UNIVERSITY OF SURREY

Faculty of Engineering & Physical Sciences
Department of Physics
Guildford, Surrey
GU2 7XH, UK

UNDERGRADUATE PHYSICS PROGRAMMES

Student Handbook: Level HE1 Module Details

MPhys Physics
MPhys Physics with Finance
MPhys Physics with Nuclear Astrophysics
MPhys Physics with Satellite Technology
BSc Physics
BSc Physics with Finance
BSc Physics with Nuclear Astrophysics
BSc Physics with Satellite Technology

Academic Year 2008-2009

CONTENTS

INTRODUCTION

This Annex provides details of the individual taught modules for Level HE1 (first year) of the MPhys/BSc Physics (P), MPhys/BSc Physics with Finance (PwF), MPhys/BSc Physics with Nuclear Astrophysics (PNA) and MPhys/BSc Physics with Satellite Technology (PST) degree courses. This Annex should be read in conjunction with the *Physics Undergraduate Student Handbook: Programme Information and Structure*, which contains details of the overall degree structures, regulations, staffing and assessments.

All degree programmes are structured as a number of interrelated component modules. At Level HE1, the majority of these modules are prescribed modules and are common to students on all degree programmes. All students take modules PH1M-Physics, PH1M-Maths and PH1M-EXPP. Students then take the appropriate specialised module for their programme as shown in the attached table with MPhys Physics and BSc Physics students selecting one of two specialised modules available. Time is also reserved each week to allow students to attend modern languages courses provided by the European Language Teaching Centre of the University. It is expected that French, German, Spanish and Italian classes will be available at a number of levels.

Small Group Tutorials have been arranged to complement the lectures for the prescribed modules, and attendance is compulsory. At these weekly one-hour sessions students have the opportunity to discuss tutorial problems set by the core module lecturers and to raise any other relevant topics with their tutor.

Broadly speaking, each Level HE1 30 credit module is designed around a minimum student workload of 300 hours, although the precise number of weekly timetabled hours for each module differs according to the nature of the activity associated with the module. Each module it made up of lecture (or laboratory) components. Each module is assessed by a combination of coursework and/or examination, as described in the individual module descriptions.

Every effort has been made to ensure the accuracy of the information concerning the course of study and contained herein. The Department reserves the right to introduce changes to the information given including the addition, withdrawal or restructuring of individual modules and of the course of study.

Undergraduate Programme Modules
Level HE1 (First Year), 2008-2009 Session

Degree Programme	Multiple Module Title	Credits	Components
All programmes	Physics Multiple Module (PH1M-Physics) (PHY1013)	30	Principles of Physics Waves in Physics Atoms, Molecules & Quanta
All programmes	Mathematics Multiple Module (PH1M-Maths) (PHY1012)	30	Mathematics I Mathematics II Mathematics III
All programmes	Experimental Physics Multiple Module (PH1M-EXPP) (PHY1011)	30	Physics Laboratory I Physics Laboratory II Computational Laboratory
MPhys and BSc Physics with Nuclear Astrophysics **MPhys and BSc Physics with Satellite Technology** **MPhys and BSc Physics ***	Specialist Physics Multiple Module 1A (PH1M-SPA) (PHY1024)	30	Electronics Space, Time and Relativity Introduction to Astrodynamics and Space Science
MPhys and BSc Physics with Finance **MPhys and BSc Physics ***	Specialist Physics Multiple Module 1B (PH1M-SPB) (PHY1025)	30	Electronics Management Accounting Space, Time and Relativity
Electives			Modern Languages

* MPhys/BSc Physics students must choose from one of the three Specialist Physics Multiple Modules 1A or 1B

Module Title:	**Physics Multiple Module**
Module Short Name:	**PH1M-Physics**
Module SITS ID :	**PHY1013**

Level:	**1**	**Number of Credits:**	**30**
Module Co-ordinator:	**Professor PJ McDonald**		
Module Components:	**Principles of Physics** **Waves in Physics** **Atoms, Molecules and Quanta**	**Dr PH Regan** **Professor PJ McDonald** **Dr Z Podolyak**	

Module Availability:	**Autumn and Spring Semester (Y)**

Assessment Pattern

Unit(s) of Assessment	**Weighting Towards Module Mark(%)**
Autumn Coursework	18%
Spring Coursework	10%
Principles of Physics Examination	24%
Waves in Physics Examination	24%
Atoms Molecules and Quanta Examination	24%
Qualifying Condition(s): Physics programme regulations refer.	

Assessment Schedule

Autumn Coursework:
Two class tests: one in week 10 and one in week 15, covering both the Principles of Physics and Waves in Physics material

Spring Coursework:
Class test in week 6 on Atoms, Molecules and Quanta material

Examination Paper 2 (May):
Answer 3 questions on Principles of Physics (Section A)
Answer 3 questions on Waves in Physics (Section A)
Answer 3 questions on Atoms, Molecules and Quanta (Section A)

Answer 2 from 3 questions on Principles of Physics (Section B)
Answer 2 from 3 questions on Waves in Physics (Section B)
Answer 2 from 3 questions on Atoms, Molecules and Quanta (Section B)

Pre-requisite/Co-requisites

Principles of Physics, Waves in Physics & Atoms Molecules and Quanta :
Pre-university education to Advanced Level standard or equivalent.

Module Overview

Principles of Physics:
This component covers some of the fundamental principles in classical physics including a discussion of units of measurement, the kinematics and dynamics of objects and conservation laws.

Waves in Physics:
This component covers introductory concepts of simple harmonic motion and waves, drawing on, and bringing together examples from different branches of physics including mechanics, optics, electronics, crystallography and electromagnetism. The course builds on Principles of Physics, and as in that course component, attempts to show the unifying themes between the different

subject areas.

Atoms Molecules and Quanta:
This component identifies the new theories necessary to describe physical processes when we go beyond the normal speeds and sizes experienced in everyday life. A review of new phenomena that led to the development of quantum theory follows naturally into an introduction to the theory of atomic structure. Along the way, the Schrödinger equation is introduced and elementary applications are considered. Several important aspects of the structure and spectroscopy of atoms are considered in detail.

