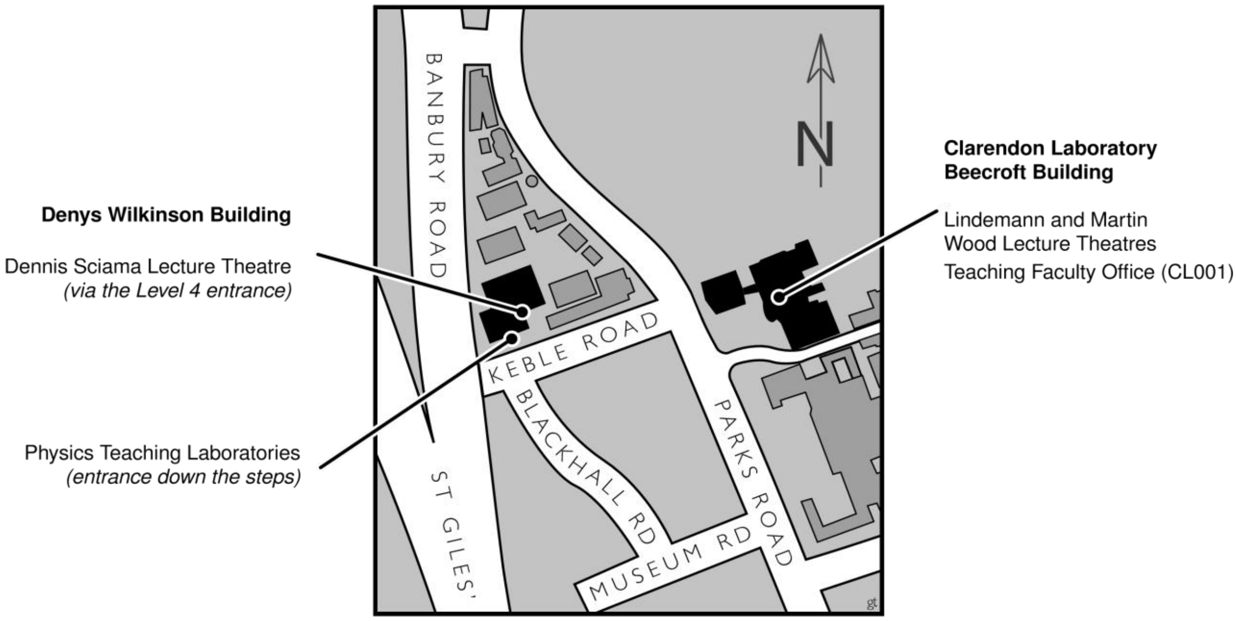
Physics Undergraduate Course Handbook 2020-2021

First Year (Prelims)

UNIVERSITY OF OXFORD

Map of the Department of Physics Buildings



Useful Department Contacts

Head of Teaching	Prof H Kraus hans.kraus@physics.ox.ac.uk	
Assistant Head of Teaching	Mrs C Leonard-McIntyre carrie.leonard-mcintyre@physics.ox.ac.uk	72407
Disability Contact	Mrs C Leonard-McIntyre carrie.leonard-mcintyre@physics.ox.ac.uk	72407
Teaching Laboratory Manager	Dr Jenny Barnes jenny.barnes@physics.ox.ac.uk	73491
Teaching Office Administration Officer	Miss H Glanville hannah.glanville@physics.ox.ac.uk	72369
Teaching Office e-mail address	teachingadmin@physics.ox.ac.uk	
Teaching lab support	labhelp@physics.ox.ac.uk	
PJCC Website	https://pjcc.physics.ox.ac.uk/	

These notes have been produced by the **Department of Physics**. The information in this handbook is for the academic year Michaelmas Term 2020, Hilary Term 2021 and Trinity Term 2021.

Contents

Coronavirus (Covid)

The University publishes updates at https://www.ox.ac.uk/coronavirus. Adaptations to the physics undergraduate course, made necessary due to Coronavirus (Covid) derive from the university guidelines and are laid out within the lectures and practical course arrangements.

Introduction to the handbook

A handbook is provided for each year of the programme and it is also useful to read the handbooks on topics available in later years. This handbook contains, amongst other things, a comprehensive book/reading list, also available via ORLO (Oxford Reading List Online); important dates for the academic year; information about the undergraduate consultative committee (PJCC); and a list of people involved in organising the course. Please read this handbook thoroughly and refer to it frequently, as it will often contain the answers to many common questions.

Other useful sources of information:

Full details about the Practical work can be found in this handbook and on Canvas.

Please refer to the *Physics and Philosophy Course Handbook* at http://www2.physics.ox.ac.uk/students/undergraduates for all details of the Physics and Philosophy course that are not covered in the *Physics Undergraduate Course Handbook*.

For particular information about college teaching, students should contact their tutors. Further information about the courses can be obtained from the Department of Physics website http://www2.physics.ox.ac.uk/students/undergraduates and from the Physics Teaching Office.

In this document, Michaelmas Term (MT), Hilary Term (HT), Trinity Term (TT), refer to Michaelmas, Hilary and Trinity Terms of the academic year, respectively. The weeks in each term are numbered as 1st week, 2nd week and so on, with 0th week being the week immediately before the start of full term.

For full and up-to-date information on follow this link to the lecture timetables.

The examination times given in this handbook are based on information available in September 2020. These may change and the definitive times are those published by the examiners on the official examiners' page.

The Examination Regulations relating to this course are available at https://examregs.admin.ox.ac.uk/. If there is a conflict between information in this handbook and the Examination Regulations then you should follow the Examination Regulations. If you have any concerns please contact the Assistant Head of Teaching by e-mail at carrie.leonard-mcintyre@physics.ox.ac.uk.

The information in this handbook is accurate as at **5 October 2020**, however it may be necessary for changes to be made in certain circumstances, as explained at http://www2.physics.ox.ac.uk/students/undergraduates. If such changes are made, the Department will publish a new version of this handbook together with a list of the changes and students will be informed.

Important dates and deadlines

Michaelmas Term	Event	Time	Location
Week 0	Introduction to the Department (Induction)	Fri 14:15	Online only
Week 1	Laboratory Introduction	Mon 12:00	Online only
Week 1	Safety Lecture	Mon 14:00	Online only
Week 4	Deadline for CO01 (computing)	Fri 17:00	Teaching Laboratories
Week 8	Deadline for CO02 (computing)	Fri 17:00	Teaching Laboratories

Hilary Term	Event	Time	Location
Week 4	Entry for Prelims	Fri	*
Week 7	Deadline for CO6x (computing)	Fri 17:00	Teaching Laboratories

Trinity Term	Event	Time	Location
Week 1	Last day to do practicals and get any outstanding work assessed	Fri 10:00	Teaching Laboratories
Week 2	Deadline for marking Practical work	Fri noon	Teaching Laboratories
Week 3	Entry for Short Option choices	Fri	*
Week 7	Prelims examination		**

* Students submit their entries via their College Office and Student Self Service.
** See https://www.ox.ac.uk/students/academic/exams/timetables for the exam timetables.
*** See http://www.physics.ox.ac.uk/lectures/ for lecture details.

Introduction to the Department of Physics

The Department of Physics

The Department of Physics at the University of Oxford is one of the largest in the UK, with an average annual intake of just under 200 undergraduates, of whom approximately 180 study for an MPhys or a BA in Physics and approximately 15-20 for an MPhysPhil in Physics and Philosophy. The academic staff are based in six sub-departments: Astrophysics; Atmospheric, Oceanic and Planetary Physics; Atomic and Laser Physics; Condensed Matter Physics (including BioPhysics); Particle Physics and Theoretical Physics. These represent the main areas of research carried out in the Department.

The Department is located in **four** buildings shown on the map on page **2**: the Denys Wilkinson Building (DWB) on the west side of Parks Road; the Beecroft Building, Clarendon Laboratory and the Atmospheric, Oceanic and Planetary Physics Building on the east side of Parks Road. **You will need to use your University card to gain access to all physics buildings.** The Beecroft Building is a solely research building, and therefore not available for use by undergraduates.

The Physics Teaching Office

All undergraduate teaching is arranged and organised in the Department by the Physics Teaching Office. Tutorials are arranged by college tutors. The Physics Teaching Office is located in the Clarendon Laboratory.

Teaching Laboratories

All the undergraduate teaching laboratories are located on the lower two floors of the DWB, together with a reception area where undergraduates can meet and obtain refreshments; the entrance is from Keble Road down a flight of steps.

Lecture Theatres

There are lecture rooms in all buildings, the main ones being the Martin Wood and Lindemann Lecture Theatres in the Clarendon Laboratory and the Dennis Sciama Lecture Theatre in the DWB. The current entrance to the Clarendon laboratory is from the Martin Wood Building where you will find the Martin Wood Lecture Theatre. The Lindemann Lecture Theatre is on the first floor. To enter the DWB, go up the wide concrete steps from Keble Road; turn left at the top and the entrance is facing you. Once inside, the lecture theatre is one floor up from the entrance.

Communications

Academic staff have pigeon holes in the building where they have an office and there is a messenger service that can be used to deliver mail between colleges and departments. Staff may also be contacted by telephone or by e-mail.

All administrative information about the course and the examinations is sent to students by e-mail. It is **essential** that students using e-mail accounts~~,~~ other than their college account, **joe.bloggs@college.ox.ac.uk**, set the forwarding appropriately and check their e-mail regularly, **at least once a day during term.** Some important information from the Physics Teaching Office and University is sent to individual students by the messenger service, or is distributed via College Senior Physics Tutors. Notices about the examinations are posted on the official examiners' page.

