UNIVERSITY OF MELBOURNE

SCHOOL OF PHYSICS

BACHELOR OF SCIENCE WITH HONOURS IN PHYSICS

COURSE INFORMATION DOCUMENT FOR 2008
FOR ALL PART IV STUDENTS

Summary of Honours Course Offerings, 2008 *

* Note the lecturer(s) will provide detailed syllabi at the commencement of their lectures. This current document is the outcome of deliberation of the School and is intended primarily as a guide for Honours and Post-Grad Dip. Students in making intelligent decisions in consultation with their supervisor regarding Honours Course Selections. This information is subject to change. All courses are intended to be 24 lectures in a demi-semester, four days per week.

Semesterisation for 2008 (as in the Honours Information (PDF) document on the web and handed out to all Honours Students):

Demi-Semester 1:

401 Quantum Mechanics A	QM-A	Scholten
402 Quantum Mechanics B	QM-B	tba

Demi-Semester 2:

403 Particle Physics I	PPI	Barberio
408 Quantum & Advanced Optics	QAO	Chantler
406 Statistical Mechanics	SM	Melatos
407 Quantum Field Theory	QFT	Volkas
404 Condensed Matter	CM	Martin

Demi-Semester 3:

409 Particle Physics II	PPII	Foot
410 Scattering & Imaging	SI	Allen
413 General Relativity	GR	tba
415 Extragalactic Astrophysics & Cosmology	EAC	Wyithe

Chris Chantler
Part IV (Honours & Post-Grad Diplomas) Year Organizer

TIMETABLE 2008

Research Commencement*	04-Feb		
Hons Orientation Week:	11-Feb	-	15-Feb
Demi-semester 1**	18-Feb	-	11-Apr
Non-teaching period†	*21-Mar*	-	*30-Mar*
Examination Period	21-Apr (QMA) &		23-Apr (QMB)
Demi-semester 2**	28-April	-	6-Jun
Examination Period	16-Jun	-	23-Jun

Provide a title and a short abstract (1 page) for your project 24 -Jun

Research Period	24-Jun	-	20-Jul
Demi-semester 3**	21-Jul	-	29-Aug
Examination Period	08-Sep	-	12-Sept

Part III/IV BBQ 2-Oct @ 1pm©

Research Period	13-Sep	-	03-Nov

Research Reports Due03-Nov *by noon to Cilla (room 106)*

Practice Talks	*6-Nov*	-	*7-Nov*
Honours Talks	*10-Nov*	-	*11-Nov*

End of Honours BBQ 1pm after the talks on 11 Nov in the Physics courtyard

Honours Dinner 12-Nov *at University House at 7.30pm (students pay for their meal and school pays for drinks and venue - approximately $54 pp)*

* Students are expected to arrive around this date and to commence administrative issues including allocation of keys and office desks; and to begin discussions and efforts relating to their Research Projects. The actual date can depend upon discussions with the Research Supervisor.
**Lectures "lost" due to public holidays will be re-arranged by the lecturer concerned.
† Period from Good Friday through Easter week. AVCC common week
©Honours students host this BBQ so cooking and setting up is done by the students from 11am. Class representatives liaise with Cilla

COURSE OUTLINES

QUANTUM A 401
Assoc. Prof. Robert Scholten

- Principles of 1-particle quantum mechanical systems, states and Hilbert space operators, observables, eigenstates and probabilities
- Superpositions of eigenstates. Commutators, complete sets and uncertainty relations. Matrix representations and change of basis.
- Unitary transformations, translations and linear momentum. Wave mechanics from Hilbert Space Time evolution, Hamiltonian and Schrodinger Equation
- Some Approximations to the Schrodinger Equation: Semi-classical or WKB approximation, Variational method
- Symmetries, Rotations and Angular Momentum Symmetries and conservation laws. Groups
- A surprise: SU(2) Interlude: spin-1/2 Eigenvalues and eigenstates of total angular momentum. Orbital angular momentum. Tensor Products. Addition of angular momentum. Tensor Operators

QUANTUM B 402
tba

- Relativistic Quantum Mechanics. The Klein-Gordon Equation, Dirac Equation and Dirac Algebra, Non-relativistic and Extreme Relativistic Approximations, Plane Waves, Electromagnetic Interactions, Lorentz Transformation of the Dirac Equation, The Klein Paradox Interpretation of Negative Energy States
- Time Dependent Perturbation Theory. The Fermi Golden Rules, Scattering in the Born Approximation, Phase shifts and scattering.
- Many Body Systems. The occupation number representation, Fock space and creation and annihilation operator
- The Electromagnetic Field. The Free Field, Emission and Absorption of Radiation, Scattering of Radiation, Scattering by Dirac Electrons

PARTICLE PHYSICS 1: 403
Dr Elisabetta Barberio

- Introduction Quarks and leptons Interactions and gauge bosons
- Accelerators and Detectors Accelerators Fixed Target and colliding beam experiments Interaction of particles with matter Detectors
- The Discrete Symmetries Parity Charge Conjugation Time reversal CPT
- Resonances Breit-Wigner Phase shifts Delta, J/psi, and Z as examples
- Symmetries SU(2) Flavour SU(3) Colour SU(3)
- Electro-weak phenomenology Leptons Neutrino mixing and oscillations
- Weak interactions of quarks
- Deep Inelastic scattering The parton model Counting quarks

