

# Quantum Mechanics

## PHYS-C0252

### lecture starts 10:15

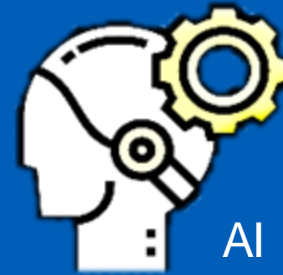
*First lecture on 1.11.2021*

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**Teaching assistants:** Andras “Marci” Gunyho and Niko Savola

**QUANTUM  
TECHNOLOGY  
WILL CHANGE THE  
WORLD  
(FOR BETTER)**

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# CHEMISTRY AND PHARMA



AI

## ENERGY



## SUSTAINABILITY



## FINTECH



## CYBER SECURITY

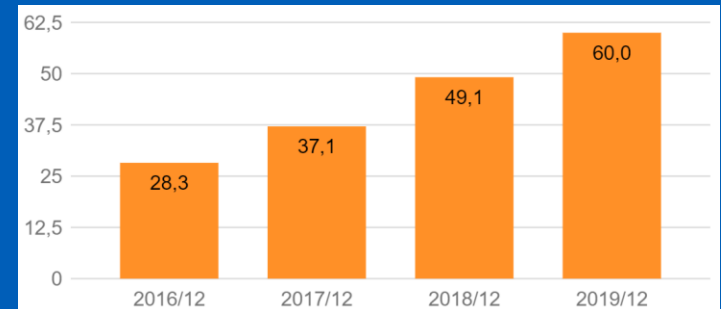


# INDUSTRY RAMPING UP

## QUANTUM COMPUTING GLOBAL MARKET PROJECTIONS



## ANNUAL REVENUE OF QUANTUM TECH INDUSTRY IN FINLAND (MILLIONS OF EUROS)



<https://www.statista.com/statistics/936010/quantum-computing-future-market-outlook-forecast/>

**many scientific  
questions to be  
answered**

**finally job opportunities  
in quantum**

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**what an amazing  
time to study  
quantum  
technology!**

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# Quantum technology - timetable

## Year 1 Autumn

MS-A0111 Diff & int calculus 1

MS-A0011 Matrix algebra

CS-A1110 Programming 1

ELEC-C9420 Intro to quantum tech

Intro for BSc students

TU-A1300 Industrial eng manag.

Language course

## Spring

MS-A0502 Probability & statistics

MS-A0211 Diff & int calculus 2

MS-A0311 Diff & int calculus 3

CS-A1120 Programming 2

ELEC-C9430 Electromagnetism

PH-A0140 Quantum materials/StMa

## Year 2 Autumn

MS-C1350 Part diff eqs

CS-A1140 Data struct & algorith

PHYS-C0252 Quantum mechanics

Minor/elective

Minor/elective

Minor/elective

## Spring

ENG-A1003 Numerical Methods

PHYS-C0256 Thermo & stat mech

ELEC-C9440 Quantum info

PHYS-C0254 Quantum circuits

Aalto course

Minor/elective

## Year 3 Autumn

PHYS-C0258 Quantum labs

Major optional

Minor/elective

Minor/elective

Minor/elective

Minor/elective

## Spring

BSc thesis

Major optional

Machine Learning

Minor/elective

Minor/elective

# Intended Learning Outcomes (ILOs)

1. Is familiar with the **structure** and postulates **of quantum mechanics**
2. Can differentiate between the terms **quantum-mechanical state and wavefunction**
3. Can **solve** the eigenstates and eigenvalues of the **Schrödinger equation** in simple situations and knows how to generalize the computation to situations where analytical solution is challenging.
4. Can **integrate the quantum evolution** and the expectation values of physical quantities for simple systems.
5. Can apply **creation and annihilation operators** to analyze one-dimensional harmonic oscillator.
6. Can solve **the eigenstates of the one-dimensional harmonic oscillator**.
7. Can predict **measurement probabilities** from a given quantum state.
8. Can apply **perturbation theory** to compute eigensolutions in a situation where analytical solutions is challenging.



# PEAK AT SYLLABUS

<https://mycourses.aalto.fi/course/view.php?id=33562>

# Course content, rough

Hilbert space and Dirac notation

Operators, eigenvalues and eigenfunctions

Properties of (Hermitian) operators

Postulates of quantum mechanics (inc. superposition & meas)

Expectation values and variance

Continuous-variable bases: coordinate representation, momentum basis

Quantization of a physical system

Schrödinger equation and temporal evolution

Qubit (two-level system)

Two-level system and entanglement

Commutator and conserved quantities

Solving 1D harmonic oscillator using creation and annihilation operators

Free particles and plane waves

Particle in a box

Particles in different potential wells: infinite and finite wells in 1D

Scattering and tunneling through barriers

Bloch's theorem

Bosons and fermions

Perturbation theory (non-degenerate)

Time-dependent perturbation theory

Time dependence of operators: different pictures

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# Particularities

- In-person v.s. online
    - Future lectures and exercises organized in person (U9/U3)
    - We aim to have Zoom streaming (and recorded videos) for those who cannot attend
    - Exams are organized in person (bad experience from online exam)
  - Exercises
    - Deadline for returning solutions every Wednesday night (problems based on the lectures of the previous week)
    - Problem sets for exercises published by previous Monday
    - Trying out Zoom also on exercise sessions
    - Bonus 5 or 6 points (one full problem) to the next exam
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# Practicalities continue

- Zulip chat to ask for help. TAs will try to answer in a reasonable time frame.
- Additions?
- Questions?
  - Grading scale