Module Aims

Principles of Physics:
To provide knowledge and understanding on the fundamental principles of classical physics. To remind students of standard SI units and the role of the vector and scalar representation of physical quantities. To inform students about the motion of particles and solids under different conditions as governed by Newton's Laws. To discuss the conservation laws on which classical physics is based.

Waves in Physics:
To build on the introductory Principles of Physics component by the exploration of a range of classical physics phenomena broadly linked by the theme "waves". The component introduces the wave equation and the concepts of angular frequency and wave number which recur throughout Physics. These basic concepts are repeatedly reinforced by the examples given. The course also introduces the concepts of superposition and interference, reflection and refraction, diffraction and polarisation primarily through a study of linear optics.

Atoms Molecules and Quanta:
To provide an understanding of the principles underlying elementary quantum theory and their experimental foundation. To develop quantum principles so that the meaning and the use of the Schrödinger equation can be appreciated. To instil a knowledge of the shell and orbital structure of atoms, and key effects such as fine structure. Generally, to provide a broad foundation for further studies of atomic, nuclear and solid state phenomena, and to provide an introduction to spectroscopic notation and angular momentum coupling.

Learning Outcomes

Principles of Physics:
After completing this component, the student should be able to demonstrate through the solution of simple problems: (i) a grounding in the fundamental principles of classical physics (ii) an ability to treat physical problems within a mathematical framework and (iii) to specifically apply these concepts in mechanics.

Waves in Physics:
At the end of this component, the student should be able to (i) analyse simple systems undergoing simple harmonic motion and be able to derive equations describing the motion and expressions for the oscillation frequency; (ii) derive the wave equation for the case of, e.g. waves on a string; (iii) analyse simple waveforms travelling along, e.g. the string; (iv) undertake calculations of frequency shifts arising from the Doppler effect; (v) draw and use ray diagrams for problems in linear optics involving simple lenses, prisms and the like; (vi) know and be able to use the equations describing these ray diagrams; (vii) be able to calculate interference and diffraction patterns arising from, e.g. multiple point sources of light and slits of finite width; (viii) demonstrate an understanding of the working of selected optical instruments; (ix) derive and apply Bragg's Law for X-ray diffraction; (x) demonstrate an intuitive feel for fundamental and basic properties such as the speed, frequency and wavelength of light; and (xi) be able to work with notations based on f and λ and on ω and k;.

Atoms Molecules and Quanta:
After completing this component, the student should be able to: (i) state the reasons behind energy quantization in atoms and other physical systems; (ii) describe basic quantum phenomena and

atomic structure including fine structure; (iii) recognize the Schrödinger equation and describe in principle how it is solved; (iv) describe the basic rules for coupling two angular momenta in quantum mechanics; (v) deduce atomic electron configurations and describe them using spectroscopic notation; (vi) explain basic results in atomic spectroscopy including selection rules and the atomic hydrogen spectrum; (vii) undertake a higher level course that includes learning explicitly how to solve the Schrödinger equation.

Module Content

Principles of Physics:

- *Space, Time and Mass (3 hours)*
  SI units, multiples and submultiples of units, the units of length, mass and time, c, as a standard speed, dimensions in equations of physics. Derived units for important physical quantities, orders of magnitude, estimation and significant figures.
- *Representation of Physical Quantities (3 hours)*
  Physical quantities represented as scalars and vectors, simple operations involving vector quantities, position as a vector quantity, components, magnitudes and units, rate of change of position and velocity.
- *The Usefulness of the Vector Representation (3 hours)*
  The scalar and vector product, the right-hand rule, examples of the use of the vector product, description as a 3x3 determinant and the scalar triple product as the volume of a solid.
- *General Kinematics (3 hours)*
  Position, velocity and acceleration, motion with constant acceleration, graphical representation and dealing with infinitesimal changes.
- *General Dynamics (4 hours)*
  Newton's Laws, force and momentum, principle of superposition of forces, frictional forces and the four fundamental forces in nature.
- *Conservation Laws (8 hours)*
  Conservative forces, work done, potential and kinetic energy, the electron volt as a unit of energy, conservation of mechanical energy, conservation of momentum, conservation of energy, application to systems of particles, centre-of-mass and centre-of-mass velocity, conservation in 2-body collisions, mass and energy, $E = mc^2$.
- *Rotational Motion (6 hours)*
  Uniform circular motion, angular and centripetal acceleration, rotation of a solid about a fixed axis, moment of inertia, angular momentum and torque, conservation of angular momentum and the behaviour of the gyroscope.

Waves in Physics:

The course follows the text, *Fundamentals of Physics Extended* by Halliday, Resnick and Walker (HRW)

Wave Concepts (HRW Ch 16 and 17) (8 hours)

- Simple harmonic motion
- Longitudinal and transverse wave motion
- Frequency, angular frequency, wavelength, wave number, "speed"
- The wave equation in one dimension
- Superposition, beating, phase, group, particle velocities
- Energy and momentum

Mechanical Waves (HRW Ch 17 and 18) 5 hours

- Waves on a string, string boundaries and joins, standing waves.
- Sound waves, Doppler effect

Waves in Optics (HRW Ch 34, 35, 36 and 37) 11 hours

- Huygens construction
- Reflection, refraction, diffraction, refractive index
- Geometrical optics, lens formulae, magnification, telescope, microscope
- Optical fibres
- Interference
- Fabry Perot interferometer

- Diffraction - single, double slit and grating diffraction
- Resolving power

Waves in Crystals (HRW Ch 37 and RO Ch 2) 2 hours

- Braggs' law, diffraction patterns, X-ray
- Crystal structure, introduction to the reciprocal lattice
- Review of the course bringing out the unifying themes.
- Recapitulation and Summary 1 hour demonstrations

