University of St Andrews

FOUNDED 1413

School of Physics and Astronomy

Handbook for

1000- and 2000-level Modules

(sub-honours handbook)

2023 – 2024

SCHOOL OF PHYSICS AND ASTRONOMY
HANDBOOK FOR 1000- AND 2000-LEVEL MODULES
2023-2024

Head of School – Prof Ian Bonnell
School of Physics and Astronomy, J F Allen Building,
University of St Andrews
North Haugh, St Andrews, Fife, KY16 9SS
Tel: (01334) 463111
physics@st-andrews.ac.uk
www.st-andrews.ac.uk/physics-astronomy/

Our pre-honours students are expected to have read and understood what is in this document. If there are any discrepancies between this document and those published by the University, the latter takes precedence. Please ask staff if you have any queries. I am always happy to meet with our students to discuss any aspects of their study here.

Paul Cruickshank, Director of Teaching for the School of Physics and Astronomy
physdot@st-andrews.ac.uk, ext 3296, JF Allen Building (Physics & Astronomy) room 305.

2023_08_28, PASC

Introduction

This handbook provides information about the 1000- and 2000-level modules to be taught by the School of Physics and Astronomy in the session 2023-2024. Students are asked to read this booklet carefully, and are expected to be familiar with the contents. As well as providing useful information for you, this is the “rule book” for these modules. There should not be any disagreement between centrally published information and what is here.

This handbook of module- and School-specific policy should be read in conjunction with the University’s centrally published student handbook at https://www.st-andrews.ac.uk/education/handbook/
There will be links to specific sections of the University handbook.

1000-level (first year):	PH1011	Physics 1A
	PH1012	Physics 1B
	PH1501	Gateway – Maths for Physicists 1A
	PH1502	Gateway – Physics Skills 1A
	PH1503	Gateway – Physics Skills 1B
	AS1001	Astronomy & Astrophysics 1
	AS1101	Astrophysics 1 (condensed)
2000-level (second year):	PH2011	Physics 2A
	PH2012	Physics 2B
	AS2001	Astronomy & Astrophysics 2
	AS2101	Astrophysics 2 (condensed)

Module offerings in the School of Physics and Astronomy may change from year to year. The 2023-2024 module offerings described in this handbook are only indicative of what will be offered in future years. Nevertheless, the number and range of modules offered in 2023-2024 is broadly illustrative of the number and range of modules offered in any given year.

Each of these modules lasts for one semester and is assessed during and/or at the end of the semester in which it is taught. 1000-level modules are each worth 20 credits (except AS1101 at 5 credits), and the 2000- level modules listed are each worth 30 credits (except AS2101, 15 credits). Normally 120 credits are taken in each year of study, and this will usually include modules from other Schools.

The selection of modules depends on entry point, on the degree(s) in view, and on the student's own interests and qualifications. Those aiming for a degree involving this School will start with either Physics 1A and 1B or Physics 2A and

2B depending on their entry point. The Gateway modules (PH1501/2/3) are normally available only to students on the Physics and Astronomy Gateway programmes.

A separate Honours handbook provides details of the honours degree programmes and modules offered by the School, which normally occupy the third, fourth and fifth years of an honours degree.

This list of module offerings is for illustration purposes only and does not constitute a guarantee of the specific modules or module content to be offered in future years.

Advice and support

If you need advice, feel free to contact any member of academic or administrative staff in the School; they may be able to help you directly or should be able to tell you who to contact for particular advice. Please feel free to ask questions of your lecturers, tutors, lab demonstrators, or advisers of studies. In some cases earlier sections of this handbook suggest who might be the most appropriate person to speak with.

For general queries on academic and other issues, your Adviser of Studies, the School's Wellbeing Officers (panda_wellbeing@st-andrews.ac.uk), or the School's Director of Teaching (physdot@st-andrews.ac.uk) may be good people to start with. If you wish to speak with your Adviser of Studies and they're not available, the School's Director of Teaching is an appropriate alternative.

For advice and support on any issue, including academic, financial, international, personal or health matters, or if you are unsure of who to go to for help, you can contact Student Services through the Advice and Support Centre. They are located at 79 North Street, and the main contact number is 01334 462020, and email is theasc@st-andrews.ac.uk.
If you would like to book an appointment with a Student Services Adviser, please use the Student Services enquiry form.

If there is a problem, please talk with the School or Student Services sooner rather than later.
There is more on special circumstances later in this handbook under absence, special circumstances and extensions.
On the School web pages you can find advice under "Who can advise or help me?", and for University-provided advice and support, please see the University Student Handbook.

Aims of Our Teaching Programmes

- To provide a systematic functional knowledge and understanding of core physical concepts, principles and theories, and some of their applications.
- To provide specialist functional knowledge and understanding relevant to the degree programme, for example in astrophysics, theoretical physics, or physics.
- To provide access to physics and astronomy at the frontiers, capitalising on the strengths of the research undertaken in the School.
- To develop proficiency in the analysis of complex physical problems and the use of mathematical and other appropriate techniques to solve them.
- To develop the ability of students to organise their knowledge in a way that they can articulate the big ideas from the various modules, and can see the inter-relationship of material from different modules. Students should develop the ability to filter their knowledge in such a way that they can access the information that they need to apply to a particular problem or learning situation.
- To provide the ability to plan, execute under supervision, analyse and report upon the results of an experiment or investigation.
- To provide experience and expertise in experimental investigations for all students at the earlier stages of the programme. At least for students on the *Physics* degree programmes to develop these skills further in the honours years. At least for students on the *Astrophysics* degree programmes to develop competence in observational and computational techniques in astronomy. At least for *Physics* students to develop skills in the use of computers for control, data acquisition, and data analysis in experimental investigations.
- To develop the professional skills of teamwork, independent learning, information retrieval, critical analysis, and the communication of scientific concepts in writing and orally.
- To develop the ability to be a self-directed learner, including fostering a healthy intellectual curiosity in this and other disciplines, and the ability to determine one's own learning needs and to organise one's own learning.
- To enthuse students about the discipline and its applications, and to develop their confidence in their work using the discipline.
- To provide students in the School with an educational and social environment which encourages them to become informed, responsible, and respected members of society.
- To provide opportunities and support for all students to reach their full potential during their studies.

Entry points, requirements, and module choices

Suitably qualified students who are aiming for a degree in physics, theoretical physics, astrophysics, or a joint degree with mathematics, may consider whether they wish to take first or second year entry. The former allows a broader education, but the latter allows students to complete their honours degree one year earlier. Joint degrees with all subjects apart from Mathematics require first year entry.

You will find full details of what modules are required at all stages of your programme in the University's published programme requirements. The guidance here does not replace the programme requirements or the University course catalogue, which remain the definitive sources of information as to what is necessary for each programme.

First-year entry to Physics and Astronomy degree programmes

Most entrants aiming for a degree involving this School (around two thirds) start their programme in first year with 120 credits from first year modules.

These must include

- PH1011 Physics 1A
- PH1012 Physics 1B
- MT1002 Mathematics.

Students on an astrophysics programme must also take AS1001 Astronomy and Astrophysics 1. Some students may be required to take MT1001 Introductory Mathematics before taking MT1002.

Students on joint degrees will also have additional requirements from their other subject.

Accelerated entry to Physics and Astronomy degree programmes

The accelerated route gives direct entry to level two physics and maths modules. Qualifying students are given 120 advanced standing credits on the basis of their school/college attainment, and can then obtain an honours BSc degree in three years or an honours MPhys degree in four years. Note that the University may withdraw these advanced standing credits if the student changes

to a programme where they are no longer appropriate. See also the University student handbook on advanced standing credit and the official policy.

For **Physics, Astrophysics and Theoretical Physics** programmes, direct entry to second level currently requires

- A-levels AAA, with A in both Mathematics and Physics, or
- Advanced Higher AA in Mathematics and Physics, and Highers AAAA, or
- IB with at least 38 points including Physics and Mathematics (and one other) at HL6 or above, or
- qualifications equivalent to the above.

For **Physics and Mathematics** and **Theoretical Physics and Mathematics** programmes, direct entry to second level currently requires

- A-levels A*A*A, with A* in Maths, A in Further Maths, A in Physics.
- Advanced Highers AA in Mathematics and Physics, and AAAAB in Highers, or
- IB with at least 39 points including Physics and Mathematics (and one other) at HL6 or above, or
- qualifications equivalent to the above.

We strongly recommend that those with A-levels taking direct entry to second level should have included at least one mechanics module in their mathematics A-level.

It is not possible to take second year entry to our joint degrees with Chemistry or Philosophy. MSci Chemistry and Physics should see later in this document, and the advice on module choices for entrants available on the School webpages.

Sem 1	Sem 2
PH2011 Physics 2A (30)	PH2012 Physics 2B (30)
MT2503 Multivariate Calculus (15)	Choice (30)
MT2501 Linear Maths (15)	

A. Can lead to BSc or MPhys Physics or MPhys Theoretical Physics. The Choice credits in second semester may be at level 1 or 2.

Sem 1	Sem 2
PH2011 Physics 2A (30)	PH2012 Physics 2B (30)
AS1101 Astro 1 condensed (5)	
MT2503 Multivariate Calculus (15)	AS2001 Astronomy & Astrophysics 2 (30)
MT2501 Linear Maths (15)	**OR** [AS2101 Astrophysics 2, 15 credits and choice,15 credits]

B. With modules shown this can lead to BSc or MPhys Astrophysics, BSc or MPhys Physics or MPhys Theoretical Physics, that is to any of the single-honours degrees within the School.

Sem 1	Sem 2
PH2011 Physics 2A (30)	PH2012 Physics 2B (30)
MT2503 Multivariate Calculus (15)	MT2506 Vector Calculus (15)
MT2501 Linear Maths (15)	MT2507 Mathematical Modelling (15)

C. This selection (a specific example of A) is required for students on BSc Maths and Physics or MPhys Maths and Theoretical Physics who wish to take an **applied** maths route.

Sem 1	Sem 2
PH2011 Physics 2A (30)	PH2012 Physics 2B (30)
MT2503 Multivariate Calculus (15)	MT2501 Linear Maths (15)
MT2502 Analysis (15)	MT2505 Abstract Alegebra (15)

D. This selection is required for students on BSc Maths and Physics or MPhys Maths and Theoretical Physics who wish to take a **pure** maths route. MT2501 and MT2503 could be taken in the opposite order.

Sem 1	Sem 2
PH2011 Physics 2A (30)	PH2012 Physics 2B (30)
MT2503 Multivariate Calculus (15)	MT2501 Linear Mathematics (15)
Another 15-credit level 2 maths module, or a level 1 subject of interest, eg Maths MT1002 (20) or Astrophysics AS1001 (20)	Another level 2 maths module (15), or a level 1 subject of interest

E. If MT1002 is taken in the first semester this can give a less demanding route in to mathematics study than in A and B above. With the modules shown this can lead to BSc or MPhys Physics or Theoretical Physics.

Sem 1	Sem 2
MT1002 Mathematics (20)	PH2012 Physics 2B (30)
PH2011 Physics 2A (30)	
AS1101 Astro 1 condensed (5)	AS2101 Astrophysics 2 (15)
MT2501 Linear Mathematics (15)	MT2503 Multivariate Calculus

F. With MT1002 taken in the first semester this can give a less demanding route in to mathematics study than other routes, though is over normal credit load in semester one. This can lead to BSc or MPhys Astrophysics, Physics or Theoretical Physics.

This list of modules is for illustrative purposes only and does not constitute a guarantee of the specific modules or module content or route to be offered in future years, but should work for 2023-2024.

Entry to MSci Chemistry and Physics Programme

Students on MSci Physics and Chemistry do not normally have the option of reducing the number of years they study here, but do have two possible routes through years one and two, depending upon the school qualifications they enter with:

Those entering with Advanced Higher or A-levels in maths, physics and chemistry, all at grade A (or equivalent) may choose to spend year one doing mostly second-level chemistry, and year two doing mostly second level maths and physics. This can avoid the need to take more than 120 credits in year two, which would otherwise be required. Further details are available on the School webpages, in the note on module choices for entrant students. Students on this programme should discuss their options with their adviser of studies.

Entry to the Gateway Programme

This programme and its dedicated modules are normally available only to those who have been offered entry to this programme as part of the admissions process.

Summary of Entry Requirements for Pre-honours AS/PH Modules

PH1011 Physics 1A and AS1001/1101 Astrophysics 1 assume that students have a familiarity and competence in physics and mathematics (including calculus) equivalent to at least B-grade attainment in SQA Highers or B-grade attainment in A-levels in these subjects. Physics 1A is a pre-requisite for PH1012 Physics 1B.

PH2011 Physics 2A builds on level one physics and maths, and is also accessible for those on the accelerated entry route with the equivalent of A-grades in the SQA Advanced Highers in physics and maths. Physics 2A is a pre-requisite for PH2012 Physics 2B.

AS2001 and AS2101 Astrophysics 2 require the knowledge and skills developed in Astrophysics 1 or in the Gateway Programme, as well as in PH1011, PH1012 and MT1002.

We welcome students with other relevant qualifications on to these modules. Those from outside the UK may wish to look at past Scottish Higher Exam Papers to see the level:

www.sqa.org.uk/pastpapers/papers/papers/2019/NH_Physics_all_2019.pdf for physics and
www.sqa.org.uk/pastpapers/papers/papers/2019/NH_Mathematics_all_2019.pdf for maths.

