

STS-UY.2294 Quantum Mechanics and Information

Department of Technology, Culture and Society; NYU-Tandon

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Off. Hr: Zoom, Weds 12:30-1:30pm remote
Office: 2 MetroTech, 9th Fl., Rm929

6 MetroTech Center Rm211
Tu/Th 2:00-3:50pm
Fall 2025

I. Instructional Format: Instruction will be conducted in-class, unless circumstances require otherwise. Please be aware of the NYU policy on face masks at [nyu.edu/life/safety-health-wellness/coronavirus-information/covid-related-guidance/protective-equipment.html](https://www.nyu.edu/life/safety-health-wellness/coronavirus-information/covid-related-guidance/protective-equipment.html). Masks are not required but welcome. As a reminder, if you are ill or are exhibiting symptoms of illness (coughing, sneezing, runny nose, etc.), you should stay home until you feel better and your symptoms are gone. It's ok to miss one or two lectures in this class: these can be easily made up by discussing any missed content with me. On the other hand, if you find yourself in a situation in which you will have to miss more than a week of lectures, please see Section VII.3.ii below. I will periodically remind the class of these policies over the course of the semester.

II. Description: Quantum mechanics is the best-confirmed theory of particle dynamics in existence today. Not only is it the basis for all digital technologies, it also serves as the theoretical foundation for our best-confirmed theories of matter (quantum field theories). On the other hand, since its inception, it has been beset with conceptual problems. In particular, there is no current consensus on just how to interpret it: What would the world be like, if it were true? In this course, we will first develop the theory from a conceptual and elementary mathematical perspective, and then canvass a number of proposals as to how it should be interpreted. A central part of the course will be on conceptual issues surrounding quantum information theory and current applications like quantum teleportation, quantum computing, and quantum cryptography. This course is geared towards students with minimal background in math, physics, or philosophy.

This is a 4-credit course that meets over a 15 week semester. You should expect to devote 6.6 hours per week of supplemental time for this course. Supplemental time is time outside of classroom instruction that involves reading assignments, writing, exam preparation, homework assignments, and study time. For additional information on NYU policies related to this, please see: www.nyu.edu/academics/accreditation-authorization-assessment/resources-faqs/required-weekly-minutes.html

III. Objectives

HuSS (Humanities and Social Sciences) General Education Objectives

Think critically, creatively and independently; demonstrate information literacy; demonstrate skills in inquiry and analysis; demonstrate effective oral communication and writing skills; bring the perspectives of HuSS to bear on technical discourse; demonstrate ethical reasoning.

STS (Science, Technology and Society) Cluster Objectives

- Demonstrate a basic understanding of the following:
 - How sci & tech shape society in historical, philosophical, sociological, and cultural ways.
 - How social processes frame sci & tech enterprises, including theory construction, invention, and innovation.
 - The relation between the content of sci/tech knowledge, and the social context in which it is created.
- Demonstrate technical proficiency in a field in the natural sciences or engineering.
- Demonstrate ability to critically analyze and communicate issues involving interactions among sci, tech, & society.

IV. Reading

A. At Bookstore or online via Bobst:

1. [A] Albert, D. (1992) *Quantum Mechanics and Experience*, HUP.
2. [H] Hughes, R. I. G. (1989) *The Structure and Interpretation of Quantum Mechanics*, HUP.

B. Online at course website:

3. [Ba] Barrett, J. (1999), *The Quantum Mechanics of Minds and Worlds*, OUP, pp. 221-242.
4. [Bu] Bub, J. (2019) "Quantum Entanglement and Information", *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.), plato.stanford.edu/entries/qt-entangle.
5. [LD] Lombard, O. & D. Dieks (2021) "Modal Interpretations of Quantum Mechanics", *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.), plato.stanford.edu/entries/qm-modal.
6. [F] French, S. (2019) "Identity and Individuality in Quantum Theory", *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.), plato.stanford.edu/entries/qt-idind.
7. [RP] Rieffel, E. and W. Polak (2000) "An Introduction to Quantum Computing for Non-Physicists", <https://arxiv.org/abs/quant-ph/9809016>.

