DEPARTMENT OF PHYSICS

The Department is housed in the R W James Building, 9 University Avenue
Telephone (021) 650-3326 Fax (021) 650-3342
The Departmental abbreviation for Physics is PHY.

Professor and Head of Department:
D G Aschman, BSc (Hons) *Cape Town* DPhil *Oxon*
Professor:
D T Britton, MSc PhD *London*
A Peshier, MA PhD *Dresden*
Associate Professors:
M S Allie, MSc PhD *Cape Town* (CHED)
A Buffler, MSc PhD HDE *Cape Town*
C M Comrie, MSc *Natal* PhD *Cantab*
R W Fearick, BSc (Hons) PhD *Wits*
M Härting, Dipl Phys *Regensberg* Dr. Ing BW *München*
Senior Lecturer:
I Govender, BSc (Hons) PhD *Cape Town* HDE *Unisa*
S M Wheaton, MSc PhD *Cape Town*
Lecturers:
W A Horowitz, MA MSc PhD *Columbia*
M R Nchodu, MSc PhD *Cape Town*
S W Peterson, MA PhD *Wisconsin*
Part-time Lecturer:
G Leigh, HDE MSc *Cape Town*
Emeritus Professors:
F D Brooks, DSc *Rhodes*
J W A Cleymans, MSc D en Sc *Louvain* FRSSAf
C A Dominguez, MSc PhD *Buenos Aires* FRSSAf
S M Perez, BSc (Hons) *Wits* DPhil *Oxon*
R D Viollier, dipl phys *Basel* Dr phil nat *Basel* FRSSAf
Emeritus Associate Professors:
P E Spargo, BSc (Eng) MSc *Wits* Cert Ed *Cantab* FRSSAf
G N v d H Robertson, BSc (Hons) *Cape Town* DPhil *Oxon*
Honorary Research Associate:
F E Lubben, MSc *Delft* MA *York* PGCE *Delft*
Principal Technical Officers:
D Boulton
L N van Heerden, BSc *Stell*
Chief Technical Officers:
G K Fowle
K J Ontong
Scientific Officer:
J E Fearon, MSc *Cape Town*
Department Administrator:
N Lovric
Senior Secretary:
M Maich (part-time)
L C van Zyl
Librarian:
S Knox
Laboratory Attendants:
M Christians

L Oliver
G Swartz
Departmental Assistant:
M Lawrence

RESEARCH IN PHYSICS

The Department of Physics is accommodated in the R W James Building, which houses laboratories equipped for nuclear physics, X-ray diffraction and physics education research. Additional facilities available to the Department are provided by iThemba Laboratories for Accelerator Based Sciences (200 MeV cyclotron and a 5 MeV Van de Graaff accelerator).
Major areas of interest at present include:
1 Experimental nuclear physics: gamma ray spectroscopy, giant resonance reactions with the magnetic spectrometer, neutron cross sections, applied neutron physics (Professor D G Aschman, Associate Professors A Buffler and R W Fearick and Dr M R Nchodu).
2 Research in Theoretical Physics (Dr W A Horowitz, Dr S M Wheaton, Professor A Peshier) comprising:
(a) Structure of elementary particles.
(b) Weak interactions: Coherent neutrino interaction with matter, weak decays of particles.
(c) Quantum field theory: Quantum electrodynamics and chromodynamics in free space, in the cavity and at extreme temperatures and pressures. Confinement. Vacuum structure.
(d) Phenomenology of heavy ion reactions.
(e) Quark gluon plasma.
(f) String Theory: application of the AdS/CFT correspondence to heavy ion collisions and the quark gluon plasma.
3 UCT-ALICE research centre: Relativistic heavy ion collisions within the ALICE collaboration at CERN, Geneva, Switzerland (Associate Professor R Fearick, Professor A Peshier).
4 Nanophysics and solid state physics: Structural and electrical properties of thin films (Associate Professor C M Comrie). X-ray diffraction studies of strain fields and residual stress analysis, nanophysics in the Nanosciences Innovation Centre (Professor D T Britton and Associate Professor M Härting).
5 Physics education: Problem solving in physics, curriculum design and evaluation, language in science, students' understanding of measurement and uncertainty, modelling and visualization (Associate Professors M S Allie and A Buffler)
6 Applied Physics: Positron Emission Particle Tracking, particulate flow and interaction characterization in engineering and biological systems by computational and mechanistic modelling, measurement techniques; radiation transport modelling in industrial and medical systems (Dr I Govender and Associate Professor A Buffler, Drs S M Wheaton and SW Petersen).

