LEVEL 2 PHYSICS IN 2013

You will receive information about re-enrolment procedures for 2013 in December after exam results are released.

The structure and content of the Level 2 physics units are significantly different from those at Level 1. Launching from the strong foundation provided in Level 1, you are in a position to tackle a wide range of topics in modern physics. This is a challenge, in that you will be developing new ways to think about the world around you, which is governed by quantum physics rather than classical physics. Our experience is that students respond well to this challenge. The reward is real insight into the rich vista of physical phenomena from atomic and nuclear scales right through to cosmological scales.

If you require more information or advice about the options available to you in Level 2 Physics, please contact the second-year course coordinator:

Winthrop Professor Ian McArthur, Room 4-2 School of Physics, 6488 2737
e-mail: ian.mcarthur@uwa.edu.au.

Also see the School of Physics web site: http://www.physics.uwa.edu.au

LEVEL 2 PHYSICS UNITS

The **prerequisite** units to be able to study Level 2 Physics units are: **PHYS1001, PHYS1002 and MATH1001**

The Level 2 Physics units are

- **PHYS2001 Quantum Mechanics 1 and Electromagnetism (Semester 1)**
- **PHYS2002 The Physics of Particles (Semester 2)**

The first semester unit PHYS2001 also requires a previous pass, or concurrent enrolment, in MATH1002. PHYS2001 & PHYS2002 can be taken in any order, but PHYS2001 is only offered in first semester and PHYS2002 is only offered in second semester.

The above set of Level 1 & 2 units provides three possible pathways for further study in Physics:

- **Physics Major (Physics stream)**
- **Physics Major (Astronomy & Astrophysics stream)**
- **Physics Elective Level 3 units**

For students undertaking a Physics Major (either stream), two Level 2 complementary units have to be taken in addition to PHYS2001 and PHYS2002, namely:

- CITS2401 Computer Analysis & Visualisation (Semester 1 or 2) with prerequisite MAT3AB
- MATH2501 Mathematical Methods 3 (Semester 2) with prerequisite MATH1002

MAJOR IN PHYSICS

The Major in Physics allows a choice of either a Physics stream or an Astronomy & Astrophysics stream. The two streams do not differ at Level 1 and Level 2; this is based on the premise that a good astronomer or astrophysicist needs a strong grounding in modern Physics, Mathematics and computational techniques that form the cornerstones of current Astronomical and Astrophysical research. Level 2 Physics topics include quantum mechanics, particle physics, nuclear physics, electromagnetic theory, thermodynamics and statistical mechanics.

The Level 2 structure of the Physics Major for students who have completed the Level 1 units PHYS1001, PHYS1002 and MATH1001 is

SEMESTER 1		SEMESTER 2	
PHYS2001	Quantum Mechanics 1 and Electromagnetism	PHYS2002	The Physics of Particles
CITS2401	Computer Analysis and Visualisation	MATH2501	Mathematical Methods 3
Previous pass or concurrent enrolment in:			
MATH1002	*Mathematical Methods 2*		

For the remaining four Level 2 units (24 points): In addition to fulfilling broadening unit requirements, students are encouraged to choose units which leave open a major in another discipline.

Looking ahead to Level 3

At Level 3, all students continue to develop their knowledge and skills in classical mechanics, electromagnetism and special relativity, and enter new territory studying topics at the frontiers of modern physics.

Those in the Physics stream also undertake studies in advanced quantum mechanics, atomic physics, condensed matter physics, as well as undertaking experimental research projects.

Those in the Astronomy & Astrophysics stream undertake studies encompassing stellar birth and evolution, planetary astronomy, degenerate stars and supernovae, galaxies and their evolution, observational cosmology, astronomical techniques, as well as two advanced observational projects in optical and radio astronomy.

The Physics Major: Level 3 (Physics stream)

SEMESTER	UNIT	PREREQUISITES
1	**PHYS3001 Quantum Mechanics 2 and Atomic Physics**	PHYS2001 & 2
	PHYS3011 Mathematical Physics	PHYS2001 & 2 and MATH2501
2	**PHYS3002 Classical Mechanics and Electrodynamics**	PHYS2001 and MATH2501
	PHYS3012 Optics and Special Topics ***Special Topic: Condensed Matter Physics***	PHYS2001 & 2

The Physics Major: Level 3 (Astronomy & Astrophysics Stream)

SEMESTER	UNIT	PREREQUISITES
1	**PHYS3003 Astrophysics and Space Science**	PHYS2001 & 2 and MATH2501
	PHYS3011 Mathematical Physics	PHYS2001 & 2 and MATH2501
2	**PHYS3002 Classical Mechanics and Electrodynamics**	PHYS2001 and MATH2501
	PHYS3012 Optics and Special Topics ***Special Topic: Astrophysics***	PHYS2001 & 2

ELECTIVE PHYSICS LEVEL 3 UNITS

(For students not intending to major in Physics)

Students are able to take Physics units at Level 3 if the prerequisites are met. For example, a Level 2 & 3 Physics Elective unit sequence could be:

LEVEL	SEMESTER	UNIT	PREREQUISITES
2	1	**PHYS2001 Quantum Mechanics 1 and Electromagnetism**+	PHYS1001&2, and MATH1001
	2	**PHYS2002 The Physics of Particles**+	PHYS1001&2 and MATH1001
3	1	**PHYS3001 Quantum Mechanics 2 and Atomic Physics**	PHYS2001 & 2
	2	**PHYS3012 Optics and Special Topics** ***Special Topic: Condensed Matter Physics***	PHYS2001 & 2

Please consult with the second-year coordinator to discuss these possibilities.