Computers

In a normal year, there are numerous computer workstations in the teaching laboratories on Level 2 of the DWB and normally students can use the computers at any time during office hours including during vacations. However, in the current global situation, this facility is closed for the academic year 2020-21. We recommend that all students obtain use of a computer, either their own personal laptop or use of a college computer. The colleges all have computing facilities for their undergraduates and there is a University-wide network, which enables students to access Departmental sites and the internet. Undergraduates will also receive an account and a College e-mail address on the University computing system. All new users will be asked to abide by the University Rules on the use of computers (see https://www.ox.ac.uk/students/life). Students should check their e-mails regularly, **at least once a day during term**.

Social spaces and facilities

Normally, students are allowed to use the Common Rooms in the Clarendon Laboratory and the DWB for meals and refreshments. There are vending machines in the reception area of the teaching laboratories in the DWB and in the corridor on the first floor of the Clarendon Laboratory between the Lindemann and the Martin Wood Lecture Theatres. **You may not take any food or drink into the lecture theatres, the teaching laboratories or near any departmental computers.**

Libraries

College libraries are generally well stocked with the recommended physics textbooks, but if your library is without a book you need you should tell your tutor or your College librarian. A list of the books recommended by the lecturers is given in **Appendix A** and is also available via ORLO (Oxford Reading List Online).

Policies and Regulations

The University has a wide range of policies and regulations that apply to students. These are easily accessible through the A-Z of University regulations, codes of conduct and policies available on the Oxford Students website www.ox.ac.uk/students/academic/regulations/a-z. In particular, see the Policy on recording lectures by students (located at: http://www.admin.ox.ac.uk/edc/policiesandguidance)

Data Protection

The Physics Department follows the general guidelines laid down by the University in regard to the provisions of the Data Protection Act 1998 (see http://www.admin.ox.ac.uk/dataprotection/ for details.) Only student information relevant to the organisation of the physics courses is held by the Department.

University Policy on Intellectual Property Rights

The University of Oxford has arrangements in place governing the ownership and exploitation of intellectual property generated by students and researchers in the course of, or incidental to, their studies. More details are available at https://researchsupport.admin.ox.ac.uk/innovation/ip/policy

Copyright

Guidance about copyright is published at https://www.ox.ac.uk/public-affairs/images/copyright**.** The University holds a licence from the Copyright Licensing Agency (CLA) which permits multiple copying (paper to paper) from most copyright-protected books, journals, law reports, conference proceedings and magazines for use by students and the course tutor on registered taught courses and non-credit-bearing short courses.

Good academic practice and avoiding plagiarism

"Plagiarism is presenting someone else's work or ideas as your own, with or without their consent, by incorporating it into your work without full acknowledgement. All published and unpublished material, whether in manuscript, printed or electronic form, is covered under this definition.

Plagiarism may be intentional or reckless, or unintentional. Under the regulations for examinations, intentional or reckless plagiarism is a disciplinary offence" see www.ox.ac.uk/students/academic/guidance/skills/plagiarism.

The Teaching Office uses "*Turnitin*" as a tool that allows papers (projects) to be submitted electronically to find whether parts of a document match material which has been previously submitted. All work submitted will be checked with Turnitin. Copying sources (e.g. Wikipedia) word for word will not be accepted, unless speech marks are used around a very short extract from the source and the source is correctly referenced.

See https://weblearn.ox.ac.uk/portal/hierarchy/skills/generic/avoidplag for an online course on avoiding plagiarism.

Support for disabled students

"Disability is a much broader term than many people realise. It includes all students who experience sensory and mobility impairments, mental health conditions, long-standing health conditions, social communication conditions or specific learning difficulties where the impact on day-to-day life is substantial and long term." [ref: Student Handbook 17-18.] The Department is able to make provision for these students. Contact the Assistant Head of Teaching, the Disability Contact for the Department, about your requirements. See http://www.admin.ox.ac.uk/eop/disab/ for more information. The *Examination Regulations* provide guidance for students with special examination needs, see http://www.admin.ox.ac.uk/examregs/ for more information.

Student Life, Support and Guidance

Every College has their own system of support for students, please refer to your College handbook or website for more information on who to contact and what support is available through your College.

Details of the wide range of sources of support are available more widely in the University and from the Oxford Students website (www.ox.ac.uk/students/welfare), including information in relation to mental and physical health and disability. Students are encouraged to refer to http://www.ox.ac.uk/current_students/index.html for further information.

Your College tutors provide advice about the Physics courses, and information is also available from the Physics Teaching Office.

Complaints and appeals

If you have any issues with teaching or supervision please raise these as soon as possible so that they can be addressed promptly. In **Appendix F**, you will find precise details for complaints and appeals.

Opportunities for skills training and development

A wide range of information and training materials are available to help you develop your academic skills – including time management, research and library skills, referencing, revision skills and academic writing - through the Oxford Students website.

Employability and careers information and advice

The University Careers Service (at 56 Banbury Road) provides careers advice for both undergraduates and graduates. One of their staff specialises in advising physics students. The service has excellent contacts with many employers, and maintains links with ex-Oxford students working in many different types of job. The Careers Service also has comprehensive details on post-graduate study in the UK or abroad. Information on research opportunities is also available from the sub-departments of Physics and from tutors.

Departmental representation - The Physics Joint Consultative Committee (PJCC)

The PJCC has elected undergraduate members who meet twice in Michaelmas Term and Hilary Term, and once in Trinity Term to discuss both academic and administrative matters with academic staff representatives. The Department values the advice that it receives from this committee for improving the quality of lectures, practicals and other aspects of the physics courses. The PJCC responsibilities include updating *The Fresher's Guide,* updating the PJCC web site and web pages linked to the Teaching pages. See https://pjcc.physics.ox.ac.uk/.

Opportunities to provide evaluation and feedback

The **PJCC** organises the online distribution and collection of data from the electronic lecture feedback. See https://pjcc.physics.ox.ac.uk/ for more information. Feedback is a valuable source of information for the Department's Academic Committee, which organises the lectures and is in charge of the Physics courses. The feedback provided is used as part of the continuing review and development for Departmental, University and QAA quality assurance. Students are encouraged to make full use of the on-line management system for feedback on the practicals.

Students on full-time and part-time matriculated courses are surveyed once per year on all aspects of their course (learning, living, pastoral support, college) through the Student Barometer. Previous results can be viewed by students, staff and the general public at: https://www.i-graduate.org/services/student-barometer/. Final year undergraduate students are surveyed instead through the National Student Survey. Results from previous NSS can be found at www.unistats.com.

Mathematical, Physical and Life Sciences (MPLS) Division and University Representation

Student representatives sitting on the Divisional Board are selected through a process organised by the Oxford University Student Union (OUSU). Details can be found on the OUSU https://www.oxfordsu.org/ along with information about student representation at University level.

An undergraduate student, usually a student member of the PJCC, is a representative on the Undergraduate Joint Consultative Committee of the Division. More details can be found at https://www.mpls.ox.ac.uk/intranet/divisional-committees/undergraduate-joint-consultative-forum.

Enterprise and entrepreneurship

Enterprising Oxford is an online map and guide to innovation and entrepreneurship in Oxfordshire, developed at the University of Oxford. Whether you have an idea, a start-up or a well and truly established venture, Enterprising Oxford highlights opportunities to develop further or help support others. See http://eship.ox.ac.uk/ for more information.

The Institute of Physics

This organisation offers a number of facilities for students through its 'Nexus' network. They also have information about careers for physicists. Students are encouraged to join the IoP. See http://www.iop.org/ for more information.

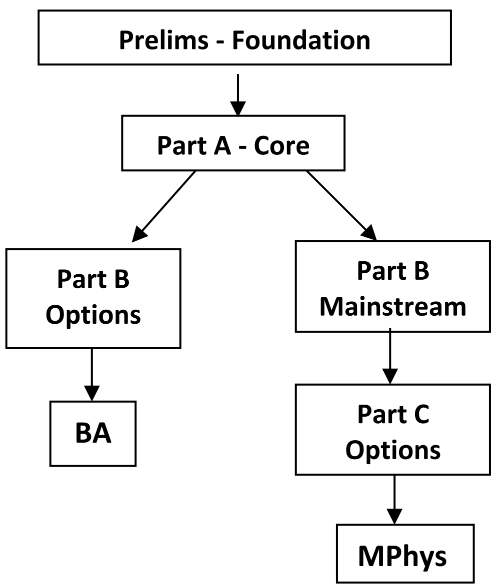
The Physics Undergraduate Courses

Aims and Objectives

Both the 3-year BA and the 4-year MPhys courses are designed to provide an education of high quality in physics, in a challenging but supportive learning environment, which will encourage all students to develop independent and critical habits of thought and learning. Both courses develop transferable skills related to communication, computing, and problem solving. Their aim is to ensure that, on graduation, all students will be in a position to choose from many different careers, and have the skills, knowledge and understanding to make a rapid contribution to their chosen employment or research area, and that those with the aptitude are prepared for postgraduate study in physics, and thus contribute to the vitality of UK research.

On completion of either course, students should have developed a thorough understanding and broad knowledge of the general theoretical and experimental scientific principles of physics, so that they have the resources to apply their knowledge to a wide range of physical phenomena. They should have learned the techniques required in a modern mathematically-based physics course, gained an understanding of the conceptual structure associated with the major physical theories, understood how to set up simple models of physical problems and learned a wide range of problem-solving skills, both analytical and computational, and how to apply them in contexts that may not be familiar. Students will also have learned the experimental techniques required by working physicists involving sound and safe procedures, how to record and analyse data and how to write accounts of laboratory work which can be clearly understood by other scientists, and will have investigated experimentally some of the most important physical phenomena.