Those entering with AP qualifications in both physics and maths should find Physics 1A accessible. Students from the USA without AP should consider taking the International Gateway entry route. It seems that without AP there is typically rather more physics covered in a UK school experience than in the USA.

Summary of Pathways for Degree Programmes Within the School

Traditional Entry Route

Level One Sem 1	Level One Sem 2
Physics 1A (20 credits)	Physics 1B (20 credits)
Maths MT1001 or MT1002 (20 credits)	Maths MT1002 or Choice (20 credits)
Astronomy 1 or Choice (20 credits)	Choice (20 credits)

Accelerated Entry Route

Acc Entry Sem 1	Acc Entry Sem 2
Physics 2A (30 credits)	Physics 2B (30 credits)
Typically Maths MT2501 and MT2503, (30credits)	More Maths, Astro 2, or choice (to 30 credits)
AS1101 for astro (5)	

Level Two Sem 1	Level Two Sem 2
Physics 2A (30 credits)	Physics 2B (30 credits)
Typically Maths MT2501 and MT2503, (30 credits)	Astro 2, level two maths, or Choice (30 credits)

Junior Honours Builds on Physics, Maths, and where appropriate Astronomy modules from second year. Honours BSc programmes need grade 11 in level two Physics modules and Maths MT2501 and 2503 (and Astronomy as appropriate), MPhys programmes need grade 15. Full details in handbooks.

All, Semester One	Physics Sem 2	Theoretical Ph Sem 2	Astronomy Sem 2
Maths for Physicists	Electromagnetism	Electromagnetism	Electromagnetism
Quantum Mechanics 1	Quantum Mechanics 2	Quantum Mechanics 2	Quantum Mechanics2
Trans skills 1st section	Trans skills 2nd section	Trans skills 2nd section	Trans skills 2ndsection
Computational Physics	Thermal & Stat Phys	Thermal & Stat Phys	Thermal & Stat Phys
Option – Electronics, Extragalactic Astro ...	Physics lab 1	Lag & Ham Dynamics	Computational Astro

Senior Honours Builds on knowledge and skills developed in JH and before. Full module choices for different programmes are given in the Honours Handbook. Honours BSc students have project this year, then should graduate. MPhys students have one further year of study.

MPhys Year Major project and advanced lecture-based modules. These modules assume knowledge of the core physics and maths covered earlier, and many will have specific pre-requisites in terms of JH and SH modules that may not be taken by all students – please plan ahead.

NB: This is just an overview. Full details are in the relevant School Handbooks and the University's Course Catalogue, including for joint degrees. There are different routes available.

1000-level (first year) modules

Co-ordinators:

		Room	e-mail
PH1011 Physics 1A PH1012 Physics 1B	Dr Bruce Sinclair	221	b.d.sinclair
Lab coordinator	Dr Cameron Rae	214	cfr
PH1501 Mathematics for Physicists 1A	Dr Irina Leonhardt	210	il4
PH1502/3 Physics Skills 1A and 1B	Dr Lucy Hadfield	304	ljh11
AS1001 Astronomy and Astrophysics 1	Dr Aleks Scholz	331	as110
AS1101 Astrophysics (Direct Entry)	Dr Anne-Marie Weijmans	334	amw23

Physics

The two first-year modules PH1011 and PH1012 introduce university physics, assuming a prior knowledge and understanding of mathematics and physics at SQA Higher grade BB (or equivalent, or higher) in these subjects. They are not a first course in physics. The modules include appropriate coverage of the traditional disciplines of classical physics, but also exposure to the ideas of modern physics including quantum concepts, and to applications including laser physics. The labs give experience in experimental investigations and techniques. It is intended that the two modules should be similar in standard to that of the SQA Advanced Higher in Physics although the syllabi will not match in detail. Students may find a much greater emphasis here on how mathematical and physical relations are determined.

Physics 1A PH1011 (20 Credits)

This module covers the core subjects of mechanics, waves and optics, and the properties of matter. It includes lectures on Newton's laws, simple harmonic motion, the different types of wave motion, geometrical and wave optics, the nature and composition of nuclei, atoms, molecules, solids, and gases.

Physics 1B PH1012 (20 credits)

This module covers the mechanics of gravitation and rotational motion, quantum phenomena, and an introduction to lasers. The module is suitable for those who have already taken Physics 1A. It includes lectures on the origins of quantum theory, and its application to atoms and other small scale systems, dynamics and conservation laws, and the principles of lasers. The module also includes a set of group-based activities associated with the use of physics ideas to solve an interesting problem.

Students who take Physics 1A and/or Physics 1B should acquire

- an understanding of the topics covered in the module,
- an ability to solve problems based on the lecture material,
- an ability to build mathematical models of physical systems
- an increased interest in exploring and understanding the physical world
- a competence in using some of the standard equipment in physics laboratories,
- an appreciation of uncertainty analysis in experimental work.
- an ability to model a real-world problem using physical concepts.
- experience of working in small groups to solve technical problems

Gateway Maths for Physicists PH1501 (20 credits)

This module provides the necessary semester-one mathematics for students following the Physics and Astronomy (Gateway) entry route. The module mirrors the content of that presented in the 1000-level course MT1001. It is designed to give students a solid mathematical background and to introduce them to a range of mathematical techniques required for physics and mathematics degrees. It is a core module in the Gateway first year and is taken in conjunction with the semester two module MT1002. The following topics will be covered: basic algebra (inequalities, functions, coordinate systems, algebraic manipulation), geometric sequences and series, techniques of differentiation and integration. Students who have a grade B at Advanced Higher Mathematics (including units 1 and 2) or B at A-level Mathematics may bypass PH1501 and take MT1002 in the first semester and MT1003 (or another module with the agreement of their adviser) in the second semester.

Gateway Physics Skills 1A PH1502 (20 credits)

The first of the two Gateway skills modules provides a grounding in studying physics at university. The aim is to consolidate basic scientific/numerical skills and equip students with the study and lab skills needed to develop a firm foundation for future learning. The module will also address problem solving in physics with the aim being to develop confident and competent physicists. To this end, emphasis is placed on the understanding of fundamental scientific concepts and the encouragement of independent study.
A short astronomy section is included to allow progression to level-two astrophysics for those who wish.
Physics Skills 1A serves as preparation for Physics Skills 1B.

Gateway Physics Skills 1B PH1503 (20 credits)

Building upon the skills developed in semester one, the second skills module continues to expand and develop problem solving and communication skills that are essential for progression to more complex challenges.

The Gateway Physics Skills 1A and 1B modules will be delivered via a combination of taught material, workshop-style tutorials, practical activities and self-study assignments. Students who successfully complete the modules, should

- be able to manage their own learning and understand the requirements of academic integrity
- be able to critically reflect and evaluate personal progress
- develop a portfolio of work to highlight the adoption and integration of good study habits
- approach problem solving in a structured way and become confident in applying knowledge to familiar and unfamiliar problems
- foster an appreciation of the interplay between different areas of physics and independently pursue topics that are of particular interest
- be developing skills in learning from and critically evaluating textual material
- be developing skills in science communication including presenting work using written and oral media.

Astronomy & Astrophysics 1 - AS1001 (20 credits)

The aim of this module is to provide an elementary understanding of the structure of the observable universe and our position within it. The physical content of the universe, its structures and their mutual interactions, are explored. It is shown how the properties of planets, stars, galaxies, etc may be determined from observations coupled with theoretical models based on physical principles. The module comprises four 10-lecture courses on The Solar System, Stars and Elementary Astrophysics, The Milky Way Galaxy, and Cosmology, thereby providing a complete overview of the subject at this level.

By the end of this module, students will have gained

- an understanding of the structure and evolution of the physical universe from the solar system, through the galaxy, to the large-scale distribution of galaxies and the origin of the universe,
- an ability to calculate astrophysical properties of planets, stars and galaxies from basic physical and mathematical models and simplified data.

Astrophysics (Direct Entry) – AS1101 (5 credits)

This is a condensed version of AS1001 that is available for accelerated-entry astrophysics students before taking level two astrophysics in the following semester.

Detailed syllabuses for all first level modules are given in Appendix B.

Entry requirements

The general entry requirements for students entering the university are described in the Undergraduate Prospectus. The following are the specific requirements for each of the first level modules in Physics and Astronomy.

Physics 1A, Physics 1B, Astronomy & Astrophysics AS1001 and AS1101
Passes are normally required in SQA Higher-grade Physics and Mathematics (minimum grades BB) or GCE A-level Physics and Mathematics (minimum grades BB), or an equivalent set of qualifications. Physics 1A is a pre-requisite for Physics 1B.

Gateway Modules
Normally only students who are registered on the Gateway to Physics and Astronomy programme may routinely take these modules.

Recommended books for 1000-level Physics and Astronomy

Some books are available as e-books to registered students. The links to booklists for AS and PH modules on the School's web page will show you what is available, and will provide links as appropriate.
www.st-andrews.ac.uk/physics-astronomy/students/ug/timetables-handbooks/

All students may wish to read *Learn How to Study* (3rd edition), by D Rowntree (Macdonald 1998) which provides training in study techniques.

Physics
The core text is Halliday and Resnick's Principles of Physics, 11th Edition, Global Edition, by J Walker, ISBN: 978-1-119-45401-4. Those who wish to purchase a paper copy may do so for around £55. The University library is purchasing online access to a pdf of this textbook for Physics 1A, 1B, 2A, and 2B students.

Other texts that students may also wish to consult are:-

- Physics for Scientists and Engineers: A Strategic Approach with Modern Physics by R D Knight, Pearson, 2014 electronic book
- *Understanding Physics,* 1st Edition by K Cummings, PW Laws, E F Redish, P J Cooney, Wiley, 2004
- *Sears and Zemansky's University Physics* by H D Young and R A Freedman (12th edition, Addison-Wesley 2008 or other edition), and
- *Physics for Scientists and Engineers* by P A Tipler and G P Mosca (6th edition, Freeman 2008).

Additional possible reading for the lasers course is *Understanding Lasers* by J Hecht, (3rd Edition, IEEE Press 2008), though we do not recommend purchase; there are multiple copies in the library.

Useful reading for the labs is *Measurements and their Uncertainties: A Practical Guide to Modern Error Analysis* by I G Hughes and T P A Hase, Oxford, 2010. This is available through the library as an ebook.

Astronomy & Astrophysics AS1001 and AS1101
The main recommended books for this module are *Astronomy – a Physical Perspective* by M L Kutner (CUP 2003), and *Cosmic Perspective*, by J O

Bennett. Both are available as an e-book via the University Library, and both are available in hard copy on loan in the library.

Tutorials and Workshops

For Physics 1A each student will typically attend a tutorial per week and a workshop (problem-solving class) most weeks; for Physics 1B arrangements are similar. Tutorials will involve discussions on lecture material and the solution of conceptual and numerical problems based on the course. Students are expected to have attempted all designated tutorial problems in advance of the tutorial and are required to bring their written solutions to the tutorial. They are also required, prior to the tutorial, to submit a self-reporting form and answers to selected problems for feedback. In the workshops, students attempt problems on current lecture topics with demonstrator assistance.

Students will also work though maths revision exercises at the start of the PH1011 class. The purpose of this exercise is to re-acquaint students with the mathematics that will be required to undertake this module. Students carry out mathematical exercises (largely in their own time, but with demonstrator support available) on topics which cover part of the syllabus of Higher and A-level Mathematics. A problem sheet for this work is submitted for assessment.

The Gateway modules involve significant amounts of tutorial and workshop time with input from academic staff. Room 230 is normally used for this purpose.

Astrophysics AS1001 runs one tutorial per week, while AS1101 runs a total of 4 tutorials and 4 peer-support sessions. The tutorials will involve discussions on lecture material and the solution of conceptual and numerical problems based on the course. Students are expected to have attempted all designated tutorial problems in advance of the tutorial.

Practical Work

Physics

The aims of first level practical work in physics are

- to allow an exploration of relevant physics,
- to illustrate the subject matter covered in the lectures,
- to introduce students to some of the modern equipment that is used in physics laboratories,
- to teach the principles of precision and accuracy and methods of uncertainty propagation,
- to teach the principles of experimental techniques and methods of analysis underlying experimental procedures.

PH1011 has nine required lab sessions during the semester (one weekly starting in week 2) plus a self-study Maths for Lab revision activity at the start of the semester with the opportunity to ask for assistance during your lab session in Week 2. Each lab session is 2½ hours and we expect that the work covered should require less than 4-5 hours per week in total.
To make best use of lab sessions we suggest that you should use time beforehand to familiarise yourself with each activity's material contained in the laboratory manual, including attempting pre-lab assignments where asked for. Time afterwards may also be used for attempting post-lab assignments, completing other data analysis, or completing a laboratory notebook-style record on an experiment.
The important laboratory skills developed in Physics 1A will be developed further in future hands-on experimental work aimed more at exploring physics.

