PHYS 234: Quantum Physics 1

Instructor: Norbert Lütkenhaus, QNC 4129
Administrative Assistant: Lisa David, QNC 4123
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Lectures and Tutorials:
Lecture  M,W,F 10:30-11:20 am DC 1351
Tutorial 101
Section 101: F 3:30-4:20 pm, RCH 109
Section 102: F 3:30-4:20 pm, RCH 209
Section 103: F 3:30-4:20 pm, RCH 106
Section 104: F 11:30-12:20 pm, RCH 209
Section 105: F 3:30-4:20 pm, DWE 3519
Section 106: F 3:30-4:20 pm, DWE 3517

Office hours:
M 12:00-1:00 pm (QNC 4129)
M 6:00- 7:00 pm (QNC 4129)

Additional office hours can be arranged on request. Any change of office hours will be made known on the LEARN system.

Teaching Assistants:
Aimee Heinrichs
Alexander Smith
Behnaz Bagheri
Elizabeth Gould
Peter Groszkowski

Teaching assistants can be reached using the mail function of the LEARN website. They will set up office hours that will be made known on the announcement boards of the LEARN system.

Textbook:
Required text:
- David McIntyre
  Paradigms in Physics: Quantum Mechanics
  Addison-Wesley

Recommended auxiliary textbooks:
- B. Schumacher, M. Westmoreland
  Quantum Processes, Systems, and Information
  Cambridge University Press (2010) [about 80 CAD]
- N. Zettili
  Quantum Mechanics, Concepts and Applications
  Wiley
In addition, there are many other textbooks on Quantum Physics and I would advise students to take a look at as many as possible as they all deal with topics slightly differently. An explanation that resonates with one person may not resonate with another, so the usefulness of reading about the same material presented in a variety of formats cannot be overstated.

**LEARN Website**
We will be using the LEARN website to make material for the lectures available, including assignments and handwritten lecture notes.

Announcements will be made via the LEARN system as online notification, but also as emails. Please remember to initialize the forwarding mechanism in LEARN so that all email notifications reach you even if you are not logged into the system.

**Clicker:**
The lectures will make use of clickers, so each student is required to have an iclicker in his/her possession. Participation in the use of clicker questions will count towards the final grade.

Clicker points are based on at least one use per lecture involving clicker questions. In order to avoid issues with absences and misplaced clickers, the clicker participation will be calculated based on 90% of the lecturers using clicker events.

**Clickers need to be registered for this course.** It is in violation of academic integrity to activate a clicker during lecturers that is registered to a different student, especially if that student is not present.

To register your clicker, please go to the website http://www.student.cs.uwaterloo.ca/~pkates/uw-clicker.html and follow the instructions.

**Tutorials:**
Tutorials will be held as small tutorial groups (ca 20 students/group). Solutions to assignments will be discussed and marked assignments will be returned. Assistance will also be provided with any question you may have with the material covered in the lectures.
Assignments:
Assignment questions will be issued weekly Wednesdays.

Hand-in time: Wednesdays 10:30 am (before lectures)
Hand-in location: lecture hall DC 1351

For assignments, not necessarily all questions handed out will be graded.
In addition to those weekly assignments there will be online quizzes. They are intended to help you to check your understanding, but do not count towards the final grades.

Please Note: No late assignments will be accepted for credit without prior consultation with the course instructor.

Examinations:
– Midterm is scheduled for Tuesday, March 5, 7-9:30 pm.
– Final Exam will be scheduled by Registrar’s Office.
In both cases, further details will be provided closer to date.
Please Note: Student travel plans are not considered acceptable grounds for granting an alternative examination time. (see http://www.registrar.uwaterloo.ca/exams/finalexams.html)

Grading: The instructor will choose the best of
– 20% Assignments, 5% Clicker Participation, 30% Midterm, 45% Final Exam
– 20% Assignments, 5% Clicker Participation, 20% Midterm, 55% Final Exam

Minimum Grades for Assignment:
If less than 50% of the total number of assignment points are reached, then the assignment grade will be set to 0% for the calculation of the final grade.

Important Dates (Winter 2013):
Jan 7 - Lectures begin
Jan 25 - Drop, no penalty period ends
Feb 18-22 – University Reading week (no lectures)
Feb 22 – last day for 50 percent tuition refund
Mar 5 - MIDTERM
Mar 22 – Drop, penalty 1 period ends
         (last day to receive WD grade for withdrawing)
Apr 8 - Lectures end
Apr 10 - Drop, penalty 2 period ends
         (last day to receive WF grade)
Apr 11-25 - Examination Period

Verification of Illness
In order to request accommodation due to illness, students will have to file a Verification of Illness form with the Science Undergraduate office. Based on this filing, and an explicit request from the student, the Lecturer will decide how and if
an accommodation will be made. Note that usually no accommodation for clicker participation or missing assignments based on illness will be made.

