LEVEL I COURSES

Physics 1000A/B Physics I

Physics 1001A/B Physics for the Life & Earth Sciences I

Physics 1002 Astronomy I

Physics 1005 Physics, Ideas and Society I

Physics 1007 Space Science and Astrophysics I

The following courses comprise selected material from Physics I for Engineering students.

Physics 1003 Physics IHE

Physics 1006 Physics IHP

Physics 1000A/B: Physics I

Level: I **Units:** 6 **Duration:** Full year

Prerequisites*:* SACE Stage 2 Physics, Maths 1 & 2. In exceptional circumstances, high achieving students who have not completed Mathematics 2 may be granted exemption on application to Head of Department

Corequisite: Pure Mth 1007A/B Mathematics I

Students may be permitted to enrol in Physics 1000A/B Physics I concurrently with Pure Mth 1000A/B on application to Head of Department

Restriction: Physics 1000A/B Physics for the Life and Earth Sciences I

Contact Hours: 3 lectures, 1 tutorial per week; approx. 8 three-hour practical sessions per semester

Aims:

- to develop your understanding of the concepts of physics relevant to the world around us
- to provide experience in identifying appropriate ideas and principles of physics and their use in discussion and calculation to solve problems
- to provide the opportunity to develop the skills and knowledge required to apply the concepts of physics to practical situations
- to develop your ability to learn, independently, aspects of physics needed in new situations.

Content: Measurement and uncertainties. *Waves and Optics* - transverse and longitudinal waves, superposition, interference, standing waves, Fourier decomposition. Fermat's principle, geometric optics, physical optics, interference, Michelson interferometers, thin film interference, diffraction, resolution of telescopes. *Relativity and Quantum Physics - kinematics*, time dilation, length contraction, Lorentz transformations, transformation of velocities, relativistic momentum and energy. X-rays as waves and photons, photoelectric and Compton effects, pair production, de Broglie waves, uncertainty principle, the quantum mechanical wave function. *Mechanics* - vector kinematics, Newton's laws of motion, gravitation, work, energy, conservative forces, momentum, collisions, rotational and simple harmonic motion, equilibrium. *Thermodynamics* -temperature, heat, First Law of Thermodynamics, Kinetic Theory. *Electricity and Magnetism* - charge and current, electric field, Ohm's law, DC circuits, Coulomb and Gauss' laws, electrostatics, capacitance, magnetic field, Ampere and Faraday's laws, inductance, LC circuits. *Practical work* – measurement, sound/waves, optics, electricity, mechanics.

Assessment: written exams, assignments, practical work

References: Giancoli, D., *Physics for Scientists and Engineers*, 3rd Ed. (Prentice Hall). Halliday D., Resnick R. and Walker J., *Fundamentals of Physics*, 5th ed. extended (Wiley).

Physics 1001A/B Physics for the Life and Earth Sciences I

Level: I **Units:** 6 **Duration:** Full year

Prerequisites: SACE Stage 2 Physics, Maths 1 - students without these prerequisites may apply to Head of Department for exemption

Restriction: Physics 1000A/B Physics I

Contact Hours: 3 lectures, 1 tutorial per week; about 8 three-hour practical sessions

Aims:
- to develop your understanding of the concepts of physics relevant to the world around us
- to provide experience in identifying appropriate ideas and principles of physics and their use in discussion and calculation to solve problems
- to provide the opportunity to develop the skills and knowledge required to apply the concepts of physics to practical situations
- to develop your ability to learn independently aspects of physics needed in new situations.

Content: This course does not use calculus and is intended to provide a background in physics at university level for students who wish to major in another area, such as the biological or geological sciences (Physics I and Mathematics I are recommended for students interested in Biophysics and Geophysics.) The emphasis is on physics concepts and their application to relevant problems rather than on the more theoretical or mathematical development of the course. It includes significant material not in matriculation physics or Physics I and presents a contemporary overview of the course. It includes a study of forces and equilibrium, energy, fluids, heat, electricity, magnetism, optics and quantum physics which will give students an insight into the way a physicist understands the natural world. Applications to biology, physiology, environmental physics, X-rays and radioactivity are a special feature of the course.

Note: Students intending to continue to *Physics 2000A/B Physics II* should take the course *Physics 1000A/B Physics I.* A student who gains a distinction in *Physics for the Life and Earth Sciences I* and has an acceptable University mathematical background may be permitted to enrol in *Physics II* with the consent of the Head of Department.

Assessment: written exams, tutorials, essay, practical work.

Reference: Giancoli D, *Physics: Principles with Applications*, 5th ed. (Prentice Hall)
Sternheim MM and Kane JW, *General Physics*, 2nd ed. (Wiley)

Physics 1002 Astronomy I

Level: I | **Units**: 3 | **Duration**: Semester 1

Contact Hours: 3 lectures, 1 tutorial per week; practical work: evening excursion for observations at a dark site; evening session on campus for observation of moon; three evening sessions of astronomical computing exercises.

Aims:
- to introduce you to a broad survey of knowledge about the Universe
- to enable you to use ideas of physics to explain astronomical phenomena
- to develop skills in analysing and communicating ideas
- to develop skills in conducting and reporting astronomical observations

Content: This course is primarily for students who wish to obtain an overall view of contemporary astronomy and how astronomers perceive our place in the Universe. Historical introduction. Modern astronomical instruments. The solar system, structure, dimensions, orbits, theories of origin. Solar system, spacecraft results and minor members of the system. Stars, stellar distances, types of stars, variable stars, star clusters, the Milky Way, stellar evolution. Galaxies, galactic distance scale, radioastronomy, space astronomy, cosmology.

Assessment: End of semester examination, practical work and an essay.

Reference and Recommended Reading:
JD Fix, *Astronomy: Journey to the Cosmic Frontier*, 2^{nd} ed. (McGraw-Hill)

Physics 1005 Physics, Ideas and Society I

Level: I | **Units**: 3 | **Duration**: Semester 2

Contact Hours: 2 lectures and 1 tutorial a week

Aims:
- to present the great ideas of physics and their practical consequences in such a way that public issues and debates which involve science can be approached in an informed way

Content: This course is non-mathematical in character and no previous knowledge of physics is assumed. It is intended for students of the arts, humanities and social sciences and is taught in the style of those disciplines. It may be taken by science students. *Physics 1005 Physics, Ideas and Society I* ranges from the philosophy of science at a fundamental level, and the nature of the Universe, to consideration of the scientific background to issues affecting society such as the greenhouse effect and radiation. Topics to be selected from the following: Physics and its Laws; The Fundamental Constituents of Matter; People and Energy; Space, Time and Relativity; The Realm of the Atom; The Universe.

Assessment: 2 x 2000 word Essays, tutorial work

References: There are no required texts. A reading list will be distributed.

Note: This course is offered in the B.A. degree but may be taken by other students.

Physics 1007 Space Science and Astrophysics I

Level 1 **Units**: 3 **Duration**: Semester 1

Restriction: PHYSICS 1002 Astronomy I

Contact Hours: 3 lectures, 1 tutorial, 3 hours experimental/observational work per week

This course provides an overall view of contemporary astronomy and our place in the astronomer's universe. Historical introduction. Modern astronomical instruments. The solar system, structure, dimensions, orbits, theories of origin. Sun-system relations, individual planets, spacecraft results and minor members of the system. Stars, stellar distances, types of stars, variable stars, star clusters, the Milky Way, stellar evolution. Galaxies, galactic distance scale, radioastronomy, space astronomy, cosmology.