For PH1012 students will attend ten lab sessions (one 2½ hours session per week starting in week 2), that will focus on developing experimental skills. We expect that most of your practical work should be completed within these normal laboratory hours, with some time 'at home' prior to the start of a practical to familiarise yourself with the upcoming work and attempt the pre-lab questions; between lab sessions for producing graphs or completing other data analysis; and at the end to finalise your analysis and write a short conclusion to your notes.
It is anticipated you should spend no more than 4-5 hours per week on lab-related work on this module. Toward the end of semester, experimental work will focus on problem solving and group-work skills.

A detailed description of the arrangements for laboratory related work will be provided separately, including weekly schedules and information on assessed assignments.

Astronomy & Astrophysics

The aim of practical work is to teach the acquisition and analysis of astronomical data through simple observations, exercises, and computer simulations. Students will gain an appreciation of the physical properties of objects in the universe, e.g., planetary motions, masses and temperatures of stars, distances to stars and galaxies, and the age of the universe.

AS1001 has six lab afternoons in the semester, AS1101 has two. These laboratory sessions are 2½ hours long. AS1001 students work individually, in pairs, or in small groups at their own pace on experiments selected from a range which may cover planetary motions, radiation laws, properties of the Sun and of the stars, the distribution of stars and galaxies in space, and the expansion of the Universe. AS1101 lab sessions focus on galaxies and cosmology, and the development of programming skills.

Monitoring and Assessment

The progress of students taking each module will be monitored in different ways. For Physics 1A and Physics 1B, the workshops and tutorials entail some written work, some of which is submitted for feedback, as well as a class test in the middle of the semester. Astronomy and Astrophysics 1 has two class tests during the semester, intended to focus attention on material covered in recent lectures. Those taking AS1101 have a class test, a take-home exam, and online quizzes. The Gateway skills modules are entirely continuously assessed.

AS1001, PH1011, PH1012 and PH1501 all have examinations consisting of one written paper of two hours at the end of the semester. There is no choice of questions in the AS and PH exams. Resit examinations for those who are eligible (roughly, those who get a module grade between 4.0 and 6.9, have met stated minimum requirements on individual assessment components and have not been issued an Academic Alert FINAL) are held late in the summer. For any continuous assessment component that is specified in the reassessment below, the mark is carried over from what was given during the semester.

Details of the 20-point grading scale used in 1000- and 2000-level Physics and Astronomy modules may be found later in this handbook on page 46.

Overall grades for the modules are determined according to the formulae below. **Note that there are additional conditions on the performance in individual elements: not meeting these requirements will normally result in a grade of 0X for the module, which means failing with no right to re-assessment.**

Note also that in modules which have an exam, at least grade 7.0 in the exam itself is required to pass the module.

PH1011 60% examination, 15% class test, 25% labs (Reassessment the same)

Must achieve at least grade 4.0 in the class test.

Must achieve at least grade 7.0 in the laboratory work.

Must achieve at least grade 2.0 in the examination.

PH1012 50% exam, 25% labs, 15% Group Discovery Project, 10% class test
(Re-assessment the same)

Must achieve at least grade 4.0 in the class test.

Must achieve at least grade 7.0 in the laboratory work.

Must achieve at least grade 2.0 in the examination.

PH1501 50% exam, 50% continuous assessment
(Reassessment 100% exam)

Must complete and submit to an adequate standard a minimum of 75% (measured by credit contribution) of the continuously assessed components of the module.

Must achieve at least combined grade 4.0 in the class tests.

Must achieve at least grade 2.0 in the examination.

PH1502 100% continuous assessment:

Problem solving and study skills exercises (60%), practical work (25%), independent and group research assignments (15%)

(Reassessment 60% new assignments, 40% carried through from semester)

Must complete and submit to an adequate standard a minimum of 75% (measured by credit contribution) of the continuously assessed components of the module.

PH1503 100% continuous assessment

Problem-solving and study skills exercises (45%), Astronomy short course (25%), practical work (15%), poster development and presentation (15%),

(Reassessment 60% new assignments, 40% carried through from semester)

Must complete and submit to an adequate standard a minimum of 75% (measured by credit contribution) of the continuously assessed components of the module.

Must achieve at least grade 4.0 in the class test.

AS1001 60% examination, 15% tests, 25% practical

(Re-assessment 75% examination, 25% practical)

Must achieve at least combined grade 4.0 in class tests.

Must achieve at least grade 7.0 in the laboratory work.

Must achieve at least grade 2.0 in the examination.

AS1101 50% class test, 25% practical, 15% take-home exam, 10% online quizzes

(Reassessment 75% new class test, 25% practical work)

Must achieve at least grade 4.0 in the laboratory work.

Must achieve at least grade 4.0 in the class test.

In modules that have both examination and continuously assessed components, a student who achieves less than grade 7.0 in the exam but meets the other requirements detailed above will receive an overall grade for the module which is determined by the formulae above but subject to a maximum grade 6.9.

Medals and Prizes

In AS1001, PH1011, PH1012, a medal is awarded to the student with the best performance overall in the assessment. There is also a medal for overall work for the Gateway modules (PH1501-3). The J F Allen Prize in Physics is awarded to the most outstanding student in PH1011 and PH1012 taken together. The

Margaret Stewart Prize is awarded to the student in the module AS1001 who gains the highest grade.

Academic Alerts

The University operates a system of academic alerts, as described in the University handbook, academic alerts.
The aim of the Alert system is to help students by flagging up problems before they seriously affect students' grades. Academic Alerts will be issued by email from a member of staff within the School and will tell students what is wrong, what they are required to do and what support the University can offer. If students do not take the action required they will get another Alert, and eventually may automatically get a grade of zero and fail that module. The system is designed to help and support students to remedy any problems or issues before these lead to failing a module. Alerts will never appear on a student's permanent transcript. For more information on Academic Alerts and details on how the categories work, see the University's policy on Academic Alerts and the accompanying guidance for students.

Note that a "FINAL" alert can result in a student receiving grade 0X for the module with no right to a resit examination. This can have serious consequences for their university study.

In all pre-honours modules in physics and astronomy, attendance at all classes (lectures, tutorials, workshops, and any specified practical work) is strongly recommended and in some cases is a requirement. In level-one modules (apart from AS1101) in this School, to avoid a FINAL alert, a student must:

1. For tutorials in PH1011, PH1012 and AS1001 participate in a minimum of 75% of the tutorials of the module.
2. For tutorials in PH1011 and PH1012 hand in on time a serious attempt at the specified hand-in questions for a minimum of 75% of the tutorials.
3. For tutorials in AS1001 attempt the Moodle tutorial quizzes for at least 75% of tutorials.
4. For PH1011 and PH1012 attend a minimum of 75% of the required laboratory sessions, and achieve a grade of at least 7.0 overall for the laboratory work. Failure to meet these requirements will result in failure of the module overall, with no right to re-assessment (a grade of 0X).

5. For Physics (PH) modules, attend a minimum of 75% of the workshops, and in the case of Physics 1B, 50% of the scheduled group-project sessions.
6. For AS1001 and PH1501, achieve a grade of at least 4.0 in the combined score for the class tests.
7. For PH1011 and PH1012, achieve a grade of at least 4.0 for the class tests.
8. For PH1501, PH1502 and PH1503 complete and submit to an adequate standard a minimum of 75% (measured by credit contribution) of the continuously assessed components of the module.
9. For PH1501, PH1502 and PH1503 attend at least 75% of the scheduled classes, including tutorials and supported study sessions.
10. For PH1502 attain at least a grade 4.0 for the Astronomy class test.
11. For all modules with examinations, achieve a grade of at least 2.0 in the final examination. (This includes the case of students who fail to attend the examination without a satisfactory reason.)

For AS1101 to avoid a FINAL academic alert a student must

1. Attain at least grade 4.0 in the lab work.
2. Attain at least grade 4.0 in the class test.

Any justifiable reasons for absence from tutorials, workshops, labs, tests and exams should be presented by a self-certificate of absence (see University student handbook: self-certification). In such cases students should also immediately contact the member of staff concerned to arrange how and when the missed work should be undertaken. Late justifications of missing work will be accepted only in exceptional circumstances.

Progression

Students are normally expected to gain at least grade 7 in all level-one modules for progression to level two.

Grade 7 does not indicate mastery of the material, and we expect our students to be aiming for a much higher grade than this. Knowledge and skills developed and practised in first year are the foundations for second year in this School.

2000-level (second year) modules

Co-ordinators:

		Room	e-mail
Physics (PH2011, PH2012)	Prof Graham Turnbull Dr Cameron Rae (laboratory)	220 214	gat cfr
Astrophysics (AS2001, AS2101)	Dr Claudia Cyganowski	335	cc243

Physics

The two second year physics modules are intended to be suitable for those who have taken appropriate first-year physics and maths modules, and those who have taken direct entry into second year on the basis of good Advanced Higher, A-Level, IB, or equivalent qualifications including physics and maths.

PH2011 Physics 2A and PH2012 Physics 2B run semesters 1 and 2 respectively and both are required for any of the degrees taught within the School. Students taking them should acquire

- The ability to reason through scientific concepts, to relate different concepts to one another and to solve qualitative and quantitative problems in the areas covered in the courses with a toolkit of problem-solving techniques.
- Laboratory skills, including the planning of experimental investigations, the use of modern test equipment, and the construction of electronic circuits.
- An appreciation of the value of learning of physics as a transformative experience in terms of motivated use (using physics beyond the course e.g. in everyday situations) and expansion of perception (seeing the world through the lens of physics).

In addition, students who have taken Physics 2A should be able to

- Identify a hierarchy of physical concepts and mathematical equations pertinent to mechanics, understanding which are the most fundamental and which follow from the fundamental laws.

- Embed previously acquired knowledge correctly within the more general framework of mechanics presented in the course and to be aware of the limits of applicability and connectivity of that previous knowledge and its relation to newly acquired knowledge.
- Solve elementary problems in mechanics, being confident in correctly identifying concepts that are applicable to each problem and to correctly visualise and analyse the problem to allow a solution to be formulated.
- Be confident in the use of vectors, their manipulation, their transformation to different coordinate systems, and to be clear about why vectors are necessary to properly understand some problems. This includes being able to visualise a problem in mechanics and then to correctly formulate the problem in vector notation to allow a solution to be arrived at. To be clear about when the reduction of a vector problem to a scalar one is possible or advantageous.
- Be confident in the use of Cartesian, polar and cylindrical coordinates, transformations between them, and to recognise which might be the most appropriate system to work in or which system might facilitate better insight into a problem or provide greater ease of solution.
- Apply concepts of classical mechanics to derive equations of motion for oscillatory systems.
- For undamped and simple cases of damped, forced and coupled oscillations, solve the resulting equations of motion and distinguish between general and specific solutions.
- Represent oscillatory motion physically, mathematical and graphically and explain the connections between these representations.
- Give numerous real-world examples of oscillatory systems and be able to model these systems using different representations.
- State the postulates of special relativity, and use them to derive the formulas for length contraction and time dilation.
- Use the Lorentz transformations to find the spacetime coordinates of events in different reference frames.
- Draw and interpret spacetime diagrams.
- Derive and apply the relativistic velocity addition formula.
- Give multiple examples of experimental evidence that supports the theory of special relativity.
- Use the relativistic definitions of energy and momentum, and transform these quantities between different reference frames.

- Identify invariant quantities in special relativity, distinguish invariants from conserved quantities, and use both concepts to determine the outcome of relativistic collisions.
- Give multiple examples of experimental evidence that support the theory of special relativity.
- State the zeroth, first and second laws of thermodynamics, explain their physical meaning and relate them to the thermodynamic identity.
- Solve problems involving thermal expansion, heat capacity and the transport of energy by heating in terms of the thermal properties of materials.
- Appreciate the differences between reversible and irreversible processes.
- State the ideal gas law and equipartition theorem and apply them to a variety of different thermodynamic problems.
- Distinguish between the concepts of heat and work and perform and explain basic calculations for these quantities for ideal gases under various conditions.
- Describe the essential assumptions and conclusions of the kinetic theory of ideal gases and apply these to problems involving ideal gases, including the Maxwell-Boltzmann speed distribution and its behaviour.
- Describe the difference between a macrostate and a microstate of a system and explain the links between multiplicity and the likelihood of a macrostate.
- State the thermodynamic and statistical definitions of entropy and explain the link between them, and relate changes in entropy to the reversibility of a process.
- Explain selected thermodynamic cycles, including the Carnot cycle and state an expression for the Carnot efficiency and the link between entropy and heat engines and refrigerators.
- Write and use computer programs to run simple experiments using microcontrollers.

In addition, students who have taken Physics 2B should be able to

- Represent transverse and longitudinal waves and waves in one, two and three dimensions physically, mathematically and graphically and explain the connections between these representations.
- Explain similarities and differences between different types of mechanical waves, and between mechanical and electromagnetic waves.

