

## 660 SYLLABUS Fall 2016 (3 credit hours)

**COURSE:**               **Quantum Mechanics I**  
**ALL course information is posted on BlackBoard**

**TEXT/Materials:**   Lecture notes and homework are posted on blackboard

**CLASS MEETINGS:** Lecture Section 1: **Mo/We 3.30-4.45pm**, Tourette 227

**Instructor:**           Michel van Veenendaal, Tourette 223

**Office Hours:**       **Mo/We 2-3pm**, or by appointment.

**Email:**               [veenendaal@niu.edu](mailto:veenendaal@niu.edu)

**Web page:**           See blackboard

### SCHEDULE OF TESTS:

MIDTERM   **Wednesday 10/12, 3.30-4.45pm**

FINAL       **Monday 12/5, 4-5.50pm** (be aware of potential exam conflicts)

### GRADING:

- Homeworks   40%   (there will be (appr.) four graded homeworks, dates TBD).
- Midterm       30%
- Final          30%

The final grades are curved. Therefore, the final grade depends on the distribution of the grades. Typical relationships between the weighted tests/final and the grades are

A	> 85
B	70 - 85
C	55 - 70
D	TBD

Note that these ranges are indicative and that the instructor remains the right to change the values depending on the performance of the students and the difficulties of the exams.

### MINIMUM REQUIREMENTS TO PASS THE COURSE:

- An aggregate numerical value of at least 50% of the total points is required to pass the course, with no component (homework, midterm, final) worse than 25%.

### HOMEWORK ASSIGNMENTS:

- Appr. 4 sets.
- Late turn in of homework permissible only under unusual circumstances.

## **COURSE DESCRIPTION:**

Quantum mechanics I offers an in-depth introduction to the field including the necessary mathematical details. Topics include: wave and matrix mechanics, potential problems, the harmonic oscillator, propagation in space and time, harmonic oscillator, perturbation theory, hydrogen atom, molecules and solids, spin.

## **INTENDED LEARNING OUTCOMES:**

In 660, students are taught the physical and mathematical aspects underlying the basic concepts of quantum mechanics. Whereas lower-level courses introduce quantum mechanics at a qualitative and algebraic level, students will learn to approach quantum mechanics with the appropriate mathematical tools, such as differential equations and linear algebra. The material covered in this class allows them to approach fundamental and applied problems in advanced graduate courses and in their research. The class covers essential topics that are part of the basic knowledge of any graduate student working in fields that require knowledge of quantum mechanics, such as condensed-matter physics and high-energy physics. Through exercises, the students will obtain a hand-on approach to problem solving in quantum mechanics and be able to use the material in their future research.

**Prerequisites:** previous course(s) on Quantum Mechanics at the level of D.J. Griffiths, Introduction to Quantum Mechanics, Prentice-Hall

**Required textbook:** The class will be taught on lecture notes which are available on blackboard.

### **Optional Readings.**

For a deeper understanding, you may also want to consult these books:

R. L. Liboff, Introductory Quantum Mechanics

E. Merzbacher, Quantum Mechanics

R. Shankar, The Principles of Quantum Mechanics

Note that there are many other textbooks available at different levels.

## **SYLLABUS:**

### 1 Wave mechanics page

1.1 wavemechanics

1.2 Schrödinger equation

1.3 Eigenvalues and eigenfunctions

1.4 Free particles

1.5 Bound particles

### 2 Quantization, Tunneling, and Phase Shifts

2.1 Particle in a periodic box

2.2 Particle in a box

2.3 Potential step

2.4 Square potential well

2.5 Square potential barrier

- 3 Matrix mechanics
  - 3.1 Two-level problem
  - 3.2 Basis functions
  - 3.3 Bras and kets
  - 3.4 Matrix algebra
  - 3.5 Eigenvalue problems and unitary transformations
  - 3.6 Dual spaces
  - 3.7 Expectation values and probability
  - 3.8 A graphical way of looking at quantum mechanics
- 4 Propagation in space and time
  - 4.1 Two-level system
  - 4.2 The Gaussian wave packet
  - 4.3 Phase and group velocities
  - 4.4 Heisenberg's uncertainty principle
  - 4.5 Unitary transformations
- 5 Harmonic oscillator
  - 5.1 Harmonic oscillator
  - 5.2 Schrödinger equation approach
  - 5.3 Solution using operators
  - 5.4 Harmonic oscillator in matrix form
  - 5.5 Operators and wavefunctions
  - 5.6 Correspondence principle
  - 5.7 Two-dimensional harmonic oscillator
- 6 Perturbation Theory
  - 6.1 Time-independent perturbation theory
  - 6.2 Infinite perturbation theory
  - 6.3 Green's functions
  - 6.4 Time-dependent perturbation theory
- 7 Hydrogen atom
  - 7.1 Spherical coordinates
  - 7.2 Angular momentum
  - 7.3 Spherical harmonics
  - 7.4 Angular momentum in matrix form
  - 7.5 Higher-order tensors
  - 7.6 Radial wavefunction
  - 7.7 Conceptual aside: The hydrogen atom in terms of bosons
- 8 Molecules and solids
  - 8.1 Creation and annihilation operators
  - 8.2 Systems with a finite size: the benzene molecule
  - 8.3 A linear chain of 1s orbitals
  - 8.4 Nearly free-electron model in one dimension
  - 8.5 Tight-binding versus nearly-free electron model
- 9 Spin
  - 9.1 spin
  - 9.2 Massless particle
  - 9.3 The geometry of space: Two dimensions

- 9.4 Geometry of Space: Three dimensions
- 9.5 Matrices as unit vectors

**COURSE POLICIES INCLUDE:**

1. Be respectful of each other (this applies to Instructors, TA's and students). Some specifics include:
  - a. No cell phone/ electronic device usage in class (except calculators). Cell/ smart phones must be turned off or silenced and placed in backpacks, etc. (not in pockets or on desks). Violators may be required to turn in their devices to the Instructor for the remainder of the class period.
  - b. If you need to leave class early, let your Instructor/ TA know
2. Laptops/ notebooks may be used for lecture materials and taking notes only.
3. Be aware of the policies and procedures regarding your rights as well as responsibilities that are published in the NIU Student Code of Conduct. It is available on line at [http://www.stuaff.niu.edu/judicial/24430jo\(body\).pdf](http://www.stuaff.niu.edu/judicial/24430jo(body).pdf) .
4. The instructor and the university reserve the right to modify, amend, or change the course syllabus (course requirements, grading policy, etc.) as the curriculum and/or program require.
5. Americans with Disabilities Statement (available at: [http://niu.edu/disability/accessibility\\_statement/index.shtml](http://niu.edu/disability/accessibility_statement/index.shtml)).  
If you need an accommodation for this class, please contact the Disability Resource Center as soon as possible. The DRC coordinates accommodations for students with disabilities. It is located on the 4th floor of the Health Services Building, and can be reached at 815-753-1303 (V) or drc@niu.edu.
6. For academic integrity, see <http://www.niu.edu/isye/graduate/integrity.shtml>