Assessment: exam, practical work

LEVEL II COURSES

Physics 2000A/B Physics II

Physics 2001 Classical Mechanics II

Physics 2002 Classical Fields and Mathematical Methods II

Physics 2004 Introductory Quantum Mechanics and Applications II

Physics 2007 Environmental Physics II

Physics 2009 Photonics II

Physics 2000A/B Physics II

Level: II **Units**: 8 **Duration**: Full Year

Prerequisite: PHYSICS 1000A/B Physics I (Pass Div 1) or equivalent; MATHS 1007A/B Mathematics I (Pass Div 1) or MATHS 2004 Mathematics IIM (Pass Div 1)
Corequisite: APP MTH 2007 Differential Equations II; either APP MTH 2006 Methods in Applied Mathematics II or APP MTH 2002 Vector Analysis and Complex Analysis
Assumed corequisite: PHYSICS 2001 Classical Mechanics II
Restriction: PHYSICS 2003 Electromagnetism and Relativity II (3418); PHYSICS 2004 Introductory Quantum Mechanics and Applications II (6051); PHYSICS 2002 Classical Fields and Mathematical Methods II (9600)

Contact Hours: 3 lectures, 1 tutorial per week; about 20 three-hour practical work sessions per semester

Aims:
- to enable you to develop your understanding of physics concepts
- to improve your ability to engage in physical reasoning
- to improve your problem--solving skills in experimental and theoretical physics

Content: Physics for Planet Earth – structure, temperature and evolution of the universe, thermal equilibrium, thermodynamics, entropy and 2nd law, state functions, entropy of black holes, thermodynamics of energy generation, energy options for planet Earth, blackbody radiation and equilibrium, radiative equilibrium in atmospheres, the greenhouse effect, transport processes in gases. Quantum mechanics – content as for Physics 2004 Introductory Quantum Mechanics with Applications II. Electromagnetism and Mathematical Methods – content as for PHYSICS 2002 Classical Fields and Mathematical Methods II (9600). *Optics* - geometrical and physical optics, ray tracing, aberrations, polarisation, Fraunhofer diffraction, lasers. *Practical work* – instrumentation, general physics, modern physics and project work.

Assessment: End of semester exams, laboratory work, tests.

Reference: Taylor EF and Wheeler JA, *Spacetime* Physics, (Freeman)
Eisberg R and Resnick R, *Quantum Physics of Atoms*, Molecules, Solids, Nuclei and Particles, (Wiley)
Pedrotti FL and Pedrotti LS, *Introduction to Optics*, Prentice Hall

Physics 2001 Classical Mechanics II

Level: II **Units:** 2 **Duration:** Semester 1

Prerequisite: PHYSICS 1000A/B Physics I or equivalent; MATHS 1007A/B Mathematics I (Pass Div 1) or MATHS 2004 Mathematics IIM (Pass Div 1)
Corequisite: APP MTH 2007 Differential Equations II; either APP MTH 2006 Methods in Applied Mathematics II or APP MTH 2002 Vector Analysis and Complex Analysis II

Contact Hours: 2 Lectures a week; 1 tutorial a fortnight

Content: Newton's laws. Conservation laws, central forces, Kepler problem. Many particle systems, rigid bodies, moment of inertia tensor, angular momentum, Eulers equations. Generalised coordinates. Lagrange's equations, Hamilton's equations.

Assessment: Class exercises, essay and oral presentation, 3 hour final exam.

Physics 2002 Classical Fields and Mathematical Methods II

Level: II **Units**: 2 **Duration**: Semester 2

Prerequisite: MATHS 1007A/B Mathematics I (Pass Div 1) or MATHS 2004 Mathematics IIM (Pass Div 1); APP MTH 2007 Differential Equations II; either APP MTH 2006 Methods in Applied Mathematics II or APP MTH 2002 Vector Analysis and Complex Analysis

Assumed knowledge: PHYSICS 1000A/B Physics I
Restriction: PHYSICS 2000A/B Physics II (2653)

Contact Hours: 24 lectures and tutorials.

Content: Scalar and vector field concepts, derivatives of fields, line, surface and volume integrals, curvilinear coordinates, Gauss' and Stokes' theorems. Gauss' law. Poisson's equations, electrostatics and method of images, boundary value problems, vectors and tensors.

Assessment: Class exercises, final 2 hour exam; tests

Physics 2004 Introductory Quantum Mechanics and Applications II

Level: II **Units:** 2 **Duration:** Semester 1

Prerequisite: PHYSICS 1000A/B Physics I (Pass Div 1) or equivalent; PURE MTH 1007/B Mathematics I (Pass Div 1) or PURE MTHS 2004 Mathematics IIM (Pass Div 1)
Corequisite: APP MTH 2007 Differential Equations II; either APP MTH 2006 Methods in Applied Mathematics II or APP MTH 2002 Vector Analysis and Complex Analysis
Restriction: PHYSICS 2000A/B Physics II (2653)

Contact Hours: 24 lectures, 8 tutorials

Content: Wave Mechanics with examples from atomic, sub–atomic and solid state physics. Double slit experiment, de Broglie hypothesis, Heisenberg uncertainty principle. Operators. Commutator. Interference of measurements. Polarised light. Wave equation. Probability density and current. Time independent Schrodinger equation. Energy quantisation. Particle in a one-dimensional box. Kronig–Penny model. Pauli exclusion principle. The threee-dimensional box. Harmonic oscillator in one dimension. Raising and lowering operators. Barrier penetration. Schrodinger equation in three dimensions. Angular momentum. The Hydrogen atom.

Assessment: exam, assignments

Reference: Eisberg R and Resnick R, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles,* (Wiley), Bransden BH and Joachain CJ, *Introduction to Quantum Physics*

Physics 2007 Environmental Physics II

Level: II **Units**: 4 **Duration**: Semester 2

Prerequisite: 6 units of laboratory based Level 1 Science courses
Assumed Knowledge: Year 12 Physics and Mathematics I

Contact Hours: 3 hours of lectures, 1 tutorial and 6 hours of practical work per week

Content: Environmental Physics aims to provide tools and skills derived from the physicists view of the environment, and to provide guidance in their use in understanding the physical world. The topics covered are selected from the following areas:- The Basic Components of Physics including topics from: Fluid Dynamics; Diffusion; Optics and Thermodynamics. Elementary Atomic and Nuclear Physics. Elementary Spectroscopy including topics from: The Solar Spectrum; The Interaction of Light and Matter, and the Spectroscopy of Atmospheric Gases and Biomolecules. The

Ozone Filter, The Scattering of Light, The Global Energy Balance, The Greenhouse Model, Elements of Weather and Climate, Energy for Human Use including: Heat transfer, Heat Engines, Energy Storage and Transport, Renewable Energy Resources and Nuclear Energy. The Transport of Pollutants including topics from, Diffusion, Fluid Flow, Turbulence and Plumes in the Air. Noise including Basic Acoustics and the Control of Sound. Teaching is through lectures, laboratory and project work.

