661 SYLLABUS Spring 2017 (3 credit hours)

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

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

CLASS MEETINGS: Lecture Section 1: **Tu/Th 3.30-4.45pm**, Tourette 227

Instructor: Michel van Veenendaal, Tourette 223
Office Hours: **Tu/Th 2-3pm,** or by appointment.
Email: veenendaal@niu.edu
Web page: See blackboard

SCHEDULE OF TESTS:

MIDTERM **Monday 3/7, 3.30-4.45pm**
FINAL **Monday 5/9, 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 II offers an in-depth introduction to the field including the necessary mathematical details. Topics include: Hydrogen atom, molecules and solids, spin, electromagnetic field, relativistic quantum mechanics, and relativistic effects in the Schrödinger equation.

INTENDED LEARNING OUTCOMES:

Quantum mechanics II 661 is a follow-up on QM-I 660. In 660, students were introduced to the basic concepts of quantum mechanics. 661 will treat more advanced topics such as relativistic quantum mechanics and focus on applying quantum mechanical principles on atoms, molecules, and solids. The course also provides a larger overview in physics by looking at the connections between quantum mechanics and electricity and magnetism. Students will also learn to approach quantum mechanics with the appropriate mathematical tools, such as differential equations and linear algebra. 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.

STUDENT ASSESSMENT:

The students are tested on the material through graded homework and exams.

Prerequisites: 660 and 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:

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

10 Electromagnetic field
10.1 Gauge invariance
10.2 Equations of motion
10.3 Quantization of the free photon field
10.4 The photon propagator

11 Relativistic quantum mechanics
11.1 Relativity
11.2 Klein-Gordon equation
11.3 Space-time
11.4 Dirac equation
11.5 Alternative view of Dirac equation
11.6 Plane-wave solutions

12 Maxwell's equations
12.1 Electromagnetic field in Dirac equation
12.2 Maxwell's equations
12.3 Gauss's law
12.4 Ampere's circuital law
12.5 Faraday's law
12.6 Gauss's law for magnetism
12.7 Energy density in electromagnetic fields

13 Relativistic effects in the Schrödinger equation
13.1 Non-relativistic limit of Dirac equation
13.2 Relativistic correction in the hydrogen atom

14 Many-electron systems

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 .

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).
   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