General discussion; Linkages; Problems, Worked examples and Quizzes 5 hours

Atoms Molecules and Quanta:

- *Introduction*
  The need for quantum theory, outline of course.
- *Quanta of light*
  Electromagnetic waves and light, blackbody radiation, photoelectric effect, Compton effect.
- *Wave-particle duality*
  De Broglie hypothesis, Born interpretation, Heisenberg uncertainty principle.
- *Quantum mechanics*
  Arguments leading to the Schrödinger equation, solution for a free particle, wave functions, solution for a particle in a box, implications for energy quantization.
- *Quantum structure of atoms*
  Atomic spectra, Franck-Hertz experiment, spectral lines for hydrogen, Bohr model, hydrogen atom in quantum mechanics, electron spin (Stern-Gerlach experiment), Zeeman effect.
- *Multi-electron atoms*
  Pauli exclusion principle, shell structure, low levels of alkali atoms, characteristic x-rays, optical spectra, addition (coupling) of angular momentum, helium spectrum.

Methods of Teaching/Learning

Principles of Physics:
30 hours of lectures/demonstrations.

Waves in Physics:
30 hours of lectures, examples classes, discussion periods, tutorials and demonstration experiments.

Atoms Molecules and Quanta:
30 hours of taught periods including lecture and tutorial classes.

Selected Texts/Journals

Principles of Physics:
Main Course Text

i. D Halliday, R Resnick and J Walker, *Fundamentals of Physics*, 7th Edition, John Wiley, New York (2005) ISBN 0-471-21643-7 (required).

NB: This is the latest edition, earlier editions are also suitable.

There are many other very similar books available which cover broadly the same material including (but not limited to) the following;

i. H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 10th Edition, Addison Wesley Longman, San Francisco (2000) ISBN 0-201-70059-X.
ii. R. A. Serway and J. W. Jewett Jnr., *Physics for Scientists and Engineers, with Modern Physics*, 6th Edition, Thomson, Belmont (2004) ISBN 0-534-40844-3
iii. P. M. Fishbane, S. G. Gasiorowicz and S. T. Thornton, *Physics for Scientists and Engineers, with Modern Physics*, 3rd Edition, Pearson Prentice Hall, New Jersey (2005) ISBN 0-13-191182-1

Further Recommended Reading:

Waves in Physics:

i. Rosenberg, *The Solid State*, Oxford.
ii. Pain, *The Physics of Vibrations and Waves*, John Wiley, New York.
iii. Gough, Richards and Williams, *Vibrations and Waves*, Prentice-Hall.

Atoms Molecules and Quanta:

i. K Krane, *Modern Physics*, [Second Edition], Wiley, 1996, ISBN 0-471-82872-6 2
ii. R Eisberg and R Resnick, *Quantum Physics*, Wiley, 1974, ISBN 0-471-87373X.

Module Title:	**Mathematics Multiple Module**
Module Short Name:	**PH1M-Maths**
Module SITS ID:	**PHY1012**

Level:	**HE1**	**Number of Credits:**	**30**
Module Co-ordinator:	**Professor JA Tostevin**		
Module Components:	**Mathematics I (10)** **Mathematics II (10)** **Mathematics III (10)**	**Professor JA Tostevin** **Professor JA Tostevin** **Dr M Oi**	

Module Availability:	**Autumn and Spring Semester (Y)**

Assessment Pattern

Unit(s) of Assessment	**Weighting Towards Module Mark(%)**
Autumn Coursework	30%
Spring Coursework	20%
Mathematics 2 Examination	25%
Mathematics 3 Examination	25%
Qualifying Condition(s) Physics programme regulations refer.	

Assessment Schedule

Autumn Coursework:
Two class tests, in weeks 10 and 15

Spring Coursework:
Two class tests in week 6, one on Mathematics 2 and one on Mathematics 3

Examination Paper 1 (May):
Answer 4 questions on Mathematics 2 (Section A)
Answer 4 questions on Mathematics 3 (Section A)

Answer 3 from 4 questions on Mathematics 2 (Section B)
Answer 3 from 4 questions on Mathematics 3 (Section B)

Pre-requisite/Co-requisites

Mathematics 1:
Advanced Level/AS-Level Mathematics or equivalent

Mathematics 2:
PH1M – Mathematics 1 component

Mathematics 3:
PH1M – Mathematics 1 component

Module Overview

Mathematics 1:
This component is offered on a supervised self-study basis in weeks 4-15 of the Autumn semester. Delivery is primarily by supported workshop classes with only occasional lectures, as required. The units of work are a selected subset of the FLAP (Flexible Learning Approach to Physics) units developed by the Open University. Mathematics 1 enhances basic mathematical skills to a little beyond Advanced level standard, providing the mathematical foundations needed for the subsequent Mathematics 2 and 3 components and other introductory (level HE1) Physics modules.

Mathematics 2:
This component is a lecture, self-study, and workshop format course. It introduces hyperbolic functions and their properties, including their connection with spherical trigonometric functions. It will expand upon the use of Taylor and other series expansions and will derive and give practice in the use of Fourier series. Methods of solution of simple first- and second-order ordinary differential equations are discussed with reference to simple physical applications.
Mathematics 3:
This component is a lecture, self-study, and workshop format course. The component covers matrices, simple linear algebra concepts, and an introduction to vector analysis and its applications. The component deals with functions of more than one variable, their derivatives and their integrals, including line integrals, double and triple integrals, and their associated applications.

Module Aims

Mathematics 1:
To provide background knowledge and practice and confidence in the use of basic mathematical manipulation skills to a little beyond Advanced level standard in algebra, functions, real and complex numbers, and the differential and integral calculus.

Mathematics 2:
To enable students to define hyperbolic functions, to derive and use Fourier series, and to solve simple first- and second-order ordinary differential equations, including the concepts and appreciation of convergence tests of numerical series.
Mathematics 3:
To provide an understanding of functions of more than one variable, their derivatives, and the location of minima and maxima of functions of two variables. To enable the use multiple integrals to calculate surface and volume properties. To introduce matrices and to define and give practice in the use matrices and of some of the important constructs of introductory linear algebra.

