Quantum Mechanics Week 1: Class Prep

Please study this worksheet before Wednesday's Week 1 tutorial, and submit your solutions to the Class Prep exercises by the end of Tuesday. The estimated total time requirement is 2 hours.

Overview

This week we'll study the mathematical structure of Quantum Mechanics! We'll learn about:

- The Schrödinger equation and the meaning of the wavefunction
- How observable quantities are represented by function operators, which have eigenfunctions and eigenvalues
- How the measurement process in quantum mechanics is represented mathematically

This worksheet will help you get the most out of this week's tutorial, by covering some introductory aspects in advance of the class.

Resources for Learning

Please study the Week 1 resources. The estimated time requirement is 1 hour.

Video: The Week 1 video summarises the topics we'll study this week. The running time is 28:55.

Textbook: You can find more information on these topics in Griffiths: Chapter 1.1-1.4.

You are free to search for and use other resources in addition to (or instead of) the above, as long as you can answer the following Class Prep exercises.

Class Prep Exercises

Please answer these short exercises on paper and submit your scanned answers by the end of Tuesday. After studying the above resources, the estimated time requirement for these exercises is 1 hour.

1) Write down the time-dependent Schrödinger equation which must be satisfied by the wavefunction $\Psi(x,t)$ of a particle of mass m moving in a 1D potential $V(x)$.

2) In the case of a constant potential $V(x) = V_0$, show by substitution that the time-dependent Schrödinger equation in Q1 is satisfied by the wavefunction,

$$\Psi(x,t) = \begin{cases} Ne^{-\lambda x}e^{-i\omega t}, & x > 0 \\ Ne^{+\lambda x}e^{-i\omega t}, & x < 0 \end{cases}$$

where λ is a real positive number, and find an equation for λ in terms of the other variables.

3) Determine the normalisation constant N for the wavefunction given in Q2, which ensures that $\int_{-\infty}^{\infty} |\Psi(x,t)|^2 \, dx = 1$.

4) What is the probability of finding the particle in the range $0 < x < 1/\lambda$?

5) Write down an equation defining the eigenfunctions $\phi_n(x)$ and eigenvalues a_n of an operator, $\hat{A}$.

6) Consider the operator $\hat{A} = \frac{d}{dx}$. Use the definition in Q5 to show that $\phi = e^{ax}$ is an eigenfunction of this operator. What is the corresponding eigenvalue?

7) Write down the 3 key properties of the operators representing quantum mechanical observables.

Grading and getting help

How this is graded: Class Prep assignments are always graded on *completeness & effort*. If you submit a reasonable effort for all parts on time, you will receive full marks regardless of all details being correct. Otherwise, you will not receive a grade. Each Class Prep assignment represents 1% of the unit grade.

After you have studied this week's learning resources, these exercises are not supposed to take more than 1 hour to complete. If you've been working purposefully on these exercises for 30 minutes and you're struggling with the content, please stop and ask for help. You can work with a friend, e-mail the instructor (cblake@swin.edu.au) or ask a question on the Week 1 Discussion Board in Canvas.

The rest of this week's activities

In Wednesday's tutorial class we'll expand on the Class Prep exercises to:

- Apply the orthogonality integral to demonstrate that 2 eigenfunctions are orthogonal
- Determine the coefficients of expansion of a wavefunction in terms of eigenfunctions
- Analyse a given wavefunction to determine the set of values that can be obtained in a particular measurement, and their probabilities
- Determine the expectation value of a measurement

Finally, **please complete the Week 1 Online Quiz** (10 multiple choice questions) by the end of Sunday Week 1. Each Online Quiz represents 1% of the unit grade.