Assessment: exam laboratory, project work

References:

Boeker E and Grondelle R, *Environmental Physics*, Wiley, 1995
Physics for Life and Earth Sciences and Physics I textbooks

Courses: This course may be taken for the following program(s): *Bachelor of Environmental Science, Bachelor of Science (Maths and Comp. Sciences) Bachelor of Computer Science, Bachelor of Science, Bachelor of Science (Jurisprudence).*

Note: this course is a compulsory component of the course Bachelor of Environmental Science but may be taken by other students.

Physics 2009 Photonics II

Level: II **Units**: 2 **Duration**: Semester 2

Prerequisites: 3643 Physics I (Pass Div I) or alternative and 9786 Mathematics I (Pass Div 1), or 9595 Mathematics IMI (Pass Div I).
Corequisite: Physics 2000A/B Physics II

Contact Hours: 1 lecture, three hour practical per week, 1 tutorial per fortnight.

Content: This course will introduce students to the fundamental physics of modern optical and photonic technology. Optical fibres and waveguides. Fundamental properties of light. Electron energy bands in semiconductors and the implications of direct and indirect bandgaps. Light emitting and laser diodes and LEDs. Exciton Quantum confinement including quantum dots, wires and wells. Characteristics of Bragg gratings.

Assessment: Written exam, continuous assessment of laboratory work and a formal laboratory report.

Reference:

LEVEL III COURSES

Physics 3000 Computational Physics

Physics 3002 Experimental Physics III

Physics 3003 Mathematical Physics

Physics 3004 Quantum Mechanics III

Physics 3005 Advanced Quantum Mechanics

Physics 3006 Advanced Dynamics and Relativity

Physics 3007 Introduction to Physics Research

Physics 3008 Physics of Solid State Devices

Physics 3009 Statistical Mechanics

Physics 3012 Atomic and Nuclear Physics

Physics 3013 Astrophysics III

Physics 3014 Atmospheric and Environmental Physics

Physics 3016 Education in Physics with Industrial Cooperation (EPIC) A

Physics 3017 Education in Physics with Industrial Cooperation (EPIC) B

Physics 3018 Electromagnetism III

Physics 3019 Physical Optics III

Physics 3020 Photonics III

Physics 3000 Computational Physics

Level: III **Units:** 2 **Duration:** Semester 1

Prerequisite: MATHS 1007A/B Mathematics I (Pass Div I) or MATHS 2004 Mathematics IIM (Pass Div I)

Assumed knowledge: PHYSICS 2000A/B Physics II, APP MTH 2007 Differential Equations II, APP MTH 1000 Scientific Computing or COMP SCI 1002A/B Computer Science I or equivalent

Contact Hours: 2 lectures, 1 hour tutorial per week

Aims:

- develop basic computer skills in Windows, e-mail and WWW
- experience of some useful packages such as Mathematica
- cover aspects of theoretical and experimental scientific computation
- understand enough theory to enable intelligent application of packages

Content: A selection of basic computational procedures (a hands-on course). Overview of Unix, packages and languages, esp. Fortran, available in the department: IDL, IMSL, Mathematica, Maple and Matlab. Basic mathematical operations: differentiation, integration, finding roots. Solving ordinary DEs; Data analysis, linear and non-linear least squares, chi squared statistic; Fourier methods, sampling, convolution, filtering, FFT. Modelling: basics, interpolation, solving problems of algebraic equations; Series/Laplace solution of ODEs; Generation of numerical code: Function evaluation, Optimisation (Horner's rule, forward differencing).

Assessment: written exam, computing project, class exercises

References:

SE Koonin, Computational physics, (Addison-Wesley 1986)
PL DeVries, A first course in computational physics, (Wiley 1994)
S Wolfram, Mathematica, a system for doing mathematics by computer, (Addison-Wesley 1991)
WH Press, BP Flannery, SA Teukolsky, WT Vetterling, Numerical Recipes in C (or Fortran or Pascal), (Cambridge University Press 1989)

Physics 3002 Experimental Physics III

Level: III **Units:** 3 **Duration:** Semester 1

Prerequisite: PHYSICS 2000A/B Physics II or equivalent
Restrictions: 2838 Experimental Physics and Electronics

Contact Hours: 9 hours practical work per week

Aims:
- to learn new laboratory skills with research-type equipment
- to develop skills in recording and reporting experiments
- to demonstrate the interaction between theory and experiment in scientific investigations
- to learn the basics of practical analogue circuits and interfacing detectors

Content: Laboratory experiments in selected areas including atomic and nuclear physics, optics, thin films and electromagnetism, plus a practical electronics course related to analogue circuits and operational amplifiers.

Assessment: Laboratory work 35%, report on selected experiment 15%, open and closed book tests 50%

Physics 3003 Mathematical Physics

Level: III **Units:** 2 **Duration:** Semester 1

Prerequisite: MATHS 1007A/B Mathematics I (Pass Div I) or MATHS 2004 Mathematics IIM (Pass Div I)
Assumed knowledge: PHYSICS 2002 Classical Fields and Mathematical Methods II or equivalent; APP MTH 2007 Differential Equations II; and either APP MTH 2006 Methods in Applied Mathematics II, or APP MTH 2002 Vector Analysis and Complex Analysis; PURE MTH 2002 Algebra II; PURE MTH 2006 Real and Complex Analysis II;
Restriction: Mathematical Methods (4324)

Contact Hours: 2 lectures, 1 tutorial per week

Aims: Mathematical physics is that branch of physics which focusses on the mathematical structure of the principal theories of physics. This course concentrates on the mathematical techniques required for a full appreciation of the theories and their mathematical structures. It is very broad in scope and introduces some advanced pure mathematics which relates to physics.

Content: Vector spaces, linear operators, inner product spaces. Linear functionals, dual space, tensors, r-vectors, Grassmann algebra. Quaternions, Lie algebras and Lie groups. Continuous vector spaces, distributions, Fourier transforms, Green's functions for Laplace's equation and the wave equation.

Assessment: class exercises 20%, 2 hour exam 80%

Physics 3004 Quantum Mechanics III

Level: III **Units**: 3 **Duration**: Semester 1

Prerequisite: PHYSICS 1000A/B Physics I (Pass Div I); MATHS 1007A/B Mathematics I (Pass Div I) or MATHS 2004 Mathematics IIM (Pass Div I)

Assumed knowledge: PHYSICS 2004 Introductory Quantum Mechanics and Applications II or PHYSICS 2000A/B Physics II

Contact Hours: 3 lectures, approx. 1 tutorial per week

Aims: This Department places great emphasis on understanding quantum mechanics, because its principles lie at the heart of modern physics - experimental, theoretical, and mathematical. Ordinary quantum mechanics, as discussed in this course, describes non - relativistic, microscopic systems; relativistic effects such as creation of particle - antiparticle pairs are neglected. Relativistic quantum mechanics is introduced in Advanced Quantum Mechanics, as a precursor to Quantum Field Theory in Honours where a complete amalgamation of relativity and quantum mechanics is achieved.