Learning Outcomes

Mathematics 1:
The component will bring students who begin this component at different levels of competence and expertise, based on their mathematics entry grades, to a more uniform level by the end of their first Semester. All students will have consolidated techniques covered at Advanced level, especially integration and differentiation, and had a first exposure or revision of complex numbers and series.

Mathematics 2:
By the end of this component students will be familiar with the definition and use of hyperbolic functions and the basis and application of Fourier series for a number of different functions and physical situations. They will be able to test numerical and functional series for their convergence properties and will be able to solve simple first- and second-order ordinary differential equations.

Mathematics 3:
By the end of this component, students will be able to use matrices to represent and solve sets of linear equations. They will be able to evaluate derivatives and integrals of two- and multi-variable functions and be able to apply these to find maxima and minima and to the calculation of physical quantities such as volume, mass, moments of inertia and centre of gravity of various geometric shapes with both homogeneous and inhomogeneous densities.

Module Content

Mathematics 1: Autumn Semester
FLAP units: worked through at a rate of one unit per week
- i. Arithmetic and Algebra (M1.1)
- ii. Solving equations (M1.4)
- iii. Series expansions and approximations (M1.7)
- iv. Introducing complex numbers (M3.1)
- v. Polar representation of complex numbers (M3.2)
- vi. Basic differentiation (M4.2)

vii. Further differentiation (M4.3)
viii. Stationary points and graph sketching (M4.4)
ix. Taylor series and polynomial approximations (M4.5)
x. Basic integration (M5.2)
xi. Techniques of integration (M5.3)

Mathematics 2: Spring Semester

1: Introduction to hyperbolic functions and their properties, derivatives, and series forms.
2: Further examples of sequences, limits, convergence and series analysis.
3: Fourier series; Euler-Fourier formula on $(-\pi,\pi)$, harmonics, Dirichlet convergence conditions, odd and even functions, sine and cosine series, extension to interval $(-L,L)$
4: First-order differential equations; the method of separation of variables and integrating Factors. Exact differential equations. Simple second order equations with constant coefficients, general and particular solutions.

Mathematics 3: Spring Semester

1: Matrices and vectors and the rules of matrix algebra. Rotations expressed in matrix form. Linear equation sets; eigenvectors.
2: Functions of two or more variables. Partial derivatives and Taylor's theorem. Maxima, minima and saddle points.
3: Line integrals, multiple integrals; double and triple integrals, changes of variables, the Jacobian, the use of spherical and cylindrical coordinates.

Methods of Teaching/Learning

Mathematics 1: Autumn Semester
Student – 40 workshop hours and two formative progress tests.

Mathematics 2: Spring Semester
15-20 hours of lectures and 10-15 hours of workshop sessions: 30 hours in total.

Mathematics 3: Spring Semester
20 hours of lectures and 10 hours of workshop sessions.

Selected Texts/Journals

Mathematics 1:

i. R Lambourne and Michael Tinker, *Basic Mathematics for the Physical Sciences*, Wiley, 2000
ii. Mary L Boas, *Mathematical Methods for the Physical Sciences*, Wiley, 1983.
iii. K. Weltner, J. Grosjean, P. Schuster and W.J. Weber, *Mathematics for Engineers and Scientists*, Stanley Thornes, 1986.
iv. Open University FLAP modules: copies distributed as Mathematics 1 Student Handbook

Mathematics 2:
In addition to the above,

i. G Stephenson, *Mathematical Methods for Science Students*, Pearson, 1973.
ii. Selected additional Open University FLAP modules.

Mathematics 3:
In addition to the above, lecture notes which can be downloaded from;
www.ph.surrey.ac.uk/~phs2mo/lecture

Module Title:	**Experimental Physics Multiple Module**
Module Short Name:	**PH1M-EXPP**
Module SITS ID (if known):	**PHY1011**

Level:	**1**	**Number of Credits:**	**30**
Module Co-ordinator:	**Dr TJC Hosea**		
Module Components:	**Practical I**	**Professor J Allam Dr RA Bacon Dr TJC Hosea Dr S Pani**	
	Practical II	**Professor PJ McDonald Dr TJC Hosea Dr RA Bacon Dr A Lohstroh**	
	Computational Laboratory	**Dr PD Stevenson**	
	Data Handling	**Professor BN Murdin**	

Module Availability:	**Autumn and Spring Semester (Y)**

Assessment Pattern

Unit(s) of Assessment	**Weighting Towards Module Mark(%)**
Autumn Coursework	50%
Spring Coursework	50%
Qualifying Condition(s): Physics programme regulations refer.	

Assessment Schedule

Autumn Coursework:
Laboratory diary aggregate mark (17%)
Laboratory written report (8%)
Laboratory class test (8%)

Spring Coursework:
Laboratory diary aggregate mark (17%)
Laboratory written report (8%)
Laboratory poster presentation (8%)

Computational Coursework:
Data analysis (8%)
Fortran assignments (18%)
Fortran class test (8%)

Note: the weight of each Coursework element to the total module mark is indicated.

Pre-requisite/Co-requisites

Practical 1, Practical 2 and Computational Laboratory:
Pre-university education to Advanced Level standard.

Module Overview

Practical 1:
A series of experiments of varying length designed to provide a common set of laboratory skills for students arriving from various backgrounds.

Practical 2:
A series of two-week experiments designed to allow students to continue developing their laboratory skills. The experiments will include at least one on a subject related to each student's chosen degree programme.

Computational Laboratory:
The processing of experimental data and the evaluation of uncertainties and errors are developed in Excel. Numerical methods and their implementation in the Fortran 95 programming language are introduced. The visualisation and presentation of results using graphics packages within both windows and X-windows environment is introduced.