On completion of their course all students will have had the opportunity either to acquire some expertise in a more specialised area of physics of their choice, or to broaden their education by study of a foreign language. MPhys students, in addition, will have acquired in-depth knowledge in two chosen specialisations within physics, and – from their project work – they will have learned how to plan and execute an open-ended piece of work, and will have gained experience of a research environment.



Subject Benchmark Statements

"... a Subject Benchmark Statement for Physics, Astronomy and Astrophysics defines what can be expected of a graduate in the subject, in terms of what they might know, do and understand at the end of their studies." [Ref. Quality Assurance Agency, 2017]

Department and College Teaching

The teaching of the courses is carried out through lectures, practical work in the laboratories, tutorials in the colleges (to which the academic staff are also attached), and classes.

There are comprehensive and challenging lecture courses, in which lecturers are allowed flexibility in their approach, which may lead to the inclusion of material reflecting developments in the field not contained in standard textbooks. Lectures are generally regarded as essential, but they are not in fact compulsory. Printed notes, problem sheets and other handouts frequently support them. Students need to learn how to take good lecture notes, and supplement them with their own private study, using textbooks and other sources recommended by the lecturers and their tutors.

Students are encouraged to take their own notes or to amend handouts as they find appropriate. Teaching material, including lecture notes or handouts must not be made available on the web without permission. Publishing material, including your version of the notes, without permission, may be in breach of Copyright. Please note that all lecture notes are only available from the Oxford domain for students.

Physics depends on experimental observations, and learning how to perform and design experiments effectively is an essential part of physics education. Practical work is recorded in logbooks, and some practicals have to be written up. Termly progress reports on laboratory work are sent to college tutors. During the first three years practical work is compulsory.

The College-based tutorial teaching provides guidance on what to study, and in what order, coupled with week-by-week work assignments. These assignments are generally problems, with the occasional essay. This is a "Socratic" mode of instruction in which students' understanding is rigorously and individually probed and expanded. College examinations (**Collections**) monitor students' progress during the intervals between University examinations, and students are given regular reports on their progress.

For the more specialised Major Options in Part C (4th year) of the MPhys course, tutorials are replaced by classes organised by the Department. Attendance at these classes is compulsory, and records are kept of students' progress.

Expectations of study and student workload (Term time and Vacations)

At Oxford, the teaching terms are quite short – they add up to about 24 weeks in one year. Students are responsible for their own academic progress and it is important that they manage their time appropriately.

A guide of a typical week* for an undergraduate Physics student during term consists of:

- 8-10 hours in lectures
- 6-8 hours in lab, plus writing up time
- 2 hours of tutorials
- 20 hours of independent study

* this is a guide only and this will vary between different students.

The University's expectation is that undergraduate students treat academic study as a full-time commitment during Full Term, with approximately 40 hours per week typically being spent on academic work. This is based on the expectation that these hours are spent on focussed work. Students should seek advice from their tutors if they find it impossible to meet their academic obligations without spending significantly longer than 48 hours per week on academic study on a regular basis.

During vacations it is essential that you set aside significant amounts of time for academic work. The course assumes that you will do this in preparation for College collections that are held at the end of 0th week. You should go over the tutorial problems and your notes, revising the material and supplementing it with information gained from tutorials and from your own reading. In addition to consolidating the previous term's work, there may be preparatory reading for the next term's courses. Your tutors may also set you some specific vacation work.

Aims of Practical Work

The major aim of practical work is to train you in the basic skills of experimental physics. More specifically, we intend that you learn how to carry out (and ultimately design) experiments and to appreciate the contribution that experimentalists make to the subject.

Thus, our aims are to enable you to:

- see, investigate and understand some of the important phenomena in physics
- become familiar with the basic scientific method
- become familiar with commonly used instrumentation and measurements in physics
- become familiar with the skills required for experimental work such as data acquisition, data analysis and computer programming
- learn how to clearly document your work in a logbook
- learn how to analyse experimental data
- learn how to present your work clearly, both orally and in writing
- learn about safe working practice
- learn how to design and develop experiments.

The Prelims (first year) practicals can be considered as a "toolbox" to give you the basic skills you need in experimental physics, before moving onto the more complicated and open-ended experiments in Parts A and B (second and third year).

Programme Specifications

Programme Specifications for the Physics courses and the Physics and Philosophy course can be found at http://www2.physics.ox.ac.uk/students/undergraduates

Accreditation

The 3-year BA and the 4-year MPhys courses are accredited by the Institute of Physics.

Accessing the Physics Teaching web pages

When you are away from Oxford, you may need to access materials on the web which are restricted. In the first instance, access to restricted resources from outside the Oxford network is provided via the Oxford University Computing Services (OUCS).

Virtual Private Network (VPN) Service

A VPN connection provides your computer with a “virtual” connection to the Oxford network - it then behaves exactly as it would if you were actually on-campus.

For access to e.g. lecture notes, use your SSO (Single Sign-On) username (coll1234).

First Year 2020-2021

Induction

The programme will be delivered online and reflects changes due to Covid. The induction information is available at https://canvas.ox.ac.uk/courses/67878 for all incoming first years.

Activity	Staff involved
Introduction to Department of Physics	Head of Department
Introduction to the Physics Undergraduate Courses	Head of Teaching
The First Year Physics Course	First Year Coordinator
Introduction to the Practical Course	Teaching Laboratory Manager
PJCC (Physics Joint Consultative Committee)	Student Representative
Women in Physics	Women in Physics Representative
Institute of Physics (IoP)	IoP Representative
Tour of Undergraduate Teaching Laboratory	Teaching Laboratory Manager

Safety Lecture

A safety lecture, which is **compulsory** for all Physics students, is held remotely on the Monday of 1st week of Michaelmas Term. Students will need to have passed the online quiz to prove attendance which includes a safety declaration **before** being allowed to carry out practicals.

If for any reason it is not going to be possible for you to complete the safety induction remotely, inform your tutor, and email labhelp@physics.ox.ac.uk before the beginning of 1st week.

Practical Work commencement

Practical work starts in the **FIRST** week of Michaelmas, at 10:00 on Thursdays and Fridays. Laboratories are allocated on a rota system. Details are given later on in this handbook or see the Prelims Practicals pages on Canvas (www.canvas.ox.ac.uk). You should not arrange commitments that clash with your practical work; however, if the allocation raises genuine difficulties for you, discuss it with your tutor well before your practical work starts.

You MUST prepare for practicals by reading the script, and any associated material the script may specifically reference, before you attend the laboratory. Any student who is not prepared may be asked to leave.

An introduction to practical work is given on Monday of 1st week at 12:00 remotely. Pairings for practical work will be registered at the Safety lecture. Further details of the practical work are given later on in this handbook or on Canvas (www.canvas.ox.ac.uk). You must check both to make sure you fully understand what you need to do to complete the practical elements of the course.

Self-study modules in basic mathematics and physics

These are designed to bridge the gap between school and university maths, mechanics, statistics and data analysis. Your tutor has more information. See also '*The Language of Physics*' J. P. Culerne and A. Machacek (Oxford). Your physics college tutors will have sent some preparatory work during the summer including information on the on-line bridging and computing courses.

Introduction to Computer Programming

During the first half of Michaelmas Term, there will be general introductory lectures on computer programming in addition to practical sessions on computing.

The Department has site licences for several powerful data analysis and mathematical software packages. See the computing section on the Prelims Practicals pages on Canvas (www.canvas.ox.ac.uk) for more information and how to download the software.

Data Analysis and Statistics

Like computing, data analysis and statistics is taught through a set of introductory lectures which are linked to the practical classes. There is a half-day introductory class specifically on data analysis at the start of MT and you will be expected to learn and develop your skills during the year's practicals.

At the end of the academic year we expect you to be familiar with how to analyse and express uncertainties on experimental measurements, and to be able to produce a competent plot of your data with an appropriate regression line. These skills are assessed in Prelims practicals and lab reports and will come up again as examinable material in Part A.

Textbooks

A list of the books recommended by the lecturers is given in **Appendix A** and is also available via ORLO (Oxford Reading List Online). Your tutor will advise you as to what books you should obtain.

First Year Physics and Maths Lectures

The syllabuses for papers CP1-4 along with those for the Short Options are in **Appendix C**. The timetable of all the lectures for Prelims is published at http://www.physics.ox.ac.uk/lectures/

Lectures start promptly at five minutes past the hour and end at five to.

There are lectures covering material examinable in Prelims and others scheduled that should be attended; those on the analysis of experimental measurements contain important material for the Teaching Laboratories.

Short Options

Short Options are intended to introduce either specialist topics or subjects outside the mainstream courses. They allow students to experiment with new material without significant prejudice to their degree class, as they carry a low weighting.

Short Options available to first years are S01, S02 or S03. The Short Option in Prelims is not subject to a resit, but is a required part of the examination. A good performance in the Short Option paper will help if you are on the borderline of a Pass or Distinction. **S02** and **S03** are **restricted** to the first year of the physics undergraduate course with students not allowed to take these options in year 2 or 3.

Academic Progress

Departments and colleges have responsibility for monitoring academic progress (including the use of OxCORT). Colleges are responsible for monitoring academic progress of their undergraduate students.

