# PHYS 251 Modern Physics 2015

| | |
|---|---|
| Offered: | Semester II |
| Credit: | 15 points |
| Pre-/Co-requisites: | None; but an understanding of the material in MATHS 208 or 250; PHYSICS 120 and 150 will be assumed. |

## Description

An advancing course including laboratories that gives an introduction to modern physics, i.e. relativity, quantum physics and astrophysics. Students are assumed to have taken at least an introductory course in calculus.

## Aims

This course aims to provide a solid foundation in relativity, quantum physics and astrophysics as required for further study in these fields at Stages 3 and 4.

## Skills and knowledge to be gained

Students who pass this course should be able to:

- State the basic postulates and consequences of special and general relativity.
- Give the relativistic forms of Newton's laws and apply these to elementary examples.
- Understand the concept and consequences of matter waves and the Heisenberg uncertainty principle.
- Understand the Born interpretation of the wave function and know how to use the wave function to compute statistical properties of a system.
- Construct solutions of the Schrödinger equation for simple quantum systems and phenomena, e.g., a particle in a 1-d box, the quantized harmonic oscillator, quantum tunneling through a potential barrier, the hydrogen atom.
- Understand the role in atomic structure of orbital magnetism, electron spin, and the Pauli exclusion principle.
- Describe the distinction between bosons and fermions and understand basic properties of the Bose-Einstein and Fermi-Dirac distributions of quantum statistical mechanics.
- Describe elementary bonding mechanisms in simple molecules and the quantisation of rotational and vibrational states of diatomic molecules.
- Understand the origin of the allowed energy bands for electrons in solids and the use of band theory to distinguish between the properties of metals, insulators and semiconductors.
- Understand the hierarchical scale of the Universe: planets, stars, and galaxies.
- Describe the different means by which astronomers detect electromagnetic radiation and measure characteristic parameters of stars, e.g., distance, mass, radius.
- Understand the equations of stellar structure and how to use them to make simple deductions about structure and evolution of stars.
- Describe the basic chains of nuclear fusion that occur in stars and the source of all elements in the Universe.
- Understand how stars combine to make stellar clusters and these combine to form galaxies.

## Syllabus

**Relativity:** principle of relativity; Michelson-Morley experiment; postulates and consequences of relativity; Lorentz transformation; relativistic form of Newton's laws; relativistic energy and mass; general relativity

**Quantum physics:** background; matter waves & de Broglie wavelength; electron diffraction & wave particle duality; Wave functions and the Born interpretation; Schrödinger equation; particle in a box; sharp energies and expectation values; quantum oscillator and quantum tunneling; Schrödinger equation 3-D; particle in 3-D box; central forces; angular momentum; hydrogen atom; orbital magnetism; Zeeman effect; electron spin; Stern-Gerlach experiment; two-electron wave functions and the exclusion principle; classical statistics; Maxwell-Boltzmann distribution; quantum statistics; bosons & fermions; molecular bonding; rotations & vibrations; band theory of solids; metals & insulators; semiconductors and semiconductor devices

**Astrophysics:** cosmic scale and subscales; observing photons with energies from TeV to feV; measuring stellar parameters; the equations of stellar structure; nuclear fusion and nucleosynthesis; stellar evolution; stellar remnants & degeneracy pressure; stellar populations & galaxies

## Learning activities and teaching methods

| Description | Study time |
|---|---|
| Lectures 36 X 1-hour | 36 hours |
| Lecture problems (15 mins) | 9 hours |
| Assignments X 6 | 36 hours |
| Laboratory work X 4 | 30 hours |
| Private study (1.5 hours/lecture) | 54 hours (recommended) |

**Inclusive learning**
Students are urged to discuss privately any impairment-related requirements face-to-face and/or in written form with the course convenor/lecturer and/or tutor.

## Assessment

| Form | Weight | Time | When |
|---|---|---|---|
| Assignments | 20% (6 × 3.33%) | 6 hours per assignment | weeks 2; 4; 6; 8; 10; 12 |
| Laboratory work | 20% (4 × 5%) | 7.5 hours per lab | weeks 2-10 |
| Exam | 60% | 3 hours | exam period |

**Academic Integrity**
The University of Auckland will not tolerate cheating, or assisting others to cheat, and views cheating in coursework as a serious academic offence. The work that a student submits for grading must be the student's own work, reflecting his or her learning. Where work from other sources is used, it must be properly acknowledged and referenced. This requirement also applies to sources on the world-wide web. A student's assessed work may be reviewed against electronic source material using computerised detection mechanisms. Upon reasonable request, students may be required to provide an electronic version of their work for computerised review. Please visit the below link for further information:
https://www.auckland.ac.nz/en/about/learning-and-teaching/policies-guidelines-and-procedures/academic-integrity-info-for-students.html

## Resources

**Prescribed text**: Serway; Moses & Moyer (2005) *Modern Physics* (3rd edition) (Thomson Brooks/Cole)
**Recommended reading**: www.astronomynotes.com; Maoz (2007) *Astrophysics in a Nutshell* (Princeton University Press)
**Website:** https://www.coursebuilder.cad.auckland.ac.nz/flexicourses/2396/publish/1/

## Feedback

Marked script and model solutions to assignments; marked exam script (if requested)

## Enrolment

Typical enrolment Semester 2: 60