Module Aims

Practical 1:
To provide an appropriate introduction and lay a secure foundation for the development of the skills of an experimental physicist. To provide an opportunity to become familiar with:
- Standard laboratory equipment
- Data and error analysis methods
- Good laboratory practice
- Presentation of scientific results

Practical 2:
To provide an opportunity for students to continue to develop a range of practical skills in the use of scientific apparatus, data analysis, and scientific communication (written and verbal).

Computational Laboratory:
To know the basic elements of probability distributions and to be able to undertake simple statistical and error analysis. To be able to use a computer spreadsheet to do such analysis, plot graphs and perform curve fitting. To introduce editors and scientific programming constructs. To introduce and, through sample programs and practical classes, to teach the use of those Fortran 95 language elements necessary to write, compile and run computer programs for simple data manipulations. To develop and enhance a student's Fortran 95 programming skills and to introduce a number of practical numerical and simulation methods applicable to physical problems.

Learning Outcomes

Practical 1:
By the end of this component, the student should be able to (i) follow detailed instructions in order to carry out simple experiments which demonstrate physical principles (ii) analyse the results of said experiments and in particular provide a detailed error analysis (iii) fully and accurately record the experiment (iv) write a detailed account of the experiment following standard scientific writing and reporting methods.

Practical 2:
By the end of this component, the student should be able to (i) follow experimental procedures and develop their own strategies for acquiring data in order to investigate a range of physical phenomena; (ii) analyse the results of experiments and, in particular, provide a detailed error analysis; (iii) fully and accurately record the experiment; (iv) write a detailed account of the experiment following standard scientific writing and reporting method; and (v) present the results of an experiment in the form of a poster.

Computational Laboratory:
At the end of this component students should have developed good programming practice in Fortran 95 and be able to apply their knowledge to solve a number of physical problems numerically. Students should be able to analyse and present reduced experimental and probabilistic results of the multiple measurements of physical observables. Specifically they should be able to quote averages and errors of such variables. They should be able to fit theoretical predictions to graphs where one independent observable is changing using the method of least squares, and find the errors in the fitting parameter(s). Students should be able to use simple error theory to find the errors of quantities dependent on (combinations of) the observables. They should be able to use simply probability distributions to predict the outcome of experiments.

Module Content

Practical 1:
For the first three weeks, students undertake a series of short experiments lasting typically one hour which cover areas such as errors, electrical measurement, waves, simple optics, Fourier synthesis and resonance. These are followed by a set of one-week experiments related to the core physics modules and or to the specialist physics courses.

Practical 2:
A series of two-week experiments (eight hours each) covering areas related to the core physics modules, including electronics. At least one experiment will be offered in an area relevant to each student's particular degree specialisation (e.g. medical physics).

Computational Laboratory:

Probability:	Discrete and continuous distributions, expectation values. Binomial, Gaussian and Poisson distributions. The Central Limit Theorem.
Statistics:	Mean, standard deviation, standard error in mean.
Data Handling:	Propagation of errors, least-squares fitting, χ^2 distribution.
Spreadsheets:	Excel spreadsheets including calculations and graphs.
Units, Matrices, Computer Algebra:	Introduction to some features of MathCad.
Introduction to the Fortran 95 Language:	Constant and variable types and their declaration, parameters, arithmetic operators and expressions, arithmetic assignments, intrinsic functions, simple input/output, relational expressions, logical expressions, the forms of the IF statement, subprograms, DO loops, arrays and their use for subscripted variables, general input/output, the format statement.
Introductory Programming Exercises:	Averages, running sums/products, function evaluation, iteration, simple simulation, use of input and output, integers and reals, random number simulations, use of arrays.
Five Computing Assignments Covering:	1) Roots of equations (Newton-Raphson); 2) numerical differentiation; 3) numerical integration; 4) random number simulations and 5) linear algebra.

Methods of Teaching/Learning

Practical 1:
Nine half-days (36 hours) of laboratory classes.

Practical 2:
Twelve half-days (48 hours) of laboratory classes.

Computational Laboratory:

Autumn Semester:	CPTL: 10 two-hour computing laboratory sessions. DH: one-hour lecture followed by one-hour tutorial session in a computing laboratory, weekly for six weeks. PC: 2 hours introductory lectures during week 3.
Spring Semester:	CPTL: 11 two-hour computing laboratory sessions.

Selected Texts/Journals

Practical 1 and Practical 2:

Required Reading:

i. Dr D Lancefield, *Physics Laboratory Handbook: Level 1*, Physics Department (a copy will be given to all students).

Recommended Reading:

i. L Kirkup, *Experimental Methods: An introduction to the analysis and presentation of data*, John Wiley and Sons, New York, 1994.
ii. R J Barlow, *Statistics*, Manchester Physics Series, Wiley, IBSN 0471-92295-1.
iii. P R Bevington and D K Robinson, *Data Reduction and Error Analysis for the Physical Sciences*, [Second Edition], McGraw Hill, 1992. The first edition with only Bevington as the author is in the Library: 519.286 BEV
iv. J R Taylor, *An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements*, [Second Edition], Scinu Books, 1997.

Computational Laboratory:

i. T M R Elis, I R Philips and T M Lahey, *Fortran 90 Programming*, Addison-Wesley.
ii. Metcalf and Reid, *Fortram 90/95 explained*, Oxford University Press, Oxford, 1996.
iii. FORTRAN 95 programming on the Departmental Intranet, http://web.ph.surrey.ac.uk/fortweb/
iv. Dr D Lancefield, *Physics Laboratory Handbook: Level 1*, Physics Department (given to all students in Practical I).
v. R J Barlow, *Statistics*, Manchester Physics Series, J Wiley, ISBN 0471-92295-1.