Content: This course introduces concepts essential for the understanding of quantum mechanics and the microscopic structure of matter. Review of principles and postulates of quantum mechanics. Mathematical formalism and Dirac bra-ket notation. Commuting observables, compatibility, and the Heisenberg uncertainty relations. Unitary transformations. Schroedinger equation and time evolution. Orbital angular momentum, spherical harmonics, and spatial rotations. Angular momentum, addition of angular momenta, and Clebsch-Gordon coefficients. Schroedinger equation in three dimensions. Separability and central forces spherical square well, hydrogen-like atoms, three-dimensional oscillator. Time-independent approximation methods Perturbation theory, variational methods, WKB approximation. Fine structure of hydrogen atom.

Assessment: 3 hour examination, class exercises and test.

References: Bransden BH and Joachain CJ, *Introduction to Quantum Mechanics*, Longman, 1989
Gasiorowicz S, *Quantum Physics*, Wiley
Sakurai JJ, *Modern Quantum Mechanics*, Addison-Wesley
Powell JL & Craseman B, *Quantum Mechanics*, Addison-Wesley

Merzbacher E, *Quantum Mechanics*, Wiley
Messiah A, *Quantum Mechanics Vols. I and II,* North-Holland
Schiff LI, *Quantum Mechanics, 3rd edn*, McGraw-Hill
Dirac PAM, *Quantum Mechanics, 4th edn*, Oxford
Feynman RP, Leighton RB, Sands M, *Lectures on Physics,* Vol. 3, Addison-Wesley

Physics 3005 Advanced Quantum Mechanics

Level: III: **Units:** 2 **Duration:** Semester 2

Prerequisite: PHYSICS 3004 Quantum Mechanics III, or equivalent
Assumed knowledge: PURE MTH 2002 Algebra II, PURE MTH 2006 Real and Complex Analysis II

Contact Hours: 2 lectures per week; 1 tutorial per fortnight

Aims:
- to familiarise students with the role of symmetries and conservation laws in our understanding of quantum mechanics

Content: This course studies advanced topics in quantum mechanics with an emphasis on symmetries and the mathematical structure of the theory. Postulates and formalism. Stern-Gerlach experiment. Angular momentum. Belli's inequalities. Symmetries,conservation laws, and unitary transformations. Position and momentum representation. Heisenberg and Schroedinger pictures. Annihilation and creation operators harmonic oscillator. Feynman path integrals. Parity. Time-reversal. Periodic potentials and Bloch wavefunctions. Coupled oscillators. Density matrix approach. Time-dependent perturbation theory -interaction picture and the Dyson series. Fermii's Golden rule. Introduction to relativistic quantum mechanics Klein-Gordon equation, Dirac equation, probability current, electromagnetic coupling.

Assessment: 2-hour exam, class exercises

Reference: Sakurai JJ, *Modern Quantum Mechanics*, Rev. edn., Addison-Wesley MA, 1994

Physics 3006 Advanced Dynamics and Relativity

Level: III **Units:** 3 **Duration:** Semester 2

Prerequisite: MATHS 1007A/B Mathematics I (Pass Div I) or MATHS 2004 Mathematics IIM (Pass Div I); PHYSICS 2000A/B Physics II or PHYSICS 2002 Classical Fields and Mathematical Methods II; PHYSICS 2001 Classical Mechanics II; PHYSICS 2002 Classical Fields and Mathematical Methods II

Restrictions: 7099 Advanced Dynamics or 7633 Relativity and Classical Field Theory

Contact Hours: 3 lectures per week; 1 tutorial per fortnight

Aims:

- to understand areas of advanced classical theoretical physics
- to obtain a background for modern theoretical and mathematical physics
- to appreciate how theories are developed

Content: Mechanics - Lagrangian mechanics, symmetries and conservation laws, small oscillations, Hamiltonian mechanics, symmetries and canonical transformations; relativity - space-time tensors, relativistic mechanics, electrodynamics; field theory - Lagrangian field theory, electromagnetic radiation.

Assessment: Class exercises 30%; 3 hour exam 70%

Recommended Reading:

Landau LD and Lifschitz EM, *Mechanics,* 2nd ed. (Pergamon, 1969)
Goldstein H, *Classical Mechanics*, 2nd ed. (Addison-Wesley, 1980)
Arnold VI, *Mathematical Methods of Classical Mechanics,* 2nd ed. (Springer-Verlag, 1989)
Percival I and Richards D, *Introduction to Dynamics*, (CUP, 1982)
Rindler W, *Introduction to Special Relativity*, (Oxford, 1991)
Landau LD and Lifschitz EM, *The Classical Theory of Fields*, 4th ed. (Pergamon, 1975)

Physics 3007 Introduction to Physics Research

Level: III **Units:** 3 **Duration:** Semester 2

Prerequisite: 8 units of Level II Physics courses
Restrictions: 9116 Laboratory Physics

Contact Hours: 9 hours in a research group per week

Aims:
- to provide an introduction to honours project work
- to give experience in oral and written communication in science.

Content: This course comprises an experimental or theoretical project in a research group, a brief oral presentation on the project to the group, attendance at departmental research talks and a wordprocessed essay on the research of the department. A workshop led by ACUE on oral and written communication with videoed practice session. A computer-based session on experimental statistics and appropriate introductory technical training for experimental students.

A wordprocessed report with abstract and bibliography on the project to be submitted at the end of the course. The course is especially recommended to students intending to do honours.

Assessment: project report 75%, research essay 15%, presentation 5%, other 5%

Physics 3008 Physics of Solid State Devices

Level: III **Units**: 2 **Duration**: Semester 2

Prerequisite: PHYSICS 2000A/B Physics II, or equivalent

Contact Hours: 2 lectures per week, 1 tutorial, 1 computer lab per fortnight

Content: This course introduces students to Crystal structures, lattices, energy bands, bandgap engineering, material growth, current carriers, carrier transport: drift, diffusion, generation and recombination; pn junctions: physics of tunnelling, LEDs; bipolar junction transistors: charge transport, amplification, switching, limitations; junction FETs; MESFETs; HEMTs; low dimensional structures; quantum confinement; super lattices; optoelectronics; photonics; ultra high speed devices. The lecture material will be supplemented by use of computer simulations of relevant topics to be performed by individual students.

Assessment: Graded assignments, final exam.

References: <u>Textbook</u>: B.G. Streetman & S. Banerjee, *Solid State Electronic Devices,* 5th ed. (Preutice Hall, 2000)

Recommended: N.W. Ashcroft & N.D. Mermin, *Solid State Physics,* (Saunders, 1976), C. Kittel, *Introduction to Solid State Physics,* latest ed. (John Wiley & Sons)

Physics 3009 Statistical Mechanics

Level: III **Units:** 2 **Duration** Semester 2

Prerequisite: PHYSICS 1000A/B Physics I (Pass Div I); and MATHS 1007A/B Mathematics I (Pass Div I) or MATHS 2004 Mathematics IIM (Pass Div I)

Assumed knowledge: PHYSICS 2000A/B Physics II

Contact Hours: 2 lectures per week, 1 tutorial per fortnight

Aims:

- to understand the fundamental importance of the partition function and its applications
- to be able to solve simple problems in statistical mechanics
- to understand how the concepts apply to quantum statistical mechanical systems

Content: This course introduces concepts essential for the understanding of both classical and quantum statistical mechanics. Topics covered include the classical thermodynamic laws and their application, postulates of statistical mechanics, statistical interpretation of thermodynamics, microcanonical, canonical and grand canonical ensembles. The methods of statistical mechanics are then used to develop the statistics for Bose-Einstein, Fermi-Dirac and photon gases. Selected topics from low temperature physics, electrical and thermal properties of matter, and astrophysics will be discussed.