Undergraduate Courses

Credit will not be given for both PHY1023H and PHY1031F. Credit will not be given for both of PHY1024F and PHY1032S.

First-Year Courses

PHY1004W MATTER & INTERACTIONS

36 HEQF credits

A calculus-based introductory course for Science students intending to continue with second-year Physics.

Course co-ordinator(s): Associate Professor A Buffler

Entrance requirements: Students will normally be expected to have passed Physical Science NSC level 5. MAM1000W (or equivalent) must have been passed or be taken concurrently.

Course outline:

MODERN MECHANICS: Conservation laws, the momentum principle, atomic nature of matter, conservation of energy, energy in macroscopic systems, energy quantization, multiparticle systems,

exploring the nucleus, angular momentum, entropy, kinetic theory of gases, efficiency of engines.
ELECTRIC AND MAGNETIC INTERACTIONS: Electric fields, electric potential, magnetic fields, electric circuits, capacitance, resistance, magnetic force, Gauss' law, Ampere's law, Faraday's law, induction, electromagnetic radiation, waves and particles.

	Period				
	Mon	**Tue**	**Wed**	**Thu**	**Fri**
Lectures:	3	3	3	3	3

Practicals: One practical or tutorial per week, Tuesday, 14h00-17h00.

DP requirements: Minimum of 30% in class record; 50% in laboratory assessment.

Assessment: Class record (weekly problem sets and class tests) counts 25%; laboratory record (weekly laboratory marks and two laboratory examinations) counts 25%; one June 2-hour examination counts 25%; one November 2-hour examination counts 25%.

PHY1023H PRINCIPLES OF PHYSICS A

18 HEQF credits

A calculus-based introductory course primarily for students on the General Entry Programme for Science (GEPS). It is possible for students from other courses to transfer to this course during the year.

Course co-ordinator(s): Associate Professor M S Allie

Entrance requirements: This course is taken by students on the General Entry Programme for Science.

Course outline:

The first half of this course provides students with the essential tools and skills that are required for dealing successfully with physics at first-year university level. The three broad areas that are covered are (a) mathematical techniques and their relationship with physical phenomena, (b) experimental procedures and (c) communication skills, in particular report writing. The second half of the course covers material similar to that of the first half of PHY1004W.

Second semester:

MECHANICS: vectors, kinematics, dynamics, work, energy power, conservative and non-conservative forces, friction, impulse, momentum, collisions, rotation, rotational dynamics, torque, rotational inertia, rotational energy, angular momentum, static equilibrium, gravitation.

PROPERTIES OF MATTER: elasticity, elastic moduli, hydrostatics, hydrodynamics.

THERMAL PHYSICS: temperature, heat, kinetic theory of gases, thermodynamics, entropy.

	Period				
	Mon	**Tue**	**Wed**	**Thu**	**Fri**
Lectures:	3	3	3	3	3

Practicals: One practical or tutorial per week, Tuesday, 14h00-17h00.

DP requirements: Minimum of 30% in class record; 50% in laboratory assessment.

Assessment: Class record (weekly problem sets and two class tests) counts 25%; laboratory record (weekly laboratory marks and a two-hour laboratory examination) counts 25%; one 3-hour written examination counts 50%.

PHY1024F PRINCIPLES OF PHYSICS B

18 HEQF credits

A calculus-based introductory course usually taken by students who have completed PHY1023H.

Course co-ordinator(s): Dr S W Peterson

Entrance requirements: PHY1023H; MAM1000W (or equivalent) must have been passed or be taken concurrently.

Course outline:

ELECTRICITY AND MAGNETISM: electric charge, electric field, Gauss' law, electric potential, capacitance, current, current density, emf, resistance, resitivity, networks, magnetic field, Biot-

Savart law, Ampere's law, electromagnetic induction, inductance, alternating currents.
VIBRATIONS AND WAVES: simple harmonic motion, damped oscillations, forced oscillations, resonance, travelling waves, phase velocity, superposition, standing waves, sound intensity, Doppler effect.
MODERN PHYSICS: electromagnetic waves, interference, diffraction, the electron, quantum physical phenomena, atomic structure, wave-particle duality, X-rays, elementary nuclear physics, radioactivity.