- Use the concepts of wave interference, energy transport and the behaviour at boundaries to calculate wave properties.
- Compare and contrast classical and quantum descriptions of light and matter, give examples where one description or the other is valid, and summarise experimental evidence that support the use of either description.
- Solve the Schrödinger equation for simple 1-D systems, and use these wave functions to calculate expectation values and measurement probabilities for observables such as energy, position and momentum.
- State Coulomb's Law and the Biot-Savart Law, Faraday's Law and Lenz's Law, the definitions of electric field, electric potential, capacitance, and inductance.
- Be able to use the above laws and definitions along with other physics and maths concepts to be able to model and solve a range of examples in electrostatics, magnetostatics, and electromagnetic induction.
- Be able to use the above ideas to justify aspects of DC circuit theory and apply this to solving simple electrical circuit problems.
- Be able to use the above definitions and laws to justify Gauss' Law and Ampere's Law, and use these two laws on a range of electrostatic and magnetostatic examples.
- Qualitatively describe how relativity and electrostatics can be brought together to explain electromagnetism.
- State descriptions of paramagnetism, diamagnetism, and ferromagnetism.
- Appreciate how the concepts in the electricity and magnetism course may be applied to particle accelerators, fusion tokomaks, atom traps, optical tweezers, modern electronics, and electrical engineering.
- State concepts of pn junctions, design circuits using AC circuit theory, build and investigate electronic circuits.

Physics 2A PH2011 (30 credits)

This module covers (i) *mechanics* – revision of Newton's laws, force, energy, work and power, central forces, conservative forces, conservation laws, gravitational theory, rigid body dynamics, statics, and fluids in motion; (ii) *oscillations in physics* - simple harmonic motion, damped, forced and coupled harmonic oscillations; (iii) *thermal physics* – including elementary thermodynamics and the notion of entropy, (iv) *the special theory of relativity* – Einstein's theory which unifies mechanics and electromagnetism and

fundamentally modifies our notions of space and time, (v) *laboratory work* – includes lab skills development and the opportunity to explore in a practical way some topics covered in lectures, and (vi) *maths revision*.

Physics 2B PH2012 (30 credits)

This module comprises lectures on (i) *quantum physics* – the Schrödinger wave equation, and the solution of the energy eigenvalue equation for simple potentials in one dimension; (ii) *electricity and magnetism* – an elementary introduction to the electromagnetic field comprising electrostatics, magnetostatics, electromagnetic induction and DC circuit theory; (iii) *waves in physics* –waves on strings, energy flow, interference and beats, sound waves, Doppler effect, phase and group velocities, wave properties of light, including polarisation, interference and diffraction, and (v) *laboratory work* – includes theoretical and practical electronics.

Astronomy & Astrophysics 2 AS2001 (30 credits)

This module is designed to complement and extend the knowledge gained in the first level module in Astronomy and Astrophysics, and to prepare the way for the more advanced topics encountered in a study of the subject at honours level. Lectures are based on the principles of physics together with mathematical techniques acquired earlier. It is intended that students should gain

- a strengthening of the skills learned in AS1001/1101 and level 1 physics and mathematics modules,
- a deeper understanding of the structure and evolution of stars, the design of telescopes and instruments for astronomical observations over the entire electromagnetic spectrum, the dynamical interactions of stars in the Galaxy, and exoplanetary science.
- a greater ability to analyse astronomical data, using the Python language and other computer packages.

Astrophysics 2 AS2101 (15 credits)

This is as AS2001, but without the observational techniques lectures and the labs. This is normally taken only by accelerated entry students who are aiming for an astronomy degree. It can also be taken by a continuing student who is more interested in theoretical aspects of astronomy and who, having already taken AS1001, is keen to take an additional level-two 15-credit maths module in S2.

Entry Requirements

For entry to either of the second-level modules in Physics, it is normally necessary to have one of the following sets of qualifications:

(a) Passes in the first level modules

PH1011 Physics 1A
PH1012 Physics 1B
MT1002 Mathematics

It is expected that students will have a total of 120 credits from first year.

(b) School/college qualifications. Passes in Advanced Higher or A-Level Physics and Mathematics, both normally at grade A, or equivalent.

Note: these grade requirements are naturally consistent with those required for accelerated (direct) entry to second level – as discussed earlier. However, they may also be satisfied by a student who is not entering directly into second level, but wishes to take one or both of the level two physics modules in their first year of study. This possibility may be of interest to students taking certain joint-honours degrees for which the possibility of direct entry to second level does not arise.

For entry to the second level modules in Astrophysics, the entry requirements are as for second-level physics, plus the requirement to have passed one of the first-level astrophysics modules AS1001 or AS1101, or the Gateway module that had Astrophysics within it.

Recommended Books

Online Book Lists & Access to e-books

Some books are available as e-books to registered students. The booklists for AS and PH modules are at
www.st-andrews.ac.uk/physics-astronomy/students/ug/timetables-handbooks/
and show the full booklist, what is available online, and provide links as appropriate.

Physics

The core text is Halliday and Resnick's Principles of Physics, 11th Edition, Global Edition, by J Walker, ISBN: 978-1-119-45401-4. Those who wish to purchase a paper copy may do so for around £55. The University library is purchasing online access to a pdf of this textbook for Physics 1A, 1B, 2A, and 2B students.

There are additional books that are recommended for consultation, and details of these can be accessed via the School's Staff and Students web page.

Additional texts (available in the library) are:-

- Physics for Scientists and Engineers: A Strategic Approach with Modern Physics by R D Knight, Pearson, 2014 ebook.
- *Understanding Physics,* 1st Edition by K Cummings, PW Laws, E F Redish, P J Cooney, Wiley, 2004,
- *Sears and Zemansky's University Physics* by H D Young and R A Freedman (12th edition, Addison-Wesley 2008 or other edition), and
- *Physics for Scientists and Engineers* by P A Tipler and G P Mosca (6th edition, Freeman 2008).

These all provide wide coverage of the lecture courses, examples of how physics is applied in realistic situations, and many problems together with hints for solving them. However, neither these nor Halliday, Resnick and Walker go as deep into the topics as do some of the courses within our modules. We recommend the following additional books, but do not expect students to purchase them. There are multiple copies in the library.

Physics 2A
Mechanics - *An Introduction to Mechanics,* D Kleppner and R Kolenkow, CUP.
Special Relativity - *Basic Concepts in Relativity and Early Quantum Theory,* R Resnick and D Halliday, (Macmillan, 1992); *Nonclassical Physics;. Beyond Newton's View,* Randy Harris (Addison Wesley Longman, CA, 1999); *Relativity Visualised*, Lewis Carroll Epstein (Insight Press, CA, 1985).
Thermal Physics - *An Introduction to Thermal Physics*, D V Schroeder (Pearson, 2004)

Physics 2B
Quantum Mechanics – *Basic Concepts in Relativity and Early Quantum Theory,* R Resnick and D Halliday, (Macmillan, 1992); *Quantum Mechanics: A Paradigms Approach*, D H McIntyre et al (Oregon State University, 2012); *Quantum Mechanics,* A. I. M. Rae (fifth edition, 2007, Chapman and Hall) - also available as an e-book; *Six quantum pieces: a first course in quantum physics*, V Scarani et al (2010); *The meaning of quantum theory: a guide for students of chemistry and physics*, J E Baggott (2004);

Physics 2A and 2B
Useful reading for the labs is Measurements and their Uncertainties: *A Practical Guide to Modern Error Analysis* by I G Hughes and T P A Hase, Oxford (2010); available as an ebook via the library.

Astronomy and Astrophysics 2
Recommended books for Astronomy & Astrophysics 2 include *Astronomy, a Physical Perspective* by M L Kutner (available as an ebook) and *An Introduction to Modern Astrophysics (second edition)* by B W Carroll and D A Ostlie

Additional reading accessible from ebooks includes
for the exoplanets course:-
Methods of Detecting Exoplanets by V Bozza, L Mancini, and A Sozzetti (eds), Springer (2016)

https://link-springer-com.ezproxy.st-andrews.ac.uk/book/10.1007%2F978-3-319-27458-4

for the observational techniques course:
To Measure the Sky: An introduction to Observational Astronomy, by F R Chromey, CUP

https://www-cambridge-org.ezproxy.st-andrews.ac.uk/core/books/to-measure-the-sky/39FFA869B7A9310AEF912733812E3447

Tutorials and Workshops

Tutorials form a valuable part of the learning process, help to develop communication skills, and provide a forum in which to explore the "*But what if*?" questions. In Physics 2A and 2B groups of about nine students meet weekly with a tutor. These tutorials will provide an opportunity to discuss queries which arise on topics covered in the lectures. Students are expected to have attempted all designated tutorial problems in advance of the tutorial and are required to bring their written solutions to the tutorial. They are also required, prior to the tutorial, to submit a self-reporting form and answers to selected problems for marking. In addition, students in Physics 2B will attend one workshop (problem solving class) each week. In Astronomy 2 students have one tutorial each week.

Practical Work

The aims of the second level practical work in physics are to build on previously acquired experimental skills while at the same time provide the opportunity for students to:

- work toward desired experimental outcomes but with greater freedom to explore the relevant topic;
- broaden competences in the use of various forms of experimental and diagnostic instrumentation;
- explore subject matter covered in lectures and, particularly in electronics, new material;
- develop skills in scientific writing.

For the Physics 2A and 2B modules students attend one afternoon session of 2½ hours (15:00 – 17:30) per week of practical work (groups will be arranged for days on which lab classes run at the start of the semester).
For all students we expect that the practical work should be completed within the time scheduled for laboratory work of up to 7.5 hours per week, including

any timetabled laboratory hours. Prior to the start of a practical you should familiarise yourself with the upcoming work and attempt any pre-lab questions; between lab afternoons you should attempt any assignments, keep your data analysis and interpretation up-to-date, and continue to prepare for upcoming work.

At the start of 1st Semester (Physics 2A), the programme is slightly different for returning students and direct entry students, as direct entry students cover some of the lab skills development that has already been explored by our returning students, to gain a similar skill set and understanding of our expectations. In 2nd Semester (Physics 2B) all students will attempt the same programme of work. There is a choice of a physics experiments, followed by work in electronics and lab-related Python programming, and a scientific writing exercise. The module also includes an opportunity to see some of our research laboratories and relate the skills being developed in the teaching laboratory to those practiced by the experimental physics researcher.

Astronomy & Astrophysics laboratory sessions are held from 3.00 - 5.30 pm on Tuesdays and Fridays, with students attending one or the other. The aims of practical work in Astronomy & Astrophysics 2 are:

- to give confidence in working with and interpreting astronomical data,
- to instil an appreciation of the practicalities and excitement of making observations using research-grade telescopes,
- to enhance students' awareness of the ever-changing nature of the night sky.

In all second level modules where practical assignments are to be handed in for marking according to a specified timetable, penalties will be applied for lateness up to and including the loss of all marks in particularly serious cases. Please see later in this handbook under coursework penalties.

Mathematics revision

A good grasp of mathematics and its application to physics is essential for all students of physics and astrophysics. During both the Physics 2A and Physics 2B modules, students will have weekly online maths revision quizzes to encourage revision and practice of mathematical techniques which they have learned previously. These quizzes are supported by pre-recorded revision lectures, and will contribute 5% of the module mark

There is additional maths support material particularly aimed at preparing students for second year maths modules available on a self-enrolment Moodle course

https://moody.st-andrews.ac.uk/moodle/enrol/index.php?id=13857

Monitoring and Assessment

Student progress is monitored in different ways. For PH2011 and PH2012 the weekly tutorials will entail submission of written work for marking and feedback, and there will be a class test at about halfway through the semester. Both AS2001 and AS2101 have two tests during the semester, intended to focus attention on material covered in recent lectures.

The examination for each module consists of one written paper at the end of the semester, of 3 hours for PH2011, PH2012, AS2001 and 2 hours for AS2101. The Physics 2A and Astronomy examination papers will continue to focus on material and techniques that should be familiar to students from the module's work. The Physics 2B examination will contain a small amount of questioning that goes beyond the sort of things seen in tutorials and lectures, which is aimed at distinguishing between the very good and the truly excellent. This is a preface to the honours module examinations which routinely have a similar "sting in the tail" of the questions for the same reason. There will be no choice of questions within these papers.

Re-assessment (resit) exams are possible only for those who gain less than grade 7.0 but more than 4.0 in the module, have met any minimum requirements on individual components of the assessment and who have not been given a FINAL Academic Alert. For any continuous assessment component specified in the reassessment below, the mark is carried over from that given during the semester.

Details of the 20-point grading scale used in 1000- and 2000-level Physics and Astronomy modules may be found later in this handbook on page 46.

Overall grades for the modules are determined according to the formulae below. **Note that there are additional conditions on the performance in individual elements: not meeting these requirements will normally result in a grade of 0X for the module, which means failing with no right to re-assessment.**

Note also that in modules which have an exam, at least grade 7.0 in the exam itself is required to pass the module.

PH2011 & PH2012	60% examination, 10% class test, 25% labs, 5% online quizzes (Re-assessment same as above) Must achieve at least grade 4.0 in class test. Must achieve at least grade 7.0 in laboratory work. Must achieve at least grade 2.0 in examination.

AS2001	60% examination, 15% class tests, 25% labs (Re-assessment 75% examination, 25% labs) Must achieve at least combined grade 4.0 in class tests. Must achieve at least grade 7.0 in laboratory work. Must achieve at least grade 2.0 in examination.
AS2101	80% exam, 20% continuous assessment (class tests) (Re-assessment 100% exam) Must achieve at least combined grade 4.0 in class tests. Must achieve at least grade 2.0 in examination.

In modules that have both examination and continuously assessed components, a student who achieves less than grade 7.0 in the exam but meets the other requirements detailed above will receive an overall grade for the module which is determined by the formulae above but subject to a maximum grade 6.9.