Module Title:	**Specialist Physics Multiple Module 1A**
Module Short Name:	**PH1M-SPA**
Module SITS ID:	**PHY1024**

Level:	**1**	**Number of Credits:**	**30**
Module Co-ordinator:	**Professor PM Walker**		
Module Components:	**Electronics** **Space, Time and Relativity –** **Introduction to Astrodynamics and Space Science –**	**Dr SJ Sweeney** **Professor J Al-Khalili** **Professor W Gelletly**	

Module Availability:	**Autumn and Spring Semester (Y)**

Assessment Pattern

Unit(s) of Assessment	**Weighting Towards Module Mark(%)**
Space Time and Relativity Examination	23%
Electronics Examination	24%
Introduction to Astrodynamics and Space Science Examination	23%
Coursework	30%
Qualifying Condition(s) Physics programme regulations refer.	

Assessment Schedule

Autumn Coursework:
Space Time and Relativity: two class tests in weeks 10 and week 15 (10%)

Spring Coursework:
Electronics: one class test in week 6 (10%)
Introduction to Astrodynamics and Space Science class test in week 6 (10%)

Note: the weight of each Coursework element to the total module mark is indicated.

Examination Paper 3 (May):
Answer 3 questions on Space Time and Relativity (Section A)
Answer 3 questions on Electronics (Section A)
Answer 3 questions on Intro. to Astrodynamics and Space Science (Section A)

Answer 2 from 3 questions on Electronics (Section B)
Answer 2 from 3 questions on Space Time and Relativity (Section B)
Answer 2 from 3 questions on Intro. to Astrodynamics and Space Science (Section B)

Pre-requisite/Co-requisites

Pre-university education to Advanced Level standard.

Module Overview

Electronics:
A brief introduction to electronic components, circuits, networks and measurements. Networks may be analysed in terms of their D.C. (steady state) or A.C. (time varying) components. Active semiconductor devices are introduced and their applications are demonstrated in simple circuits.

Space Time and Relativity:
This component introduces concepts which underpin Einstein's Special and General theories of relativity discussing events and physical phenomena from different frames of reference and in

different co-ordinate systems, and the way in which mathematics relates these descriptions. Concepts of inertial frames of reference, transformations, invariants, and elementary relativity principles and covariance, will be introduced. These tools and concepts are then used to describe some of the phenomena in Special and General Relativity.

Introduction to Astrodynamics and Space Science:
An introduction to both the basic tools required in observation in Astronomy and current views of the origins of the universe and its constituent parts.

Module Aims

Electronics:
To provide a basic introduction to electronics and its building blocks. Introduce the techniques used to predict the parameters and response of simple circuits. To draw simple parallels between the theory and practice learned in this course and other areas such as mechanics, resonance and the solution of basic differential equations. To provide the basic ideas that will allow an appreciation for the operation of the electronic measurement devices commonly used in the laboratory.

Space Time and Relativity:
This component aims to introduce, at an early stage in the student curriculum, a discussion of how physicists make measurements in space and time by construction of frames of reference, how these are established and chosen for mathematical convenience, and how measurements made by different experimenters with respect their own frames of reference can be related. The component aims to provide a familiarity with the Lorentz transformation equations and their applications in Special Relativity, and the concepts which lead to Einstein's General theory.

Introduction to Astrodynamics and Space Science:
Our ability to observe astronomical objects and our ideas about the origins of the universe have changed dramatically over the last 50 years and continue to change. The aims of this component will be a) to give a broad understanding of the methods of observation in Astronomy and Earth Observation and the methods of measuring many basic quantities such as distance in Astronomy, and b) to give an overview of our present understanding of the Physical Origins of the Universe based on the standard Big Bang Model.

Learning Outcomes

Electronics:
By the end of this component the student should have obtained a basic working understanding of electrical networks containing both passive and active components and to be able to analyze them in relation to DC and time varying signals. Students should appreciate the operation of electronic measurement devices and how their properties influence the measurements made.

Space Time and Relativity:
By the end of this component students will have an appreciation of how coordinates, lengths and intervals are transformed in special relativity and how this differs from the Newtonain/Galilean view. They will appreciate why and how Einstein was led to the conclusion that nothing can travel faster than light and how the constancy of the speed of light led to a revolution in our concepts of space and time. They will be able to transform velocities from one inertial frame to another and calculate relativistic masses, energies and momenta. They will have a basic feel for how gravity affects space and time in Einstein's general theory of relativity, but without any rigorous mathematics.

Introduction to Astrodynamics and Space Science:
On completing this component the student should have an appreciation of how observations are made in Astronomy, how estimates are made of basic quantities such as distance, masses, stellar luminosities, temperature etc. They should have an understanding of the dynamics of astronomical and satellite systems. They should also be able to apply this knowledge to an understanding of cosmological models and models of the solar system.

Module Content

Electronics:

D.C. Circuit Theory:	Electrical nomenclature, current, voltage, resistance, conductance, power and decibels. Kirchhoff's laws. Current and voltage sources, Thévenin and Norton sources. Condition for maximum power transfer. Analysis of simple networks of resistors.
A.C. Circuit Theory:	Capacitors and Inductors. Energy storage. Use of complex numbers. Concepts of reactive impedance and frequency dependence. Transient response. Tuned circuit principles, ω_0, $\Delta\omega$ and Q). Concept of link between frequency and transient responses.
Active Devices:	Diodes and bipolar transistors and their uses in rectification and amplification. Zenner and light emitting diodes.
Systems and Circuits:	Concept of feedback, operational amplifiers, frequency response of circuits with reactive components, filters, Bode plots. Active filters, differentiators, integrators. Oscillators.

Space Time and Relativity:

Introductory discussion of events, reference frames, transformations between reference frames and invariant quantities on transformation.

Introduction to relativity principles, Galilean relativity, the basis of special relativity. The constancy of the speed of light, the Michelson-Morley experiment, the relativity of simultaneity, time measurements made with clocks in relative motion (time dilation), the Lorentz transformation equations, examples and implications of time dilation and length contraction.

Spacetime diagrams and light cones, invariance of the spacetime interval.

Velocity transformations, can things go faster than light? Cerenkov radiation, relativistic mass and momentum, deriving $E=mc^2$, the relativistic Doppler effect, the twin paradox, special relativity and electromagnetism.