Physics and Philosophy

There is a corresponding Handbook for this course: *Physics and Philosophy Course Handbook* - see http://www2.physics.ox.ac.uk/students/undergraduates. Please refer to the *Physics and Philosophy Course Handbook* for all details of the Physics and Philosophy course that are not covered in the *Physics Undergraduate Course Handbook*.

The Physics and Philosophy course is run by the Joint Committee for Physics and Philosophy (P&P), which consists of three members of academic staff from each of Physics and Philosophy, together with an undergraduate representative.

Physics and Philosophy is normally a 4 year course. The first year of the course leads to the examination called Prelims, which consists of five papers, three in mathematics and physics and two in philosophy. After successfully completing Prelims, students enter the Final Honour School (FHS) of Physics and Philosophy; further details are available in the handbooks for later years and the P&P Handbook.

The aims and objectives of the physics course, stated above, apply equally – where appropriate – to the Physics and Philosophy course. Additionally, the aim of the physics components in the Physics and Philosophy course is to provide an appropriate basis for the study of foundational and philosophical aspects of physical science, in particular of quantum mechanics and special relativity.

The first year course leads to the Preliminary examination in Physics and Philosophy, in which you take papers CP1, CP3 & CP4. The syllabuses for these papers are given in **Appendix C**. See the *Physics and Philosophy Course Handbook* for further details about Prelims, including details of the Philosophy papers.

The physics papers taken by Physics and Philosophy candidates are marked on exactly the same basis as those taken by Physics candidates (please refer to the section on **Examinations**). Guidelines to the assessment criteria in philosophy papers are given in the *Physics and Philosophy Course Handbook*.

The Joint Committee for Physics and Philosophy has endorsed an algorithm for determining class boundaries, which is described posted on the official examiners' page.

First Year Patterns of Teaching

Timetable

The full Physics Undergraduate Lecture Timetable will show you when lectures are scheduled for all years.

Course structure

Four Compulsory Papers, CP1, CP2, CP3, CP4 and a Short Option.

Most colleges are able to do two classes or tutorials per week. Tutorials are done in pairs, or sometimes in threes. Classes are normally made up of all the students in that year in a College. There is approximately **one** tutorial or class per **four** lectures. As a guide, about **eight** hours of independent study are expected for each hour of tutorial or class teaching. Each Physics short option is covered by 12 lectures and examined in a 1½ hour paper

Please note the total number of lectures is provided as a guide. Numbers have been generated based on that ratio but there is no recommendation on balance of classes vs tutorials.

Students undertake 17 days of practical work.

Paper		**Faculty Teaching**	**College Teaching**
	Term	**Lectures**	**Classes/Tutorials**
CP1: Physics 1	MT	20	~10
Classical Mechanics and Special Relativity	HT	20	
	TT	4	
CP2: Physics 2	MT	17	~11
Electromagnetism, Circuit Theory and Optics	HT	24	
	TT	4	
CP3: Mathematical Methods 1	MT	32	~9
Complex Numbers and Ordinary Differential Equations	HT		
Vectors and Matrices	TT	4	
CP4: Mathematical Methods 2	MT	11	~10
Multiple Integrals and Vector Calculus	HT	26	
Normal Modes, Wave Motion and the Wave Equation	TT	4	
Additional lectures	MT	11	
	HT		
	TT	1	
S01: Functions of a Complex Variable	TT	12	
S02: Astrophysics: from Planets to the Cosmos (**only for 1st year**)	TT	12	
S03: Quantum Ideas (**only for 1st year**)	TT	12	

Practical Work

Most of the information you require for the practicals can be found online on the Prelims Practical pages on Canvas (www.canvas.ox.ac.uk). The information here details some of the most important information but you must also study the pages on Canvas as well.

Organisation

Prelims practicals take place from 10:00-17:00 on Thursday and Fridays each week of Michaelmas (October - December) and Hilary Terms (January - March). Note that for 2020-21 the labs may start at different times – please check the relevant page on Canvas. You will be allocated practicals on either Thursday or Friday. There is one hour scheduled for lunch, but the timing and duration of this break is flexible and should be scheduled to fit in with the progress of your experiment. A student who does not turn up by 10:15 forfeits their booking and the experiment can be given to another student to use. If you miss a practical one week, you may be able to do two in a subsequent week. There are also two un-allocated weeks at the end of Hilary when you are free to book in any lab. Please consult either your college tutor or email labhelp@physics.ox.ac.uk if you are getting behind with practicals.

Laboratories are staffed by demonstrators. Demonstrators are university staff or postgraduate students who are there to help you with the experiments. They provide advice and assistance whilst you are doing the experiment and will assess your performance. If you are in doubt about any aspect of the experiment, ask a demonstrator. The lab technicians have an engineering knowledge of the experiments and will help set up and fix equipment.

At the beginning of the academic year, students are allocated to the different laboratories on a rota system. SPIRe will show your allocation and the initial allocation of colleges to groups and groups to labs is shown on Canvas (www.canvas.ox.ac.uk – see under Practical arrangements.) You can only book experiments within your allocation. It is possible to work out of allocation (i.e. at a time not offered to you by SPIRe), though not to book. If you must work at a different time to your allocated slot it is recommended you contact labhelp@physics.ox.ac.uk for advice.

To fulfil the practical work requirements for the first year you must complete the following days of practicals:

Activity	Total Days Credit
EL00 (Intro to electronics) and DA01 (Data Analysis)	1
2 Electrostatics and Magnetism experiments	2
3 General Physics experiments	3
2 Optics experiments	2
2 Electronics experiments	2
CO01, CO02, CO6x (Computing in MATLAB)	4
3 reports (1 on General Physics, 2 on Optics)	1.5
Total	**15.5**

A completed experiment is one that has been carried out, assessed as satisfactory by a demonstrator, and the grade entered in your computer record on SPIRe (the Student Practical Information Record, spire.physics.ox.ac.uk). Your computer record can be examined by your tutor(s) at any time, and reports on your progress are regularly sent to tutors.

We expect you to choose, book in for, and attend the required practicals (the introductory practicals EL00 and DA01 will be booked for you). You should prepare for the experiment by obtaining and reading its instructions, called a "script", in advance (available from SPIRe and Canvas). Scripts may also contain additional explanation or theory (in Electronics the background material is in a separate manual). ***Demonstrators may ask you to leave if you do not show adequate knowledge of the practical at the start of the session.*** Most experiments also have pre-lab quizzes on Canvas which you should complete before you do the experiment to make sure you have understood the key points you will learn from the practical.

After you have completed the practical you must ensure that it is marked and that your computerised mark record on SPIRe is kept up to date. You must meet the deadlines that are set for computing exercises and reports throughout the year as detailed in this handbook and online on the Prelims Practical pages on Canvas. If you think your record is incorrect, please email labhelp@physics.ox.ac.uk with details of the issue.

For 2020-21, you work in pairs for online labs (except computing) but must work on your own for all in-person labs. Reports are always written individually. Your practical partner is usually from the same college as you. Partners are chosen at the start of Michaelmas term.

Both partners (if applicable) must participate fully in the experiment. To ensure this,

- Both practical partners should be simultaneously present throughout the lab, i.e. logbooks cannot be copied up by an absent partner retrospectively. Partners should synchronise their breaks.
- If one member of a pair is absent for more than an hour without giving prior notice, leaving one person to do the experiment alone, it will be assumed they have withdrawn from the assessment, and a mark of 0 will be given to the absent student. For 2020-21 this criteria will not be enforced as work might be working away from the lab or the student is working individually.

Unavoidable absences of one partner (e.g. a medical appointment, job interview) should be discussed with the demonstrators well before (e.g. the previous week) starting the experiment. It is often possible to rearrange - email labhelp@physics.ox.ac.uk for assistance with rearrangements.

The Frequently Asked Questions page: (https://www-teaching.physics.ox.ac.uk/FAQ/) also explains how to deal with common issues, such as what to do if you are unwell.

Assessment

Practical work is assessed by demonstrators, who will observe your experimental procedure and inspect your logbook records during the experiment. It is important to be able to present your scientific results clearly, both verbally and in writing. Verbal assessment forms part of the continual assessment of each experiment, and training in written skills is provided by the writing of summaries and reports, see the 'Report' section on Canvas.

Demonstrators will visit your experiment regularly. They will

- discuss the experiment with you; you will need to show them that you understand the underlying physics
- check what you have been recording in your logbook
- check analysis of the data and the accompanying errors
- check that you have adequately summarised your experiment in writing.

If your record is satisfactory, the demonstrator will sign your logbook and write a comment on your progress so far. If changes need to be carried out (e.g. extra comments written in), the demonstrator will request that these are done before you continue. Analysis and plotting should be done as you go along. If computer analysis is required, one partner can do this whilst the other sets up the next part of the experiment.

Marking

At the end of the experiment and after a short discussion of your work, the demonstrator will give you a mark between 0 and 5. The criteria for each mark for practicals and reports is given in **Appendix D**. A mark of 0 or 1 shows an unacceptable level of understanding and you will be asked to repeat the experiment. A mark of 2 is required to pass and obtain the credit for the practical/report. Once a student has a mark of 2 or higher, they cannot be remarked for the same practical. The marks will be used to work out practical prizes at the end of the year. A demonstrator may refuse to mark an experiment which is presented more than three weeks after the booked lab time (ignoring vacations).

