APPLICATION FOR INDEPENDENT OR DIRECTED STUDY

Student's name (or students' names) and class year(s): Tashroom Ahsan DS'20

Term and year: Terms 5 & 6, 2020-2021 Academic Year

Course Title: Quantum Mechanics

Sponsor: Brian Hill

Pass/Fail, or graded: Graded

Credits (see section 5 of the Academic Policy): 4

Please answer the following questions and attach.

1. Attach a Long Course Description (model provided in "Curriculum and Faculty Information"). If the course is expected to earn more than two credits per semester, please attach a detailed syllabus that explains the assignment of credit.

2. What will the learning arrangement be (e.g., how many meetings with the sponsor, how many hours spent by the student(s) on project activities)?

3. How will the study be evaluated?

4. How will the proposed course contribute to the student's intellectual life at Deep Springs and to his long-term academic goals? How will it serve the sponsor's academic or professional interests? Why is this the best time and place for this particular course of study?

Submitted:

_____

Student

_____

Faculty or Staff Sponsor

Approved:

_____ _____ _____

Academic Dean Curriculum Committee Chair Date:

Description

We will cover the material that is relatively standard in a one-semester junior-level course in quantum mechanics designed for physics majors and students in closely-related fields. We will follow Feynman's exposition in Volume III of The Feynman Lectures, covering almost the entirety of the core material in Chapters 1-20, but possibly omitting some of the special topics, unless time permits.

Objectives

Physics Objectives: Cover probability amplitudes, the Schrodinger equation, the wave function, operator formulation of quantum mechanics, identical particles, spin one particles, spin one-half particles, time-dependence of amplitudes, the Hamiltonian, special topic: the ammonia maser, two-state systems, hyperfine splitting in hydrogen, special topic: propagation in a crystal lattice, special topic: semiconductors, independent particle approximation and simple organic chemistry, symmetries and conservation laws, angular momentum, the states of the hydrogen atom and periodic table, special topic: superconductivity.

Mathematical Objectives: Quantum mechanics uses a lot of upper-division mathematics. We will use all of lower-division mathematics, especially differential and integral calculus, and multivariable calculus. The upper-division mathematical subjects are:

- Linear Algebra
- Complex Variables
- Differential Equations

The objective is to refresh, use, and advance the understanding of these subjects by applying them to physical examples. Use of these subjects is completely integral to learning quantum mechanics theory and solving quantum mechanics problems, and as such it will not be evaluated separately.

Readings

We will primarily follow Volume III of The Feynman Lectures, supplementing the text with the Exercises for the Feynman Lectures. The two texts are:

- Feynman, Richard P., Robert B. Leighton, and Matthew Sands. *The Feynman Lectures on Physics. 1st ed. Vol. III.* Reading (Massachusetts): Addison-Wesley, 1966.

- Feynman, Richard P., Robert B. Leighton, Matthew L. Sands. *Exercises for the Feynman Lectures on Physics.* Edited by Michael A. Gottlieb and Rudolf Pfeiffer. New York: Basic Books, a Member of the Perseus Group, 2014.

Activities

Problem sets for every chapter, mostly drawn from Feynman's associated exercise book. Midterm at the end of Term 5 and Final Exam at the end of Term 6.

2. We will meet twice a week for 1 hour per week, clarifying any content covered in readings done before meetings. Before each meeting, Tashroom will do 2.5 hours of reading, averaging just over a chapter per meeting, along with a problem set intended to take another 2 hours. Brian will grade the problem sets outside of the meeting and help Tashroom with problems, outside of meetings, whenever he requests help. The Midterm and Final exams will be 1 hour and 1 ½ hours long, respectively.

3. Grade will be determined by 50% problem sets, 15% midterm, 25% final, and demonstration of preparation and self-pacing appropriate for an independent study in a challenging subject 10%.

4. *How will the proposed course contribute to the student's intellectual life at Deep Springs and to his long-term academic goals? How will it serve the sponsor's academic or professional interests? Why is this the best time and place for this particular course of study?*

Student

Tashroom has been somewhat starving for STEM courses at Deep Springs, and this IS sets to provide him with his greatest, most daunting challenge yet in STEM. It'll rebuild his mathematical skills and provide the physics scaffolding for any later physics or chemistry courses he will take when he attends a different institution. Brian's academic interests lie in the field of quantum mechanics, including his doctoral research. He's taught quantum mechanics before at St. Mary's and though this course uses a different text, it'll cover many of the same topics and use a similar structure. Brian's available to conduct this study, and Tashroom is coming off the back of reading quantum chemistry texts over his Term 4 break, so he wants to complete the project he started before it gets too rusty.

Sponsor

Quantum mechanics is one of the most inscrutable subjects in the physics panoply, more anti-intuitive even than special and general relativity. A physicist can always benefit by revisiting it from a different angle. I last studied this material in Fall of 2019 when I taught junior-level quantum mechanics using John Townsend, *A Modern Approach to Quantum Mechanics, 2nd ed.* as the text. Richard Feynman towers over mid-20th-century physicists in multiple regards, one of which is his invention of the "path integral formulation of quantum mechanics" which is radically different from both Schrödinger's and Heisenberg's formulations. The book we have chosen is based on lectures Feynman gave to Caltech students in the mid-1960's. It is a treatment I have always been interested in working through and indeed with less advanced students I have worked though a few of the early chapters of the text. Tashroom is unusually advanced in his preparation, and he has already shown me his ability to work through material independently based on questions he asked on material he studied on his own in Term 4. Therefore, I am confident that he will put the "independent" in independent study. In summary, I will get to study a text I have always wanted to work through, with a student who I am confident can manage the demands of this material.

Timing

There is no time like the present?!?