DEPARTMENT OF PHYSICS
UNIVERSITY OF CAPE TOWN

PHY3004W: Advanced Physics

Course information 2021

Semester 2 (2 August – 1 November)

This course 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 Vula.

Entry requirements:	PHY2004W, and 40% in MAM2000W or (MAM2004H and MAM2047H)
Convenor:	Dr Tom Leadbeater, 5.12 RW James, Tom.Leadbeater@uct.ac.za Consultation: any time, or by appointment, or Wednesdays 15:00.
Lectures:	RW James LT4A / Zoom, 4th period (11h00 – 11h45), Monday to Friday. Lectures will be recorded.
Class tutors:	Robert Van Der Merwe: VMRROB003@myuct.ac.za TBC for individual modules.
Class representatives:	Victor Bantchovski: bntvic003@myuct.ac.za Tenille Bjerring: bjrten001@myuct.ac.za Nhlanhla Hlengane: hlnnhl005@myuct.ac.za Dillon Lewis: lwsdil001@myuct.ac.za
Laboratory:	Laboratory runs formal sessions with the academic in charge on Mondays from 14h00 to 17h00 in PHYLAB3 / Zoom. 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 Vula for more information.
Tutorials:	White board style tutorials will run most Tuesdays from 14h00 to 17h00. There will be a mixture of online (Zoom / MS Teams) and mask-to-mask activities where appropriate. 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.
Campus access:	In order to access campus under Covid-19 regulations, you must complete the Covid induction form (https://forms.gle/BdSL979FoBoGRPi39) once only. Then for every day you wish to access campus you must complete the daily healthcheck app using either a laptop or smartphone, the healthcheck address can be found here: https://uct.service-now.com/sp/
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 to receive full marks, and uploaded to the appropriate place on Vula

before the stated deadline. Students may work together on the problems, and discuss the results together, but the submitted work must be each student's own. 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).

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 the solutions taken from the solutions posted on the web or from previous years, also constitutes copying. A mark of zero may be awarded, or a nominal mark may be awarded at the discretion of the course convener. You will be asked to sign the faculty honour pledge and plagiarism declaration at the beginning of the course and for each assessment.

Assessment:

5 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 / Septmeber exam papers [2 hours each]	25%
2 x Nov. exam papers [2 hours each]	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 all tests and examinations. Additional formula and/or data sheets will be provided.

Duly Performed (DP) requirement: In order to qualify for writing the final examination, the following DP requirements must be met during the week starting 25 October:

- minimum of 40% in class record;
- attendance at all tests;
- completion of all laboratory reports;
- completion of the project;
- completion of 75% of the tutorials and problem sets

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

***Lecture Outline*:** There are 6 lecture modules.

EM	Electromagnetism	30 lectures	Dr. Tom Dietel
AP	Atomic Physics	25 lectures	A/Prof. Heribert Weigert
TP	Thermal Physics	25 lectures	Prof. Andre Peshier
NP	Nuclear Physics	10 lectures	A/Prof. Steve Peterson
PP	Particle Physics	10 lectures	Dr. Sahal Yacoob
SS	Solid State Physics	15 lectures	A/Prof. Mark Blumenthal

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, EM field tensor.

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)