Science students should be aware that starting with the Winter 2013 term, the only Verification of Illness forms (VIFs) that instructors will accept for accommodation for missed assessments (labs, quizzes, midterms, final exams, etc.) will be those issued by the University of Waterloo’s Health Services, when this service is open https://uwaterloo.ca/health-services/. VIFs issued by walk-in clinics will not be accepted, except when obtaining a VIF from Health Services is not possible. If a student is sick on a weekend, during off-hours, while out of town or receiving ongoing care from a family physician or specialist, it is acceptable to provide documentation from other health service providers. Information should include (1) date of the physician assessment, (2) dates of illness, (3) level of incapacitation and (4) whether the diagnosis was made by the physician or based on description by the student.

Keeping the playing field level for all of our students is a priority. Students are reminded that obtaining a VIF under false pretences is an academic offense. For tests and exams, a student found guilty of misrepresentation will receive a failing grade in the course and be suspended.

Any questions concerning this policy can be directed to an undergraduate advisor in the Science Undergraduate Office.
Office: ESC 253 (Monday: 9:30 am - 12:00 pm, 1:00 pm to 4:15 pm Tuesday-Friday: 8:30 am - 12:00 pm, 1:00 pm to 4:15 pm)
Email: current@science.uwaterloo.ca
Phone: 519-888-4567 extension 35244
Web: https://uwaterloo.ca/science/current-undergraduate-students

**Academic Integrity:**
In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check www.uwaterloo.ca/academicintegrity/ for more information.]
**Grievance:**
A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, [www.adm.uwaterloo.ca/infosec/Policies/policy70.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm). When in doubt please be certain to contact the department’s administrative assistant who will provide further assistance.

**Discipline:**
A student is expected to know what constitutes academic integrity [check [www.uwaterloo.ca/academicintegrity/](http://www.uwaterloo.ca/academicintegrity/)] to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about “rules” for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, [www.adm.uwaterloo.ca/infosec/Policies/policy71.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm). For typical penalties check Guidelines for the Assessment of Penalties, [www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm](http://www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm).

**Appeals:**
A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) [www.adm.uwaterloo.ca/infosec/Policies/policy72.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm).

**Note for Students with Disabilities:**
The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.
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Provisional Course Outline: Sequence and time line might change

PART I

Introduction, Particles and Waves, Particle-Wave Dualism
Week 1
L1 Orientation and Motivation
L2 Historical Background 1: Photo-electric effect
L3 Compton Effect, Davisson Germer Effect

Week 2
L4 Double Slit Experiment, Stern Gerlach Experiment

Part II

Basic Formalism of Quantum Mechanics
L5 Stern-Gerlach Observations
L6 Vector Spaces & Basic Quantum Mechanical Postulates

Week 3
L7 Basic Probability Theory
L8 Stern Gerlach Experiments: quantum mechanical explanation.
L9 Operators & Measurements

Week 4
L10 Operators, Matrices, Eigensystem
L11 Hermitian Operators, Selective Operations
L12 Selective and Unitary Operations

Week 5
L13 Heisenberg’s Uncertainty Relation
L14 Application: Bomb Detection
L15 Application: Quantum Zeno Effect

Week 6
L16 Dynamics, Schrödinger Equation
L17 Solutions to Schrödinger Equation
L18 Example: Dynamics of Spin ½ particle in external magnetic field

Week 7
L19 Bloch vector
L20 Review of Quantum Mechanics Formalism
L21 Review of Solution Methods

Week 8
L22 Application of Time Evolutions, e.g. Neutrino Oscillations, Atomic Clocks
Part III:

Advanced Formalism
L23 Continuous formulation of quantum mechanics, Position Operator and wavefunctions in position basis
L24 Coordinate representation and Dirac Delta Function

Week 9
L25 Momentum Operator
L26 Uncertainty relation for position/momentum, Schrödinger Equation and Free Particle on a line
L27 General Step Potentials, matching conditions

Week 10
L28 Infinite Potential Well, Parity Operator
L29 finite depth potential well
L30 unbound states, particle flux

Week 11
L31 Potential Step
L32 Tunneling at Potential Barrier, Application: Scanning Tunneling Microscope
L33 Harmonic Oscillator

Week 12
L34 Wave functions of Harmonic Oscillator Eigenstates
L35 Classical Limit of Harmonic Oscillators, applications
L36 Summary