Note that for honours entry for any degree in our School students will need good passes in PH2011 and PH2012, and also AS2*01 for astrophysics degrees. If a student for health or other reasons is permitted to defer an exam, they may wish to note that should a resit be required this will normally be in the first examination diet for that module in the following session. There is more detail on these matters elsewhere in this handbook and on the University website.

Prizes and Medals

A medal is awarded in PH2011, PH2012, and AS2001/2101 to the student who gains the highest grade. The J F Allen Prize is awarded to the most outstanding student (the highest mean module grade) in PH2011 and PH2012 taken together.

Academic Alerts

The University operates a system of academic alerts, as described in the University handbook, academic alerts.
The aim of the Alert system is to help students by flagging up problems before they seriously affect students' grades. Academic Alerts will be issued by email from a member of staff within the School and will tell students what is wrong, what they are required to do and what support the University can offer. If students do not take the action required they will get another Alert, and eventually may automatically get a grade of zero and fail that module. The

system is designed to help and support students to remedy any problems or issues before these lead to failing a module. Alerts will never appear on a student's permanent transcript. For more information on Academic Alerts and details on how the categories work, see the University's policy on Academic Alerts and the accompanying guidance for students.

Note that a "FINAL" alert can result in a student receiving grade 0X for the module with no right to a resit examination. This can have serious consequences for their university study.

In all pre-honours modules in physics and astronomy, attendance at all classes (lectures, tutorials, workshops, and any specified practical work) is strongly recommended and in some cases is a requirement. In level two modules in this School, to avoid receiving a FINAL alert, a student must:

1. For AS2001 and AS2101 attend a minimum of 75% of the tutorials.
2. For AS2001 and AS2101 modules, achieve a grade of at least 4.0 in the combined score for the tests.
3. For PH2011 and PH2012 attend, at least 7 of the weekly tutorials in the module.
4. For PH2011 and PH2012 tutorials submit on time the self-reporting form, and a serious attempt at the specified questions, for at least 7 of the weekly tutorials.
5. For PH2011 and PH2012, achieve a grade of at least 4.0 for the class tests.
6. For PH2011 and PH2012, attend a minimum of 75% of the workshops
7. For PH2011, PH2012 and AS2001 attend a minimum of 75% of scheduled laboratory classes associated with the module.

   Achieve a grade of at least 7.0 overall for the laboratory work. Failure to meet these requirements will result in failure of the module overall, with no right to re-assessment (a grade of 0X).
8. For all modules, achieve a grade of at least 2.0 in the final examination. (This includes the case of students who fail to attend the examination without a satisfactory reason.)

Any justifiable reasons for absence from tutorials, workshops, labs, tests and exams should be presented by a self-certificate of absence (see University student handbook: self-certification). In such cases students should also immediately contact the member of staff concerned to arrange how and when

the missed work should be undertaken. Late justifications of missing work will be accepted only in exceptional circumstances.

Student Work

Physics and astronomy, in common with most other worthwhile learning, needs study, practice, reflection, and further work for a student to come to terms with the material and gain the ability to use it (and to pass exams). In the same way that merely buying a textbook does not result in the owner being competent in using the material contained within it, merely turning up to lectures is not enough to understand and learn how to use ideas in physics and astronomy. There is a good deal of support available for learning here in terms of staff time, fellow students, online and paper-based resources, libraries and IT suites, teaching labs and lecture rooms, but it is up to every student to organise themselves to do what is necessary for their own learning.

We are aware that our students have all achieved great things in their previous studies and keen that high achievement carries on here. Some students join us having not had to study particularly hard to pass their school exams; some of them may be at particular risk of not putting in the thought and effort needed in their university studies.

Keeping Up

Most courses build concepts on top of understanding of previously described concepts. Therefore, ensure that you keep up with the work covered. Lectures should be about listening, understanding, asking questions if necessary, and making notes on what is happening. They should not deteriorate into a mere copying exercise! For that to be the case, you will need to be comfortable with the topics in one lecture before the next one occurs. At the end of each day of lectures, it is important to read over notes, add additional comments while ideas are still fresh in your mind, and sort out any difficulties you may have. Reading a textbook, discussing with a friend, or asking your tutor or lecturer can all help. As well as preparing you for the next lecture, this is likely to have the added benefit of aiding your memory of the topic for the end-of-module exams.

Please bear in mind that just because you have seen some topics before in previous study, you may not be as familiar with the ins and outs of the material as we would wish you to be. Here we are as much interested in where physical and mathematical relationships come from as in being able to use them. By understanding the ideas (and limitations) on which a relationship is built, we are better placed to know how and when to use it.

Practice

In a subject such as ours, memorising facts is not enough (though it is still important). We aim to develop an understanding of the subject, and how it can

be applied. To help in this, we encourage you to try appropriate questions and problems that relate to the course. The questions in the tutorial sheets and labs should help you practise your physics in the same way that any other skill has to be practised to improve it. Where you find difficulties, look again at the lectures and your notes, textbooks, or discuss with friends and tutors. Bring questions and queries to tutorials for discussion - that is what tutorials are provided for! Please make good use of your tutors. If there are not enough questions on the tutorial sheets, then there are many more relevant questions in your course textbook.

We aim to teach our students to understand physics and astronomy, not just to pass exams. However, we realise that examination results are important, and it is useful to practice past exam questions. Students may access past papers through MySaint. Example past exam solutions are available via the School's web page.

Responsibility

We hope you are here because you have an interest in physics and astronomy. There are many attractions to life as a student, but a sensible balance between study and recreation must be found. To be a decent physicist or astronomer (even for those doing only one module) you will need to think about the science and get practice in applying it to different situations. The same comments apply to other subjects too.

Time Allocation

In addition to their attendance at scheduled classes, students are expected, through independent study, to work at augmenting their knowledge and understanding of the topics currently being taught in lectures. The QAA specifies that each unit of credit should correspond to 10 hours of study time for the average student at that level. This corresponds to a time commitment of around 40 hours per week for students taking the normal 120 credits per year. This means that the average student in the 20-credit level-one modules in the School should be allocating about 13 hours a week to each module, and in the 30-credit level-two modules about 20 hours a week.

Forty hours a week of study should allow time for students to engage in other activities. While we realise that some students will wish or need to take paid employment, we suggest that during semester time where possible this should not be so many hours that it impacts significantly on your abilities to study.

Self-directed Study

As one of the aims of our teaching programme is “To develop the ability to be a self-directed learner, including fostering a healthy intellectual curiosity in this and other disciplines, and the ability to determine one’s own learning needs and to organise one’s own learning” students are expected and encouraged to use information in the library and online to help their studies, as well as discussing physics with other students and with staff.

The School encourages students to form groups that can meet on a regular basis to discuss the work being covered in the teaching programme.

If you encounter difficulties in understanding the lecture material which cannot easily be resolved, for example by reference to textbooks or discussion with a classmate or your tutor, you are encouraged to approach the lecturer concerned who will be pleased to deal with queries of this type.

General Information

Advisers of Studies

Your Adviser of Studies is available to be consulted on any academic queries which may arise during the year. They provide guidance at the start of the session on selection of modules etc. Any subsequent change in module registration can only be done in consultation with your adviser and needs be completed within the first week from the start of term. Any changes thereafter would also need the permission of the Associate Dean. Should you wish to see your adviser and they are not available, the School's Director of Teaching may be able to assist with some queries.

External References

The School's degree programmes are designed with reference to the QAA Subject Benchmark Statement and the UK Institute of Physics specification of "The Physics Degree"
The School's teaching and assessment is monitored by external examiners. These are experienced academics from other physics departments. They are consulted on significant changes to the teaching programme, and they attend module boards to monitor fairness in the assessment process and to ensure that academic standards at St Andrews are at an appropriate level compared with other UK physics and astronomy departments.

Examinations

Most modules involve an exam at the end of the semester. **All exams for 1000- and 2000-level AS and PH modules will be in-person invigilated exams.** The School's exam papers normally have no choice of questions. Exams may be close together, and so work to be on top of the entire semester's material well before the exam weeks start. This is also good study practice – you want this material and its understanding to stick for future work, and not just be a cram for exam and then forget. Although we run degree programmes that are assessed module by module, the knowledge and skills developed in one module are often needed in subsequent modules.

For the 2023-24 session we expect that all examinations will be timed invigilated exams taken in-person. Before sitting examinations, all students must ensure that they have read and fully understand the University's examinations policy.

Exam papers are checked by School staff, and by our external examiners. An exam question that aims to assess student competence in parts of the relevant module will also likely require familiarity and competence with material from previous study. Questions in an exam may require competence with material from different parts of the module. There is no suggestion that in one module exam the questions should be uniformly distributed from across the module. Please see additional information on exams on the School webpage.

Via the School's Current students web page you can find for most current modules one past examination paper and one sample solution. The University's MySaint portal gives access to the last few years of exam papers.

Deferred examinations

Deferral of an assessment refers to taking it after the end of the corresponding semester. This is not a right and permission will be granted only when the School judges that genuine and compelling grounds for deferral exist.

Requests for deferred exams in Physics and Astronomy should be directed to the School's Director of Teaching, Paul Cruickshank, at
physdot@st-andrews.ac.uk.
Please also copy in the School's Examinations Officer
panda-exams@st-andrews.ac.uk.

Deferred exams will have the same format as the original exam. For semester 1 exams, deferrals will take place in the semester 2 exam diet, or immediately following it.
For semester 2 exams, deferrals will take place immediately after the Semester 2 exam diet. The dates may be found in the University's Key Dates for Students, in which it's called the "extended exam diet". These exams are organised by the University's Exams Office.

If you are permitted to defer an exam, then you will be expected to be available in St Andrews at the time the deferred exam is scheduled, and to make suitable travel arrangements where necessary. You are advised to check your email regularly to ensure that you do not miss the deferred exam.

Deferrals beyond the academic year will only take place in truly exceptional circumstances and will require the approval of the Deans. The School will refer the student to Student Services, the Registry Officer (Student Support), or the appropriate Associate Dean Students (UG students) or Associate Provost

Students (PGT students). Please note that deferral beyond the academic year can have significant implications for progression, and may require a leave of absence.

Re-assessment exams

Re-assessment exams for semester 1 modules will take place in the extended exam diet after the semester 2 exam diet, and will be in-person invigilated exams.
Re-assessment exams for semester 2 modules will be online exams, held in the University's online August exam diet.

Absence, special circumstances and extensions

If you find that special circumstances are impeding your studies, you should alert the School's Director of Teaching as soon as possible. You can do this directly, or through Student Services (theasc@st-andrews.ac.uk) or the School's Wellbeing Officers (panda_wellbeing@st-andrews.ac.uk). Please get in touch at the **first** sign of difficulties.

If, for any reason, you are unable to engage with part of a module, you should complete as soon as possible a Self-Certificate online. (See the University Student Handbook: Self-certification.)

Any illness or special circumstance that affects assessed work or compulsory activity (for example tutorial, lab work, class test) **must** be noted. If you are absent from a small-group teaching session please also inform the tutor or lab head in advance if possible. If you miss assessed work or a compulsory activity you should contact the module coordinator to determine what you should do to try to fill the learning or assessment objectives. You should be aware of and act upon the University's Academic Alerts Policy.

If you wish to request an extension for a piece of assessed (for credit) coursework, you should use the School's online extension request form. Note that this form is specific to Physics and Astronomy: if you wish to request an extension for a module in another school, then please use the form for that school. Extensions should always be requested in advance of the deadline, save in truly exceptional circumstances. Please see the University's policy on extenuating circumstances for guidance on what does (and does not!) constitute an extenuating circumstance.

Absence from exams, which is a serious matter, due to illness or any other unavoidable reason should be reported by contacting the School **and** submitting a self-certificate as soon as possible, preferably before the exam time, and no later than three days after the exam. See the section on deferred exams later in this handbook.

It may also be possible and appropriate for the School to "S-code" a module result, which indicates that the assessment of that module has been affected by special circumstances. See the University student handbook: Special circumstances - S-coding and the University's policy on S-coding.

In some cases, for example of longer-term illness, the appropriate mechanism to assist the student is a leave of absence. See the University student handbook: Leave of absence. This should be discussed with an adviser at Student Services, though the School's Director of Teaching can give some advice on the process and implications. See also the University's policy on leave of absence, re-engagement and withdrawal.

The 0-20 Grading Scale – Pre-Honours Physics and Astronomy

The University uses a 20-point Common Reporting Scale for module grades. The minimum grade for which credits for the modules are awarded (i.e. a bare pass) is 7.0.

Please note that a grade of 7.0 is not regarded as a "good" grade, and a set of grade sevens at honours level may not result in a student being awarded an honours degree.

In the School of Physics and Astronomy, normal practice is to assess submitted work such as exam scripts initially in terms of percentage marks. The module percentage mark is then calculated, and this is then converted to a grade by a mapping procedure.

The correspondence between percentages and grades, for all first and second level modules offered by the School of Physics and Astronomy, is as follows, though in principle this may be changed by the Module Board (including the external examiner) if necessary. We aim to avoid any need to change the mapping scheme used, and this happens relatively rarely. Please note that a different mapping is in place for honours modules.

