DEPARTMENT OF PHYSICS
UNIVERSITY OF CAPE TOWN

PHY3004W: Advanced Physics

Course information 2025

PHY3004W completes the major in Physics. The theory component aims to develop advanced skills in problem solving within physics, and includes the following topics: electromagnetism, thermal physics, atomic physics, nuclear & particle physics, and solid-state physics. The laboratory component includes practical and computational tasks to develop advanced skills of experimentation and scientific communication.

Each student registered for this course is required to have a laptop for use during class sessions as well as after hours. The minimum specifications of the laptop are available at www.phy.uct.ac.za. (A tablet or "netbook" will not be suitable).

You will be asked to adhere to the science faculty code of honour, and the departmental plagiarism declaration, which can be found on Amathuba.

Entry requirements:	PHY2004W, and 40% in MAM2000W or (MAM2004H and MAM2047H)
Convenor:	Dr Tom Leadbeater, 5.12 RW James, Tom.Leadbeater@uct.ac.za (semester 1) Consultation: any time, or by appointment, or Wednesdays 15:00. Dr Trisha Salagaram, 5.13 RW James, Trisha.Salagaram@uct.ac.za (semester 2) Consultation: any time, or by appointment, or TBC.
Lectures:	RW James LT2A, 4th period (11h00 – 11h45), Monday to Friday. Lectures will be recorded. Resources can be found on Amathuba.
Class tutors:	Mikayla Chaplin: CHPMIK002@myuct.ac.za TBD:
Tutor consultation:	Mikayla: Monday 12h00 Phylab3, Friday 13h00 Phylab3 TBD
Class representatives:	TBD
Laboratory:	Laboratory runs formal sessions with the academic in charge on Mondays from 14h00 to 17h00 in PHYLAB3. Students will be granted swipe card access to the laboratory at other times during the day and are expected to attend laboratory tasks as assigned by schedule. See the 'Laboratory' folder on Amathuba.
Tutorials:	White board tutorials will run most Tuesdays from 14h00 to 17h00 in PHYLAB2. Attendance will be recorded and used for DP purposes. Solutions to tutorials will not be posted, so students are to ensure that they use the tutorial time effectively.
Class tests:	Class tests will assess conceptual understanding of the lecture modules delivered, usually occurring towards the end of each module. Class tests will sit from 14h00 in PHYLAB2 and will adhere to the usual examination rules.
Weekly problem sets:	Each week a problem set will be issued. One or more questions (determined by the lecturer) will be marked by the tutors. Solutions must be written completely and legibly and submitted before the stated deadline to receive full marks. Students may work together on the problems, and discuss results, but the submitted work must be individual. Late submissions will not be accepted.

Project: As part of the integrated assessment requirement of the course, a project will involve independent reading, research, and measurement or computation. Projects will have time scheduled in the second semester. Projects are equivalent to 10% of the course record and should represent an appropriate amount of effort (i.e. 3x laboratory reports, or around 50 hours). A poster presentation at the end of semester 2 will form summative assessment of the projects.

Plagiarism: The automated plagiarism detection utility TurnItIn will be used for all assessed work. The real criterion is this: work that you hand-in for credit is work that you must yourself understand. If copying from others is detected, the work of both the copier and the copied will not be marked, and a mark of zero will be awarded to each, and university disciplinary procedures may be invoked. Submitting solutions taken from the web, generated by AI, or from previous years also constitutes plagiarism. A mark of zero may be awarded, or a nominal mark may be awarded at the discretion of the course convener. Students are asked to sign the faculty honour pledge and plagiarism declaration at the beginning of the course and for each assessment.

Assessment:

4 x class tests	15%
Laboratory record (7 practicals):	20%
24 x weekly problem sets:	5%
1 x project report and presentation:	10%
2 x June exam papers [2 hours + 10 mins reading]	25%
2 x November exam papers [2 hours + 10 mins reading]	25%

There is a subminimum of 40% required on the average of the four examinations (see Science Faculty Handbook). At the discretion of the lecturer in charge of each module, students may bring an appropriate formula sheet to tests and examinations. Additional formulae and/or data will be provided as required.

Duly Performed (DP) requirement: To qualify for writing the final examination, the following DP requirements must be met during the week starting 13 October:

- minimum of 40% class record;
- attendance at all tests and tutorials;
- completion of all laboratory reports;
- completion of the project;
- completion of 85% of the problem sets

Course record: You can check your course record using the Amathuba gradebook.

Lecture Outline**:** There are 6 lecture modules (total 120 lectures).

NP	Nuclear Physics	15 lectures	Prof. Andy Buffler
EM	Electromagnetism	25 lectures	Dr. Tom Leadbeater
TP	Thermal Physics	25 lectures	Prof. Andre Peshier
AP	Atomic Physics	25 lectures	A/Prof. Mark Blumenthal
SS	Solid State Physics	15 lectures	Dr. Trisha Salagaram
PP	Particle Physics	15 lectures	Dr Mawande Lushozi

Details for the modules are given below:

Electromagnetism: Maxwell's equations in vacuum and in matter, conservation laws, momentum and angular momentum in EM fields, EM waves, absorption and dispersion, wave guides, gauge transformations, retarded potentials, electric and magnetic dipole radiation, power radiated by a point charge, special relativity, four-vectors, relativistic electrodynamics.

Atomic Physics: Atoms; x-rays; angular momentum in quantum mechanics; spherical harmonics; hydrogen atom; transitions and selection rules; spin, fine structure, Lamb shift, Zeeman effect, hyperfine structure; helium atom; multi-electron atoms; atomic structure and the periodic table.

Thermal Physics: Temperature, heat and work, first law of thermodynamics, ensembles and entropy, second law of thermodynamics, Boltzmann distribution and Helmholtz free energy, thermal radiation, chemical potential and Gibbs distribution, Femi-Dirac statistics, electrons in metals, Bose-Einstein statistics, phonons, photons and the black-body distribution, the Bose-Einstein condensate, application to classical and quantum systems.

Nuclear and Particle Physics: basic properties of nuclei, nuclear binding energy and the semi-empirical mass formula, nuclear shell model, radioactivity and the radioactive decay series; alpha, beta and gamma radioactivity; interaction of radiation with matter, radiation dosimetry; standard model of particle physics, Feynman diagrams, high energy particle physics experimentation.

Solid State Physics: Crystal structure; lattice vibrations; electron states in solids; nearly free electron model, energy band theory; semiconductor physics and devices.

Prescribed textbooks:

The following list of textbooks are prescribed for the 6 modules, building upon the prescribed texts from PHY2004W. The module lecturers may recommend other texts to complement their courses and may provide additional materials through Vula.

- Griffiths, D.: Introduction to Electrodynamics (Pearson, 2014)
- Griffiths, D.: Introduction to Quantum Mechanics (Pearson, 2005)
- Schroeder, D.: Introduction to Thermal Physics (Pearson, 2013)
- Martin, B.: Nuclear and Particle Physics (Wiley, 2006)
- Hoffmann, P.: Solid State Physics - An Introduction (Wiley, 2007)