of classical mechanics, followed by a description of the issues that lead to the discovery of quantum mechanics. Among the topics to be covered are:

- the real- and complex-valued models for the position and momentum operators, the Heisenberg uncertainty principle, and the Stone-von Neumann theorem,
- the problem of quantization and the Groenewold-van Hove theorem, and the model of Weyl quantization,
- the Schrödinger equation solved for several particular examples,
- the harmonic oscillator,
- the quantization of the angular momentum and its relationship to the representation theory of Lie groups, and the spin,
- the hydrogen atom,
- some basic facts about geometric quantization.

All necessary notions and results from differential geometry, representation theory, functional analysis, and differential equations will be introduced and explained. The aim of this course is to display a menagerie of mathematical methods that relevant to quantum theory, to show how combining tricks from various areas of mathematics helps us unlock the secrets of nature.

Learning outcomes: The students should learn the fundamentals of quantum mechanics which, hopefully, will help them become more competitive on the job market.

Assessment of learning outcomes: There will be three easy in class exams over the fundamental concepts and results taught.

Other matters:

ADA accommodations (TTU Operating Policy 34.22). Any student who, because of a disability, may require special arrangements in order to meet the course requirements should contact the instructor as soon as possible to make any necessary arrangements. Students should present appropriate verification from Student Disability Services during the instructors office hours. Please note: instructors are not allowed to provide classroom accommodations to a student until appropriate verification from Student Disability Services has been provided. For additional information, please contact Student Disability Services in West Hall or call 806-742-2405.

Absence for observance of a religious holy day (TTU Operating Policy 34.19). 1. "Religious holy day" means a holy day observed by a religion whose places of worship are exempt from property taxation under Texas Tax Code 11.20. A student who intends to observe a religious holy day should make that intention known in writing to the instructor prior to the absence. A student who is absent from classes for the observance of a religious holy day shall be allowed to take an examination or complete an assignment scheduled for that day within a reasonable time after the absence. A student who is excused may not be penalized for the absence; however, the instructor may respond appropriately if the student fails to complete the assignment satisfactorily.

Academic Honesty (TTU Operating Policy 34.12). It is the aim of the faculty of Texas Tech University to foster a spirit of complete honesty and high standard of integrity. The attempt of students to present as their own any work not honestly performed is regarded by the faculty and administration as a most serious offense and renders the offenders liable to serious consequences, possibly suspension. Scholastic dishonesty includes, but is not limited to, cheating, plagiarism, collusion, falsifying academic records, misrepresenting facts, and any act designed to give unfair academic advantage to the student (such as, but not limited to, submission of essentially the same written assignment for two courses without the prior permission of the instructor) or the attempt to commit such an act.

TTU Resources for Discrimination, Harassment, and Sexual Violence: Texas Tech University is committed to providing and strengthening an educational, working, and living environment where students, faculty, staff, and visitors are free from gender and/or sex discrimination of any kind. Sexual assault, discrimination, harassment, and other Title IX violations are not tolerated by the University. Report any incidents to the Office for Student Rights and Resolution, (806)-742-SAFE (7233) or file a report online at titleix.ttu.edu/students. Faculty and staff members at TTU are committed to connecting you to resources on campus. Some of these available resources are: TTU Student Counseling Center, 806-742-3674, <https://www.depts.ttu.edu/scc/> (Provides confidential support on campus.) TTU Student Counseling Center 24-hour Helpline, 806-742-5555, (Assists students who are experiencing a mental health or interpersonal violence crisis. If you call the helpline, you will speak with a mental health counselor.) Voice of Hope Lubbock Rape Crisis Center, 806-763-7273, voiceofhopelubbock.org (24-hour hotline that provides support for survivors of sexual violence.) The Risk, Intervention, Safety and Education (RISE) Office, 806-742-2110, rise.ttu.edu (Provides a range of resources and support options focused on prevention education and student wellness.) Texas Tech Police Department, 806-742-3931, <http://www.depts.ttu.edu/tttd/> (To report criminal activity that occurs on or near Texas Tech campus.)

Standard rules regarding the Coronavirus (which apply to both face-to-face and online classes)

If at any time during this semester you feel ill, in the interest of your own health and safety as well as the health and safety of your instructors and classmates, you are encouraged not to attend

face-to-face class meetings or events. Please review the steps outlined below that you should follow to ensure your absence for illness will be excused. These steps also apply to not participating in synchronous online class meetings if you feel too ill to do so and missing specified assignment due dates in asynchronous online classes because of illness.

1. If you are ill and think the symptoms might be COVID-19-related:

- a) Call Student Health Services at 806.743.2848 or your health care provider.
- b) Self-report as soon as possible using the Dean of Students COVID-19 webpage. This website has specific directions about how to upload documentation from a medical provider and what will happen if your illness renders you unable to participate in classes for more than one week.
- c) If your illness is determined to be COVID-19-related, all remaining documentation and communication will be handled through the Office of the Dean of Students, including notification of your instructors of the period of time you may be absent from and may return to classes.
- d) If your illness is determined not to be COVID-19-related, please follow steps 2.a-d below.

2. If you are ill and can attribute your symptoms to something other than COVID-19:

- a) If your illness renders you unable to attend face-to-face classes, participate in synchronous online classes, or miss specified assignment due dates in asynchronous online classes, you are encouraged to visit with either Student Health Services at 806.743.2848 or your health care provider. Note that Student Health Services and your own and other health care providers may arrange virtual visits.
- b) During the health provider visit, request a return to school note.
- c) E-mail the instructor a picture of that note.
- d) Return to class by the next class period after the date indicated on your note. Following the steps outlined above helps to keep your instructors informed about your absences and ensures your absence or missing an assignment due date because of illness will be marked excused. You will still be responsible to complete within a week of returning to class any assignments, quizzes, or exams you miss because of illness.