The Prelims Practical pages on Canvas (www.canvas.ox.ac.uk) have a variety of additional information including links to SPIRe and useful documents on, for example, experimental errors. A full list of the experiments in the Prelims practicals can be found in **Appendix E.**

Physics Examinations

The Examiners are a committee set up each year under the Proctors. The Prelims Examiners may be assisted by a number of Assessors to set and mark some individual papers. In general, papers for Prelims are not set and marked by the course lecturers; indeed the identity of the examiner for any paper is confidential. The identity of the candidates is hidden from the examiners; no communication between the examiners and the candidate (or the candidate's tutor) is allowed except via the candidate's College's Senior Tutor and the Junior Proctor. The questions are required to be set in conformity with the syllabus, whose interpretation is guided by previous papers except where there has been an explicit change of syllabus. The current syllabuses for the Prelims examinations in physics are printed in **Appendix C**.

Examination Entry

Entry for the Prelims exam is at the end of 4th week of Hilary Term and 3rd week of Trinity Term for Short Option choices. Entries are made through your College and are usually organised by the College Secretary or College Academic Office, however it is your responsibility to make sure that your entry is made correctly. See https://weblearn.ox.ac.uk/portal/site/:mpls:physics:teaching:undergrads:exammatters.

The *Examination Regulations* provide guidance for students with special examination needs. "... An application ... shall be made as soon as possible after matriculation and in any event not later than the date of entry of the candidate's name for the first examination for which special arrangements are sought." Please see The *Examination Regulations* http://www.admin.ox.ac.uk/examregs/ for more information.

See **Appendix B** for information about the types of calculators which may be used in Public examinations.

Examination Dates

After the examination timetables have been finalised they are available at https://www.ox.ac.uk/students/academic/exams/timetables.

Examination Regulations

The regulations for the Preliminary examinations are published in the *Examination Regulations* and are also published at www.admin.ox.ac.uk/examregs/.

Examination Conventions

Examination conventions are the formal record of the specific assessment standards for the course or courses to which they apply. They set out how your examined work will be marked and how the resulting marks will be used to arrive at a final result and classification of your award. They include information on: marking scales, marking and classification criteria, scaling of marks, progression, resits, use of viva voce examinations, penalties for late submission or over-length work.

The Academic Committee is responsible for the detailed weightings of papers and projects. The definitive version will be published not less than one whole term before the examination takes place. The precise details of how the final marks are calculated are published on the official examiners' page.

Examination Preparation

There are a number of resources available to help you. Advice is available from your College tutor and the Oxford Student Union. See http://www.ousu.org/ for the Student Union.

Past Exam papers

Past examination papers and the data sheet are available on the Physics webpages. See http://www2.physics.ox.ac.uk/students for more details.

Examiners' Reports

The names of the examiners are published in the Examination Conventions official examiners' page. Students are strictly prohibited from contacting external examiners and internal examiners directly.

Sitting your examination

Information on (a) the standards of conduct expected in examinations and (b) what to do if you would like examiners to be aware of any factors that may have affected your performance before or during an examination (such as illness, accident or bereavement) are available on the Oxford Students website (www.ox.ac.uk/students/academic/exams/guidance).

Students are allowed calculators, except when the Examination Conventions published on the official examiners' page explicitly forbid their use in the examinations. The calculators must conform to the rules set out at "Regulations for the Conduct of University Examinations: Part 10 Dictation of Papers,..., Calculators and the types of calculators which may be used in the Public examinations are in **Appendix B**.

Prelims Examination

The first year is a foundation year and towards the end Trinity Term you will take the Preliminary Examination (Prelims).

Physics	Physics and Philosophy
Four compulsory papers CP1, CP2, CP3, CP4 Short option paper and Practical Work	Three Physics papers CP1, CP3, CP4 Two Philosophy papers

(i) Each of the compulsory papers will be in two sections.

Section A - containing short compulsory questions; Section B - containing problems (answer three from a choice of four). The total marks for sections A and B will be 40 and 60, respectively. The compulsory papers are individually classified as Pass and Fail, with a Pass mark of 40%.

(ii) One of the Short Options S01, S02 or S03 is chosen. These subjects will be covered by lectures at the start of Trinity Term.

(iii) The practical work requirement for Prelims is **17** days credit, made up of practicals, computing assignments and write ups. Candidates failing to complete their practicals will be required to complete them before entry to the Part A.

The current syllabuses for the Prelims are given in **Appendix C**. See **Appendix B** for information about the types of calculators which may be used in the Public examinations.

The examiners will take into account the performance in the whole examination (the four compulsory papers, the Short option paper and Practical Work) when considering the award of a Distinction and when considering borderline scripts.

Assessment of Practical Work

First Year (Prelims) practical work must be complete with an up-to-date computer record by noon on the Friday of 1st week of Trinity. The *Examination Regulations* read: "Failure to complete practical work under cl. 2(i), without good reason, will be deemed by the Moderators as failure in the Preliminary examination and the candidate will be required to complete the outstanding practicals either by examination or by completing them alongside second year study, before entry to the Part A examination will be permitted. In these circumstances, distinction at the Preliminary examination will not be possible."

Prizes and commendations are awarded for good practical work. There are prizes for students with the best practical work, and commendations are awarded to approximately the top 10% of students.

Examination Results

After your examination, your tutor will be told the scaled marks that you obtained in each paper and your overall rank amongst candidates in Prelims. This information will not be published, but will be provided to enable your tutor to give you some confidential feedback and guidance. Students are able to view their examination results at https://www.ox.ac.uk/students/academic/exams/results. Marks displayed in the Student Self Service are given as percentages; e.g.

Assessment Unit Title	Assessment Unit No.	Assessment Type	Mark (%)	Grade
CP3 Mathematical Methods 1	A10285W1	Written	0-100	-
CP1 Physics 1	A10287W1	Written	0-100	-
CP2 Physics 2	A10288W1	Written	0-100	-
CP4 Mathematical Methods 2	A10289W1	Written	0-100	-
S1 Functions of a Complex Variable	A14120W1	Written	0-100	-
17 Days Practical Work	A15284L1	Practical	-	P (Pass) or F (Fail)

Year Outcomes for Prelims

Possible Year Outcomes	Explanation
D (Distinction)	Candidate has passed with distinction and is allowed to continue to the second year.
P (Pass)	Candidate has passed and is allowed to continue to the second year.
PP (Partial Pass)	Candidate has failed one or two written papers and must retake the examination in those papers.
F (Fail)	Candidate has either failed three or four of the compulsory written papers and/or to complete practical work. **Candidates must check their student record to establish the grounds for the Fail classification.**
	Candidate has failed three or four compulsory written papers and must retake all four compulsory written papers at a subsequent examination.
	Candidate is not allowed to continue to Part A, except that candidates failing due to incomplete practical work are permitted to continue to Part A **subject** to completing practical work **before** entering for the Part A examination. The **17** days of Practical Work (Assessment Unit Grade) will be classed as **PN** (Pending).

Prelims do not count towards your final classification. Details relating to final degree classification can be found in the handbooks for later years.

If you are unhappy with an aspect of your assessment you may make a complaint or academic appeal (see https://www.ox.ac.uk/students/academic/complaints).

Resits

Failed compulsory papers can be re-taken in September. The University requires that these papers must be passed at no more than two sittings: see the *Examination Regulations* ('The Grey Book') for full details. There are no resit exams for Short Options and a poor mark will not lead to failure in Prelims, but good performance helps if you are on the borderline of a Pass or a Distinction.

Prelims Prizes

Prizes may be awarded for excellence in various aspects of Prelims

- Prelims Examination Prizes
- Physics Prelims Practical work prizes

Information about prizes available is normally published in the Examination Conventions for Physics, and Physics and Philosophy. Once prizes are awarded the prize list is published at http://www2.physics.ox.ac.uk/students/undergraduates

Examination in further years

The FHS (Final Honour School in Physics), also called **Finals**, is taken in parts over the final two (BA) or three (MPhys) years of your course. You can look ahead to the details of these examinations by browsing the handbooks for those years at https://www2.physics.ox.ac.uk/students/undergraduates.

Appendix A Recommended Textbooks

(main text * supplementary text)** ***Books listed as far as possible by Short Options and Examination Papers Lecturers will give more details at the start of each course***

First Year

Data analysis and Statistics

'Measurements and their Uncertainties A practical guide to modern error analysis', Hughes, Ifan & Hase, Tom, (OUP 2010)

'Scientific Inference: Learning from Data', 'Simon Vaughan, Cambridge, 2013)

CP1: Physics 1

Classical Mechanics

'Classical Mechanics', M W McCall (Wiley 2001)

'Introduction to Classical Mechanics', A P French & M G Ebison (Chapman & Hall) (Out of print but in most libraries)

'Analytical Mechanics', 6th ed, Fowles & Cassidy (Harcourt 1999)

'Fundamentals of Physics' (Chapters on Mechanics), Halliday, Resnick & Walker (Wiley)

'Physics for Scientists & Engineers', (Chapters on Mechanics) P A Tipler & G Mosca (W H Freeman)

'Introduction to Classical Mechanics', D. Morin (CUP)

'Classical Mechanics', T W B Kibble & F H Berkshire (Imperial College Press, 2004)

'Analytical Mechanics', 1st edition, L Hand & J Finch (Cambridge University Press, 1998)

'An Introduction to Mechanics', D. Kleppner & R.Kolenkow (Cambridge University Press, 2013)

'Understanding Mechanics', A. J. Sadler, D. W. S. Thorning (Oxford University Press, 1996)

Special Relativity

'Special Relativity', A P French, (MIT, Physics Series) [Nelson, 1968]

'Spacetime Physics', E F Taylor & J A Wheeler (Freeman, 1992) Several publishers including Nelson, Chapman & Hall.