	Period				
	Mon	**Tue**	**Wed**	**Thu**	**Fri**
Lectures:	3	3	3	3	3

Practicals: One practical or tutorial per week, Wednesday, 14h00-17h00.
DP requirements: Minimum of 30% in class record; 50% in laboratory assessment.
Assessment: Class record (weekly problem sets and two class tests) counts 25%; laboratory record (weekly laboratory marks and a two-hour laboratory examination) counts 25%; one 3-hour written examination counts 50%.

PHY1031F GENERAL PHYSICS A

18 HEQF credits
A non-calculus introductory course for Science students who do not intend proceeding to second-year courses in Physics.
Course co-ordinator(s): Associate Professor C M Comrie
Entrance requirements: Students will be expected to have passed Physical Science at NSC level 5.
Course outline:
MECHANICS: vectors, kinematics, dynamics, work, energy, power, conservative and non-conservative forces, friction, impulse, momentum, collisions, rotation, rotational dynamics, torque, rotational inertia, rotational energy, angular momentum, static equilibrium, gravitation.
PROPERTIES OF MATTER: elasticity, elastic moduli, hydrostatics, hydrodynamics.
THERMAL PHYSICS: temperature, heat, kinetic theory of gases, thermodynamics.
VIBRATIONS AND WAVES: simple harmonic motion, damped oscillations, forced oscillations, resonance, travelling waves, phase velocity, superposition, standing waves, sound waves, sound intensity, Dopper effect.

	Period				
	Mon	**Tue**	**Wed**	**Thu**	**Fri**
Lectures:	3	3	3	3	3

Practicals: One practical or tutorial per week, Monday, Wednesday, Thursday or Friday, 14h00-17h00.
DP requirements: Minimum of 30% in class record; 50% in laboratory assessment.
Assessment: Class record (weekly problem sets and two class tests) counts 25%; laboratory record (weekly laboratory marks and a 2-hour laboratory examination) counts 25%; one 3-hour written examination counts 50%.

PHY1032S GENERAL PHYSICS B

18 HEQF credits
A non-calculus introductory course for Science students who do not intend proceeding to second-year courses in Physics.
Course co-ordinator(s): Dr S M Wheaton
Entrance requirements: At least 40% in PHY1031F, or PHY1023H
Course outline:
ELECTRICITY AND MAGNETISM: electric charge, electric field, Gauss' law, electric potential, capacitance, current, current density, emf, resistance, resitivity, networks, magnetic field, Biot-Savart law, Ampere's law, electromagnetic induction, inductance, alternating currents.

OPTICS: Geometrical optics, polarization, electromagnetic waves, interference, diffraction.
MODERN PHYSICS: the electron, quantum physical phenomena, atomic structure, wave-particle duality, X-rays, elementary nuclear physics, radioactivity.

	Period				
	Mon	**Tue**	**Wed**	**Thu**	**Fri**
Lectures:	3	3	3	3	3

Practicals: One practical or tutorial per week, Monday, Wednesday, Thursday or Friday, 14h00-17h00.

DP requirements: Minimum of 30% in class record; 50% in laboratory assessment.

Assessment: Class record (weekly problem sets and two class tests) counts 25%; laboratory record (weekly laboratory marks and a two-hour laboratory examination) counts 25%; one 3-hour written examination counts 50%.

Second-Year Courses

PHY2009S INTERMEDIATE PHYSICS

24 HEQF credits

A course normally taken by students who have not completed PHY1004W, to prepare them for PHY2014F and PHY2015S.

NOTE: This course will only run subject to the availability of staff.

Course co-ordinator(s): Dr W A Horowitz

Entrance requirements: PHY1023H and PHY1024F (or equivalent), and MAM1005H (or equivalent), MAM1006H must be taken concurrently.