Assessment*:* 2 hour exam, class exercises

References: F. Reif, *Fundamentals of Statistical and Thermal Physics*, (McGraw Hill) , F. Mandl, *Statistical Physics*, (Wiley)

Physics 3012 Atomic and Nuclear Physics

Level: III **Units:** 2 **Duration:** Semester 2

Prerequisite: PHYSICS 2000A/B Physics II, or equivalent
Assumed knowledge: PHYSICS 3004 Quantum Mechanics III
Restriction: PHYSICS 3010 Structure of Matter (3426)

Contact Hours: 3 lectures per week

Aims & Content: This course is concerned with the main features of elementary particles, nuclei, atoms and solids. Since these are quantum systems, their understanding requires an application of the ideas of quantum mechanics. However, in this course, the emphasis is on physical understanding and insight rather than rigorous theoretical formulation. The atomic physics part of the course deals with helium, interaction of atoms with time-varying electromagnetic fields (including selection rules).
In nuclear and particle physics, interactions within and between nucleons are used to develop an understanding of why some nuclides are stable and others are not, and to discuss the size and shape of nuclei, models of the nucleus, radioactive decay, properties of nuclei in excited states, and the quark-parton model of elementary particles.

Assessment: 3 hour exam, assignments.

References: Eisberg R & Resnick R, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles,* Wiley, 1995
Woodgate G K, *Elementary Atomic Structure*, 2nd ed, Oxford UP, 1980
Williams W S C, *Nuclear and Particle Physics*, Oxford UP, 1991

Physics 3013 Astrophysics III

Level: III **Units:** 2 **Duration:** Semester 2

Prerequisite: PHYSICS 2000A/B Physics II, or equivalent

Contact Hours: 2 lectures per week, 1 tutorial per week

Assessment: Written exam, marked assignments, short presentation on topic of interest

Content: A survey of the universe at all scales and wave lengths/energies. Stellar astrophysics and studies of the interstellar medium and magnetic fields. Cosmic ray acceleration and propagation; pulsars, gamma-ray astrophysics; radio and x-ray astronomy. Space experiments including HST and COBE.

Physics 3014 Atmospheric and Environmental Physics

Level: III **Units:** 2 **Duration:** Semester 2

Prerequisite: PHYSICS 2000A/B Physics II, or equivalent

Contact Hours: 2 lectures per week, 1 tutorial per week

Assessment*:* Written exam, marked assignments

Content: The course is an introduction to the physics of planetary atmospheres, with a focus on the Earth's atmosphere including environmental and climate issues. Topics will include radiative transfer in the Sun-Earth system, thermodynamics of the atmosphere, cloud physics, atmospheric motions and circulation, the role of aerosols and minor constituents, such as water vapour, carbon dioxide and ozone, in determining climate, and the impact on the environment of anthropogenic actions.

Reference Books:
Andrews DG, Holton JR, and Leovy CB, *Middle Atmosphere Dynamics*, (Academic Press, 1987)
Houghton J, *The Physics of Atmospheres*, (Camb. Univ., 1977)
Holton J, *An Introduction to Dynamic Meteorology*, (Academic Press, 2nd ed)
Brasseur G, and Solomon S, *Aeronomy of the middle atmosphere*, (Reidel, 1986)
Kelley, M, *The Earth's Ionosphere*, (Academic Press, 1989)
Rishbeth H, and Garriott OG, *Introduction to Ionospheric Physics*, (Academic Press, 1969)

Physics 3016 Education in Physics with Industrial Cooperation (EPIC) A

Level: III **Units:** 0 **Duration:** Semester 2

The Department offers a program whereby students enrolled in third year of the B.Sc. or B.Sc. (Optics and Photonics) or B.Sc. (Space Science and Astrophysics), who have achieve at let an average credit level in Levels 1 and 2 and at least a credit in PHYSICS 200A/B Physics II, can apply to enrol in a cooperative program with industry.
EPIC A consists of 4-5 months of full-time work on a project in industry in Semester 2 of year 3.
EPIC B consists of 4-5 months of full-time work on a project in industry in Semester 1 of year 4.
The students receive financial support provided by the industry. The EPIC A and EPIC B projects must be different and are jointly agreed by the Department of Physics and Mathematical Physics and the industrial partner. A written report must be prepared on each project and approved by both the industrial partner and the Department. The performance of each student will be monitored by a committee within the Department. Unsatisfactory work reports or course grades may result in the student leaving the EPIC program.

Physics 3017 Education in Physics with Industrial Cooperation (EPIC) B

Level: III **Units:** 0 **Duration:** Semester 1

See PHYSICS 3016

Physics 3018 Electromagnetism III

Level: III **Units:** 3 **Duration:** Semester 1

Prerequisite: PHYSICS 2000A/B Physics II or PHYSICS 2002 Classical Fields and Mathematical Methods II or equivalent
Restriction: PHYSICS 3001 Electromagnetism and Optics (6459); Electromagnetism (6849)

Contact Hours: 3 lectures, 1 tutorial per week

Content: Electrostatics; Laplace's equation, Poisson's equation, boundary value problems; electric fields in matter, electric dipole and multipoles, electric polarisation; magnetostatics, vector potential and gauge transformations; Faraday's law, energy stored in magnetic field; magnetic fields in matter, magnetisation; Maxwell's equations; EM waves in free space, plane waves; Maxwell's equations in matter; Poynting's theorem. Waveguides; wave equation as boundary value problem, microwave waveguide, optical fibre, modes, dispersion in a waveguide.

Assessment: exam, continuous assessment of tutorial work

References: Griffiths DJ, *Introduction to Electrodynamics*, 2nd ed. (Prentice Hall)

Physics 3019 Physical Optics III

Level: III **Units:** 2 **Duration:** Semester 2

Prerequisite: PHYSICS 2000A/B Physics II or equivalent
Restriction: PHYSICS 3001 Electromagnetism and Optics (6459); Optics (1384)

Contact Hours: 2 lectures per week, 1 tutorial per fortnight

Content: Lorentz electron oscillator model, microscopic theory of refractive index and dispersion, optics of dielectrics and metals, Kramers-Kronig relations, Maxwell's equations and EM waves in free space; Fresnel equations, reflection and refraction of EM waves at interfaces; diffraction theory, Fresnel and Fraunhofer diffraction; Fourier optics, spatial filtering.

