

## **School of Physics & Astronomy**

### **Important Degree Information:**

#### **B.Sc./M.A. Honours**

The general requirements are 480 credits over a period of normally 4 years (and not more than 5 years) or part-time equivalent; the final two years being an approved honours programme of 240 credits, of which 90 credits are at 4000 level and at least a further 120 credits at 3000 and/or 4000 (H) levels. Refer to the appropriate Faculty regulations for lists of subjects recognised as qualifying towards either a B.Sc. or M.A. degree.

#### **B.Sc./M.A. Honours with Integrated Year Abroad**

The general requirements are 540 credits over a period of normally 5 years (and not more than 6 years) or part-time equivalent; the final three years being an approved honours programme of 300 credits, of which 60 credits are gained during the integrated year abroad, 90 credits are at 4000 level and at least a further 120 credits at 3000 and/or 4000 (H) levels. Refer to the appropriate Faculty regulations for lists of subjects recognised as qualifying towards either a B.Sc. or M.A. degree.

#### **M.Phys. Honours**

The general requirements are 600 credits over a period of normally 5 years (and not more than 6 years) or part-time equivalent; the final three years being an approved honours programme of 360 credits, of which 120 credits are at 5000 level and a further 210 credits (minimum) at 3000 and 4000 levels.

#### **M.Sci. Honours (being phased out)**

General requirements of 540 credits over a period of normally 4 years; of which 300 credits are in an approved honours programme. See earlier regulations.

#### **M.Sci. Honours**

The general requirements are 600 credits over a period of normally 5 years (and not more than 6 years) or part-time equivalent; the final three years being an approved honours programme of 360 credits, of which 120 credits are at 5000 level and a further 210 credits (minimum) at 3000 and 4000 levels.

#### **B.Eng. Honours**

The general requirements are 480 credits over a period of normally 4 years (and not more than 5 years) or part-time equivalent; the final two years being an approved honours programme of 240 credits, of which 90 credits are at 4000 level and a further 150 credits at 3000 and 4000 levels.

#### **M.Eng. Honours**

The general requirements are 600 credits over a period of normally 5 years (and not more than 6 years) or part-time equivalent; the final three years being an approved honours programme of 360 credits, of which 120 credits are at 5000 level and a further 240 credits at 3000 and 4000 levels.

**Other Information:** In the case of students who spend part of the Honours Programme abroad on a recognised Exchange Scheme, the Programme Requirements will be amended to take into account courses taken while abroad.

**The Honours syllabus is undergoing a major change commencing in 2002-03 and Programme requirements listed below are those for students entering the first year of the Honours Programme in 2002-03 or subsequently. Students entering the Second Year of the Honours programme in 2002-03 should refer to School Handbooks and consult Honours Advisers for the requirements of their honours programme.**

## Physics & Astronomy - Honours

<b>Degree Programmes</b>	<b>Programme Requirements at:</b>
<p>(B.Sc. Honours): <b>Astrophysics</b></p>	<p><b>Single Honours Astrophysics (B.Sc.) Degree:</b>  <b>Level 1:</b> 80 credits comprising: PH1001 or PH1011, PH1002 or PH1012, MT1002 and AS1001. For those who enter at second level, the PH modules are not required.</p> <p><b>Level 2:</b> At least 120 credits comprising: 11 or better in AS2001, PH2011, PH2012, and in MT2101 or (MT2001 and MT2003).</p> <p><b>Level 3:</b> 110 credits comprising: AS3011 – AS3013, PH3014, PH3061, PH3062, and PH3064 – PH3067.</p> <p><b>Level 4:</b> At least 50 credits comprising: AS4103, and at least two of AS3014, AS3015, AS4021-AS4024, and PH4031.</p> <p><b>Other Information:</b> This programme applies to all students entering third level from September 2002 onwards.</p>
<p>(M.Sci. Honours): <b>Astrophysics</b></p>	<p><b>Single Honours Astrophysics (M.Sci.) Degree:</b>  <b>Level 1:</b> 80 credits comprising: PH1001, PH1002, MT1002, and AS1001.</p> <p><b>Level 2:</b> At least 120 credits comprising: 15 or better in AS2001, PH2011 and PH2012, and 11 or better in MT2101 or (MT2001 and MT2003).</p> <p><b>Level 3:</b> 125 credits comprising: AS3011 – AS3013, AS3101, PH3014, PH3061, PH3062, and PH3064 – PH3067.</p> <p><b>Level 4:</b> At least 55 credits comprising: AS4024 and at least 45 credits from AS3015, AS4021, AS4022, AS4023 and PH4031</p> <p><b>Level 5:</b> 75 credits comprising: AS5101 and at least two of AS5001, AS5002, AS5003.</p> <p><b>Other Information:</b> This programme applies only to students entering third level in September 2002.</p>
<p>(M.Phys. Honours): <b>Astrophysics</b></p>	<p><b>Single Honours Astrophysics (M.Phys) Degree:</b>  <b>Level 1:</b> 80 credits comprising: PH1001 or PH1011, PH1002 or PH1012, MT1002 and AS1001. For those who enter at second level, the PH modules are not required.</p> <p><b>Level 2:</b> At least 120 credits comprising: 15 or better in AS2001, PH2011 and PH2012, and 11 or better in MT2101 or (MT2001 and MT2003).</p> <p><b>Level 3:</b> 140 credits comprising: AS3011 – AS3015, PH3014, PH3061, PH3062, and PH3064 – PH3067.</p> <p><b>Level 4:</b> 60 credits comprising: AS4021-AS4024, PH4031.</p> <p><b>Level 5:</b> 90 credits comprising AS5001-AS5003 and AS5101.</p> <p><b>Other Information:</b> This programme applies to all students entering third level from September 2002 onwards.</p>