Course outline:

VECTOR FIELDS IN PHYSICS: Vector calculus, div, grad, curl, line, surface and volume integrals, Gauss' Theorem, Stokes' Theorem, applications to fluid dynamics and electromagnetism.
STATISTICAL MODELLING OF RADIATION AND MATTER: mathematical descriptions of solids, liquids and gases, entropy, temperature, the Boltzmann distribution, thermodynamics, statistical models of photons, statistical models in quantum mechanics, wave-particle duality.

	Period				
	Mon	**Tue**	**Wed**	**Thu**	**Fri**
Lectures:	5	5	5	5	5

Practicals: One practical or tutorial per week, Wednesday, 14h00-17h00.

DP requirements: Minimum of 35% in class record, completion of all laboratory reports and 75% of tutorial work, attendance at all class tests.

Assessment: Class record (tests, tutorials, projects, laboratory work) counts 50%, one 2-hour paper written in November counts 50%.

PHY2014F WAVES & ELECTROMAGNETISM

24 HEQF credits

Course co-ordinator(s): Professor D G Aschman

Entrance requirements: PHY1004W or (PHY2009S and MAM1043H), a full first-year course in Mathematics and MAM2000W or (MAM2004H and MAM2046W) as corequisite.

Course outline:

VIBRATIONS AND WAVES: Harmonic oscillations, damped and forced oscillations, resonance, Fourier analysis, harmonic chains, waves, dispersion, interference, diffraction.
ELECTROMAGNETISM: Vector calculus (div, grad, curl), electrostatics, special techniques for potentials, electric fields in matter, magnetostatics, Magnetic fields in matter, current, Ohm's law, circuits, electromagnetic induction, electrodynamics, Maxwell's equations.

	Period				
	Mon	**Tue**	**Wed**	**Thu**	**Fri**
Lectures:	4	4	4	4	4

Practicals: One practical per week, Monday, 14h00-17h00.

DP requirements: Minimum of 35% in class record; completion of all laboratory reports, 75% of tutorial work and problem sets; attendance at all tests; all proficiency tests.

Assessment: Class record (tests, weekly problem sets and laboratory work) counts 50%; one 3-hour examination written in June counts 50%.

PHY2015S CLASSICAL & QUANTUM MECHANICS

24 HEQF credits

Course co-ordinator(s): Associate Professor R W Fearick

Entrance requirements: As for PHY2014F.

Course outline:

CLASSICAL MECHANICS: Review of Newton's laws, constraints, D'Alembert principle, Lagrangian formulation of mechanics, conservation laws, applications, central forces, planetary motion, small oscillations, normal co-ordinates.

QUANTUM MECHANICS: The basic assumptions of quantum mechanics, solutions of Schrödinger's equation, properties of wave functions and operators, one-dimensional applications, angular momentum in quantum mechanics, three-dimensional applications, the hydrogen atom, approximate methods.

	Period				
	Mon	**Tue**	**Wed**	**Thu**	**Fri**
Lectures:	4	4	4	4	4

Practicals: One computational practical per week, Monday, 14h00-17h00.

DP requirements: Minimum of 30% in class record; completion of all laboratory reports and 75% of tutorial work, attendance at all tests.

Assessment: Class record (tests, weekly problem sets and laboratory work) counts 50%; one 3-hour paper written in November counts 50%.

Third-Year Courses

PHY3021F ADVANCED PHYSICS A

36 HEQF credits

Course co-ordinator(s): Associate Professor R W Fearick

Entrance requirements: PHY2014F and PHY2015S, and MAM2000W or (MAM2004H and MAM2046W) must have been completed or be taken concurrently.

Course outline:

ELECTROMAGNETISM: Maxwell's equations in vacuum and in matter, conservation laws, momentum and angular momentum in electromagnetic fields, electromagnetic waves, the Fresnel relations, laws of optics, absorption and dispersion, frequency dependence of permittivity, wave guides, gauge transformations, retarded potentials, electric and magnetic dipole radiation, power radiated by a point charge, special relativity, four-vectors, relativistic kinematics, relativistic electrodynamics, the electromagnetic field tensor.

THERMODYNAMICS AND STATISTICAL 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, Fermi-Dirac statistics, electrons in metals, Bose-Einstein statistics, phonons, photons and the black-body distribution, the Bose-Einstein condensate, applications to classical and quantum systems.