Assessment: exam, continuous assessment of tutorial work

References: Guenther R, *Modern Optics,* (Wiley)

Physics 3020 Photonics III

Level: III **Units:** 2 **Duration:** Semester 1

Prerequisite: PHYSICS 2000A/B Physics II or equivalent; PHYSICS 2009 Photonics II

Contact Hours: 2 lectures per week, 1 tutorial per fortnight

Content: Introduction to lasers; interaction of light with matter, probability of emission and absorption, stimulated emission, Bose-Einstein statistics, coherence. Laser resonators, Fabry-Perot, stability of resonators, resonator geometries, gaussian beams, diffraction, modes. Macroscopic description of gain medium, dispersion, rate equations, saturation, broadening, hole-burning, optocoupling, pulsed lasers, Q-switching, mode-locking. Quantum wells in semiconductor lasers; fibre devices; fibre lasers, fibre Bragg gratings, fibre couplers, wavelength division multiplexing.

Assessment: exam, continuous assessment of tutorial work

HONOURS COURSES

COURSES:

Physics 4000A/B Honours Physics

2259 Honours Physics (midyear)

Physics 4001A/B Honours Mathematical Physics

UNITS:

Astrophysics

Atmospheric Physics

Atomic Collision Processes (Flinders)

Atomic and Molecular Physics

Cosmology

Differential Geometry and General Relativity

Electrodynamics

Experimental Methods

Gauge Field Theories

Lasers and Non-Linear Optics

Nuclear and Radiation Physics

Nuclear Theory and Particle Physics

Quantum Field Theory

Relativistic Quantum Mechanics and Particle Physics

Advanced Statistical Mechanics (Flinders)

Honour Topics in Statistical Mechanics

Physics 4000A/B Honours Physics

Level: Honours **Units Value:** 24 **Duration:** Full Year

NOTE: Students considering taking this course are advised to see the Head of Department as soon as possible, preferably before enrolling for the third year of their program. In exceptional circumstances, with the approval of the Faculty, it is possible to take honours on a half-time basis over two years – see Specific Academic Program Rule 5.7.4 of the BSc program rules.

Prerequisites: Major in Experimental or Theoretical Physics. Preferred background is double major in Physics. Approval of Head of Department.

Contents: It is possible to take Honours in either experimental or theoretical physics. The Honours program may include lecture programs on astrophysics, atmospheric physics, atomic and molecular physics, cosmology, differential geometry and general relativity, electrodynamics, experimental methods, gauge field theories, general relativity, lasers and nonlinear optics, many-body theory, nuclear radiation physics, nuclear theory and particle physics, relativistic quantum mechanics, quantum field theory, statistical mechanics/many-body theory, solid state physics and unified gauge theories.

Each student will also be expected to undertake a substantial experimental or theoretical research project on which a report will be prepared. Full details may be obtained by application to the Head of Department.

Research Project: All students must engage in one individual project. The project may include some independent research and must be summarised in a written report submitted by the due date. This report should be carefully prepared and should contain a connected account of the topic chosen, written from an independent and critical standunit. The report should clearly define the extent of the student's own work. The topic chosen may form the basis for further work for a higher degree, although this is not necessarily the case. The topic may either be proposed by the student or selected from a list provided by the Department and must be approved by the Head who will also assign a staff member as supervisor. It is likely that background reading and other preparatory work will be required so it is essential that work is started on the project during the first weeks of February.

A list of projects is available from the Head's office in early February. The projects are classified by research group and supervisor. You should read the projects carefully and consult potential supervisors. The final choice is made by consultation with the Honours Co-ordinator and supervisor in the event that the same project is requested by more than one student.

Towards the end of the year there will be an **interview** during which candidates will be questioned on their project work and on their knowledge of physics in general. They may be questioned on their own and other seminars which they are expected to have attended during the year.

Courses: *Physics 4000A/B Honours Physics and 2259 Honours Physics (midyear)* are available to those taking the course of *Bachelor of Science*. These courses are also available to students with a B Sc (Ma. & Comp. Sci.) who transfer to the Faculty of Science. *Physics 4001A/B Honours Mathematical Physics* is available to those taking the course of *Bachelor of Science in the Faculty of Mathematical and Computer Sciences or Bachelor of Computer Science.*

Physics 4001A/B Honours Mathematical Physics

See School of Mathematical and Computer Sciences for syllabus details.

Honours Astrophysics

Level: Honours **Duration:** Semester 2

Aims: to illustrate the application of the laws of physics to theory and experiment to obtain a deeper understanding of the Universe

Content: *New Views of the Universe*: Structure and phenomena revealed by multiwavelength studies, Hubble Space Telescope, COBE, gravitational lenses, quasars and active galaxies. Overview of radio astronomy, a survey of the radio sky, introduction to pulsars. Magnetic fields, particle acceleration and X- and gamma ray production. Overview of X-ray astronomy, techniques, a survey of the X-ray sky. *High Energy Astrophysics:* Overview of γ-ray astronomy. Compton Gamma Ray Observatory (CGRO), techniques used in different energy ranges on the CGRO and results. Gamma-rays from astrophysical sources: gamma ray bursts, cosmic ray interactions leading to pion production, π^0 decay, bremsstrahlung, synchrotron emission, inverse Compton effect. Atmospheric Cerenkov (TeV). *Pulsars:* Neutron stars: formation, birth rates, evolution, equation of state, “glitching”; binary pulsars, gravitational radiation and confirmation of General Relativity; pulsar electrodynamics. *Accretion onto Compact Objects:* X-ray sources, binary systems, Roche Potential, mass transfer, effect on orbital parameters, accretion disc, spherical accretion. *Interstellar Medium:* Equation of radiative transfer, spectral lines, atomic transitions, brightness temperature, 21 cm line, galactic rotation and spiral structure, molecular transitions, molecular hydrogen, thermal bremsstrahlung, ionized hydrogen, supernova remnants. *Cosmic Ray Air Showers:* Description of air showers, experimental techniques, basic features. Cascade equations, electromagnetic showers, hadronic showers, hadron and lepton fluxes. Discrimination between electromagnetic and hadron showers, astronomy with air showers.

Assessment: Two assignments (30%), exam (70%).

Reference: Longair, MS, *High Energy Astrophysics, Vols 1 and 2,* 2nd ed. (CUP, 1994)

Honours Atmospheric Physics

Level: Honours **Duration:** Semester 2

Content: The course is an introduction to the physics of planetary atmospheres, with a focus on the Earth's atmosphere including environmental and climate issues. Topics will include radiative transfer in the Sun-Earth system, thermodynamics of the atmosphere, cloud physics, atmospheric motions and circulation, the role of aerosols and minor constituents, such as water vapour, carbon dioxide and ozone, in determining climate, and the impact on the environment of anthropogenic actions.

Reference Books:
Andrews DG, Holton JR, and Leovy CB, *Middle Atmosphere Dynamics*, (Academic Press, 1987)
Houghton J, *The Physics of Atmospheres*, (Camb. Univ., 1977)
Holton J, *An Introduction to Dynamic Meteorology*, (Academic Press, 2nd ed)
Brasseur G, and Solomon S, *Aeronomy of the middle atmosphere*, (Reidel, 1986)
Kelley, M, *The Earth's Ionosphere*, (Academic Press, 1989)
Rishbeth H, and Garriott OG, *Introduction to Ionospheric Physics*, (Academic Press, 1969)

Honours Atomic and Molecular Physics

Level: Honours **Duration:** Semester 2

Content: The single-particle self-consistent potential method for many particle systems, the stationary variation method, the semi-classical (WKB) method, and the adiabatic approximation. The dynamics and spectra of diatomic molecules. Separation into electronic, vibrational and electronic motions, adiabatic Born-Oppenheimer approximation, factors controlling the strengths of radiative transitions, and corrections to the adiabatic Born-Oppenheimer approximation.