QUANTUM AND ADVANCED OPTICS 408
Assoc. Prof. Chris. T Chantler

- Atom-photon interactions – *What is light, and what does it do?*
- Quantum Optics & Coherence Theory
- Fluctuation properties of coherent light
- The quantized radiation field - photon optics
- Diffraction of electromagnetic and quantum mechanical waves
- Laser & X-ray Optics
- Transition Theory
- Basic Laser Operation
- Density Matrices (Pure vs Mixed States)
- Atom Optics
- Relativistic Approaches to the Schrödinger Equation
- Origin & basis of QED in few-electron systems
- [Optional Additional topics: Analytic and Numerical Techniques for Atomic Systems; Hansch's frequency combs; optical parametric oscillators; sapphire clock devices; and experimental tests of major theories (QED, General Relativity, electro-weak)]

QUANTUM FIELD THEORY 407
Professor Ray Volkas

- Classical Field Theory
- Quantum Theory of Radiation Review quantisation of the free field
- Dispersion Relations and Causality
- The Dirac Field Review properties of the Dirac Equaion Bilinear covariants Second quantisation of the Dirac Equation
- Perturbation Theory S matrix expansion Mott scattering The Feynman rules Compton Scattering Particle Decays Moller Scattering
- CPT in Quantum Mechanics and Field Theory
- Renormalisation Electron Self-energy Photon Self-energy Lamb Shift
- Introduction to Yang-Mills Theories

STATISTICAL MECHANICS B 406
Dr Andrew Melatos

Statistical Physics will be taught in two parts, which alernate from one year to the next:

STATISTICAL PHYSICS A: EQUILIBRIUM PHYSICS OF INTERACTING SYSTEMS

- The density matrix, pure and mixed systems. The microcanonical, canonical and grand canonical ensembles in density matix form. Review of basic results for non-interacting Bose and Fermi systems.
- Bose condensates with interactions. The Bogolyubov transformation. BEC in traps. The Gross-Petiaveski equation.
- Pairing in Fermi Systems. Superconductivity. BCS theory. High T_c superconductors.
- The classical limit. The virial expansion for real gasses.
- Phase transitions. Classification. Critical Exponents and thermodynamic inequalities. The Ising Model in 1 and 2 Dimensions. Mean field approxiamtion. Renormalisation group methods. Scaling and relations between critial exponents.
- Connections to field theory.

STATISTICAL PHYSICS B: NON-EQUILIBRIUM PHYSICS OF INTERACTING SYSTEMS

- The density matrix, pure and mixed systems. The microcanonical, canonical and grand canonical ensembles in density matix form. Review of basic results for non-interacting Bose and Fermi systems.
- Non-equilibrium systems. The equation of motion for the density matrix, and its application to neutrino transport.
- The classical limit. The kinetic equations of classical statistical physics. BBGKY equations. Boltzmann equation. Relaxation time approximation. The microscopic derivation of the equations of fluid mechanics. Classical transport theory --- viscosity, thermal conductivity, diffusion.
- The quantum kinetic equations. Electrical and thermal conductivity of metals. Superfluidity and superconductivity.
- Chaos, ergodic theorems, and the approach to equilibrium.
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CONDENSED MATTER 404
Dr Andrew Martin

- Essential principles in solid-state physics: lattice structure, band theory, phonons
- Semiconductors, transistors, defects
- Low dimensional electron systems - electron gases, quantum hall effect, quantum wires, dots, SETs
- qubits and quantum computing
- Nanoscale magnetism and spin-polarised properties in the solid state

PARTICLE PHYSICS 2: 409
Dr Robert Foot

- Lie Algebras and Groups Lie Algebras Representations of Lie Algebras
- Groups Representations of Groups Lie Groups
- Classical Symmetries Continuous Symmetries Spontaneous Breaking of Global Symmetry
- QED Matter Particles and Interactions Local U(1) Symmetry Global U(1)
- Symmetry in QED Running of Coupling Constants
- QCD Quark Colour Local SU(3) Symmetry The QCD Running Coupling
- Global Symmetries in QCD
- Spontaneous Breaking of Local Symmetry An Abelian Example Non-Abelian
- Examples Systematics of the Higgs Mechanism
- The Electroweak Theory The Electron and its Neutrino Leptons Quarks The Complete Lagrangian CP Violation Global Symmetries in the Electroweak Theory

SCATTERING AND IMAGING 410
Assoc. Prof. Les. Allen

- Essentials of collision theory
- Propagation and scattering of x-rays, electrons, protons and neutrons in homogeneous and inhomogeneous media
- Imaging theory - aberrations
- Quantum mechanical phase problem - interferometric (e.g. holography) and noninterferometric methods (e. g. adaptive optics)
- Inverse scattering problems - ill-posedness, regularization etc.
- Structure retrieval at the atomic level
- Tomography

GENERAL RELATIVITY 413
tba

- Tests of GR. Special relativity: A review, Lorentz transformations, motion of Point Particles, Maxwell's Equations
- The Equivalence Principle
- Space-curvature. Metric equations. Geodesics
- Tensor algebra.
- Riemann curvature tensor. Stress-energy tensor
- Einstein's equations. The Newtonian limit. Field Equations of GR. Bianchi Identities, the Einstein Tensor. Uniqueness. Action Principle. Palatini formulation.
- Some solutions and applications (bending of light, red-shift, advance of perihelion, Shapiro time-delay, Black holes, Gravitational Lensing)
- Gravitational Waves.
- Cosmology
- Kaluza-Klein Physics. Extra Dimensions. String Theory.
- Differential Geometry

EXTRAGALACTIC ASTROPHYSICS & COSMOLOGY 415
Dr Stuart Wyithe

- Distances in cosmology
- AGN engines
- Structure in the early universe