'Relativity made Relatively Easy', A M Steane (OUP) 2012

'The Wonderful World of Relativity', A M Steane (OUP) 2011

'Spacetime Physics', E F Taylor & J A Wheeler (Freeman, 1992)

'Introducing Special Relativity', W S C Williams (Taylor & Francis, 2002)

CP2: Physics 2

Electronics and Circuit Theory

'Electronics Circuits, Amplifiers & Gates', D V Bugg (A Hilger, 1991) **

'Electronics Course Manual', G Peskett (Oxford Physics)

'Basic Electronics for Scientists and Engineers', Dennis L. Eggleston, CUP 2011, ISBN 0521154308 *

Electromagnetism

'Electromagnetism', Second Edition, I S Grant, W R Phillips, (Wiley, 1990) ISBN: 978-0-471-92712-9**

'Introduction to Electrodynamics, 'David J. Griffiths 4th Edition (Pearson)

'Electromagnetism, principles and applications', P Lorrain & Dale R Corson, 2nd ed (Freeman) *

'Electricity and Magnetism', W J Duffin, (McGraw Hill, 1990)*

`Electricity and Magnetism, Volume 1 only: B.I.Bleaney and B.Bleaney, Third Edition (Oxford Classic Texts In The Physical Sciences), reissued 2013. (A more advanced text, but lots of good examples for reference).

Optics

'Optics', E Hecht, 4th ed (Addison-Wesley, 2003) *

'Optical Physics', A. Lipson, S. G. Lipson and H. Lipson, 4th ed (Camridge University Press, 2011) *

'Introduction to Modern Optics', G R Fowles, 2nd ed 1975 (still in print as a Dover paperback)

'Essential Principles of Physics', P. M. Whelan and M. J. Hodgson (any edition from the 1970s)

CP3 & CP4: Mathematical Methods 1 & 2

Calculus

'Mathematical Methods for Physics and Engineering: A Comprehensive Guide', K F Riley, M P Hobson and S J Bence (CUP, 2002), ISBN 0521-81372 7 (HB), ISBN 0521-89067 5 (PB) **

'Mathematical Methods in the Physical Sciences', Boas *

'All you ever wanted to know about Mathematics but were afraid to ask', L Lyons (CUP, 1995) *

Vectors and Matrices

'Mathematical Methods for Physics and Engineering: A Comprehensive Guide', K F Riley, M P Hobson and S J Bence (CUP, 2002), ISBN 0521-81372 7 (HB), ISBN 0521-89067 5 (PB) **

'Mathematical Methods in the Physical Sciences', Boas *

Ordinary Differential Equations and Complex Numbers

'Mathematical Methods for Physics and Engineering: A Comprehensive Guide', K F Riley, M P Hobson and S J Bence (CUP, 2002), ISBN 0521-81372 7 (HB), ISBN 0521-89067 5 (PB) **

'Mathematical Methods in the Physical Sciences', ML Boas

'Ordinary Differential Equations', L S Pontryagin (Pergamon, 1962)

'Ordinary Differential Equations', V I Arnold (Springer, 2006)

'Differential Equations', Tikhonov, A. N., Vasil'eva, A. B. & Sveshnikov, A. G. (Berlin: Springer, 1985)

'Ordinary Differential Equations: An Elementary Textbook for Students of Mathematics, Engineering, and the Sciences', Tenenbaum, M. & Pollard, H. (Mineola, NY: Dove, 1986)

'An Introduction to Ordinary Differential Equations', Coddington, E. A., (Mineola, NY: Dover, 1990

'Nonlinear Dynamics and Chaos', Strogatz, S. H., (Cambridge, MA: Westview Press, 1994)

'Stability, Instability and Chaos: An Introduction to the Theory of Nonlinear Differential Equations', Glendinning, P., (Cambridge: Cambridge University Press, 1994)

Multiple Integrals

'Mathematical Methods for Physics and Engineering: A Comprehensive Guide', K F Riley, M P Hobson and S J Bence (CUP, 2002), ISBN 0521-81372 7 (HB), ISBN 0521-89067 5 (PB) **

'Mathematical Methods in the Physical Sciences', Boas

Vector Calculus

'Mathematical Methods for Physics and Engineering: A Comprehensive Guide', K F Riley, M P Hobson and S J Bence (CUP, 2002), ISBN 0521-81372 7 (HB), ISBN 0521-89067 5 (PB) **

'Mathematical Methods in the Physical Sciences', Boas

'Advanced Vector Analysis', C E Weatherburn (1943)

Mathematical Methods

'Mathematical Methods for Physics and Engineering: A Comprehensive Guide', K F Riley, M P Hobson and S J Bence (CUP, 2002), ISBN 0521-81372 7 (HB), ISBN 0521-89067 5 (PB) **

'Mathematical Methods in the Physical Sciences', Boas*

'Partial Differential Equations for Scientists and Engineers,' G Stephenson, 3rd ed reprinted 1998, Imperial College Press) **

‘Fourier Series and Boundary Value Problems’, Churchill and Brown (McGraw-Hill) *
‘Intro to Mathematical Physics, Methods & Concepts’, Chun wa Wong, (OUP) *
‘Mathematical Methods for Physics and Engineering’, K F Riley, (CUP) *
‘Mathematical Methods of Physics’, J Mathews and R L Walker, (Benjamin) *

Waves

French: https://www.amazon.co.uk/Vibrations-Waves-P-French/dp/8123909144
Tikhonov: https://www.amazon.co.uk/Equations-Mathematical-Physics-Dover-Books-ebook/dp/B00EYVP9GG/
Arnold: https://www.amazon.co.uk/Lectures-Partial-Differential-Equations-Universitext/dp/3540404481/

Short Options

S01: Functions of a Complex Variable

‘Mathematical Methods for Physics and Engineering: A Comprehensive Guide’, K F Riley, M P Hobson and S J Bence (CUP, 2002), ISBN 0521-81372 7 (HB), ISBN 0521-89067 5 (PB) **
‘Mathematical Methods in the Physical Sciences’, Boas
‘Mathematical Methods for Physicists’, Arfken
‘Complex Variables’, Spiegel

S02: Astrophysics: from planets to the cosmos

‘Introductory Astronomy & Astrophysics’, Zeilek & Gregory
‘Universe’, Kaufmann & Freedman

S03: Quantum Ideas

‘QED’, R P Feynman (Penguin)
‘Quantum Theory: A Very Short Introduction’, J. Polkinghorne (OUP)
‘The New Quantum Universe’, T. Hey and P. Walters (CUP)
‘The Strange World of Quantum Mechanics’, Daniel F. Styer (CUP)

Appendix B Note on Calculators for ALL Public Examinations*

The regulations are likely to follow recent practice which is:

A candidate may bring a pocket calculator into the examination provided the calculator meets the conditions set out as follows:

- The calculator must not require connection to any external power supply.
- It must not be capable of communicating (e.g. by radio) with any other device.
- It must not make a noise that could irritate or distract other candidates.
- It must not be capable of displaying functions graphically.
- It must not be capable of storing and displaying text, other than the names of standard functions such as 'sin' or 'cosh'.
- It must not be able to store programs or user-defined formulae.
- It must not be able to perform symbolic algebra, or perform symbolic integration or differentiation.
- Within the above, the calculator may be capable of working out mathematical functions such as sin(x), log(x), exp(x), x^y and it may contain constants such as π.
- The examiners may inspect any calculator during the course of the examination.

Notes:

These guidelines follow closely the regulations on the 'Use of calculators in Examinations' in the University *Examination Regulations* ('The Grey Book') and https://examregs.admin.ox.ac.uk. The exact requirements in a given year will be published by the Examiners.

The intention of the rules is to prevent the possibility of a candidate obtaining an advantage by having a powerful calculating aid (or of reading stored information as a substitute for knowing it). It is appreciated that candidates may already own calculators that are excluded by these rules. In such a case the candidate is responsible for obtaining a more basic calculator that is within the rules, and for becoming familiar with it in advance of the examination.

*** for the Physics papers when the use of calculators are permitted**

Appendix C Syllabuses for the First Year (Preliminary Examination in Physics)

Introduction

Compulsory papers: Each of the Papers CP1 - CP4 is a 2½ hour paper in two sections; Section A: Short compulsory questions (total marks 40) and Section B: Answer 3 problems from 4 (total marks 60)
Short Options will be examined by a single compendium paper divided into sections - one for each option - each containing 3 questions. Each Short Option has three questions: answer two questions from ***one Short Option*** *in 1½ hours. All questions are worth 25 marks.*

Syllabuses for CP1 CP2, CP3 and CP4 are given below. Those for CP1, CP3, and CP4 are also applicable for the **Preliminary Examination in Physics and Philosophy**
also
Syllabus for A2P (CP2 *withou*t Circuit Theory and Optics) for the **Final Honour School in Physics and Philosophy (Part A)**

CP1. Physics 1

Newton's law of motion. Mechanics of particles in one dimension. Energy, work and impulse. Conservation of linear momentum including problems where the mass changes, e.g. the motion of a rocket ejecting fuel. Conservation of energy.

Vector formulation of Newton's law of motion. Time-dependent vectors and differentiation of vectors.

Mechanics of particles in two dimensions. Equations of motion in Cartesian and plane polar co-ordinates. Simple cases of the motion of charged particles in uniform **E** and **B** fields.

Projectiles moving under gravity, including such motion subject to a damping force proportional to velocity. Dimensional Analysis.