References:
Herzberg G, *Spectra of diatomic molecules*,
Struve WS, *Fundamentals of molecular spectroscopy*, (Wiley)
Schiff LI, *Quantum mechanics*, 3rd ed.(McGraw-Hill)
Landau L and Lifschitz E, *Quantum mechanics: non-relativistic theory*, (Pergamon, 1977)
Condon E and Shortley G, *The theory of atomic spectra*,
Morrison M et al., *Quantum states of atoms, molecules, and solids*, (Prentice-Hall)

Honours Cosmology

Level: Honours **Duration:** Semester 2

Content: Observational input: Olber's paradox; Hubble law; matter content of the Universe. Homogeneous and isotropic cosmologies: Energy conditions; Friedmann-Robertson-Walker models; Cosmological redshift; Luminosity distance; Angular-diameter distance; Galaxy number count / redshift relation; Surface brightness test; Expansion age of the Universe; Particle and event horizons; de Sitter space; Steady state model; Friedmann-Lemaître models. Bianchi models. Thermodynamics and phase transitions in the expanding universe: Thermal history of the Universe; Primordial nucleosynthesis; Recombination - Saha equation. Structure formation: spherical collapse model; Jeans' analysis in expanding universe; evolution of curvature and isocurvature fluctuations. Inflation.

Reference books:
Kolb EW and Turner MS, *The Early Universe*, (Frontiers in Physics Series No. 69) (Addison-Wesley, 1990)
Narlikar JV, *Introduction to Cosmology*, 2nd ed. (CUP,1993)
Peebles PJE, *Principles of Physical Cosmology*, Princeton UP, 1993)
Weinberg S, *Gravitation and Cosmology: Principles and applications of the general theory of relativity*, (Wiley, 1972)

Honours Differential Geometry and General Relativity

Level: Honours **Duration:** Semester 1

Content: Special relativity. Equivalence Principle. Newtonian tidal tensor and geodesic deviation. Differential geometry: Manifolds; Tangent vectors; Tangent and co-tangent spaces; Tensors; Exterior derivative; p-forms; Metric; Parallel transport; Covariant derivative; Connection 1-forms; Torsion; Geodesic motion; Curvature 2-forms; Cartan's structural equations; Fundamental theorem of differential geometry; Ricci and Bianchi identities; Geodesic deviation; Measurement of the Riemann tensor; Tensor densities; Integration on manifolds; Lie derivative; Killing vectors and conservation laws. General relativity: Einstein's equations; Weak field limit (linearised gravity); Newtonian limit; Einstein-Hilbert action and variation principle; Schwarzschild solution; Kepler problem for timelike and null geodesics; Deflection of light; Precession of the perehelion of Mercury; Gravitational redshift; Kruskal-Szekeres extension.

Reference books: D'Inverno R, *Introducing Einstein's Relativity*, Oxford, 1992
Schultz BF, *A First Course in General Relativity*, Cambridge, 1985
Wald RM, *General Relativity*, Chicago UP, 1984

Honours Electrodynamics

Level: Honours **Duration:** Semester 1

Prerequisites: An understanding of the content of the Level III course 6459 Electromagnetism and Optics will be assumed.

Content: This course is mainly about electromagnetic radiation: its properties, propagation, and generation. The early discussion of basic electromagnetism emphasizes those aspects useful in understanding radiation. The objective of the course is that each person taking it gain a knowledge of, and physical insight into, the main features of the behaviour of electromagnetic waves, methods of treating them quantitatively, and an understanding of the conditions for the validity of those mathematical methods. Content includes a review of electromagnetic fields in vacuum and in matter; electromagnetic waves, waveguides and cavities, with perfect conductor walls and good conductor walls, and radiation

References: Vanderlinde J, *Classical Electromagnetic Theory*, Wiley, 1993
Jackson JD, *Classical Electrodynamics, 2nd edn.*, Wiley, 1975
Griffiths DJ, *Introduction to Electrodynamics*, 2nd edn., Prentice Hall, 1981
Marion JB and Heald MA, *Classical Electromagnetic Radiation, 2nd edn.*, Academic Press, 1980
Lim YK, *Introduction to Classical Electrodynamics*, World Scientific, 1986
Panofsky WKH and Phillips M, *Classical Electricity and Magnetism*, Addison-Wesley, 1956
Landau L and Lifshitz E, *The Classical Theory of Fields*, Addison-Wesley, 1951
Feynman R P, Leighton RB and Sands M, *The Feynman Lectures on Physics, Volume II*, Addison-Wesley, 1964

Honours Experimental Methods

Level: Honours **Duration:** Semester 1

Content: An introduction to statistical and Fourier techniques, with applications to experimental design and data analysis. This course concentrates on ideas and applications rather than mathematics. Major topics include Statistics, Domain Transform Methods, and a short section on experimental practice. Topics to be discussed in relation to statistics will include probability theory, Binomial distribution, Poisson distribution, Normal distribution, Rayleigh distribution, null hypotheses, rejection criteria, equivalence of means, correlation analysis, least-squares fitting, analysis of variance.
Topics relating to domain transform methods will include: Fourier transform, impulse response and frequency response of circuits, convolution, numerical filters, signal averaging, effect of a delay, sampling theorem, aliasing, power spectrum, auto and cross-correlation functions, Wiener-Khintchine theorem; Fourier transform

spectroscopy, applications to diffraction, optical signal processing, scattering in three dimensions, Ewald sphere.

Recomended Reference Books:
Bevington PR, and Robinson DK, *Data Reduction and Error Analysis for the Physical Sciences, Second Edition,* McGraw-Hill, 1992
Bracewell, *Fourier Transform and its Applications*, (McGraw-Hill)

Other Useful Reference Books:
Huntsberger DV and Billingsley P, *Elements of statistical inference*, (Allyn & Bacon Inc.)
Hoel, *Introduction to Mathematical Statistics*, 2nd ed.
Topping, *Error of Observation and their Measurement*,
McCall RB, *Fundamental Statistics for Psychology,* (Harcourt Brace Jovanovich)
Press WK, Flannery BP, Teukolsky SA, and Vetterling WT, *Numerical Recipes*, Cambridge University Press, 1988
Jennison, *Fourier Transforms and Convolutions for Experimentalist*,
Ratcliffe, *Reports on Progress in Physics*, 19, 188, 1956
Lange, *Correlation Techniques*, (Iliffe)
Campbell and Foster, *Fourier Transforms for Practical Applications*,
Goldman, *Frequency Analysis, Modulation and Noise*, (McGraw Hill)
Bendat and Piersol, *Measurement and Analysis of Random Data*, (Wiley)
Champeney, *Fourier Transforms and their Physical Applications*, (Academic Press, 1973)
Randall RB, *Frequency Analysis,* Bruel & Kjaer Press, 1987
Stewart I, *Everyday Statistics*, Part 1, 8 May 1993, Part II, 4 December 1993, New Scientist

Honours Gauge Field Theories

Level: Honours **Duration:** Semester 2

Content: Quantum electrodynamics, quantum chromodynamics, electroweak theory of Glashow, Weinberg and Salam, standard model. Techniques developed include: global and local symmetries, gauge transformations, parallel transport, choice of gauge, gauge-invariant quantities, Feynman rules, path integrals, Fadeev-Popov ghosts, dimensional regularisation and renormalisation.