<b>Degree Programmes</b>	<b>Programme Requirements at:</b>
<p>(B.Sc. Honours): <b>Physics</b></p>	<p><b>Single Honours Physics (B.Sc.) Degree:</b>  <b>Level 1:</b> 60 credits comprising: PH1001 or PH1011, PH1002 or PH1012, and MT1002. For those who enter at second level, the PH modules are not required.  <b>Level 2:</b> At least 90 credits comprising: 11 or better in PH2011, PH2012, and in MT2101 or (MT2001 and MT2003).  <b>Level 3:</b> 125 credits comprising: PH3002, PH3014, PH3061, PH3062, PH3064 – PH3067, PH3101 and PH3102.  <b>Level 4:</b> 45 credits comprising: PH4021 and PH4111.  <b>Other Information:</b> This programme applies to all students entering third level from September 2002 onwards.</p>
<p>(B.Sc. Honours): <b>Physics and Chemistry, Computer Science, Internet Computing, Logic &amp; Philosophy of Science, Mathematics.</b></p>	<p><b>Physics element of Joint Degree:</b>  <b>Level 1:</b> 60 credits comprising: PH1001 or PH1011, PH1002 or PH1012, and MT1002. For those who enter at second level, the PH modules are not required.  <b>Level 2:</b> At least 90 credits comprising: 11 or better in PH2011, PH2012, and in MT2101 or (MT2001 and MT2003).  <b>Level 3:</b> 65 credits comprising: PH3061, PH3062, PH3064 – PH3067.  <b>Level 4:</b> No specific requirements – see B.Sc. Honours statement at beginning of chapter  <b>Other Information:</b> This programme applies to all students entering third level from September 2002 onwards.</p>
<p>(B.Sc. Honours): <b>Physics with French<sup>^</sup>; Physics with Management</b></p> <p><sup>^</sup> available also as 'with Integrated Year Abroad Degrees'</p>	<p><b>Physics element of Major Degree Programmes:</b>  <b>Level 1:</b> 60 credits comprising: PH1001 or PH1011, PH1002 or PH1012, and MT1002. For those who enter at second level, the PH modules are not required.  <b>Level 2:</b> At least 90 credits comprising: 11 or better in PH2011, PH2012, and in MT2101 or (MT2001 and MT2003).  <b>Level 3:</b> 95 credits comprising: PH3002, PH3061, PH3062, PH3064 – PH3067, and at least one of PH3101, PH3102.  <b>Level 4:</b> 45 credits comprising: PH4021 and PH4111.  <b>Other Information:</b> This programme applies to all students entering third level from September 2002 onwards.</p>
<p>(M.Phys. Honours): <b>Physics</b></p>	<p><b>Single Honours Physics (M.Phys) Degree:</b>  <b>Level 1:</b> 60 credits comprising: PH1001 or PH1011, PH1002 or PH1012, and MT1002. For those who enter at second level, the PH modules are not required.  <b>Level 2:</b> At least 90 credits comprising: 15 or better in PH2011 and PH2012, and 11 or better in MT2101 or (MT2001 and MT2003).  <b>Level 3:</b> 140 credits comprising: PH3002, PH3004, PH3014, PH3061, PH3062, PH3064 – PH3067, PH3101 and PH3102.  <b>Level 4:</b> 35 credits comprising: PH4021, PH4028 and PH4030.  <b>Level 5:</b> 45 credits comprising: PH5101.  <b>Other Information:</b> This programme applies to all students entering third level from September 2002 onwards.</p>

## Physics & Astronomy - Honours

<b>Degree Programmes</b>	<b>Programme Requirements at:</b>
(M.Sci. Honours): <b>Physics</b>	<p><b>Single Honours Physics (M.Sci) Degree:</b>  <b>Level 1:</b> 60 credits comprising: PH1001, PH1002 and MT1002.</p> <p><b>Level 2:</b> At least 90 credits comprising: 15 or better in PH2011 and PH2012, and 11 or better in MT2101 or (MT2001 and MT2003).</p> <p><b>Level 3:</b> 110 credits comprising: PH3002, PH3014, PH3061, PH3062, PH3064 – PH3067, PH3101 and PH3102.</p> <p><b>Level 4:</b> 35 credits comprising: PH4021, PH4028 and PH4030.</p> <p><b>Level 5:</b> 45 credits comprising: PH5101.</p> <p><b>Other Information:</b> This programme applies only to students entering third level in September 2002.</p>
(M.Phys. Honours): <b>Physics with Photonics</b>	<p><b>Physics with Photonics (M.Phys.) Degree:</b>  <b>Level 1:</b> 60 credits comprising: PH1001 or PH1011, PH1002 or PH1012, and MT1002. For those who enter at second level, the PH modules are not required.</p> <p><b>Level 2:</b> At least 90 credits comprising: 15 or better in PH2011 and PH2012, and 11 or better in MT2101 or (MT2001 and MT2003).</p> <p><b>Level 3:</b> 155 credits comprising: PH3002, PH3005, PH3010, PH3014, PH3061, PH3062, PH3064 – PH3067, PH3101 and PH3102.</p> <p><b>Level 4:</b> 50 credits comprising: PH4021, PH4027, PH4028 and PH4030.</p> <p><b>Level 5:</b> 75 credits comprising: PH5005, PH5008 and PH5101.</p> <p><b>Other Information:</b> This programme applies to all students entering third level from September 2002 onwards.</p>
(M.Sci. Honours): <b>Physics with Photonics</b>	<p><b>Physics with Photonics (M.Sci.) Degree:</b>  <b>Level 1:</b> 60 credits comprising: PH1001, PH1002 and MT1002.</p> <p><b>Level 2:</b> At least 90 credits comprising: 15 or better in PH2011 and PH2012, and 11 or better in MT2101 or (MT2001 and MT2003).</p> <p><b>Level 3:</b> 155 credits comprising: PH3002, PH3005, PH3010, PH3014, PH3061, PH3062, PH3064 – PH3067, PH3101 and PH3102.</p> <p><b>Level 4:</b> 50 credits comprising: PH4021, PH4027, PH4028 and PH4030.</p> <p><b>Level 5:</b> 75 credits comprising: PH5005, PH5008 and PH5101.</p> <p><b>Other Information:</b> This programme applies only to students entering third level in September 2002.</p>
(M.Sci. Honours): <b>Theoretical Physics and Mathematics</b>	<p><b>Theoretical Physics element of Joint M.Sci. Degree:</b>  <b>Level 1:</b> 40 credits comprising: PH1001, PH1002.</p> <p><b>Level 2:</b> 60 credits comprising: 15 or better in PH2011 and PH2012.</p> <p><b>Level 3:</b> At least 65 credits comprising: PH3061, PH3062, PH3064, PH3065, PH3067, and PH3073 or MT4507.</p> <p><b>Level 4:</b> 25 credits comprising: PH4029, PH4032.</p> <p><b>Level 5:</b> At least 45 credits comprising: PH5002, PH5004, PH5102 or MT5998, and at least one of PH4022, PH5003, PH5011 and PH5012.</p> <p><b>Other Information:</b> This programme applies only to students entering third level in September 2002.</p>

<b>Degree Programmes</b>	<b>Programme Requirements at:</b>
(M.Phys. Honours): <b>Theoretical Physics and Mathematics</b>	<p><b>Theoretical Physics element of Joint M.Phys. Degree:</b>  <b>Level 1:</b> 40 credits comprising: PH1001 or PH1011, PH1002 or PH1012. For those who enter at second level, the PH modules are not required.</p> <p><b>Level 2:</b> 60 credits comprising: 15 or better in PH2011 and PH2012.</p> <p><b>Level 3:</b> At least 65 credits comprising: PH3061, PH3062, PH3064, PH3065, PH3067, and PH3073 or MT4507.</p> <p><b>Level 4:</b> 50 credits comprising: PH4022, PH4028, PH4029 and PH4032.</p> <p><b>Level 5:</b> At least 45 credits comprising: PH5002, PH5004, PH5102 or MT5998, and at least one of PH5003, PH5011 and PH5012.</p> <p><b>Other Information:</b> This programme applies to all students entering third level from September 2002 onwards.</p>
(M.Phys. Honours): <b>Theoretical Physics</b>	<p><b>Single Honours Theoretical Physics (M.Phys.) Degree:</b>  <b>Level 1:</b> 60 credits comprising: PH1001 or PH1011, PH1002 or PH1012, and MT1002. For those who enter at second level, the PH modules are not required.</p> <p><b>Level 2:</b> At least 90 credits comprising: 15 or better in PH2011 and PH2012, and in MT2101 or (MT2001 and MT2003).</p> <p><b>Level 3:</b> 120 credits comprising: MT3501, PH3002, PH3014, PH3061, PH3062, PH3064-PH3067, PH3073.</p> <p><b>Level 4:</b> 75 credits comprising: PH4021, PH4022, PH4028- PH4030, PH4032.</p> <p><b>Level 5:</b> At least 75 credits comprising: PH5002, PH5004, PH5102 and at least one of PH5003, PH5011 and PH5012.</p> <p><b>Other Information:</b> This programme applies to all students entering third level from September 2002 onwards.</p>
(M.Sci. Honours): <b>Theoretical Physics</b>	<p><b>Single Honours Theoretical Physics (M.Sci.) Degree:</b>  <b>Level 1:</b> 60 credits comprising: PH1001, PH1002 and MT1002.</p> <p><b>Level 2:</b> At least 90 credits comprising: 15 or better in PH2011 and PH2012, and in MT2101 or (MT2001 and MT2003).</p> <p><b>Level 3:</b> 120 credits comprising: MT3501, PH3002, PH3014, PH3061, PH3062, PH3064-PH3067, PH3073.</p> <p><b>Level 4:</b> 65 credits comprising: PH4021, PH4022, PH4029, PH4030, PH4032.</p> <p><b>Level 5:</b> At least 75 credits comprising: PH5002, PH5004, PH5102 and at least one of PH5003, PH5011 and PH5012.</p> <p><b>Other Information:</b> This programme applies only to students entering third level in September 2002.</p>