Systems of point particles. Centre of mass (or momentum) frame and its uses. Torque and angular momentum. Conservation of angular momentum. Two-body collisions.

Central forces. Importance of conservation of energy and angular momentum. Classification of orbits as bound or unbound (derivation of equation for $u=1/r$ not required; explicit treatment of hyperbolae and ellipses not required). Inverse square central forces. Examples from planetary and satellite motion and motion of charged particles under the Coulomb force. Distance of closest approach and angle of deviation.

Calculus of variations. Principle of stationary action (Hamilton principle). The Euler-Lagrange equation. Constraints. Application to particle motion in one and two dimensions. Small oscillations, normal coordinates. Compound pendulum. Conservation laws. Noether's theorem. The Hamiltonian and energy conservation.

Moment of inertia of a system of particles. Use of perpendicular- and parallel-axis theorems. Moment of inertia of simple bodies. Simple problems of rigid body dynamics. Angular impulse, collision and rolling. The concept of principal axes. Angular momentum and total energy in rigid body rotation.

Special Relativity

Special theory of relativity restricted throughout to problems in one or two space dimensions. The constancy of the speed of light; simultaneity. The Lorentz transformation (derivation not required). Time dilation and length contraction. The addition of velocities. Invariance of the space-time interval. Proper time.

Energy, momentum, rest mass and their relationship for a single particle. Conservation of energy and momentum and the use of invariants in the formation sub-atomic particles. Elementary kinematics of the scattering and decay of sub-atomic particles, including photon scattering. Relativistic Doppler effect (longitudinal only).

CP2. Physics 2

The treatment of electromagnetism is restricted to fields in vacuo. Vector operator identities required will be given on the data sheet. Complicated manipulations of vector operators will not be set.

Electromagnetism

Coulomb's law. The electric field **E** and potential due to a point charge and systems of point charges, including the electric dipole. The couple and force on, and the energy of, a dipole in an external electric field. Energy of a system of point charges; energy stored in an electric field. Gauss' Law; the **E** field and potential due to surface and volume distributions of charge (including simple examples of the method of images), no field inside a closed conductor. Force on a conductor. The capacitance of parallel-plate, cylindrical and spherical capacitors, energy stored in capacitors.

The forces between wires carrying steady currents. The magnetic field B, Ampere's law, Gauss' Law ("no magnetic monopoles"), the Biot-Savart Law. The **B** field due to currents in a long straight wire, in a circular loop (on axis only) and in straight and toroidal solenoids. The magnetic dipole; its **B** field. The force and couple on, and the energy of, a dipole in an external **B** field. Energy stored in a **B** field.

The force on a charged particle in **E** and **B** fields.

Electromagnetic induction, the laws of Faraday and Lenz. EMFs generated by an external, changing magnetic field threading a circuit and due to the motion of a circuit in an external magnetic field, the flux rule. Self and mutual inductance: calculation for simple circuits, energy stored in inductors. The transformer.

Charge conservation, Ampere's law applied to a charging capacitor, Maxwell's addition to Ampere's law ("displacement current").

Maxwell's equations for fields in a vacuum (rectangular co-ordinates only). Plane electromagnetic waves in empty space: their speed; the relationships between **E**, **B** and the direction of propagation.

Circuit Theory

EMF and voltage drop. Resistance, capacitance, inductance and their symbolic representation. Growth and decay of currents in circuits, time constant. The concept of complex impedance in steady-state AC circuit analysis.

Ideal Op-amp: inverting and non-inverting amplifier circuits; summation, integration and differentiation circuits.

Optics

Elementary geometrical optics in the paraxial approximation. Refractive index; reflection and refraction at a plane boundary from Huygens' principle and Fermat's principle; Snell's Law; total internal reflection. Image formation by reflection at a spherical boundary; concave and convex mirrors. Real and virtual images. Magnification. Image formation by refraction at a spherical boundary and by converging and diverging thin lenses. Derivation of the expression for the focal length of a thin lens. *[Non-examinable: Image formation by systems of thin lenses or mirrors as illustrated by: a simple astronomical telescope consisting of two convex lenses, a simple reflecting telescope, a simple microscope.]*

Simple two-slit interference (restricted to slits of negligible width). The diffraction grating, its experimental arrangement; conditions for proper illumination. The dispersion of a diffraction grating. (The multiple-slit interference pattern and the resolution of a diffraction grating are excluded.) Fraunhofer diffraction by a single slit. The resolution of a simple lens.

***Note:* the above electromagnetism syllabus is also that for the Physics and Philosophy Part A paper A2P. Electromagnetism, *excluding* the sections on Circuit Theory and Optics.**

CP3. Mathematical Methods 1

Differential equations and complex numbers

Complex numbers, definitions and operations. The Argand diagram; modulus and argument (phase) and their geometric interpretation; curves in the Argand diagram. De Moivre's theorem. Elementary functions (polynomial, trigonometric, exponential, hyperbolic, logarithmic) of a complex variable. (Complex transformations and complex differentiation and integration are excluded.)

Ordinary differential equations; integrating factors. Second-order linear differential equations with constant coefficients; complementary functions and particular integrals. Application to forced vibrations of mechanical or electrical resonant systems, including the use of a complex displacement variable; critical damping; quality factor (Q), bandwidth, rms, peak and average values. *[Physical interpretation of complex impedance and power factor is not assumed]*

Vector algebra

Addition of vectors, multiplication by a scalar. Basis vectors and components. Magnitude of a vector. Scalar product. Vector product. Triple product. Equations of lines, planes, spheres. Using vectors to find distances.

Matrices

Basic matrix algebra: addition, multiplication, functions of matrices. Transpose and Hermitian conjugate of a matrix. Trace, determinant, inverse and rank of a matrix. Orthogonal, Hermitian and unitary matrices. Vector spaces in generality. Basis vectors. Scalar product. Dual vectors. Linear operators and relation to matrices. Simultaneous linear equations and their solutions. Determination of eigenvalues and eigenvectors, characteristic polynomial. Properties of eigenvalues and eigenvectors of Hermitian linear operators. Matrix diagonalisation.

CP4. Mathematical Methods 2

Elementary ideas of sequences, series, limits and convergence. (Questions on determining the convergence or otherwise of a series will not be set.) Taylor and MacLaurin series and their application to the local approximation of a function of one variable by a polynomial, and to finding limits. (Knowledge of and use of the exact form of the remainder are excluded.) Differentiation of functions of one variable including function of a function and implicit differentiation. Changing variables in a differential equation, integration of functions of one variable including the methods of integration by parts and by change of variable, though only simple uses of these techniques will be required, such as $\int x \sin x \, dx$ and $\int x \exp(-x^2)\, dx$ The relation between integration and differentiation, i.e. $\int_a^b dx$ (*df/dx*) and *d/dx* ($\int_a^x f(x')dx'$).

Differential calculus of functions of more than one variable. Functions of two variables as surfaces. Partial differentiation, chain rule and differentials and their use to evaluate small changes. Simple transformations of first order coefficients. (Questions on transformations of higher order coefficients are excluded.) Taylor expansion for two variables, maxima, minima and saddle points of functions of two variables.

Double integrals and their evaluation by repeated integration in Cartesian, plane polar and other specified coordinate systems. Jacobians. Probability theory and general probability distributions.
Line, surface and volume integrals, evaluation by change of variables (Cartesian, plane polar, spherical polar coordinates and cylindrical coordinates only unless the transformation to be used is specified). Integrals around closed curves and exact differentials. Scalar and vector fields. The operations of grad, div and curl and understanding and use of identities involving these. The statements of the theorems of Gauss and Stokes with simple applications. Conservative fields.

Waves

Coupled undamped oscillations in systems with two degrees of freedom. Normal frequencies, and amplitude ratios in normal modes. General solution (for two coupled oscillators) as a super-position of modes. Total energy, and individual mode energies. Response to a sinusoidal driving term.

Derivation of the one-dimensional wave equation and its application to transverse waves on a stretched string. D'Alembert's solution. Sinusoidal solutions and their complex representation. Characteristics of wave motion in one dimension: amplitude, phase, frequency, wavelength, wavenumber, phase velocity. Energy in a vibrating string. Travelling waves: energy, power, impedance, reflection and transmission at a boundary. Superposition of two waves of different frequencies: beats and elementary discussion of construction of wave packets; qualitative discussion of dispersive media; group velocity. Method of separation of variables for the one-dimensional wave equation; separation constants. Modes of a string with fixed end points (standing waves): superposition of modes, energy as a sum of mode energies.

Data Analysis and Statistics

A-level Maths plus the bridging material in (a) data analysis and statistics and (b) computing are assumed.

- Qualitative introduction explaining what experiments are, what they are used for in science, and other relevant concepts such as hypothesis or model testing.
- The fundamental origins of experimental uncertainty, e.g. shot and Johnson noise
- Examples throughout the course, from contemporary physics or famous discoveries, discussing experimental design, technique, and instrumentation as well as data analysis
- Uncertainties in measurements including dominant error, random and systematic errors, accuracy and precision, derivation and use of error propagation formulae assuming independent, normally distributed errors (ie no covariance matrices).
- Gaussian and Poisson distributions (as the distributions found in first year practicals), central limit theorem, least squares fitting (including weighted), meaning of residuals, confidence limits, simple statistical tests.
- Practical implementation of the above in software and in data presentation, including

a) How to produce a plot (e.g. labels, units, title, expression of uncertainties etc.).

b) How to describe and present a numerical answer sensibly, with appropriate precision.

c) Other useful skills in physics such as estimation. A pragmatic approach to data analysis should be stressed.