Grade 5.0 corresponds to 40%. Between 0% and 40%, the grade is the percentage mark divided by 8, meaning that grade 7.0 (bare pass) corresponds to 45%.

Grade 17.0 corresponds to 70%. Between 40% and 70% there is a linear mapping of percentage marks onto grades. For example, grade 11.0

corresponds to 55% and grade 15.0 to 65%. Grade 20.0 corresponds to 100%. Between 70% and 100% there is a linear mapping of percentage marks onto grades. For example, grade 18.0 corresponds to 80%, and 19.0 to 90%.

This percentage to grade mapping for level one and two physics and astronomy is shown in a different (and **approximate**) format on the following page.

%	Grade	Comment
10	1.3	
15	1.9	
16	2.0	
17	2.1	
18	2.3	
19	2.4	
20	2.5	
21	2.6	
22	2.8	
23	2.9	
24	3.0	
25	3.1	
26	3.3	
27	3.4	
28	3.5	
29	3.6	
30	3.8	
31	3.9	
32	4.0	Minimum for resit
33	4.1	
34	4.3	
35	4.4	
36	4.5	
37	4.6	
38	4.8	
39	4.9	
40	5.0	
41	5.4	
42	5.8	
43	6.2	
44	6.6	
45	7.0	Minimum for credit
46	7.4	
47	7.8	
48	8.2	
49	8.6	
50	9.0	
51	9.4	
52	9.8	
53	10.2	
54	10.6	
55	11.0	
56	11.4	
57	11.8	
58	12.2	
59	12.6	
60	13.0	
61	13.4	
62	13.8	
63	14.2	
64	14.6	
65	15.0	2000-level mean grades required for MPhys Honours entry
66	15.4	
67	15.8	
68	16.2	
69	16.6	Deans' List threshold
70	17.0	
71	17.1	
72	17.2	
73	17.3	
74	17.4	
75	17.5	
76	17.6	
77	17.7	
78	17.8	
79	17.9	
80	18.0	
81	18.1	
82	18.2	
83	18.3	
84	18.4	
85	18.5	
86	18.6	
87	18.7	
88	18.8	
89	18.9	
90	19.0	
91	19.1	
92	19.2	
93	19.3	
94	19.4	
95	19.5	
96	19.6	
100	20.0	

Progression to Honours Physics and Astronomy

More details are given in appendix E of this handbook, but in general terms, those wishing to join the physics or astronomy honours programmes normally need to pass specified 2000-level modules for entry to BSc Honours, or achieve 15 or better in specified 2000-level modules for entry to MPhys Honours. Astrophysicists need to do likewise in second year astrophysics. Full details are on the University website and the programme requirements.

Deans' List

The University has an annual award for academic excellence, promoted by the Deans of the University. Details can be found in the University Student Handbook: Deans' list.

Penalties for late submission and word/space limits

In those cases where work requires to be handed in for marking, a deadline will be defined in advance and one of a defined range of penalties will be applied for late submission, as per the University policy on coursework penalties.

If no specific penalty is noted, then the "default" penalty of the School will be used, which is penalty A stated in the University policy. If you are unclear about the penalties associated with the late submission of any piece of assessed work, please contact the member of staff concerned.
Where word or page limits apply to a piece of work to be submitted, any penalties for not satisfying the criteria will be published to students in advance. If no specific penalty is noted, then the "default" penalty for this School is penalty A in the University policy.

For the case of laboratory work in Physics 1A, Physics 1B, Physics 2A, Physics 2B, and Astrophysics AS2001 you will need to manage your time effectively and ensure that all continuously assessed work is submitted for marking by stated deadlines. Marks will be deducted under a modified version of Scheme B of the University's policy on coursework penalties, where a valid explanation for failing to submit on time is not forthcoming. Scheme B as written will apply except in the cases of a paper submission being due, or already overdue, for submission at 17:00 on a Friday.

Where such a piece of work is submitted on the subsequent Monday before 10:00 (Physics 2 and Astro 2) or 12:00 (Physics 1) a 10% penalty (in addition to any penalties accrued before 17:00 on Friday) will be applied; this being largely consistent with a missed deadline on any other weekday.

Submission after those times on the Monday will result in the application of the full penalty applicable under Scheme B, inclusive of Saturday and Sunday, i.e. 45% in

addition to any penalties incurred before 17:00 on the Friday and subsequent to 17:00 on the Monday.

For the case of laboratory work in AS1X01 lab books are normally expected to be submitted at the end of the lab session. Marks will be deducted under a modified version of Scheme B of the University's policy on late submission of work, where a valid explanation for failing to submit on time is not forthcoming. Scheme B will apply except in the cases of a paper submission being due, or already overdue, for submission at 17:30 on a Friday. Where such a piece of work is submitted on the subsequent Monday before 09:30 there will be a 10% penalty, a 15% penalty for work submitted up until 17:30, and so on, on top of any penalty already gained by the Friday afternoon.

The Gateway modules PH1501, PH1502, PH1503 will all use University scheme B for any work that is submitted late.
Students are expected to be at written exams, class tests, and similar scheduled assessments, and will be given a zero if they do not attend without good reason.

Good academic practice, and academic misconduct

See the University Student Handbook on good academic practice. Academic integrity is fundamental to the values promoted by the University. All students must exhibit good academic practice and should familiarise themselves with the University policy on good academic practice and its guidance on the policy.

"Not knowing" the regulations is not regarded as an acceptable excuse for academic misconduct. The University takes academic misconduct offences extremely seriously, and penalties even for first offences can be severe.

Proof reading

The University has a policy on proof reading for language correction.

Unless forbidden in the assignment instructions, our School permits the use of proof reading for language correction under the conditions of this policy. Please note that there is a major difference between proof reading for language correction at sentence-level and wholesale restructuring of written work or "ghost writing". The latter two may lead to hearings under the University's Good Academic Practice policy.

Feedback, and access to examination scripts

See University Student Handbook: Feedback on assessed work. You should be able to receive feedback on any piece of work that you are asked to submit. Part of the learning process is reflecting on this feedback and making note of what aspects of your work process you wish to repeat in future assignments, and what improvements you should strive for in the future. If you are not clear from any written or oral comments what are the issues involved, please discuss this with the person

who marked the work, or if this is not possible then with the relevant module coordinator. Work submitted for tutorials may be discussed in the relevant tutorial. Generic feedback to students after an exam is usually posted on Moodle.

Students may see their examination scripts after the assessment process has been completed. Students wishing to do this should contact their module coordinator in the first instance.

Appeals and complaints

The University is committed to ensuring as high a quality student experience as possible while studying at St Andrews. Occasionally things may go wrong and if you are experiencing a difficulty, or are dissatisfied with your academic experience, you should raise concerns as soon as possible. See the University Student Handbook: Academic appeals and complaints.

For possible academic appeals involving this School you are invited to discuss the matter informally with relevant staff in the School first.

If there are extenuating personal circumstances that may affect your academic performance or impact on your progression you **must** bring these to the attention of an appropriate member of staff (for example your Adviser of Studies, module coordinator or the appropriate Associate Dean) as soon as possible and normally prior to completing any assessment. If you base a subsequent academic appeal on such extenuating personal circumstances, you will be required to provide valid reasons to explain why you failed to notify the examiners or other relevant persons of these circumstances prior to completing the assessment.

Within the School of Physics and Astronomy, any complaint or appeal should be addressed (after any informal approach has been tried) to the Director of Teaching or, if the Director of Teaching has already been involved, to the Head of School. Academic issues which could be the subject of an appeal or complaint include the effects of extenuating personal circumstances materially affecting academic performance of which the University was not aware when the academic decision was taken, and which could not reasonably have been disclosed by the student, and the improper conduct of an assessment that has material impacted on the results awarded.
www.st-andrews.ac.uk/students/rules/appeals/policy/

The Students' Association employs Iain Cupples, the Student Advocate (Education), whose job it is to ensure that you receive help with writing and submitting a submission. Iain can also accompany you to any hearing. He should be your first point of contact as soon as you feel you need help.

Teaching Sessions

Lectures

Please make sure that you keep up to date with your studies, and aim to digest all the material from your lectures before each tutorial.

To get the most out of a lecture you should make your participation active. Take notes, consider how the material relates to previous study, note remaining questions you have, and prepare a summary in your own words of the main things you've learned from the lectures.

Active participation will be hugely beneficial to you. Our subject is so much more than a pile of facts to be memorised. Look for the underlying ideas. See how particular techniques can be used in different situations. Ask yourself what approximations have been made, and why these are (or are not) justified in different situations. Aim not just to be able to reproduce what you saw in this derivation or problem, but to be able to work out related but different derivations or problems on your own.

Think carefully about how best to structure your studies: it's a good idea to set time aside for serious study with each lecture. Ensure that each week you're up to date with reviewing notes, making summaries, tackling tutorial questions, and asking questions. In many lecture-based modules you will also do significant reading around the subject.

If you are having any issues (be they work or personal) which are affecting your studies on a module, please contact the module coordinator, the School's Student Wellbeing Officers, or Student Services to let them know so that they can assist.

Tutorials

Tutorials feature in many modules. For tutorials you should

- Consider beforehand the material covered up to that time in the module and work out what queries you may wish to bring to the discussions.
- Attempt all tutorial work that is scheduled to have been done by that session and consider what aspects of that you would like to discuss.

Laboratories

Prepare for the activity as requested, engage actively, be willing to ask questions where you have them, and aim to understand the broader learning goals not "just" how to do this particular thing that you are doing at that time.

J F Allen library

The J F Allen library is located in the Physics and Astronomy building. Some relevant books are also available as e-books.

If you have suggestions for additional physics and astronomy books that you think should be in the Library, please contact Dr Hongsheng Zhao (hz4@st-andrews.ac.uk) or email morebooks@st-andrews.ac.uk.

The Library's online reading list service enables you to find and access the books, journal articles, and other resources you are expected to use for your module. By clicking links in online reading lists you can see straight away the location and availability of books in the Library and get direct access to online resources. By logging in you can use the features which allow you to record what resources you've used, plan ahead, and create personal study notes. You can also export citations to Endnote from reading lists.

The Library subscribes to a large number of journals, most of which are available electronically. There are printer/photocopier/scanners in the Library, operated by your matric card. You can make payments to your account online.

To find out if your module has a reading list check the module in MMS or Moodle, or check the Online Reading List page on the Library website www.st-andrews.ac.uk/library/information/subjectguides/readinglists/

Online resources and information about books available can be searched from the Library's Physics & Astronomy page: http://libguides.st-andrews.ac.uk/panda. Past examination questions for the last few years are available via MySaint, and tutorial sheets and solutions for some modules are available via MySaint.

Main Library staff can offer assistance by email, phone or chat www.st-andrews.ac.uk/library/contact/. Vicki Cormie (vhc1@st-andrews.ac.uk) is the Academic Liaison Librarian for Physics & Astronomy and is happy to be contacted for any help in using Library resources.

Work spaces

The J F Allen library is one space in the building in which students may study; this it is intended to be a quiet area. Please check its availability.
The main concourse of the Physics and Astronomy building has group-study tables behind the cafeteria. These are equipped with large screen computer monitors. The main part of the concourse may be used as a study and/or social area.
The University Library is another study space. If seminar/tutorial rooms in the building are not booked out for teaching or meetings, it is normally possible to use these for work. In all cases, please adhere to any rules on room capacity. The School office staff can provide information on availability.

Computing facilities

The Physics and Astronomy PC classroom, which is next to the main entrance of the building, contains 32 PCs, a data projector, and Uniprint facilities,.
IT Services operate other clusters of computers and provide training in the use of hardware and software as well as the username and password required to log on the computers and for email. Many computers in the honours laboratory will be used by students during their lab/computational sessions, and may often be used outside laboratory time by students in the School for more general work-related activity.

Lockers

The School has a limited number of lockers available for rent (£10 annual fee plus £10 deposit). Initial priority is given to those in their honours years. Contact the Building Manager, Dr Andrew Bunting, asb8@st-andrews.ac.uk.

Student-Staff Council and School President

The Student-Staff Council (SSC) has representatives for students in each level of study, postgraduate representatives, and members of staff. Its primary purpose is to serve as a forum for the discussion of academic issues, but it also oversees some of the social facilities available in the building and some student activities. The SSC normally meets twice per semester. Meeting minutes may be accessed from the School's Student Staff Council web page.

The SSC is chaired by the School Student President, who is elected by students at the end of the previous session. For 2023-24 the School President is Anna Conti, and may be contacted by email at physicspresident@st-andrews.ac.uk.

Student representatives are elected from honours year and subject groups, and normally hold office for the whole academic year. Representatives discuss teaching matters with the Year Co-ordinator, and report to meetings of the Council on the issues raised and the action taken. All students are encouraged to discuss any issues directly with the relevant module coordinators or other members of teaching

All students staff, but may also raise concerns or comments with their class reps or the School President for transmission to the relevant member of staff and/or Student Staff Council.

The Vacation Awards Committee disburses grants to students studying in the School who wish to pursue worthwhile projects during the Summer vacation. The Social Committee is responsible for the organisation of some social events which may take place during the year.

Diversity, Respect, Community

The University of St Andrews is fully committed to respect and fair treatment for everyone, eliminating discrimination and actively promoting equality of opportunity and delivering fairness to all. Please see the University Equality, Diversity and Inclusion policy.