## Physics & Astronomy - Honours

<b>Degree Programmes</b>	<b>Programme Requirements at:</b>
<p>(B.Eng. Honours):  <b>Microelectronics and Photonics</b></p>	<p><b>Single Honours Microelectronics and Photonics (B.Eng.) Degree:</b>  <b>Level 1:</b> 60 credits comprising: PH1011, PH1012 and MT1002.</p> <p><b>Level 2:</b> Modules taught by University of Dundee: 120 credits comprising: EG2101, EG2102, EG2107, EG2201, EG2202, EG2204.</p> <p><b>Level 3:</b> 120 credits comprising: PH3005, PH3010, PH3064, PH3065, PH3066, PH3101, PH3102 and modules taught by the University of Dundee: PE1, PE2.</p> <p><b>Level 4:</b> 120 credits comprising: PH4025, PH4027 and modules taught by the University of Dundee: PE423, PE426, PE472.</p>
<p>(M.Eng. Honours):  <b>Microelectronics and Photonics</b></p>	<p><b>Single Honours Microelectronics and Photonics (M.Eng.) Degree:</b>  <b>Level 1:</b> 60 credits comprising: PH1011, PH1012 and MT1002.</p> <p><b>Level 2:</b> Modules taught by University of Dundee: 120 credits comprising: EG2101, EG2102, EG2107, EG2201, EG2202, EG2204.</p> <p><b>Level 3:</b> 120 credits comprising: PH3005, PH3010, PH3064, PH3065, PH3066, PH3101, PH3102 and modules taught by the University of Dundee: PE1, PE2.</p> <p><b>Level 4:</b> 120 credits comprising: PH4025, PH4027 and modules taught by the University of Dundee: PE423, PE426, PE472.</p> <p><b>Level 5:</b> 120 credits comprising: PH5005, PH5008 and modules taught by the University of Dundee: PE523, CE5201 and PE555.</p>
<p>(M.Sci. Honours):  <b>Physics and Chemistry (M.Sci. Honours) 5 year Degree</b></p>	<p><b>Physics element of Physics-Chemistry M.Sci. Degree:</b>  <b>Level 1:</b> 60 credits comprising: PH1011, PH1012, MT1002</p> <p><b>Level 2:</b> At least 90 credits comprising: 15 or better in PH2011 and PH2012, and 11 or better in MT2101 or (MT2001 and MT2003)</p> <p><b>Level 3:</b> At least 95 credits comprising: PH3002, PH3061, PH3062, PH3064, PH3065, PH3066, PH3067, and at least one of PH3101, PH3102</p> <p><b>Level 4:</b> 30 credits comprising: PH4021, PH4023</p> <p><b>Level 5:</b> At least 30 credits comprising: either PH5101 or CH5441, and at least 2 PH5000 level modules excluding PH5101</p>

## **Modules**

**Normally the prerequisite for each of the following 3000 or 4000 level Honours modules is entry to the Honours Programme(s) for which they are specified, as well as any additional specific prerequisite(s) given.**

**General degree and non-graduating students wishing to enter 3000 or 4000 level modules must consult with the relevant Honours Adviser within the School before making their selection.**

**The Prerequisite for each of the following 5000 level modules is entry to the M.Sci. or M.Phys. Programme(s) for which they are specified, save where an additional prerequisite is given.**

## **Astronomy (AS) Modules**

### **AS3011 Galaxies**

Credits: 10.0 Semester: 2

Prerequisite: AS2001

Description: This module introduces the basic elements of extragalactic astronomy. This includes the morphological, structural and spectral properties of galaxies, the fundamental plane for elliptical galaxies and the Tully-Fischer relation for spirals. We discuss rotation curves and the need for dark matter. These relationships are used to derive the local value of the Hubble constant along with complementary methods such as the globular cluster luminosity function and surface brightness fluctuations. We assess the space density of galaxies and derive the mean matter density of our local universe. The module also contains material covering our local group and the nearby Virgo and Coma clusters.

Class Hour: To be arranged.

Teaching: 2 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

### **AS3012 Exoplanetary Science**

Credits: 10.0 Semester: 2

Description: This module introduces the rapidly-developing field of the study of planetary systems beyond our own. It builds on ideas of star formation and stellar structure introduced in AS2001, extending them to the formation of planets in circumstellar accretion discs, and the internal structures of gas-giant planets. New ideas of inward planetary migration due to tidal drag, and dynamical interactions between planets, are introduced. Observational techniques for detecting and studying exoplanets are discussed. The theory of radiative transfer in planetary atmospheres is introduced, in the context of the absorption and scattering mechanisms that may be operating. Cloud formation physics and methods for predicting and identifying the most likely condensates in planetary atmospheres at different temperatures are also covered.

Class Hour: To be arranged.

Teaching: 2 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

### **AS3013 Computational Astrophysics**

Credits: 10.0 Semester: 2

Prerequisite: AS2001

Description: The aim of this module is to introduce students to the concepts involved in computational astrophysics. From a general introduction to a current programming language (Fortran90), students are shown how to explore the basics of problem solving using numerical techniques and their application to astrophysical phenomena. The second part of the module involves the development of a numerical integrator to solve orbits in various gravitational potentials. Students then gain experience with the basics of numerical accuracy, and explore the dynamics of orbits in generalised gravitational potentials from planetary to Galactic systems.

Class Hour: To be arranged.

Teaching: 2 lectures/workshops and some computer sessions.

Assessment: Continuous Assessment = 100%

## Physics & Astronomy - Honours

### AS3014 Observational Astrophysics

Credits: 15.0 Semester: 1

Availability: 2003-04

Prerequisite: AS2001

Description: This is an observational and laboratory-based module that introduces students to the hands-on practical aspects of planning observing programmes, conducting the observations and reducing and analysing the data. Observations are secured at the University Observatory using various telescopes for CCD photometry of star clusters and galaxies, and for CCD spectroscopy of stars. Further sources of data may be made available from international observatories. Students gain experience in observation, data analysis, the UNIX operating system, standard astronomical software packages and modelling, and report writing.

Class Hour: To be arranged.

Teaching: Two 3 hour laboratories.