UNITS AND MODULES

Level 2 Physics units consist of a number of lecture *modules,* as well as a laboratory component. The modules within each of the second-year physics units are shown below (with numbers of lectures shown in brackets). Detailed information about individual modules is given overleaf.

Semester 1

PHYS2001
QUANTUM MECHANICS 1 AND ELECTROMAGNETISM

Quantum Mechanics (24)	
Electromagnetism (16)	Data Analysis (4) and 5 labs

Semester 2

PHYS2002
THE PHYSICS OF PARTICLES

Many Particle Systems (24)	
Particle and Nuclear Physics (16)	Fourier Analysis (4) and 5 labs

SECOND YEAR COMPUTER FACILITY

This is a facility within the School of Physics that is available exclusively to second-year students. Accounts are available to all second-years on fast and well-equipped machines, and students are encouraged to use the facility for general computing purposes (including email, web access, work for units in other disciplines and printing at subsidized rates).

THE MODULES

Quantum Mechanics

Newtonian mechanics describes very well physical phenomena that occur on everyday length and energy scales. Einstein realized that for matter travelling at speeds close to that of light, it is a poor approximation to reality and must be replaced by special relativity. It also slowly became clear from experimental evidence in the early part of this century that Newtonian mechanics and classical electromagnetic theory also fail to provide an adequate description of nature on atomic length scales. Through the work of physicists such as Bohr, Schrödinger, Heisenberg and Dirac, a radical new picture of nature at microscopic scales emerged, in the form of quantum mechanics. This has proven to be an astonishingly successful and powerful theory, and forms the basis of our present understanding of the properties of matter via solid state, molecular, atomic, nuclear and (with the incorporation of relativity) particle physics.

The objective of this course is to provide you with the means to start coming to grips with the world in quantum terms. Physical systems are described by wavefunctions that contain all the information that can be determined about the system by performing measurements. In particular, it is not in general possible to predict the outcome of a measurement of a quantity like position or momentum, but only the *probability* of various outcomes. Also, the very act of measurement disturbs a system and this places limits on the precision with which quantities like position and momentum can be simultaneously specified, beautifully encapsulated in the Heisenberg uncertainty principle. The Schrödinger equation is the tool that allows the determination of the wavefunction describing a given physical system. The main thrust of the course is therefore toward solving the Schrödinger equation in various physical situations and learning how to extract and interpret the information hidden in the wavefunction. The applications of these ideas to real physical systems is also addressed.

Many-Particle Systems

Much of modern physics is concerned with explanation of *macroscopic* phenomena in terms of the underlying behaviour of the atoms or molecules that are the *microscopic* elements of the *many-particle system.* Although it is true that, at the microscopic level, the world as we know it obeys the laws of quantum mechanics, our everyday experience forces us to think about systems that are large, and for which the actual rules that govern the microscopic behaviour are secondary to those imposed by the sheer size of the system. For example, even a single grain of sand contains of the order of 10^{20} molecules of SiO_2 and so we need to ask what large-scale behaviours or collective properties such a system has. Some of these so-called macroscopic properties are so general that they are meaningful for all systems. Concepts such as energy, temperature and pressure are familiar examples. Less familiar is the idea of entropy and this turns out to be the fundamental key to understanding the link between the microscopic structure and the macroscopic behaviour.

This module sets out to establish a deep understanding of the general properties of macroscopic systems from a microscopic viewpoint, with the concept of entropy playing a central role. The relationship to *classical thermodynamics* is made clear and tools are developed that reveal the full power of thermodynamic argument. Having established the central importance of the macroscopic thermodynamic parameters, the course addresses the question of how these might be calculated in specific systems. The basic tools of *statistical mechanics* are revealed and compared with the more direct, but much more restricted ideas of *kinetic theory.*

The module is a fundamental building block essential to subsequent studies of all of condensed matter physics, whether it be superconductivity or pulsar physics, lasers or even life itself.

Particle and Nuclear Physics

This module provides students with an introduction to the quantum descriptions of the electromagnetic, weak and strong interactions that are at the core of the Standard Model of Particle Physics. Of these three fundamental interactions, only the electromagnetic interaction manifests itself on macroscopic length scales, where it is well described by Maxwell’s classical theory of Electrodynamics. However, this classical description breaks down on atomic and subatomic length scales and must be replaced by a quantum description, Quantum Electrodynamics (QED). The strong and weak interactions only manifest themselves on subatomic length scales, and so do not have a classical description. Students will come to understand the quantum description of interactions between elementary particles as due to exchange of virtual particles. Each of the fundamental interactions is characterized by a range and an intrinsic strength. The differences between the strong, weak and electromagnetic interactions will be explained in terms of the quantum description of the interaction.

Electromagnetism

Of the four known forces in nature, the electromagnetic force is all-pervading, being effective at subatomic distances (the realm of the strong and weak forces, each being of extremely short range) and at astronomical distances (the realm where the gravitational force is significant). A proper study of electro-magnetism is therefore central to physics, being an excellent example of the evolution of a physical theory from basic experiments to a mathematical formulation of great beauty and elegance.

The module will cover topics from Coulomb's law through to plane waves in dielectrics. Relativity will be used to explain the Lorentz transformation and the transformation of electric and magnetic fields.