Accelerating frames of reference, the principle of equivalence, curvature of space-time, experimental tests of GR: Mercury's perihelion, the gravitational redshift, the bending of light due to gravity. Black holes, singularities, the event horizon, frames of reference inside and outside the horizon.

Introduction to Astrodynamics and Space Science:

Celestial Mechanics:	Newtonian Mechanics, Kepler's Laws, Binary Stars, stellar masses, satellite launching and orbits
Electromagnetic spectrum:	Blackbody radiation, Wien's Law, spectral lines, Doppler effect, temperature
Telescopes and space telescopes:	basic optics, refraction and reflection, interferometry, optical telescopes, radio-telescopes, infra-red, ultra-violet and X-ray astronomy, telescopes in orbit
Planetary Physics:	Review of the planets in the Solar System and their moons. Sizes, composition and atmospheres of planets. Theories of planetary formation
Earth observation:	Thermal emission from surface, new IR observation, meteorology, land and sea surface deformations and temperature, vegetation and fisheries conservation, mapping, pollution monitoring.
Stars and galaxies:	Measurements of Distance, Temperature and Luminosity, Hertzsprung-Russell Diagram. Star formation and evolution, stellar energy sources, nucleosynthesis (basic ideas)
Big Bang Cosmology:	Hubble's Law. Age and size of the Universe. Cosmic Microwave Background. Initial high energy interactions. Particle and nucleon formation. Primeval nucleosynthesis.

Methods of Teaching/Learning

Electronics:
30 hours of lectures / demonstrations and tutorial classes.

Space Time and Relativity:
30 hours of lecture and tutorial classes.

Introduction to Astrodynamics and Space Science:
30 hours of lectures, examples and tutorial classes.

Selected Texts/Journals

Electronics:

i. C K Alexander and M N O Sadiku, *Fundamentals of Electric Circuits*, McGraw Hill (2003).
ii. D V Bugg, *Circuits, Amplifiers and Gates*, Adam Hilger.
iii. P Horowitz and W Hill, *The Art of Electronics*, Cambridge University Press (highly recommended for the more advanced student).

Space Time and Relativity:

i. D Halliday, R Resnick and J Walker, *Fundamentals of Physics Extended, [Fifth Edition], John Wiley, New York 1997*.
ii. K Krane, *Modern Physics,* [2nd Edition], John Wiley 1996.
iii. W Rindler, *Introduction to Special Relativity*, Oxford University Press.
iv. A P French, *Special Relativity,* W W Norton & Company, New York 1968.
v. E F Taylor and J A Wheeler, *Spacetime Physics*, Freeman
vi. J S Al-Khalili, *Black Holes, Wormholes and Time Machines,* Institute of Physics Publishing 1999.

Introduction to Astrodynamics and Space Science:

i. W J Kaufmann, *Universe*, 4th Edition, Freeman & Co. 1991. ISBN 0-7167-2094-9
ii. Bradley W Carroll and Dale A Ostlie, *Modern Astrophysics*, Addison-Wesley Publ. Co. Inc, 1996. ISBN 0-201-54730-9

For Earth Observation, please consult:

i. J B Campbell, *Introduction to Remote Sensing (2nd edition)*, Taylor and Francis, 1996, ISBN 0-7484-0663-8
ii. Lillesand and Kiefer, *Remote Sensing and Image Interpretation (3rd edition)*, Wiley, 1994, ISBN 0-471-30575-8

Module Title:	**Specialist Physics Multiple Module 1B**
Module Short Name:	**PH1M-SPB**
Module SITS ID (if known):	**PHY1025**

Module Provider (AOU):	**PH00**		**Subject (3 letters):**	**PHY**
Level:	**1**		**Number of Credits:**	**30**
Module Co-ordinator:	**Dr DA Faux**			
Module Components:	**Electronics** **Management Accounting** **Space, Time and Relativity**	**Dr SJ Sweeney** **Faculty of Management and Law** **Professor JS Al-Khalili**		

Module Availability:	**Autumn and Spring Semester (Y)**

Assessment Pattern

Unit(s) of Assessment	**Weighting Towards Module Mark(%)**
STR and Electronics Coursework	20%
Space Time and Relativity Examination	23%
Electronics Examination	24%
Financial Accounting Examination & Coursework (FML)	33%
Qualifying Condition(s) Physics programme regulations refer.	

Assessment Schedule

Autumn Coursework:
Space Time and Relativity: two class tests in weeks 10 and week 15 (10%)

Spring Coursework:
Electronics: one class test in week 6 (10%)
Financial Accounting assignment diary (3%)
Financial Accounting two class tests (10%)

Note: the weight of each Coursework element to the total module mark is indicated.

Examination Paper 3 (May):
Answer 3 questions on Electronics (Section A)
Answer 3 questions on Space Time and Relativity (Section A)

Answer 2 from 3 questions on Electronics (Section B)
Answer 2 from 3 questions on Space Time and Relativity (Section B)

Financial Accounting Open Book Examination (May):

Pre-requisite/Co-requisites

Electronics, Financial Accounting and Space Time & Relativity:
Pre-university education to Advanced Level standard.

Module Overview

Electronics:
A brief introduction to electronic components, circuits, networks and measurements. Networks may be analysed in terms of their D.C. (steady state) or A.C. (time varying) components. Active semiconductor devices are introduced and their applications are demonstrated in simple circuits.

Financial Accounting:
This component is designed to give students a practical study of the basic principles of financial accounting. The enable them to understand and use data from accounting systems that will be

presented to employees working in all business functions.

Space Time and Relativity:
This component introduces concepts which underpin Einstein's Special and General theories of relativity discussing events and physical phenomena from different frames of reference and in different co-ordinate systems, and the way in which mathematics relates these descriptions. Concepts of inertial frames of reference, transformations, invariants, and elementary relativity principles and covariance, will be introduced. These tools and concepts are then used to describe some of the phenomena in Special and General Relativity.