Assessment: Continuous Assessment = 100%

### AS3015 Nebulae

Credits: 15.0 Semester: 1

Availability: 2003-04

Prerequisite: AS2001

Description: This module introduces the physics of astrophysical plasmas, as found in stars and interstellar space, where interactions between matter and radiation play a dominant role. A variety of absorption, emission, and scattering processes are introduced to describe exchanges of energy and momentum, which link up in various contexts to control the state and motion of the matter, to regulate the flow of light through the matter, and to impress fingerprints on the emergent spectrum. The theory is developed in sufficient detail to illustrate how astronomers interpret observed spectra to infer physical properties of astrophysical plasmas. Applications are considered to photo-ionize nebulae, interstellar shocks, nova and supernova shells, accretion discs, quasar-absorption-line clouds, radio synchrotron jets, radio pulsars, and x-ray plasmas.

Class Hour: To be arranged.

Teaching: 3 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

### AS3101 Astrophysics Laboratory 1

Credits: 15.0 Semester: 1

Availability: 2002-03 only.

Prerequisite: AS2001

Description: The aim of the module is to familiarise students with a wide range of problems and techniques in astronomy and astrophysics, while allowing them to pursue individual interests. Students gain experience in the application of many transferable skills including: observation, measurement; data analysis; computer programming and modelling; and report writing. Students are required to tackle four units of practical work, each lasting about twelve hours, covering principles of astronomical observation, astrometry, photometry, stellar spectroscopy and theoretical astrophysics.

Class Hour: 2.00 - 5.00 pm Monday and 2.00 - 5.00 pm Thursday.

Teaching: Two laboratories.

Assessment: Continuous Assessment = 100%

**AS4013 Stellar Physics**

Credits: 15.0 Semester: 1

Availability: 2002-03 only.

Anti-requisite: AS3003

Description: This module develops the physics of stellar interiors and atmospheres from the basic equations of stellar structure introduced in AS2001. Topics include: the equation of state that provides pressure support at the high temperatures and densities found in normal and white-dwarf stars; the interaction of radiation with matter, both in terms of radiation-pressure support in super-massive stars and in terms of the role of opacity in controlling the flow of energy from the stellar interior to the surface; the equation of radiative transfer and the effects of local temperatures, pressures and velocity fields on the continuum and line absorption profiles in the emergent optical spectrum. Computer-aided tutorial exercises illustrate the computational schemes that represent one of the triumphs of late 20th-century physics, in their ability to predict the observable properties of a star from its radius and luminosity, which in turn are determined by its mass, age and chemical composition.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

**AS4014 Stellar Dynamics**

Credits: 15.0 Semester: 2

Availability: 2002-03 only.

Prerequisite: AS2001

Anti-requisite: AS3004

Description: The syllabus for this module includes: brief review of two-body motion; application to binary systems of stars observed with various techniques (velocities, pulsar-timing); extension to n-body systems of point-masses and use of virial theorem; gravitational potentials resulting from non-spherical masses, with application to tidal phenomena on the Earth and on stars, and resulting from distribution of point-masses over large distances, with application to the observed structure of galaxies; numerical methods for calculating orbits. The statistical treatment of large numbers of self-gravitating masses; the collisionless Boltzmann equation and its application to determining the masses of galaxies and clusters of galaxies; the 'dark matter' problem.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

**AS4021 Gravitational Dynamics**

Credits: 10.0 Semester: 2

Availability: 2003-04

Prerequisite: AS2001

Description: This module aims to explore the basics of gravitational dynamics and its application to systems ranging from planetary and stellar systems to clusters of galaxies. Starting from two-body motion and orbits under a central-force law, the course describes the calculation of extended potentials and their associated orbits. The use of the virial theorem and the statistical treatment of large numbers of self-gravitating bodies is then developed with application to stellar systems. Applications of these methods are made to several different astrophysical objects ranging from collisions in globular clusters to the presence of dark matter in the universe.

Class Hour: To be arranged.

Teaching: 2 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

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### AS4022 Observational Cosmology

Credits: 10.0 Semester: 2

Availability: 2003-04

Prerequisite: AS2001

Description: The module starts with Olber's paradox, (why is the sky dark at night?) and its resolution (that the universe had a beginning) and then reviews the evidence that the universe is currently expanding at  $68 \pm 10$  km/s/Mpc. We then develop a mathematical framework capable of dealing with expanding curved space-time and derive the basic equations which govern the expansion and curvature of the universe as a function of time. We test the predictions, strengths and weaknesses of this standard model including the cosmic microwave background, big bang nucleosynthesis and the need for the theory of inflation. We find that the fate of the universe is entirely dependent on the current density of matter, radiation and vacuum energy, and review the latest observations which measure these key parameters. Finally the ultimate fate of the Universe is revealed.

Class Hour: To be arranged.

Teaching: 2 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

### AS4023 Stars

Credits: 15.0 Semester: 2

Availability: 2003-04

Prerequisite: AS2001

Description: This module develops the physics of stellar interiors and atmospheres from the basic equations of stellar structure introduced in AS2001. Topics include: the equation of state that provides pressure support at the high temperatures and densities found in normal and white-dwarf stars; the interaction of radiation with matter, both in terms of radiation-pressure support in super-massive stars and in terms of the role of opacity in controlling the flow of energy from the stellar interior to the surface; the equation of radiative transfer and the effects of local temperatures, pressures and velocity fields on the continuum and line absorption profiles in the emergent spectrum. Computer-aided tutorial exercises illustrate the computational schemes that represent one of the triumphs of late 20<sup>th</sup>-century physics, in their ability to predict the observable properties of a star from its radius and luminosity, which in turn are determined by its mass, age and chemical composition.

Class Hour: To be arranged.

Teaching: 3 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

### AS4024 Binary Stars and Accretion Discs

Credits: 10.0 Semester: 1

Prerequisite: AS2001

Description: Since binary stars are as common or more common than single stars in the universe, it is appropriate that there should be a whole module devoted to their study. This module discusses: two-body orbital motion, methods for determining orbits from velocities, pulse-timing, and spatially-resolved systems, analyses of light curves, and the resultant masses, radii, and luminosities of stars of all types found in binaries – from pre-main-sequence stars to neutron stars and black holes. The module also presents accounts of theoretical models and observations on the processes of mass exchange and mass loss in binaries including accretion discs, streams, and outflows.

Class Hour: To be arranged.

Teaching: 2 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

**AS4103 Project in Astrophysics 1**

Credits: 30.0 Semester: Whole Year

Anti-requisite: AS3103

Description: The project aims to develop students' skills in searching the appropriate literature, in experimental and observational design, the evaluation and interpretation of data, and the presentation of a report. The main project is preceded by a review essay. There is no specific syllabus for this module. Students taking the BSc degree select a project from a list of those which are available, and are supervised by a member of the academic staff.

Assessment: Project and Oral Examination = 100%

**AS5001 Astronomical Data Analysis**

Credits: 15.0 Semester: 1

Availability: 2003-04

Prerequisite: AS2001

Anti-requisite: AS4001

Description: This module develops an understanding of basic concepts and offers practical experience with the techniques of quantitative data analysis. Beginning with fundamental concepts of probability theory and random variables, practical techniques are developed for using quantitative observational data to answer questions and test hypotheses about models of the physical world. The methods are illustrated by applications to the analysis of time series, imaging, spectroscopy, and tomography datasets. Students develop their computer programming skills, acquire a data analysis toolkit, and gain practical experience by analyzing real datasets.