Assessment: Marked Assignments.

Reference: Peskin M.E. and Schroeder D.V., *Quantum Field Theory*, (Addison Wesley).

Honours Lasers and Non-linear Optics

Level: Honours **Duration:** Semester 1

Content: Introduction to lasers and non-linear optics, interaction of light with matter, probability of emission and absorption, stimulated emission, Bose-Einstein statistics, coherence. Laser resonators, Fabry-Perot, classification of resonators, graded reflectivity, geometries, rings, gaussian waves, diffraction, modes. Macroscopic description of gain medium, dispersion, rate equations, saturation, broadening, hole-burning, optocoupling, pulsed lasers, Q-switching, mode-locking, Non - linear optics, including second harmonic generation, three and four wave mixing, optical phase conjugation, real time holography, with numerous examples taken from current research and applications, including the industrial, remote sensing, military and medical fields.

Assessment: Two take-home exams and a talk on one aspect of the course with hand-out.

Reference: Milonni PW and Eberly JH, *Lasers*, (Wiley,1988)

Honours Nuclear and Radiation Physics

Level: Honours **Duration:** Semester 2

Aims: To provide an understanding of radiation and nuclear physics from an experimental viewunit, applied to environmental and medical physics. Medical physics is a very applied field in which a good physical understanding of both theory and instrumentation is required. Experience with computer simulation is provided

Content: *X-rays:* bremsstrahlung, characteristic lines, fluorescent radiation, exposure, fluence, dose units and measurement. *Interaction of photons with matter*: definition of cross-section, half value thickness and exponential law in narrow beam geometry, photoelectric effect, Auger electrons, Rayleigh scattering, Compton effect, Klein-Nishina theory, pair production, nuclear effect and giant resonance, UV radiation, total attenuation and absorption co-efficients, contrast media and intensifier screens, detection of photons in NaI and Ge, build-up and depth-dose profiles in wide beam geometry, Kerma, high-energy electron-photon cascades and cosmic rays. Diagnostic X-rays and radiation therapy.

Charged particles: energy losses, Rutherford and Mott scattering, Bragg ionization curve, dE/dx, stopping power, Bethe-Bloch theory, range-energy, straggling and Landau distribution of energy losses, radiation losses, Bethe-Heitler formula, Møller scattering, multiple scattering and Fermi-Eyges theory, electron beam therapy. *Nuclear Physics:* nuclear properties, stability, shell and collective models, binding energies and decay by fission, alpha, beta, and gamma, selection rules examples and applications, autoradiography, radioactive series decay, Bateman equations, accelerator mass spectrometry, semi-empirical mass formula, Fermi theory and Kurie plot, laboratory generators, nuclear medicine, internal conversion, annihilation, selection rules and isomers. *Nuclear Reactions:* charged particles and neutrons, 1/v law, fast and slow neutrons, neutron sources, resonances, reactors, detectors, neutron activation, neutron capture therapy, nuclear spectroscopy.

Assessment: Assignment on each half of the course (33%), exam (67%)

References: Johns HE and Cunningham JR, *Physics of Radiology*, 4th ed. (C.C Thomas, Springfield, NJ: 1983)
Lederer CM, Shirley VS, *Table of Isotopes*, 7th edition, Wiley
Williams WSC, *Nuclear & Particle Physics*, Oxford: 1991
Leighton RB, *Principles of Modern Physics*, (McGraw-Hill, 1968)
Evans RD, *The Atomic Nucleus*, McGraw-Hill.

Honours Nuclear Theory and Particle Physics

Level: Honours **Duration:** Semester 2

Content: The content of the course varies in alternate years. In alternate years the syllabus includes QCD, hadron structure and deep inelastic scattering. In 1999 the emphasis will be on QCD.

References: Leader E & Predazzi E, *An Introduction to Gauge Theories*, (Cambridge University Press, 1996)
Muta T, *Foundation of Quanum Chromodynamics*, (World Scientific, 1987)
Roberts RG, *The Structure of the Proton: Deep Inelastic Scattering*, (Cambridge University Press, 1990)
Close, Frank, *An Introduction to Quarks & Partons*, (Academic Press, 1979)

Honours Quantum Field Theory

Level: Honours **Duration:** Semester 1

Content: Photons and the electromagnetic field, Lagrangian field theory, the Klein-Gordon field, the Dirac field, photons: covariant theory, the S-matrix expansion, Feynman diagrams and rules in QED, QED processes in lowest order, radiative corrections.

Assessment: Written examination and marked assignments.

References: Peskin ME and Schroeder DV, *Introduction to Quantum Field Theory*, Addison Wesley, 1995
Mandl F and Shaw G, *Quantum Field Theory*, (J. Wiley and Sons, 1984)

Other Useful References:
Bjorken JD and Drell SD, *Relativistic Quantum Fields*, (McGraw-Hill, 1965)

Itzykson C and Zuber JB, *Quantum Field Theory*, (McGraw-Hill, 1980)
Peskin ME and Schroeder DV, *An introduction to Quantum Field Theory*, (Addison-Wesley, 1995)
Ramond P, *Field Theory: A modern primer*, (Addison-Wesley, 1990)
Ryder LH, *Quantum Field Theory*, (Cambridge University Press, 1985)
Weinberg S, *The Quantum Theory of Fields*, (Cambridge University Press, 1995)
Zinn-Justin J, *Quantum Field Theory and Critical Phenomena*, (Oxford University Press, 1993)

Honours Relativistic Quantum Mechanics and Particle Theory

Level: Honours **Duration:** Semester 1

Content: Dirac equation: Lorentz covariance, quantum mechanics and probability density; Non-relativistic limit, spin, magnetic moment; Gamma matrices, proof of covariance; Plane-wave solutons, problems with negative energies. Hydrogen atom; Dirac's hole theory, discrete symmetries: P, C, T. Particle Physics: Elementary particles - stable and unstable; Strong, electromagnetic and weak interactions; Symmetries and conservation laws; Applications of C, P, T; G-parity; Rotations and angular momentum; SU(2) isospin; SU(3) and the eightfold way; Quarks and colour.

Honours Topics in Statistical Mechanics

Level: Honours **Duration:** Semester 2

Content: Boltzmann's H-theorem. Equilibrium Statistical Mechanics; the laws of thermodynamics, Thermodynamic potentials, Gibbs-Duheim and Maxwell relations, Response functions, Microcanonical ensemble, Grand-canonical ensemble, Phenomenology of phase transitions. Exactly solved models; The 1D Ising model, Mean field approximations, The Q-state Potts model, The 2D Ising model (for H=0), The Heisenberg model, The 6-vertex model. Statistical Field Theory; The renormalization group, Path integrals in quantum mechanics, Path integral for the harmonic oscillator, Perturbation theory for phi^4 theory.

Assessment: Take-home exam and marked assignments.