Module Aims

Electronics:
To provide a basic introduction to electronics and its building blocks. Introduce the techniques used to predict the parameters and response of simple circuits. To draw simple parallels between the theory and practice learned in this course and other areas such as mechanics, resonance and the solution of basic differential equations. To provide the basic ideas that will allow an appreciation for the operation of the electronic measurement devices commonly used in the laboratory.

Financial Accounting:
The key aims of this module is to enable students to understand the how any why of recording, preparing and interpreting financial information.

Space Time and Relativity:
This component aims to introduce, at an early stage in the student curriculum, a discussion of how physicists make measurements in space and time by construction of frames of reference, how these are established and chosen for mathematical convenience, and how measurements made by different experimenters with respect their own frames of reference can be related. The module component aims to provide a familiarity with the Lorentz transformation equations and their applications in Special Relativity, and the concepts which lead to Einstein's General theory.

Learning Outcomes

Electronics:
By the end of this component the student should have obtained a basic working understanding of electrical networks containing both passive and active components and to be able to analyze them in relation to DC and time varying signals. Students should appreciate the operation of electronic measurement devices and how their properties influence the measurements made.

Management Accounting:
On successful completion of this component the students will be able to;

- Record transactions using double-entry book-keeping
- Understand the structure of an accounting system and ledgers
- Balance accounts and extract a trial balance
- Prepare a profit and loss account and a balance sheet from a trial balance
- Interpret financial statements with regard to solvency, profitability and working capital management
- Understand the regulatory framework that surrounds financial accounting
- Understand how different types of company structure are financed

Space Time and Relativity:
By the end of the component students will have an appreciation of how coordinates, lengths and intervals are transformed in special relativity and how this differs from the Newtonain/Galilean view. They will appreciate why and how Einstein was led to the conclusion that nothing can travel faster than light and how the constancy of the speed of light led to a revolution in our concepts of space and time. They will be able to transform velocities from one inertial frame to another and calculate relativistic masses, energies and momenta. They will have a basic feel for how gravity affects space and time in Einstein's general theory of relativity, but without any rigorous mathematics.

Module Content

Electronics:

D.C. Circuit Theory:	Electrical nomenclature, current, voltage, resistance, conductance, power and decibels. Kirchhoff's laws. Current and voltage sources, Thévenin and Norton sources. Condition for maximum power transfer. Analysis of simple networks of resistors.
A.C. Circuit Theory:	Capacitors and Inductors. Energy storage. Use of complex numbers. Concepts of reactive impedance and frequency dependence. Transient response. Tuned circuit principles ω_0, $\Delta\omega$ and Q). Concept of link between frequency and transient responses.
Active Devices:	Diodes and bipolar transistors and their uses in rectification and amplification. Zenner and light emitting diodes.
Systems and Circuits:	Concept of feedback, operational amplifiers, frequency response of circuits with reactive components, filters, Bode plots. Active filters, differentiators, integrators. Oscillators.

Management Accounting:

- Double entry book-keeping
- Trial balances
- Structure of accounting systems
- Fixed assets and depreciation
- Profit and loss accounts
- Balance sheets
- Cash flow statements
- Interpretation of accounts

Space Time and Relativity:

Introductory discussion of events, reference frames, transformations between reference frames and invariant quantities on transformation.

Introduction to relativity principles, Galilean relativity, the basis of special relativity. The constancy of the speed of light, the Michelson-Morley experiment, the relativity of simultaneity, time measurements made with clocks in relative motion (time dilation), the Lorentz transformation equations, examples and implications of time dilation and length contraction.

Spacetime diagrams and light cones, invariance of the spacetime interval.

Velocity transformations, can things go faster than light? Cerenkov radiation, relativistic mass and momentum, deriving $E=mc^2$, the relativistic Doppler effect, the twin paradox, special relativity and electromagnetism.

Accelerating frames of reference, the principle of equivalence, curvature of space-time, experimental tests of GR: Mercury's perihelion, the gravitational redshift, the bending of light due to gravity. Black holes, singularities, the event horizon, frames of reference inside and outside the horizon.

Methods of Teaching/Learning

Electronics:

30 hours of lectures / demonstrations and tutorial classes.

Financial Accounting:

- The teaching and learning strategy is designed to allow a student to come to grips with what is essentially a subject mix of theory and practice.
- Lectures to illustrate the principles
- Regular tutorials on a weekly basis (tutors are available for answering questions from the students).
- Numerous practical exercises to test students understanding on an ongoing basis.

- Team based coursework
- Making lecture handouts available to students
- Support of lecture material by directed reading in selected textbooks

Space Time and Relativity:
30 hours of lecture and tutorial classes.

Selected Texts/Journals

Electronics:

iv. C K Alexander and M N O Sadiku, *Fundamentals of Electric Circuits*, McGraw Hill (2003).
v. D V Bugg, *Circuits, Amplifiers and Gates*, Adam Hilger.
vi. P Horowitz and W Hill, *The Art of Electronics*, Cambridge University Press (highly recommended for the more advanced student).

Financial Accounting:

Required Reading:
i. David Cox (latest edition), *Business Accounts,* Osborne Books, ISBN 1-872962-63-7
Recommended Reading:
1. Atrill, P and McLaney E, *Financial Accounting,* 4th Edition, PT Prentice Hall
Other Indicative Reading:
Articles and other matieral from the financial pages of newspapers and journals such as;
The Economist
Financial Times
The Business
Fortune

Space Time and Relativity:

vii. D Halliday, R Resnick and J Walker, *Fundamentals of Physics Extended, [Fifth Edition], John Wiley, New York 1997*.
viii. K Krane, *Modern Physics,* [2nd Edition], John Wiley 1996.
ix. W Rindler, *Introduction to Special Relativity*, Oxford University Press.
x. A P French, *Special Relativity,* W W Norton & Company, New York 1968.
xi. E F Taylor and J A Wheeler, *Spacetime Physics*, Freeman
xii. J S Al-Khalili, *Black Holes, Wormholes and Time Machines,* Institute of Physics Publishing 1999.