Class hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: Continuous Assessment = 100%

**AS5002 Star Formation and Plasma Astrophysics**

Credits: 15.0 Semester: 2

Prerequisite: AS2001

Anti-requisite: AS4002

Description: The aim is to describe the physics of how a magnetic field interacts with a plasma, and to use this knowledge to explore the role of magnetic fields in the formation of solar-like stars and in compact objects with accretion discs. The syllabus comprises: Solar-like magnetic activity on other stars. The basic equations of magneto-hydrodynamics. Stellar coronae: X-ray properties and energetics of coronal loops. Energetics of magnetic field configurations. MHD waves and propagation of information. Solar and stellar dynamos: mean field models. Star formation: properties of magnetic cloud cores, magnetic support. Physics of accretion discs: transport of mass and angular momentum. Accretion on to compact objects and protostars. Rotation and magnetic fields in protostellar discs. Rotation distributions of young solar-type stars. Magnetic braking via a hot, magnetically channelled stellar wind.

Class hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

**AS5003 Contemporary Astrophysics**

Credits: 15.0 Semester: 1

Anti-requisite: AS4004

Description: This module will provide an annual survey of the latest, most interesting, developments in astronomy and astrophysics at the research level. Emphasis will be placed upon the application of knowledge and expertise gained by students in their other modules to these current research topics.

Class Hour: To be arranged.

Teaching: 3 lectures and some tutorials

Assessment: 2 Hour Examination = 100%

## Physics & Astronomy - Honours

### AS5101 Project in Astrophysics 2

Credits: 45.0 Semester: Whole Year

Anti-requisite: AS4101

Description: The project aims to develop students' skills in searching the appropriate literature, in experimental and observational design, the evaluation and interpretation of data, and the presentation of a report. The main project is preceded by a review essay. There is no specific syllabus for this module. Students taking the M. Phys. or M.Sci. degree select a project from a list of those which are available, and are supervised by a member of the academic staff.

Assessment: Project and Oral Examinations = 100%

## Physics (PH) Modules

### PH3002 Solid State Physics 1

Credits: 15.0 Semester: 2

Description: This introductory course is intended to show how the various optical, thermal and electrical properties of solids are related to the nature and arrangement of the constituent atoms in a solid. For simplicity, emphasis is given to crystalline solids. The module examines: symmetry properties of crystals; common crystalline structures; the behaviour of waves in crystals; waves of atomic motion, leading to thermal properties; electronic energy states: conductors, insulators, semiconductors; electrical properties arising from the wave nature of electrons; examples of the fundamental theory to typical solids such as simple metals, silicon and other semiconductors, and magnetic materials.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

### PH3004 Digital & Analogue Circuits

Credits: 15.0 Semester: 1

Description: This course will introduce and develop the basic principles of the synthesis and analysis of digital and analogue circuits. It will advance students' knowledge of transistor circuits and introduce them to the structure and uses of microprocessors. It will cover: passive circuit elements, solution of circuits by differential equations and Laplace transforms; types of impulses, system functions and frequency responses; circuit synthesis; design of digital circuits - combinational, synchronous, asynchronous and pulse mode; internal structure of microprocessors, and memories and structure of microprocessor systems; unipolar and bipolar transistors, amplifiers and switches, types of amplifiers.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

### PH3005 Laser Physics 1

Credits: 15.0 Semester: 1

Description: This module presents a basic description of the main physical concepts upon which an understanding of laser materials, operations and applications can be based. The syllabus includes: basic concepts of energy-level manifolds in gain media, particularly in respect of population inversion and saturation effects; conditions for oscillator stability in laser resonator configurations and transverse and longitudinal cavity mode descriptions; single longitudinal mode operation for spectral purity and phase locking of longitudinal modes for the generation of periodic sequences of intense ultrashort pulses (i.e. laser modelocking); illustrations of line-narrowed and modelocked lasers and the origin and exploitability of intensity-induced nonlinear optical effects.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

**PH3010 Modern Optics**

Credits: 15.0 Semester: 2

Description: This course formulates the main aspects of physics used in modern optics, lasers and optoelectronic systems. Topics covered include: polarised light and its manipulation, with descriptions in terms of Jones' vectors and matrices; Fresnel's equations for transmittance and reflectance at plane dielectric interfaces; reflection and transmission of multi-layer thin films plus their use in interference filters; interpretation of diffraction patterns in terms of Fourier theory; spatial filters; the theory and use of Fabry-Perot etalons; laser cavities and Gaussian beams.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

**PH3011 Information and Measurement**

Credits: 15.0 Semester: 2

Availability: 2002-03

Description: The course explains what information is, how we process it, and how it is collected by making measurements. The first eight lectures concentrate on the basics of measurement, information theory, and processing systems. The rest of the course uses various examples to show how these basics are put into use. The CD system is used to illustrate information collection, processing, and communication in digital form. Data compression/reduction is illustrated with examples which include digital compact cassette. Other illustrations include the methods used by spies to encrypt messages and the applications of chaotic systems and signals.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

**PH3014 Transferable Skills for Physicists**

Credits: 15.0 Semester: Whole Year

Description: The aim of the module is to develop the key skills of oral and written communication, information technology, team working and problem solving. This will be done in the context of physics and astronomy. Guidance, practice and assessment will be provided in the preparation and delivery of talks, critical reading of the literature, report and essay writing, developing and writing a case for resources to be expended to investigate a particular area of science, tackling case studies.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials or workshops.

Assessment: Continuous Assessment on basis of exercises = 100%

**PH3061 Quantum Mechanics 1**

Credits: 10.0 Semester: 1

Description: This module introduces the main features of quantum mechanics. The syllabus includes: early ideas on quantisation, the emergence of the Schrödinger equation, the interpretation of the wave function and Heisenberg's uncertainty relation. The concepts of eigenfunctions and eigenvalues. Simple one-dimensional problems including potential wells and barriers; the linear harmonic oscillator. Solution of the Schrödinger equation for central forces, the radial Schrödinger equation, and the hydrogen atom. Students are introduced to computer simulations of one-dimensional problems and are required to carry out computer-based exercises.

Class Hour: To be arranged.

Teaching: 2 lectures, 2 PC classroom sessions and some tutorials.

Assessment: Continuous Assessment = 25%, 2 Hour Examination = 75%

## Physics & Astronomy - Honours

### PH3062 Quantum Mechanics 2

Credits: 10.0 Semester 2

Prerequisite: PH3061

Description: This module explores more of the main features of quantum mechanics, taking for granted a knowledge of the material in PH3061. The syllabus includes a treatment of perturbation theory, and time dependence of the wave function including transitions between stationary states. Students are introduced to the quantum mechanics of a system of particles, which leads on to the distinction between fermions and bosons and applications to atoms, metals and neutron stars.

Class Hour: To be arranged.

Teaching: 2 lectures and some tutorials.

Assessment: Continuous Assessment = 25%, 2 Hour Examination = 75%

### PH3064 Electromagnetism 1

Credits: 10.0 Semester: 1

Description: This module covers the main branches of electrostatics and magnetostatics, starting from the laws due to Coulomb and Biot-Savart. The electric scalar potential is introduced and its use in calculating fields is illustrated. The effects of dielectric and magnetic media are discussed, as is the origin of the displacement current. Maxwell's equations are derived in terms of the four fields E, D, B and H and the wave equation is deduced.