	Period				
	Mon	**Tue**	**Wed**	**Thu**	**Fri**
Lectures:	4	4	4	4	4

Practicals: Two sessions per week, Monday and Thursday, 14h00-17h00.

DP requirements: Satisfactory completion of tutorial assignments and laboratory reports.

Assessment: Class tests, essays, projects and laboratory reports count 50%; one 3-hour paper and one 2-hour paper count 50%.

PHY3022S ADVANCED PHYSICS B

36 HEQF credits

Course co-ordinator(s): Professor D G Aschman

Entrance requirements: PHY2014F and PHY2015S, and MAM2000W or (MAM2004H and MAM2046W) must have been completed or be taken concurrently.

Course outline:

ATOMIC PHYSICS: atomic structure and spectra, selection rules, fine structure, molecular structure and spectra.

NUCLEAR AND PARTICLE PHYSICS: properties of nuclei, nuclear forces, nuclear structure and reactions, radioactivity, decay modes, interactions of elementary particles, quarks & leptons, symmetries and the gauge forces.

SOLID STATE PHYSICS: crystal structure; lattice vibrations, electron states in solids, energy band theory, semiconductor physics and devices.

	Period				
	Mon	**Tue**	**Wed**	**Thu**	**Fri**
Lectures:	4	4	4	4	4

Practicals: Two sessions per week, Monday and Thursday, 14h00-17h00.

DP requirements: Class record 50%, laboratories 50% and satisfactory completion of tutorial assignments.

Assessment: Class tests, essays, projects and laboratory reports count 50%; one 3-hour paper and one 2-hour paper count 50%; oral exam 2%.

Postgraduate Courses

PHY4000W BSc (HONS) IN PHYSICS

160 HEQF credits

(includes research project of 40 credits)

Course co-ordinator(s): Professor A Peshier

Entrance requirements: Entrance requirement is a BSc degree with a major in Physics. Enrollments are limited to an overall total of 15 in PHY4000W, PHY4001W and PHY4002W. Acceptance will be at the discretion of the Head of Department who will consult the Honours course convener. Criteria for acceptance include a pass of 60% in PHY3021F and PHY3022S, or equivalent; and a pass of 50% in MAM2000W or MAM2046W or equivalent; and in cases where the Head of Department deems it necessary, favourable referee reports. Preference may be given to UCT graduates who meet the entrance requirements.

Course outline:

The Honours course in Physics consists of the following compulsory modules: Research Project (core), Quantum Mechanics (core), Electromagnetism (core), Statistical Mechanics, Computational Physics, Nuclear Physics and Solid State Physics. Further elective modules may be chosen from Classical Mechanics, Particle Physics, Physics Education and Relativistic Quantum Mechanics, and approved advanced level modules offered by the Departments of Astronomy and Mathematics and Applied Mathematics. Additional modules may be also offered by the Physics Department.

DP requirements: 30% for class tests and problem sets.

Assessment: The pass mark is 50% and is based on an aggregation of all modules, and is further subject to the subminimum criteria of obtaining a minimum mark of 35% in the project, passing two thirds of all modules, and achieving a mark of at least 35% percent in all but one of the core modules. The research project will count 25% of the final mark.

PHY4001W BSc (HONS) IN THEORETICAL PHYSICS

160 HEQF credits

(includes research project of 40 credits)

Course co-ordinator(s): Professor A Peshier

Entrance requirements: Entrance requirement is a BSc degree with majors in Physics and Mathematics or Physics and Applied Mathematics. Enrollments are limited to an overall total of 15 in PHY4000W, PHY4001W and PHY4002W. Acceptance will be at the discretion of the Head of Department who will consult the Honours course convener. Criteria for acceptance include a pass of 60% in PHY3021F and PHY3022S, or equivalent; a pass of 60% in MAM3000W or MAM3040W, or equivalent; and in cases where the Head of Department deems it necessary, favourable referee reports. Preference may be given to UCT graduates who meet the entrance requirements.

Course outline:

The Honours course in Theoretical Physics consists of the following compulsory modules: Research Project (core), Quantum Mechanics (core), Electromagnetism (core), Statistical Mechanics, Classical Mechanics, Particle Physics and Relativistic Quantum Mechanics. Further elective modules may be chosen from Nuclear Physics, Solid State Physics, Computational Physics and Physics Education, and approved advanced level modules offered by the Departments of Astronomy and Mathematics and Applied Mathematics. Additional modules may be also offered by the Physics Department.

