Physics and Astronomy

General Course Information

PHYS203
Relativistic and Quantum Physics

0.125 EFTS 15 Points Semester 2

Course Coordinator and Quantum Physics Section

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Description

A. Introduction to quantum physics with a focus on bringing out its applications. Topics covered include wave-particle duality, one-dimensional barriers and wells, hydrogen atom, electron spin, and electron configuration of atoms. **B.** Introduction to relativistic mechanics, including space-time transformations, dynamics and collisions of relativistic particles.

Assessment

5% Tutorial attendance
10% Homework Assignments (9, counting **best 8** for a total of 10%).
21% Test 1: Week 4 (Quantum Physics Section only)
21% Test 2: Week 8 (Quantum Physics Section only)
43% Final Examination (Relativity Section 2/3 and Quantum Physics Section 1/3)

Pre-requisites P: (1) PHYS102; (2) MATH102 or EMTH118; **RP**: MATH103 or EMTH119
These prerequisites may be replaced by a high level of achievement in NCEA Level 3 Physics and Mathematics with Calculus or other background as approved by the Head of Department.

Recommended Textbooks

- Serway, R A; Moses, C J; Moyer, C A. Modern physics. 3rd ed. 2005
  ISBN 9780357671023 [Main text]
- Thornton, S T; Rex, A. Modern physics for Scientists and Engineers. 5th ed. 2019
  ISBN 9781337919456 [Also recommended]

(There are copies for loan in the Library.)

Recommended Reading

- French, Anthony P. and Taylor, Edwin F. *An Introduction to Quantum Physics*. W.W. Norton, 1978.
- Griffiths, David J., *Introduction to Quantum Mechanics*., Prentice Hall, 1995.
- Krane, Kenneth S., *Modern Physics*, 2nd ed., J. Wiley & Sons, 1996.
  (Note: This book is very similar to Serway, Moses and Moyer.)
- Kittel, Charles et al., *Mechanics* (Berkeley Physics Course Vol 1), 2nd ed., McGraw-Hill, 1973.
- French, Anthony P., *Special Relativity*, Norton, 1968.

Lecture Notes and Lecture Recordings

Lecture notes will be available on Learn: http://learn.canterbury.ac.nz/. The lecture notes are not complete, and you are expected to attend lectures to fill in the missing derivations and figures.

Lectures will be videoed by Echo360 and made available following each lecture. This service is intended for students who cannot avoid missing a lecture due to a clash or illness etc. and is not a substitute for attending lectures in person. Please attend and engage by asking questions whenever something is not clear.

Goal of the Course

Provide a conceptual understanding of the physical principles of quantum mechanics, together with the technical understanding for applying these principles to determine the quantitative properties of physical systems where quantum physics is applicable. Provide a thorough knowledge of relativistic dynamics and its application to various physical situations.

Learning Outcomes

Students will:

- Have acquired a conceptual understanding of the principles of quantum mechanics and their implications for physical measurements
- Have mastered the mathematical techniques used to solve the Schrödinger equation in simple situations, and quantitatively describe physical observables in related systems
- Have developed and be able to demonstrate writing and associated communication skills.
- Have mastered space-time transformations for reference frames travelling at relativistic speeds.
- Have mastered techniques to calculate the dynamics of relativistic particles and collisions between relativistic particles.
- Have developed and be able to demonstrate competency to solve appropriate physics problems in the concepts of the course

Summary of Course Content

Part A. Quantum Physics (24 Lectures, 8 Tutorials)

1. Wave-Particle Duality
    - Black-body radiation; Photoelectric effect; Compton effect; X-ray production
    - Pair annihilation and production
    - Young's double slit experiment for light
2. Wave-like properties of particles
    - Electron diffraction
    - Davison-Germer experiment
    - Diffraction of neutrons, protons, etc.
    - Young's double slit experiment for massive particles
    - Uncertainty and classical waves
    - Heisenberg uncertainty principle and classical waves
3. The Schrödinger Equation
    - Justification and solution of the time-independent Schrödinger Equation
    - Probabilities and interpretation
    - Schrödinger’s cat
    - Particle in a box: infinite square well
4. Applications of the Schrödinger Equation
    - Reflection and transmission coefficients
    - Barrier penetration
    - Tunnelling and applications
    - Finite square well
    - Double barrier resonant tunnelling
    - Particles in boxes in two and three dimensions
    - Harmonic oscillator
5. Hydrogen atom
    - Properties of atoms and Bohr model
    - Three-dimensional eigenfunction solutions for the hydrogen atom
    - Role of electron angular momentum
    - Stern-Gerlach experiment and electron spin
    - Atomic transitions and selection rules
6. Electron configuration of atoms and molecules
    - Pauli exclusion principle and properties of atoms
    - Bonding and molecules
    - Introduction to solids and band theory

Part B. Relativity (12 Lectures, 4 Tutorials)

1. Relativistic Kinematics
    - Inertial frames of reference
    - Galilean transformations
    - Relativity Principle; Speed of light; Lorentz transformations
    - Space-time
2. Relativistic Dynamics
    - Relativistic energy and momentum
    - Relativistic dynamics
    - Relativistic collisions
    - Electromagnetism and Relativity
    - Equivalence principle

Timetable

See https://courseinfo.canterbury.ac.nz/GetCourseDetails.aspx?course=PHYS203&occurrence=26S2(C)&year=2026

Homework Assignments should be handed into the collection box on the ground floor of Beatrice Tinsley by 4 pm on Thursday. **If the markers suspect AI use (see below), one-on-one oral exams will be arranged to test your knowledge of the subject matter.**

Tutorial attendance: 5% of the course marks are awarded for tutorial attendance. A roll will be taken. There are 12 tutorials in total. **You may miss 2 tutorials with no penalty.** Tutorial questions will be posted each Thursday.

If you are unable to attend a tutorial in person, to be marked as present you must submit your answers to the tutorial questions **by 11 am on Saturdays**, to a Learn portal with your reason for not being able to attend the tutorial in person (e.g., distance student, illness, etc.). The answers will not be marked; you simply need to demonstrate that you have made a reasonable attempt to answer the questions. This option should be viewed as a last resort; the tutorials are intended for discussion to aid learning.

Generative AI tools must not be used in this course

You are strictly prohibited from using generative artificial intelligence (AI) to generate any materials or content related to the assessment. This is because *students are expected to solve problems and demonstrate knowledge and understanding without the assistance of AI*. The use of AI-generated content is not permitted and may be considered a breach of academic integrity. Please ensure that all work submitted is the result of your own human knowledge, skills, and efforts.

General Physics and Astronomy Information

Please consult the document General Information for Physics and Astronomy Students on the web page:
https://static.canterbury.ac.nz/uccommunity/science/phys-chem/PHYS%20-%20Course%20Outlines/General.PDF