Class Hour: To be arranged.

Teaching: 2 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

### PH3065 Electromagnetism 2

Credits: 10.0 Semester: 2

Prerequisite: PH3064

Description: This module extends the treatment of electromagnetism in PH3064. The magnetic vector potential is introduced and its use in magnetic field calculations illustrated. Poisson's equation and Laplace's equation are derived, and used to obtain solutions for the electrostatic potential. Starting from Maxwell's equations, electromagnetic waves are discussed in some depth, including their propagation in various media, their behaviour at boundaries, their interaction with matter, and their generation.

Class Hour: To be arranged.

Teaching: 2 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

### PH3066 Mathematics for Physicists

Credits: 10.0 Semester: 1

Description: The module aims to develop mathematical techniques that are required by a professional physicist or astronomer. There is particular emphasis on the special functions which arise as solutions of differential equations which occur frequently in physics. Analytic mathematical skills are complemented by the development of computer-based solutions using Mathcad. The emphasis throughout is on obtaining solutions to problems in physics and its applications. Specific topics to be covered will be Fourier transforms, the gamma function, the Dirac delta function, partial differential equations and their solution by separation of variables technique, series solution of second order ODEs, Hermite polynomials, Legendre polynomials and spherical harmonics.

Class Hour: To be arranged.

Teaching: 2 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

**PH3067 Thermal Physics**

Credits: 15.0 Semester: 1

Description: This module gives a detailed account of thermodynamics and kinetic theory, and an introduction to statistical mechanics. The laws of thermodynamics are discussed including the concepts of work, internal energy, reversible and irreversible processes, entropy, Carnot engines and refrigerators, and a treatment of the thermodynamic potentials. In kinetic theory, the Maxwell velocity distribution is derived, followed by a discussion of mean free path and transport properties – diffusion, thermal conductivity and viscosity. In the final section students are introduced to the concepts of statistical mechanics including the microscopic basis for entropy, the partition function and its uses, and a brief introduction to Fermi and Bose distributions.

Class Hour: To be arranged.

Teaching: 3 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

**PH3073 Classical Mechanics**

Credits: 10.0 Semester: 2

Anti-requisite: MT4507. (MT3807)

Description: The module covers the foundations of classical mechanics as well as a number of applications in various areas. Starting from the principle of least action, the Lagrangian and Hamiltonian formulations of mechanics are introduced. The course explains the connection between symmetries and conservation laws and shows bridges between classical and quantum mechanics. Applications include planetary motion, particle scattering, oscillators, and chaos.

Class Hour: To be arranged.

Teaching: Two lectures and some tutorials.

Assessment: Continuous Assessment = 30%, 2 Hour Examination = 70%

**PH3101 Physics Laboratory 1**

Credits: 15.0 Semester: 2

Description: The aims of the module are (i) to familiarise students with a wide variety of experimental techniques and equipment, and (ii) to instil an appreciation of the significance of experiments and their results. The module consists of four sub-modules on solid state physics, lasers, interfacing, and signal processing.

Class Hour: 2.00 - 5.00 pm Monday and 2.00 - 5.00 pm Thursday

Teaching: Two 3 hour laboratories.

Assessment: Continuous Assessment = 100%

**PH3102 Physics Laboratory 2**

Credits: 15.0 Semester: 1

Description: The aims of the module are (i) to familiarise students with a wide variety of experimental techniques and equipment, and (ii) to instil an appreciation of the significance of experiments and their results. Students select four sub-modules from a list comprising solid state physics, optics and spectroscopy, circuits and circuit simulations, microprocessors, lasers and vacuum techniques.

Class Hour: 2.00 - 5.00 pm Monday and 2.00 - 5.00 pm Thursday

Teaching: Two 3 hour laboratories.

Assessment: Continuous Assessment = 100%

## Physics & Astronomy - Honours

### PH4021 Atomic Physics

Credits: 15.0 Semester: 2

Prerequisite: PH3061, and prior or concurrent PH3062. (PH3001)

Anti-requisite: PH3008

Description: This module provides a rational basis to the identification of atomic energy states and the various interactions of electrons within atoms. It provides an understanding of aspects of laser physics, solid state and stellar physics. The syllabus includes: electron cloud model of an atom; electron spin; magnetic moments of electron behaviour; spin-orbit interactions and possible states of electron energy; one and two-electron systems; line intensities; Lande g-factors; weak Zeeman and strong Paschen-Back magnetic field effects; Stark electric field effects; hyperfine structure and Lamb shifts; magnetic resonance and ESR in atomic beam experiments; molecular structure: electronic, vibrational and rotational effects.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

### PH4022 Nuclear and Particle Physics

Credits: 15.0 Semester: 2

Anti-requisite: PH3026

Description: The aim of this module is to describe in terms of appropriate models, the structure and properties of the atomic nucleus, the classification of fundamental particles and the means by which they interact. The syllabus includes: nuclear sizes, binding energy, spin dependence of the strong nuclear force; radioactivity, the semi-empirical mass formula; nuclear stability, the shell model, magic numbers; spin-orbit coupling; energetics of  $\beta$ -decay,  $\alpha$ -decay and spontaneous fission; nuclear reactions, resonances; fission; electroweak and colour interactions, classification of particles as intermediate bosons, leptons or hadrons. Standard model of leptons and quarks, and ideas that go beyond the standard model.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

### PH4023 Magnetism and Superconductivity

Credits: 15.0 Semester: 1

Prerequisites: PH3002, PH3061, PH3062, PH3064 and PH3065. (PH3001, PH3007)

Anti-requisite: PH3027

Description: The module presents a range of magnetic phenomena in solids, develops the theoretical models for them and explains how the chemical features and structure of real materials influence the magnetic properties. The syllabus includes: review of magnetic field vectors, magnetisation, shape effects; superconductivity, phase diagrams, thermodynamic and London models; coherence length, surface energies, type I and II materials; quantised flux and fluxoid lattice; Bean model, BCS theory, macroscopic quantum effects, Josephson tunnelling; modern superconducting materials, Langevin diamagnetism, local moment paramagnetism; mean field models, exchange, direct and indirect, and RKKY interactions; magnetic order; delocalised model, Landau diamagnetism, Pauli paramagnetism, Stoner model, spin waves; materials - rare earth, transition elements, alloys and compounds; domains; examples of current problems in magnetism.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

**PH4024 Computational Physics**

Credits: 15.0 Semester: 2

Availability: 2002-03 only.

Anti-requisite: PH3039

Description: The aim of this module is to introduce students to the use of the computer as an analytical tool in physics and astronomy. The module comprises: (i) an introduction to programming in a high-level language including editing, structured programming and the essentials of the language required to program for scientific application; (ii) the application of Mathcad to problems involving matrices and tensors, differential equations, Fourier transforms and Monte Carlo methods; (iii) the application of computational methods to scientific problem solving.

Class Hour: To be arranged.

Teaching: Two lectures each week and two 1 hour laboratories.