DP requirements: 30% for class tests and problem sets.

Assessment: The pass mark is 50% and is based on an aggregation of all modules, and is further subject to the subminimum criteria of obtaining a minimum mark of 35% in the project, passing two thirds of all modules, and achieving a mark of at least 35% percent in all but one of the core modules. The research project will count 25% of the final mark.

PHY4002W BSc (HONS) IN MATHEMATICAL & THEORETICAL PHYSICS

160 HEQF credits

(includes research project of 40 credits)

Course co-ordinator(s): Professor A Peshier

Entrance requirements: Entrance requirement is a BSc degree with majors in Physics and Mathematics or Physics and Applied Mathematics. Enrollments are limited to an overall total of 15 in PHY4000W, PHY4001W and PHY4002W. Acceptance will be at the discretion of the Head of Department who will consult the Honours course convener and the Head of the Department of Mathematics and Applied Mathematics. Criteria for acceptance include a pass of 60% in PHY3021F and PHY3022S, or equivalent; a pass of 60% in MAM3000W or MAM3040W, or equivalent; and in cases where the Head of Department deems it necessary, favourable referee reports. Preference may be given to UCT graduates who meet the entrance requirements.

Course outline:

The Honours course in Theoretical and Mathematical Physics comprises 12, and optionally up to 14 units. The course consists of the following compulsory modules: Research Project (core), Quantum Mechanics (core), Electromagnetism (core), Advanced Mathematical Methods (core, offered by the Department of Mathematics and Applied Mathematics), and Classical Mechanics. Further elective modules may be chosen from Statistical Mechanics, Particle Physics, Relativistic Quantum Mechanics, Nuclear Physics, Solid State Physics, Computational Physics and Physics Education, and approved advanced level modules offered by the Departments of Astronomy and Mathematics and Applied Mathematics. Additional modules may be also offered by the Physics Department.

DP requirements: 30% for class tests and problem sets.

Assessment: The pass mark is 50% and is based on an aggregation of all modules, and is further subject to the subminimum criteria of obtaining a minimum mark of 35% in the project, passing two thirds of all modules, and achieving a mark of at least 35% percent in all but one of the core modules. The research project will count 25% of the final mark.

PHY5000W MASTERS IN PHYSICS

180 HEQF credits

The Masters in Physics consists of the completion of a research project on an approved topic on which a dissertation must be presented. General rules for this degree may be found in the front of the handbook.

PHY5001W MASTERS IN THEORETICAL PHYSICS

180 HEQF credits

The Masters in Theoretical Physics is obtained by satisfactorily completing a research project on which a dissertation must be presented. Students are required to participate in courses which may be offered on topics such as quantum electrodynamics, relativistic quantum field theory, particle physics, electroweak and strong interactions. General rules for this degree may be found in the front of the handbook.

PHY5003W DISSERTATION COMPONENT OF THE MSc IN ASTROPHYSICS & SPACE SCIENCE

90 HEQF credits

Entrance requirements: AST5003F

Dissertation: Students will work on an approved research topic on which a dissertation must be presented.

PHY5006W MASTERS IN TERTIARY PHYSICS EDUCATION

180 HEQF credits

The Masters in Physics consists of the completion of a research project on an approved topic on which a dissertation must be presented. General rules for this degree may be found in the front of the handbook.

PHY6000W PhD IN PHYSICS

360 HEQF credits

The PhD degree may be undertaken either in the field of Physics or of Theoretical Physics. In both cases students are required to complete an original research project on which an acceptable thesis must be presented. Students of Theoretical Physics, in addition, must participate successfully in an advanced course entitled Special Topics in Theoretical Physics and in the MSc courses in Theoretical Physics listed above, if these have not been attended previously. Candidates are referred to the rules for this degree as set out in Book 3, General Rules and Policies.

PHY6001W PhD IN TERTIARY PHYSICS EDUCATION

360 HEQF credits

Candidates for the PhD degree are required to complete an approved original research project on which an acceptable thesis must be presented. Candidates are referred to the rules for this degree as set out in Book 3, General Rules and Policies.