V. Requirements: This course has two websites: A Brightspace website, brightspace.nyu.edu, and a public website, <https://research.engineering.nyu.edu/~jbain/philqm/index.html>.

1. **12 homework assignments.** These are posted in the Contents section in Brightspace. Please submit them by their due dates to links in the Brightspace Assignments folder. Your final homework grade will be calculated from the best 10 of your 12 assignment grades. Two optional extra credit assignments may also be submitted and will count towards your final homework grade.

Homework submission format: The preferred file type is .pdf. Please label the file you submit using the following format:

<assignment number>.<last name>_<first initial>.<file type>

Example: Jon Bain's .pdf submission for homework #7 should be labeled:

07.Bain_J.pdf

2. **One paper** of 5-7 pages. Suggested topics are posted in the Contents section in Brightspace.
 - (a) The paper must conform to writing guidelines that are posted in the Contents section of Brightspace and that will be explained in class. The use of AI is permitted to formulate and organize ideas, but the text of your paper should be your own, and not AI-generated.
 - (b) The paper should be submitted to the relevant link in the Assignments folder in Brightspace.

Submission format: The preferred file type is .pdf. Please label the file you submit using the following format:

Paper_<last name>_<first initial>.<file type>
 - (c) Late paper policy: There are no extensions on the due date. Late papers will be accepted but will be given a penalty of a third of a grade point for every period of 7 days after the due date. *Example:* An A paper turned in 1-7 days late will receive an A-; an A paper turned in 8-14 days late will receive a B+; an A paper turned in 15-21 days late will receive a B; etc. *Late papers cannot be accepted after the date of the final.*
3. **One midterm and one final.** Each exam will be in-class and consist of 8 short answer questions, of which you will be asked to pick 6 to respond to; and 3 short essay questions, of which you will be asked to pick 2 to respond to. A response to a short answer question should be no more than 1 paragraph in length (~3-4 sentences), and a response to a short essay question should be no more than 1 page in length (~3-4 paragraphs). Both will be closed-notes/closed-text/smart-phones off. Please be aware that rest-room breaks are prohibited during examinations. For the policy on makeup exams, please see Section VII.3.ii below.

VI. Grade Distribution: Homework: 25% total Midterm: 25% Paper: 25% Final: 25%

VII. Reminders on University Policies

1. **Inclusion Statement.** NYU values an inclusive and equitable environment for all students. I hope to foster a sense of community in this class and consider it a place where individuals of all backgrounds, beliefs, ethnicities, national origins, gender identities, sexual orientations, religious and political affiliations, and abilities will be treated with respect. It is my intent that all learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. If this standard is not being upheld, please feel free to speak with me.
2. **Moses Statement.** If you would like to request accommodations, please contact the Moses Center for Students with Disabilities (CSD) at 212-998-4980, mosescsd@nyu.edu, <https://www.nyu.edu/life/global-inclusion-and-diversity/centers-and-communities/accessibility.html>, 726 Broadway, 2nd Flr. You must be registered with CSD to receive accommodations.
3. **Standards and Procedures.** The NYU-Tandon Office of Student Affairs maintains a Community Standards and Procedures website at engineering.nyu.edu/life/student-affairs/community-standards-procedures. It contains information relevant to:
 - (i) **Incompletes.** It is NYU-Tandon policy that incompletes can be given only in extenuating circumstances (medical emergencies, accidents, *etc.*). An incomplete cannot be given because of a heavy course load, job commitments, or because you've simply fallen behind. For this reason, you should attend every lecture and make sure you're aware of assignment deadlines and exam dates. If you find yourself falling behind during the semester, do not hesitate to contact me. If you think you qualify for an incomplete grade at the end of the semester, see the procedure in (ii) below.
 - (ii) **Excuses due to illness or circumstances.** If you are experiencing an illness or any other situation, emotional or physical, that might affect your academic performance in a class (for instance, if you have to miss more than a week of lectures, or you think you qualify for an incomplete grade at the end of the semester), please email or schedule a visit with Deanna Rayment, Coordinator of Student Advocacy, Compliance and Student Affairs, Dibner Hall Room LC 240C, eng.studentadvocate@nyu.edu. Deanna is your official advocate at NYU-Tandon. (No other NYU school offers a similar service to its students!) She can reach out to your professor on your behalf when warranted. She can also advise you on all issues related to Health and Wellness. For legal and privacy reasons, you should not directly contact your professor with requests and concerns of this nature.
 - (iii) **University Honor System.** Please be aware of the university policy on cheating and plagiarism in the Student Code of Conduct. Cheating on an exam, or plagiarizing on an essay assignment, are sufficient reasons for receiving an F in the course. The Code of Conduct can be downloaded from the Office of Student Affairs website listed above.
4. **Grading Policy.** The following is NYU-Tandon's grading policy for all undergrad classes:

A	Excellent (4.000)	S	Satisfactory
A-	Excellent (3.667)	U	Unsatisfactory Progress
B+	Good (3.333)	W	Withdrew Officially
B	Good (3.000)	I	Incomplete (converts to F after 180 days)
B-	Good (2.667)	AUD	Auditor Status
C+	Satisfactory (2.333)	NR	No record
C	Satisfactory (2.000)	P	Passing
C-	Satisfactory (1.667)		
D+	Minimum Passing Grade (1.333)		
D	Minimum Passing Grade (1.000)		
F	Failure (0.000)		

VIII. Class Schedule

The following schedule may be subject to revision over the course of the semester. Reading assignments should be completed by the date on which they appear.

1	Tues 9/2. <i>The 2-Slit Experiment</i>	Thurs 9/4. <i>The 2-Path Experiment</i> [A] Chap 1; [H] Intro.
2	9/9. <i>A Modicum of Linear Algebra</i> [A] pp. 17-30; [H] Chap 1.	9/11. <i>Principles of Quantum Mechanics</i> [A] pp. 30-47; [H] Chaps 2, 3. hw1 due
3	9/16. <i>Entangled States</i> [A] pp. 47-60; [H] Chap 5.	9/18. <i>Entangled States, cont.</i> [A] Chap 3; [H] pp. 155-164. hw2 due
4	9/23. <i>EPR and Bell</i>	9/25. <i>EPR and Bell, cont.</i> [RP]; [Bu]. hw3 due
5	9/30. <i>Quantum Cryptography</i>	10/2. <i>Quantum Dense Coding</i> hw4 due
6	10/7. <i>Quantum Teleportation</i>	10/9. <i>Quantum Computation</i> hw5 due
7	10/14. Monday Classes Meet	10/16. <i>Quantum Computation, cont.</i> hw6 due
8	10/21. <i>Quantum Error Correction</i>	10/23. <i>Quantum Error Correction, cont.</i> hw7 due
9	10/28. Midterm	10/30. <i>The Kochen-Specker Theorem</i> Optional: [H] Chap 6, pp. 164-175.
10	11/4. <i>The Measurement Problem</i> [A] Chap 4; [H] Chap 9.	11/6. <i>GRW</i> [A] Chap 5. hw8 due
11	11/11. <i>Many Worlds, Many Minds</i> [A] Chap 6.	11/13. <i>Many Worlds, cont.</i> hw9 due
12	11/18. <i>The Bare Theory</i> [Ba].	11/20. <i>Bohm</i> [A] Chap 7. hw10 due
13	11/25. <i>Bohm, cont.</i>	11/27. Thanksgiving Break
14	12/2. <i>Modal Interpretations</i> [A] Appendix; [LD].	12/4. <i>Quantum Logic</i> Optional: [H] Chap 7. hw11 due
15	12/9. <i>Quantum Identity & Individuality</i> [F].	12/11. <i>Quant. Ident. & Individ., cont.</i> Paper due; hw12 and extra credits due