Assessment: Continuous Assessment on basis of projects = 100%

**PH4025 Physics of Electronic Devices**

Credits: 15.0 Semester: 2

Anti-requisite: PH3040

Description: The course describes the physical phenomena involved in the operation of semiconductor devices, and then shows how the phenomena determine the properties of specific devices such as the transistor. Although only a few devices are described, the student taking the course should acquire a sufficient background to understand a wide variety of modern semiconductor devices. The course covers: semiconductor properties: band gaps, optical and electrical properties; conduction in an electric field and by diffusion; factors determining the concentrations of electrons and holes; the continuity equation; properties of pn junctions and Schottky diodes; typical devices: bipolar transistor, field-effect transistor, MOSFET, light emitting diodes, semiconductor lasers.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

**PH4026 Radio and Coherent Techniques**

Credits: 15.0 Semester: 2

Availability: 2003-04

Anti-requisite: PH3041

Description: The aim of this course is to explain the techniques used by radio, microwave and mm-wave engineers to communicate, and collect, information. It concentrates mainly upon radio techniques to explain how coherent electromagnetic signals can be employed to carry information. Practical examples are given to illustrate the way the basic concepts can be applied. These include an explanation of how FM stereo radio and colour TV work as examples of signal multiplexing. The course looks at microwave and millimetre-wave techniques and shows how electronics and optics can be mixed at higher signal frequencies. Using the examples of spy and other types of satellites, it also explains how radar and passive sensing systems can be used to gather information.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

## Physics & Astronomy - Honours

### PH4027 Optoelectronics and Nonlinear Optics 1

Credits: 15.0 Semester: 1

Prerequisite: PH3064, PH3065. (PH3007)

Anti-requisite: PH3050

Description: The course provides an introduction to the basic physics underpinning optoelectronics and nonlinear optics, and a perspective on contemporary developments in the two fields. The syllabus includes: an overview of optoelectronic devices and systems; optical modulators; acousto-optics; Bragg and Raman-Nath; propagation of light in anisotropic media; electro-optics; waveguide and fibre optics; modes of planar guides; optical detectors-pn, pin, avalanche; nonlinear optics; active and passive processes in second and third order; second harmonic generation; phase matching; coupled wave equations; parametric oscillators; self-focusing and self-phase-modulation; optical bistability; phase conjugation; solitons; Rayleigh; Raman and Brillouin scattering.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

### PH4028 Quantum Mechanics 3

Credits: 10.0 Semester: 2

Availability: 2003-04

Prerequisites: PH3061, PH3062

Description: This module presents the main theoretical basis of quantum mechanics, starting with the representation of dynamical variables by operators. The Fourier transform of the wave function is shown to provide information on the momentum distribution. The importance of commutators is demonstrated, and the general uncertainty relation is derived. Other topics which are treated are the variational principle, matrix mechanics, operator methods for finding eigenvalues and eigenfunctions, spin angular momentum, and the total angular momentum for one electron atoms.

Class Hour: To be arranged.

Teaching: 2 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

### PH4029 Statistical Mechanics

Credits: 10.0 Semester: 2

Availability: 2003-04

Prerequisite: PH3067

Description: Statistical mechanics provides techniques for determining macroscopic properties of systems of interacting quantum particles. The module covers: Ensembles and basic postulates. Derivation of thermodynamical properties from canonical ensemble; application to crystals and to ideal gases at high temperatures. The microcanonical ensemble. Interchangeability of ensembles. System of two state particles and negative temperatures. The grand canonical ensemble. Applications to ideal gases of fermions and bosons at arbitrary temperatures, to white dwarf and neutron stars, to electrons in metals, to liquid helium, to black body radiation and to crystals.

Class Hour: To be arranged.

Teaching: 2 lectures and some tutorials.

Assessment: 2 hour Examination = 100%

**PH4030 Computational Physics**

Credits: 10.0 Semester: 2

Availability: 2003-04

Description: The module starts with five sessions in programming with Pascal (building on level 2 work) followed by eight sessions on numerical analysis using Pascal. This material is likely to include: numerical solution of nonlinear equations including graphical methods and Newton-Raphson method. Interpolation including Lagrange interpolation polynomial and Neville iterative interpolation. Curve fitting. Numerical integration including trapezoidal rule, Simpson's rule and Gauss' integration formula. Numerical solution of ODEs including Runge Kutta methods, with relevant exercises. There will be an emphasis on physical examples throughout. The module finishes with a small computational project. Assessment is done continuously via short tests, assignments and the project.

Class Hour: To be arranged.

Teaching: 2 one-and-a-half hour sessions.

Assessment: Continuous Assessment = 100%

**PH4031 Fluids**

Credits: 15.0 Semester: 1

Availability: 2003-04

Description: This module provides an introduction to fluid dynamics, and addresses the underlying physics behind many everyday flows that we see around us. It starts from a derivation of the equations of hydrodynamics and introduces the concept of vorticity and the essentials of vorticity dynamics. The influence of viscosity and the formation of boundary layers is described with some straightforward examples. The effect of the compressibility of a fluid is introduced and applied to shock formation and to the conservation relations that describe flows through shocks. A simple treatment of waves and instabilities then allows a comparison between theory and readily-observed structures in clouds, rivers and shorelines.

Class Hour: To be arranged.

Teaching: 3 lectures and some tutorials.

Assessment: 2 Hour Examination = 100%

**PH4032 Relativity and Fields**

Credits: 15.0 Semester: 1

Availability: 2003-04

Prerequisites: PH3073 or MT4507 (MT3807)

Description: The course analyses classical fields in physics such as the electromagnetic field. Fields are natural ingredients of relativity, because they serve to communicate forces with a finite velocity (the speed of light). The module covers the tensor formalism of special relativity, relativistic dynamics, the Lorentz force, Maxwell's equations, retarded potentials, symmetries and conservation laws, and concludes with an outlook to general relativity.

Class Hour: To be arranged.

Teaching: Three lectures and some tutorials.

Assessment: Continuous Assessment = 30%, 2 Hour Examination = 70%

**PH4111 Project in Physics 1**

Credits: 30.0 Semester: Whole Year

Prerequisites: At least one of PH3101, PH3102

Anti-requisite: PH3103

Description: The project aims to develop students' skills in searching the physics literature and in experimental design, the evaluation and interpretation of data, and in the presentation of results. The main project is preceded by a review essay on a topic which may be related to the theme of the project or may be unrelated to it. There is no specific syllabus for this module. Students taking the BSc degree select a project from a list offered, and are supervised by a member of staff.

Assessment: Project and Oral Examination = 100%

## Physics & Astronomy - Honours

### PH4112 Physics Project

Credits: 120 Semester: Whole Year  
Availability: Available to non-graduating students only  
Anti-requisite: PH3107

Description: This module is for non-graduating students who wish to pursue a project in physics lasting the whole session. The project is designed to develop students' skills in searching the literature, in the design of the investigation of the topic, in the evaluation and interpretation of data and in the presentation of results. There is no specific syllabus for this module, and students select their project topic in consultation with their supervisor.

Class Hours: No specific hours.  
Teaching: Weekly meetings with supervisor.  
Assessment: Continuous Assessment = 100%

### PH5001 Metals and Semiconductors

Credits: 15.0 Semester: 1  
Prerequisites: PH3002, PH3061 and PH3062.  
Anti-requisite: PH4001

Description: The aim of this module is to develop an understanding of band-structure in crystalline solids, Fermi surfaces in reciprocal space and the Boltzmann transport equation. It examines: reciprocal space concepts reviewed and extended; tight-binding theory for simple cubic structure; Kronig-Penney model; fermi surfaces in real structures; measurement techniques; Landau levels, Shubnikov-de Haas and de Haas-van Alphen experiments; Boltzmann transport of charge and thermal energy.