We are keen that this School continues to be a place where we all value and respect each other, and that we continue to have here a community of scholars that includes students and staff. We are keen that members of our community continue to assist and support each other.

The School's Equality, Diversity, and Inclusion Committee, which includes the School President, actively promotes this endeavour.

We are pleased to have "Juno Champion" status from the Institute of Physics and an Athena SWAN Silver award following submission of details of our activities aiming to provide a workplace that is good for all. Students with concerns or suggestions about equality or diversity are asked to speak to one of the committee.

Disabilities, learning differences, mental health, wellbeing

See University Student Handbook: Disability support and also the University's advice for students with disabilities.

If for disability or related reasons you require support, please contact the Disability Team in Student Services via the links above. Student Services provides support for a wide range of situations.

The School's disabilities and specific learning difficulties (SpLD) coordinator is available to liaise with any of the School's students. The School will work in conjunction with Student Services to ensure that appropriate reasonable adjustments are in place for students who have registered that they have a disability. Our aim is to try to make the same or equivalent facilities and experiences and learning outcomes available to all. However, notifications and adjustments

All students cannot always be immediate, and students are welcome to contact our disability officer directly to advise them of their situation.

Most of the JF Allen building is accessible to those with disabilities affecting mobility. This is via the main entrance and the lift located at the opposite corner of the building from the main entrance. In the event of an emergency the lift must not be used. Where students may have a problem evacuating the building in an emergency, particularly from the top floor, they should contact Environmental, Health and Safety Services who will, with the help of the School Disability Officer and Student Services, produce a Personal Emergency Evacuation Plan (PEEP). This plan will ensure that the person knows what actions to take in an emergency and also what actions the School needs to put in place to support evacuation in an emergency. An evacuation chair is in the stairwell outside room 301, roughly above the main entrance to the building. They may be able to make their presence known to the janitor or the emergency services using the telephone there.

We recognise that not all students are comfortable with disclosing difficulties with health, disability, etc, but the team members at Student Services are an excellent resource to give advice to students and schools on allowances and support, with due regard to confidentiality. We strongly advise relevant students to contact Student Services sooner rather than later. Most students have a one-to-one consultation with a member of staff from Student Services during their time in St Andrews.
www.st-andrews.ac.uk/students/advice/disabilities/

Student Services provides individual consultations for those with concern about wellbeing and about mental health. They also run events during the year, some for students who are concerned about their own wellbeing, and some for students who would like to learn more about how to help support a friend who may have anxiety, low mood, an eating disorder, etc.

An online system called Silver Cloud is available. This is a computer based self-help system that offers helpful programmes to address a range issues including low mood / depression, anxiety, stress and body image/eating worries. This system can be used independently by students, or by students with support from a member of staff in Student Services.
https://www.st-andrews.ac.uk/students/advice/personal/silvercloud/

We recognise that there are times when things can get tough for students. There are few people who sail through university without any problems. Please be aware that there are people here to assist you, both within the School (Wellbeing Officers, amongst others) and at Student Services. Please do communicate with them. You may also wish to speak with someone anonymously after hours, and this can be

All students done by a call to a trained student volunteer at Nightline between 8pm and 7am in term time on 01334 462266.
https://www.st-andrews.ac.uk/nightline/

Centre for Educational Enhancement and Development (CEED) resources

The University's Centre for Educational Enhancement and Development (CEED) can provide additional input to help students develop the skills they need for their academic studies and beyond. See the University Student Handbook: CEED.
More information is also available on the CEED webpages.

English Language Support

The Academic English Service (AES) offers free language development to matriculated students. The language development is offered in several forms, ranging from one-to-one tutorials to workshop programmes and online resources. Further information is available on the AES website and self-enrol Moodle page.
If you would like further information, please contact academicenglish@st-andrews.ac.uk.

Fees

There are no extra fees for pre-honours labs and similar in the School. In line with University policy, the School may expect students to purchase a small number of textbooks as part of their study.

Health and Safety

The Head of the School of Physics and Astronomy is responsible for health and safety within the School and its buildings and requires all persons who enter the buildings for any purpose to take reasonable care of the health and safety of themselves and of others. The School Safety Officer is listed in the key contacts section later in this handbook. The School's safety policy is available from the School webpage.

Lists of first aiders, their locations, and their contact numbers, are displayed on notices in the building. If you require first aid, please contact a first aider, or ask any member of staff to do this for you. Mrs Linda Cousins in the School Office is one of the first aiders.

First aid boxes are located at the main entrance, in the School Office, outside room 301, outside the honours teaching labs, and at the lift entrances. The nearest first aid box is noted on the first aid notices around the building. An emergency evacuation chair for those with mobility difficulties is in the corridor outside room 301.

Anyone who is in the J F Allen building outside the time during which there is janitor cover should sign in and out in the late working book at the janitors' desk.

Academic Session

The dates for the session, including examination periods, are published on the University's web pages on semester dates.

Orientation Week is an integral part of the University semester, and students are expected to devote some time in this period to their studies. Many classes will run on the Thursday and Friday of Orientation Week. Independent Learning Week (week 6 of the semester) has no scheduled classes, but is a good chance to spend time consolidating your studies in the semester up to this time, and preparing for the coming weeks. There may also be work set to be done over that week. Students are expected to be available for the entire examination period.

Finding Referees

Students are likely to wish to use members of academic staff as referees in applications for summer work experience, etc. To this end, they are advised to cultivate a professional relationship with appropriate staff members. The more a member of staff knows about a student, the more useful a reference they can write. A student's tutor may be in a good position to write a reference. Students should seek the permission of staff members to use them as referees before naming them. As staff members are not permitted to disclose information about students without explicit permission, potential referees may ask for written statements from students authorising disclosure. It may be worth noting that student attitude and attainment through their time at St Andrews can be relevant, which may be another reason for working hard throughout the degree programme.

Appendix A - Key Contacts/Coordinators

School Level		Room	Email
Head of School	Prof Ian Bonnell	215	hospanda
Director of Teaching (DoT)	Dr Paul Cruickshank	305	physdot
Director of Research	Prof Peter Wahl	207	physdor
Director of PG Research Studies	Prof Vivienne Wild	308	physdopg
Secretary (teaching matters)	Mrs Linda Cousins	211	physics
School Senior Secretary	Ms Lesley Aitken	211	physics

Advisers of Study

Pre-honours	Dr Claudia Cyganowski	335	cc243
	Dr Michael Mazilu	337	mm17
	Dr Antje Kohnle	314	ak81
	Dr Andreas Rost	333	a.rost
	Dr Juan Varela	342	jv32
Junior Honours	Prof Graham Smith	219	gms
	Prof Moira Jardine	318	mmj

Module and programme coordinators

Physics 1A	Dr Bruce Sinclair	221	b.d.sinclair
Gateway PH1501	Dr Irina Leonhardt	210	il4
Gateway PH1502 & PH1503	Dr Lucy Hadfield	304	ljh11
Astronomy AS1001	Dr Aleks Scholz	331	as110
Astronomy AS1101	Dr Anne-Marie Weijmans	334	amw23
Physics 2A and 2B	Prof Graham Turnbull	220	gat
Astronomy AS2001 and AS2101	Dr Claudia Cyganowski	335	cc243

Examination Officer	Prof Brendon Lovett	205	panda-exams
Disabilities Coordinator	Mrs Linda Cousins	211	physics
Health and Safety Officer	Dr Andrew Bunting	244	asb48
Wellbeing Officer	Dr Sebastian Schulz	343	panda_wellbeing
Wellbeing Officer	Dr Lucy Hadfield	304	panda_wellbeing
First Aid	Mrs Linda Cousins et al	211	physics
Deferred exams etc requests	Dr Paul Cruickshank	221	physdot
Library rep	Dr Hongsheng Zhao	316A	hz4
Careers Officer	Prof Graham Smith	219	gms
Equality, Diversity and Inclusion	Dr Janet Lovett	243	physeqdiv
School Student President	Anna Conti	physicspresident	

For full contact details of all School staff, please see the School's People web page.

Appendix B: Syllabuses of 1000-level Modules

This list of module offerings is for illustrative purposes only and does not constitute a guarantee of the specific modules or module content to be offered in future years.

PH1011 Physics 1A

Mechanics I (10 lectures) **Dr Lucy Hadfield**

Kinematics: Vectors and scalars. Motion with constant acceleration in a straight line and in two dimensions. Motion under gravity. Calculation of projectile trajectories, including maximum height, time of flight, range etc.

Dynamics: Newton's laws of motion, force, mass, and acceleration, inertial reference frames. Work and energy, including potential energy, kinetic energy, and energy conservation.

Momentum: conservation of momentum in the absence of external forces, impulse of a force

Waves and Optics (15 lectures) **Dr Bruce Sinclair**

What is Light? Ideas of waves and particles, and how light is generated.

Ray Optics: Snell's law, and the use of a lens for imaging. Thin lens formula.

Oscillations: SHM of spring. Velocity, acceleration and phase, for mechanical oscillations. Extension to a pendulum. Relation between SHM and circular motion. Energy in SHM. Tuning fork and other resonators.

Travelling Waves: Transverse and longitudinal travelling waves, and connection with oscillations. Sound waves, waves on strings, Electromagnetic waves. Transverse velocity and acceleration. Energy carried by a wave. Doppler effect for sound, extended to light. Superposition, beats, phase change on reflection.

Standing Waves: Standing waves on strings. Nodes and antinodes. Resonant wavelengths and frequencies in strings and pipes. The laser resonator.

Wave Optics: Young's slits and two beam interference. Temporal and spatial coherence and its relevance to interference patterns. Michelson interferometer and its use in precision length measurements. Anti-reflection coatings and thin-film interference. Multiple-beam interference. Wavelength separation by diffraction grating.

Properties of Matter (14 lectures) **Dr Janet Lovett**

Atomic basis of matter: Atoms and molecules, Dalton's and Avogadro's hypotheses, atomic weight, the mole, Avogadro's number.

Nature of atoms: charge quantisation, measurement of e and e/m for electrons. Behaviour of charged particles in electric and magnetic fields.

The nucleus: radioactivity, α, β and γ rays, exponential decay, half life, nuclear size. Isotopes, radioactive series. Protons and neutrons.

Thermal physics and kinetic theory: Temperature scales and the gas laws. Evidence for and assumptions of simple kinetic theory. Derivation of pressure formula. Molecular speeds and kinetic energy. Mean free path. Thermal conductivity, convection and radiation.

Laboratory work and maths revision **Dr Cameron Rae**

Develop core laboratory skills in data gathering, uncertainty analysis, and diagnostic instrumentation while exploring aspects of physics in a practical manner.

PH1012 Physics 1B

Mechanics II (11 lectures) **Dr Lucy Hadfield**

Circular motion: uniform circular motion, angular velocity, angular acceleration, centripetal acceleration Newton's laws of motion in angular form.

Newton's universal law of gravity: Analysis of satellite orbits, escape velocity, gravitational potential energy.

Rigid Bodies: Centre of mass, torque

Quantum Phenomena (16 lectures) **Prof Steve Lee**

Early quantum ideas: Photoelectric effect and Compton effect. Rutherford's and Bohr's models of the atom. Spectral lines, Rydberg constant.

Energy levels: Atomic spectra

De-Broglie's matter waves: Diffraction of electrons, neutrons, etc. Wave function, probability and uncertainty. Heisenberg's uncertainty principle.

Schrödinger's Equation: Introduction and examples of its applications

Selected topics from modern quantum science: Quantum technology and Bose-Einstein condensates.

Lasers and Optoelectronics (6 lectures) **Dr Juan Varela**

Lasers: Introductory overview on lasers and their applications. Basic energy level structures for laser-related media. Einstein A, B coefficients, gain coefficient, laser threshold conditions. Laser oscillator and amplifiers. Properties of laser radiation and important types of laser gain media. Some applications of lasers in science, engineering and medicine.

Group Discovery Project (9 lectures equivalent)

In groups of typically six, students will explore a real-world problem applying and extending their knowledge of physics. Students will work self-guided in groups with introductory whole-class sessions and individual group facilitator sessions to review and aid their progress. At the end of the project each group will submit a written report.

Laboratory work **Dr Cameron Rae**

Explore aspects of physics in a practical manner, broaden competence in experimental and diagnostic instrumentation, and take part in problem-based-learning laboratory group work.

PH1501 Gateway - Maths for Physicists 1A Dr Irina Leonhardt

This module aims to introduce a range of mathematical techniques required for physics and engineering degrees, practise in the use of these techniques, and to demonstrate the application of these techniques to problems in physics and astronomy.

The topics covered include basic algebra (inequalities, functions, coordinate systems, algebraic manipulation, partial fractions), geometric sequences and series, techniques of differentiation and integration, and an introduction to solving differential equations.

PH1502 & 1503 Gateway – Physics Skills 1A & 1B Dr Lucy Hadfield et al

Study Skills:

An Introductory overview of general study skills including time management, study and note taking, literature retrieval and evaluation, critical reading, effective revision skills, personal development and reflective feedback.

Physics skills:

Including unit conversion, estimating and order of magnitude calculations, dimensional analysis, scientific writing, planning and execution of practical work.

