Acknowledgement

UBC's Point Grey Campus is located on the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam) people.

Course Information

Course Title	Course Number	Webpage	Credit Value
Quantum Theory	MATH 512	Through Canvas	3

First day of teaching: Wed Sep 09; Last day of teaching: Monday Dec 07.
University closed: Sep 30, Oct 12 and Nov 11; Midterm break: Nov 09-11.

Lectures are on MWF 11:00am-11:50am in MATH 225 and on Zoom.

Prerequisites

MATH 320, MATH 321

MATH 420, MATH 421 are recommended but not required

Brief course description

The goal of MATH 512 is to introduce mathematical methods of quantum theory. No prerequisite of quantum physics is required.

The course will cover some aspects of functional analysis, operator theory and the calculus of variations with short excursions into representation theory and operator algebras. The physical axioms of quantum theory will be introduced and elementary results will be discussed.

We will introduce the Hilbert space formulation of quantum theory, discuss quantum dynamics and its relation to spectral properties of linear operators. We will also study the role of symmetries in quantum physics, in particular the rotation group thereby introducing the intrinsically quantum notion of spin. The course will conclude with a short study of strongly interacting systems and the role of locality in their analysis.

Course outline

The following is a tentative outline, with possible changes depending on interests and time availability

1. Introduction: Why quantum mechanics?
2. Mathematical structure of quantum mechanics; Hilbert spaces and spectral theory
3. Quantum dynamics; Stone's theorem, the RAGE theorem
4. (mostly individual project) The stability of matter; Lieb-Thirring inequalities
5. Symmetries; Wigner's theorem and the spin
6. Many-body quantum mechanics; operator algebras and the Lieb-Robinson bound
7. Is quantum mechanical description of reality complete?

Learning Materials

The course material is defined by what is covered in the lectures. Lecture notes will be provided. Additional reading is welcome and can be found in the following books:

- *Spectral Theory and Quantum Mechanics* by M. Lewin
- *Mathematical concepts of quantum mechanics* by S. Gustafson & M. Sigal
- *Mathematical methods in quantum mechanics, with applications to Schrödinger operators* by G. Teschl
- *Methods of modern mathematical physics I & II* by M. Reed & B. Simon
- *Analysis* by E. Lieb & M. Loss
- *Quantum spin systems on infinite lattices, a concise introduction* by P. Naaijkens
- *Quantum Mechanics* by G. Auletta, M. Fortunato & G. Parisi

Assessments of Learning and Course Grade

There will be

1. Five homework assignments
2. One final project

The course grade will be given by

$$\max\{0.75G_H + 0.25G_F, 0.5G_H + 0.5G_F\}$$

where G_H is the average grade of the assignments and G_F is the grade of the final project.

Syllabus Policies

General UBC and Mathematics Department policies can be found here.

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