Class Hour: To be arranged.  
Teaching: Three lectures or tutorials.  
Assessment: 2 Hour Examination = 100%

### PH5002 Foundations of Quantum Mechanics

Credits: 15.0 Semester: 1  
Prerequisite: PH3061 and PH3062.  
Anti-requisite: PH4002

Description: This module consists of five parts: (i) Hilbert spaces and operators including a discussion of spectral decomposition of selfadjoint operators; (ii) postulates of quantum mechanics for observables with discrete spectra with illustrative examples including various pictures (Schrodinger, Heisenberg, interaction) of time evolution; (iii) postulates of quantum mechanics for observables with continuous spectra in terms of probability distribution functions and the spectral functions; (iv) quantum theory of orbital, spin angular momenta and their addition, Pauli-Schrodinger equation; (v) introduction to relativistic quantum mechanics.

Class Hour: To be arranged.  
Teaching: Three lectures or tutorials.  
Assessment: 2 Hour Examination = 100%

### PH5003 Group Theory

Credits: 15.0 Semester: 1  
Prerequisites: PH3061 and PH3062  
Anti-requisite: PH4003

Description: This module explores the concept of a group, including groups of coordinate transformations in three-dimensional Euclidean space; the invariance group of the Hamiltonian operator; the structure of groups: subgroups, classes, cosets, factor groups, isomorphisms and homomorphisms, direct product groups; introduction to Lie groups, including notions of connectness, compactness, and invariant integration; representation theory of groups, including similarity transformations, unitary representations, irreducible representations, characters, direct product representations, and the Wigner-Eckart theorem; applications to quantum mechanics, including calculation of energy eigenvalues and selection rules.

Class Hour: To be arranged.  
Teaching: Three lectures or tutorials.  
Assessment: 2 Hour Examination = 100%

**PH5004 Quantum Field Theory**

Credits: 15.0 Semester: 1

Prerequisite: PH3073 or MT4507, and PH5002.

Anti-requisite: PH4004

Description: The syllabus for this module includes: second quantization for bosons and fermions; annihilation and creation operators; introduction to classical field theory, including the notion of Lagrangian and Hamiltonian densities; the real and complex Klein-Gordon fields for spin zero particles; the Dirac field for spin 1/2 particles; quantization of the electromagnetic field; perturbation expansion for the S matrix; Wick's theorem; origin and use of Feynman rules; outline of idea of renormalization; application to quantum electrodynamics.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

**PH5005 Laser Physics 2**

Credits: 15.0 Semester: 2

Prerequisites: PH3005, PH3061, PH3062, PH3064 and PH3065.

Anti-requisite: PH4005

Description: Quantitative treatment of laser physics embracing both classical and semiclassical approaches; transient/dynamic behaviour of laser oscillators including relaxation oscillations, amplitude and phase modulation, frequency switching, Q-switching, cavity dumping and mode locking; design analysis of optically-pumped solid state lasers; laser amplifiers including continuous-wave, pulsed and regenerative amplification; dispersion and gain in a laser oscillator - role of the macroscopic polarisation; unstable optical resonators, geometric and diffraction treatments; quantum mechanical description of the gain medium; coherent processes including Rabi oscillations; semiclassical treatment of the laser; tunable lasers.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

**PH5008 Optoelectronics and Nonlinear Optics 2**

Credits: 15.0 Semester: 2

Prerequisite: PH4027

Anti-requisite: PH4008

Description: This module develops concepts introduced in PH4027 to a level at which the student should be able to understand state-of-the-art systems in these fields and to appreciate the research literature. In particular, the ideas of nonlinear optics are developed more quantitatively and in greater depth, and the course shows how such properties can be the basis of important devices. The field of optical communication is covered, include the modes of propagation in waveguides and the use of nonlinear effects in optical waveguides. Optoelectronic devices such as SEED are described, including their roles in optical switching.

Class hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour examination = 100%

**PH5009 Advanced Mathematical Techniques in Physics**

Credits: 15.0 Semester: 1

Availability: 2002-03 only.

Anti-requisite: PH4009

Description: The module aims to develop the more sophisticated mathematical techniques that form an appropriate part of the education of a professional physicist or astronomer. Starting from examples selected from various areas of physics, the module will develop enhanced mathematical tools for the efficient solution of problems in these areas. Analytic mathematical skills will be complemented by the development of computer-based solutions. The emphasis throughout will be on obtaining solutions to problems in physics and its applications. Specific topics to be covered will include numerical analysis, probability theory and statistics, Fourier and Laplace transforms, operator techniques, selected functions and their properties, and nonlinear systems.

Class Hour: To be arranged.

Teaching: Three lectures or tutorials.

Assessment: 2 Hour Examination = 100%

## Physics & Astronomy - Honours

### PH5011 General Relativity

Credits: 15.0 Semester: 2  
Anti-requisite: PH4011

Description: This module covers: inertial frames, gravity, principle of equivalence, curvature of spacetime; basic techniques of tensor analysis; Riemannian spaces, metric tensor, raising and lowering of indices, Christoffel symbols, locally flat coordinates, covariant derivatives, geodesics, curvature tensor, Ricci tensor, Einstein tensor; fundamental postulates of general relativity: spacetime, geodesics, field equations, laws of physics in curved spacetime; distances, time intervals, speeds; reduction of equations of general relativity to Newtonian gravitational equations; Schwarzschild exterior solution, planetary motion, bending of light rays, time delays; observational tests of general relativity; Schwarzschild interior solution, gravitational collapse, black holes.

Class Hour: To be arranged.  
Teaching: Three lectures or tutorials.  
Assessment: 2 Hour Examination = 100%

### PH5012 Quantum Optics

Credits: 15.0 Semester: 2  
Prerequisite: PH3061, PH3062  
Anti-requisite: PH4012

Description: Quantum optics is the theory of light that unifies wave and particle optics. Quantum optics describes modern high-precision experiments that often probe the very fundamentals of quantum mechanics. The module introduces the quantisation of light, the concept of single light modes, the various quantum states of light and their description in phase space. The module considers the quantum effects of simple optical instruments and analyses two important fundamental experiments: quantum-state tomography and simultaneous measurements of position and momentum.

Class Hour: To be arranged.  
Teaching: Three lectures or tutorials.  
Assessment: 2 Hour Examination = 100%

### PH5101 Project in Physics 2

Credits: 45.0 Semester: Whole Year  
Prerequisite: PH3101  
Anti-requisite: PH4101

Description: The project aims to develop students' skills in searching the physics literature and in experimental design, the evaluation and interpretation of data, and in the presentation of results. The main project is preceded by a review essay on a topic which may be related to the theme of the project or may be unrelated to it. There is no specific syllabus for this module. Students taking the M.Phys. or M.Sci. degree select a project from a list offered, and are supervised by a member of staff.

Assessment: Project and Oral Examination = 100%

### PH5102 Project in Theoretical Physics

Credits: 30.0 Semester: Whole Year  
Anti-requisite: PH4102

Description: The project aims to survey the literature associated with the topic of the project and either (i) conduct original research into some problem in this field or (ii) prepare a research review of the field. In each case a written report is submitted in the range 5,000 to 10,000 words. There is no specific syllabus for this module. Students taking the M.Phys. or M.Sci. degree select a project from a list of those which are available, and are supervised by a member of the academic staff.

Assessment: Project and Oral Examination = 100%