Physics in context:

General problem-solving in physics, numerical and analytical reasoning,

Astronomy Short Course:

Solar System: structure, evolution and origin.

Planets and life: Detection and properties of extrasolar planets: bias introduced by detection methods, introduction to astrobiology.

Galaxies: Structure of the Milky Way galaxy; galaxy classification; galaxy formation and evolution.

Stellar evolution: Stars and the Hertzsprung-Russell diagram; mass-luminosity relation; stellar evolution for high and low mass stars; stellar nucleosynthesis

AS1001 Astronomy & Astrophysics 1

The Solar System (10 lectures) **Dr Hongsheng Zhao**

Brief historical introduction including basic observations and the calendar, leading to Kepler's laws of planetary motion and Newton's law of gravitation. Modern exploration of the Solar System and the study of the physical properties of the planets and their satellites - interior structure, atmosphere and climate, magnetospheres and interactions with the solar wind; physical properties of comets, meteors. The atmosphere of the Sun -photosphere, chromosphere, corona and the solar wind. Origin of the Solar System.

Stars and Elementary Astrophysics (10 lectures) **Dr Aleks Scholz**

Astronomical observations. Telescopes: optical, radio, space. Stellar brightness, apparent and absolute magnitudes, distances, inverse square law. Colours of the stars, black body radiation laws and temperature. Spectra from astronomical sources; Kirchhoff's laws for continuous, emission and absorption spectra. Spectral classification; excitation and ionisation; determination of stellar compositions. Distribution of stellar parameters; the Hertzsprung-Russell diagram. Stellar motions: Doppler effect, radial velocity, redshifts; proper motion. Binary stars for masses, radii, luminosities;

The Galaxy (10 lectures) **Dr Claudia Cyganowski**

The main-sequence mass-luminosity relationship. Star clusters, their colour-magnitude diagrams, and distances via main-sequence fitting. Effects of interstellar extinction. Spatial distribution of star clusters, differences in chemical composition. Outline of stellar evolution from formation through to end states of white dwarfs, neutron stars and black holes. Mass loss from stars, supernovae. The interstellar medium. Structure of the Galaxy -population groups, spiral structure, rotation curve.

Cosmology (10 lectures) **Dr Rita Tojeiro**

A preview of the universe. The extragalactic nebulae (galaxies). The determination of extragalactic distances. Types of galaxies. The Hubble classification. Properties of galaxies - sizes, masses, spectra and luminosities. The distribution of galaxies in space - clusters and superclusters. The red-shift - distance relation. Hubble's law. The expansion of the universe. The age of the universe. The Big Bang origin of the universe. A critical density for expansion and contraction. The evolution of the universe.

Practical Work

AS1101 Astrophysics (Direct Entry) Dr Anne-Marie Weijmans

This module provides a streamlined (condensed) introduction to the science of astrophysics for students who have taken direct entry to Second level and who are planning to take level two astrophysics in the second semester of the same academic year. We will cover the essential items of observational astrophysics, and how radiation that we detect on Earth can be used to develop physical models of planets, stars, the Milky Way, other galaxies, and the Universe as a whole. Topics will include stellar evolution, composition and dynamics of galaxies, black holes, the need for dark matter, the expanding Universe, and the discovery of dark energy.

Appendix C: Syllabuses of 2000-level Modules

This list of module offerings is for illustrative purposes only and does not constitute a guarantee of the specific modules or module content to be offered in future years.

PH2011 Physics 2A

Mechanics (18 lectures) **Dr Lucy Hadfield**

Dynamics of a single particle: Newton's laws of motion, inertial reference frames. Momentum, conservation of momentum in absence of external forces. Central force problems: velocity and acceleration of particles in plane polar coordinates. Work, energy and power. Conservative forces, relation between force and potential energy. Friction. Torque. Conservation of angular momentum.

Gravitation: Newton's gravitational force law, potential energy for point source. Kepler's laws for planetary motion.

Dynamics of a system of particles: Centre of mass. Internal and external forces. Translational equation of motion. Torque. Angular momentum and kinetic energy of a rotating system. Rotational equation of motion. Rigid bodies. Moments of inertia. Parallel and perpendicular axis theorems.

Oscillations in Physics (7 lectures) **Prof Graham Turnbull**

Introduction to oscillations. Mathematical description of oscillations. Circular motion and simple harmonic motion (SHM). Energy in SHM. Examples of SHM: spring-mass systems, pendulums, other oscillating systems. Damped oscillations. Types of damping, Q factor. Forced oscillations. Resonance. Examples of resonant systems. Coupled oscillations and normal modes.

Thermal Physics (11 lectures) **Dr Paolo Annibale**

Temperature, pressure and translational kinetic energy. The thermodynamic temperature scale. The notion of thermal equilibrium. Degrees of freedom. Reversible and irreversible processes. The zeroth law. Ideal gases. Mean Free Path and Maxwell Speed Distribution. Types of thermometer. Thermal expansion (linear, area and volume), interatomic forces and Lennard Jones Potential, crystal structure, elasticity. Equations of state.

Work, heat and the First law of thermodynamics. Heat capacity and phonons. Heat transport, conduction, convection and radiation. Phase changes and latent heat. Adiabatic processes, free expansion of a gas.

Entropy and the second law of thermodynamics. Direction of time. Heat engines, heat pumps, refrigerators, efficiency. Entropy from a statistical viewpoint.

Special Relativity (9 lectures) **Dr Charles Baily**

Inertial frames and Galilean relativity. The Galilean transformation equations. The postulate of special relativity. Clock synchronisation and the relativity of simultaneity. Length contraction, time dilation, and the Lorentz transformations. Proper time, invariants, and space-time diagrams. Transformation of velocity. Relativistic Doppler effect. Relativistic momentum and energy. Conservation principles and relativistic collisions.

Mathematics Revision **Dr Irina Leonhardt**

Trigonometry, dimensional analysis, complex numbers, vectors, functions, graphs, differentiation and integration, differential equations, and Taylor series.

Laboratory work **Dr Cameron Rae**

Direct entry to second year students initially follow a focused laboratory skills development programme that includes: precision and accuracy, error propagation, data analysis and graphical representation, experimental technique and laboratory notebook keeping. All students explore aspects of physics in a practical manner, broaden competence in various forms of experimental and diagnostic instrumentation and will develop data handling and interpretation skills.

PH2012 Physics 2B

Electricity and Magnetism (21 lectures) **Dr Bruce Sinclair**

Basic electrostatics: Coulomb's Law, electric field E, electric field from discrete and continuous distributions. Electric potential V, relation between E and V, examples.

DC circuit theory: electric current and drift velocity of charge-carriers. Electric potential and Kirchoff's laws. Input and output impedance of circuits, equivalent circuits.

Gauss' law and capacitors: electric flux, Gauss' law, use to solve fields around high-symmetry charge distributions, electrostatic shielding, capacitors, role of dielectric materials in capacitors.

Magnetic effects of currents: forces on charges moving in a magnetic field, Biot-Savart law and application to long straight wire and coil, force between two current carrying wires and the definition of the units of current, Ampere's law and examples.

Electromagnetic Induction: Faraday's law, Lenz's law, induced electric fields, self and mutual inductance.

Electricity and magnetism unified via relativity (qualitative). Magnetic materials.

Classical Waves (12 lectures) **Dr Paul Cruickshank**

Waves on stretched strings, the wave equation, wave velocity, transmission of energy, sound waves and light waves, the Doppler effect in sound, superposition of waves, standing waves, Fourier series, interference, Bragg scattering, beats, phase, dispersion, phase and group velocity, reflection and transmission of waves at an interface or boundary, the e-m spectrum, polarisation.

Quantum Physics (18 lectures) **Dr Charles Baily**

Photoelectric effect and photodetectors. Optical devices and single-photon experiments. Probabilistic measurements, expectation values. Entanglement and the physical interpretation of quantum mechanics. Wave functions and the Schrödinger equation in one dimension. Operators and eigenvalues. The uncertainty principle. Infinite- and finite-depth square well potential. Quantum tunnelling.

Laboratory work **Dr Cameron Rae**

All students explore aspects of physics in a practical manner, broaden competence in various forms of experimental and diagnostic instrumentation and develop analysis skills. Explore the science behind passive, pn-junction and op-amp devices and their incorporation in circuit designs while developing practical skills in electronics and develop computational skills through work with microcontrollers. Develop scientific writing skills.

AS2001 Astronomy & Astrophysics 2

Stellar Structure and Evolution (11 lectures) **Dr Kenny Wood**

The determination and distribution of stellar masses, radii and luminosities; the Hertzsprung-Russell diagram, mass-luminosity law and Vogt-Russell theorem. Sources of stellar energy, nucleosynthesis of hydrogen, helium and carbon. Star formation and evolution; the ages of star clusters; supernova events and the synthesis of heavy elements. Final states - white dwarfs, neutron stars (pulsars) and black holes. The evolution of binary stars - Roche lobe overflow, accretion discs and novae.

Exoplanetary Science (11 lectures) **Dr Paula Stella Teixeira**

Building on earlier work in the module, this course looks at the formation of planets in circumstellar accretion discs and the implication for internal structures of gas-giant and terrestrial-like planets. Theoretical models and observational techniques are discussed.

Galactic Astronomy (11 lectures) **Dr Anne-Marie Weijmans**

This course will investigate the distribution and motions of stars, gas and dust within our own galaxy in order to determine its dimensions and overall properties. Properties of other galaxies will be discussed. Topics include: galactic coordinate systems; the solar motion and distribution of stellar velocities; differential galactic rotation, the rotation velocity at the Sun and the distance to the Galactic Centre; rotation curves of the Milky Way and other galaxies; galaxy masses and "dark" matter.

Observational Techniques (11 lectures) **Dr Claudia Cyganowski**

This course provides an introduction to topics relevant to planning and interpreting astronomical observations, including: modern telescopes and telescope design; instruments and detectors for multiwavelength astronomy, including CCDs; atmospheric seeing and extinction; active and adaptive optics; photometry; spectroscopy; aperture synthesis imaging; essential coordinate systems

Laboratory work

AS2101 Astrophysics

As AS2001, but without the laboratory work and the Observational Techniques lectures.

Appendix D: Honours Degree Programmes

The honours degrees currently available are set out below. Several of these are taught wholly within the School of Physics and Astronomy, the others being given jointly with the other schools concerned. Full details of the content and structure of these programmes are contained in the separate booklet for Honours students, and the necessary modules are set out in the University's programme requirements.

BSc degrees	
Single Honours	Astrophysics
	Physics
Joint Honours	Physics and *one* of
	Philosophy
	Mathematics
MSci degree	
Joint Honours	Physics and Chemistry
MPhys degrees	
Single Honours	Astrophysics
	Physics
	Theoretical Physics
Joint Honours	Theoretical Physics and Mathematics

To obtain any one of these degrees it is normally necessary to include at second level PH2011 Physics 2A, PH2012 Physics 2B, MT2501 and MT2503 Mathematics and (for those wishing to do the Astrophysics degree) AS2001 or AS2101 Astrophysics 2. Those proceeding to a joint honours degree must also satisfy the requirements of the other subject.

The grades normally required in these modules for admission to each degree programme are set out in the University's programme requirements and summarised in appendix E. Those wishing to join the physics or astronomy honours programmes need to be aware throughout level two of the need to obtain good grades in modules to be allowed to progress to an honours programme (as well as to get good understanding and knowledge to serve as a good foundation for advanced study).

After the end of the second semester, an offer of a place in one or more of the honours programmes will normally be made to those who have achieved the required grades in the relevant second level subjects. In most cases, a final decision by a student regarding choice of honours degree need not be made until the start of the third level or even later.

Appendix E: Honours Entry Requirements

Please see the University's programme requirements which are the definitive statements on what the standard requirements are. Below is a summary of the normal requirements. Please also see the University's policy on entry to Honours and on the following page.

Students entering honours are expected to have 240 pre-honours credits (for accelerated-entry students 120 of these may be "advanced standing" credits").

For entry based on first sitting of module exams the requirements are normally

BSc Honours Programmes
Passes in PH2011 and PH2012 and
Passes in MT2501 and MT2503

For the BSc in Astrophysics, a pass is also required in AS2001 or AS2101.

For joint degree programmes, there will be additional requirements from the other School.

MPhys and MSci Programmes
Passes at mean grade 15 or better in PH2011 and PH2012 and
Passes at mean grade 15 or better in MT2501 and MT2503

For the MPhys in Astrophysics, a passing grade in AS2001 or AS2101 is included in the calculated mean with PH2011 and PH2012.
For the joint degree programmes, also the requirements of the other School.

Those in the BSc honours cohort who achieve particularly well through JH and who wish to move to the MPhys cohort may be permitted to do so. Students who fail to meet the requirements for entry to honours in their chosen degree programme are eligible to request a review of the decision. Please see the University policy on requests for review of Honours entry decisions.

DISCLAIMERS

Some of the arrangements detailed in this booklet may have to be changed, and there may be errors. The School will endeavour to notify registered students of any significant updates to this document. The University's centrally published regulations will normally take precedence in any disagreement with matters stated in this handbook. If you become aware of any disagreement, please consult with Paul Cruickshank as soon as possible.
Things that are planned for session 2023-24 may not necessarily be in place in future sessions. PASC 2023_09_08