This first year material is taught through a short lecture course and the practical work. It is continually assessed through practical work (i.e. through log book assessment, lab reports, and discussion with demonstrators). **As is usual, knowledge of the first year syllabus will be assumed in the second year, where it can be examined and/or encountered in practicals.**

S01. Functions of a complex variable

Complex differentiation and definition of analytic functions, Cauchy-Riemann equations, orthogonal families of curves and complex mapping, conformal transformations and applications.

Complex integration, Cauchy's integral theorem and integral formula, Taylor series, isolated singularities and Laurent series, residue theorem and evaluation of real integrals, Jordan's lemma and other types of integral, branch points, branch cuts and Riemann surfaces, integration with cuts or with removable singularities, other selected applications of complex calculus.

S02. Astrophysics: from planets to the cosmos

The limitations of astrophysics. The scale of the Universe. Motions of the Solar System bodies, Keplers laws. Detection and properties of exo-planets. The Sun as a star. Space weather. Physical properties of stars. Stellar structure. Energy generation, stellar lifetimes, star clusters. A qualitative view of star formation & evolution of low & high mass stars. End points of stellar evolution, white dwarf stars, supernovae, neutron stars & black holes, synthesis of the chemical elements.

The Milky Way: constituents & structure, central black hole, formation models. Properties of galaxies. The Hubble sequence. Active galaxies. The expanding universe, galaxy clusters, dark matter. Galaxy assembly. Large scale structure, the distance scale, cosmic microwave background, probes of dark energy, the hot big bang, age of the Universe, concordance cosmology.

[Note that knowledge of the prelims mechanics and special relativity courses will be assumed.]

S03. Quantum Ideas

The success of classical physics, measurements in classical physics.

The nature of light, the ultraviolet catastrophe, the photoelectric effect and the quantisation of radiation. Atomic spectral lines and the discrete energy levels of electrons in atoms, the Frank-Hertz experiment and the Bohr model of an atom.

Magnetic dipoles in homogeneous and inhomogeneous magnetic fields and the Stern-Gerlach experiment showing the quantisation of the magnetic moment. The Uncertainty principle by considering a microscope and the momentum of photons, zero point energy, stability and size of atoms.

Measurements in quantum physics, the impossibility of measuring two orthogonal components of magnetic moments. The EPR paradox, entanglement, hidden variables, non-locality and Aspect's experiment, quantum cryptography and the BB84 protocol.

Schrödinger's cat, the Copenhagen and the many-world interpretation of quantum mechanics. The de Broglie Hypothesis and interferometry with atoms and large molecules. Amplitudes, phases and wavefunctions. The Schrödinger equation.

Interference of atomic beams, discussion of two-slit interference, Bragg diffraction of atoms, quantum eraser experiments. A glimpse of quantum engineering and quantum computing.

Appendix D Mark scheme for practicals

Students must achieve at least 2 marks to obtain the credit for the practical or report. Once a student has a mark of 2 or higher, they cannot be remarked for the same practical.

Criteria for practical marking

Mark	Criterion
0	• Did not attend the practical • Was absent for more than one hour during the practical: not applicable in 2020-21 as some practicals online or students spend only part of day in lab or was absent for more than one hour during the practical
1	• Did not complete the practical (*) • Severe problems with some or all aspects of the practical • Lacked understanding of the physics of the experiment, the method and the apparatus • Limited results • No awareness of uncertainties or analysis marred by serious errors • Notes, graphs and tables absent or totally unacceptable • Commenting in any computer code is absent or inadequate • The student is unwilling or unable to improve the standard to a higher level even after substantial input from demonstrators.
2	• Basic results • Minimally acceptable work with only limited awareness of uncertainties • Plots present but lacking key aspects (e.g. axis labels, data points, clarity) • Very basic data analysis
3	• Reasonable and competent attempt at all aspects of the practical • Reasonable understanding of the physics of the experiment, the method and the apparatus • Notes, graphs and tables will be adequate, but could be improved • Some units or quantities may be wrong • There may be some inappropriate appreciation of numerical precision • Basic commenting of computer code.
4	• Good attempt at all aspects of the practical • Good understanding of the physics of the experiment, the method and the apparatus • Notes, graphs and tables are clear and correctly labelled in a well organised logbook • Good analysis and awareness of a range of types of uncertainty • Only minor errors in any calculations, units or quantities • The appropriate numerical precision required will be shown.
5	• Excellent work, showing scientific maturity and evidence of analysis, ideas or techniques well beyond those expected for the practical, for example a full awareness of statistical and systematic errors • Exhibits insight and possibly originality, combined with a very good ability to analyse and synthesise the results • Computer code will be thoroughly and clearly commented • Demonstrates a full understanding of the physics in the practical - **new for 2020-21** • Cannot be awarded for work submitted late.

*: Students who do not complete a practical can obtain a mark higher than 1 if the demonstrator feels the student fully understood all parts of the experiment which were completed and/or progress was hindered due to faulty equipment.

Criteria for report marking

Mark	Criterion
0	• Did not a write a report
1	• Severe problems with some or all of the structure of the report and plots • Limited results • No awareness of uncertainties • Referencing is absent or totally unacceptable • Inadequate English.
2	• Basic results • Minimally acceptable work with limited awareness of uncertainties • Plots present but lacking key aspects (e.g. axis labels, data points, clarity) • Very basic data analysis and discussion of results • Minimal referencing (e.g. to experimental script only).
3	• Reasonable attempt at all aspects of the report • Adequate plots, data and uncertainty analysis • Evidence of reading beyond the script e.g. in a textbook • Awareness of numerical precision • Basic commenting of any included computer code.
4	• Well organised report of good quality • Clear plots, labelled diagrams and good analysis • Awareness of a range of types of uncertainty • All references included appropriately, beyond just the lab script.
5	• Excellent work • Shows scientific maturity and evidence of analysis, ideas or techniques well beyond those expected, for example a full awareness of statistical and systematic errors or using ideas from research papers • Any included computer code will be thoroughly and clearly commented. • Demonstrates a full understanding of the physics in the practical or contained in the computer code (if applicable) • Cannot be awarded for work submitted late.

Appendix E Summary of Prelims experiments

This section lists the experiments available. A completed experiment earns one day's credit unless otherwise indicated. Scripts can be obtained from SPIRe or in the relevant section of Canvas.

Introductory Experiments

You do two introductory exercises in the first two weeks of Michaelmas Term, and you will also be scheduled some time to get started with Computing. **You will be booked in for these experiments automatically. Do not attempt to book any experiments until the end of MT week 2**.

EL00 Introduction to Electronics (0.5 day)
You will learn the basics of some of the instruments and techniques used in the electronics lab.

DA01 Introduction to Data Analysis (0.5 day) (Online only for 2020-2021)
You will carry out simple data analysis tasks with a package called Jupyter Notebook. This uses a language called Python.

Computing

Location: Room 221 (Online only for 2020-2021) Head of Lab: Dr. Elizabeth Gallas
You should attend your allocated session in MT weeks 1 and 2, as detailed on Canvas. Generally, it is up to you to plan and carry out your computing work according to the deadlines listed in the table on page 7. In the computing laboratory, students work individually. You are encouraged to discuss the work with each other, but please write your own code. Computing practicals are compulsory and are worth two days credit each in Michaelmas Term (MT) and Hilary Term (HT).
Normally the Computing lab is open from 09:00–17:00 Monday to Friday. However, during the academic year 2020-21, the computer lab will not be open for general use.
Prelims demonstrators will be available on Microsoft Teams on Thursdays and Fridays 10:00–17:00hrs (with a lunch break from 13:00-14:00) to offer help and to mark your work when you complete an objective. If you are finding computing difficult and might like to join additional group tutorials, contact the HoL: We try to organize small scale group tutorials as needed through the term.

Please see these important links:

- http://www-pnp.physics.ox.ac.uk/~gallas/Lectures/
  for Computing Lab-specific guidance on preparing for marking, booking marking slots and uploading your work to WebLearn
- http://www-pnp.physics.ox.ac.uk/~gallas/Lectures/index_1stYear.html
  for specific instructions for Prelims Computing and links to course scripts
- https://www-teaching.physics.ox.ac.uk/computing/
  for general information about use of the facilities, installing MATLAB, as well as links to course scripts.

Michaelmas Term

Your objectives are to complete the CO01 and CO02 exercises noted below. See the above links to find the laboratory scripts and other related information you will need to complete the work and the marking process before the deadlines noted on Page 7. Be sure you have all required items with you at marking time and be prepared to execute your program should the demonstrator asks you to do so.

CO01 Prelims computing introduction (1 day) - deadline MT Week 4
This first set of exercises introduce you to how to use the system and the basics of the MATLAB programming language. System use includes starting up MATLAB, the graphical user interface (GUI), the help system, and how to use it interactively for calculations and data analysis. Programming

includes understanding control flow, writing functions, manipulating data and programmable objects. Exercises are used to consolidate what you have learned.
When you have finished the CO01 exercises, follow the instructions in the above links to prepare for marking and get your work marked before the deadline.

CO02 Prelims computing exercises (1 day) - deadline MT Week 8
This is a set of more advanced MATLAB programming exercises to build more computing skills in a number of key areas.
When you have completed the CO02 exercises, you must write a concise summary of the aim, method and quantitative results in your logbook just like for all the other first year experiments. Be sure that your handwritten or printed summary is affixed firmly into your logbook pages for marking.
When you have finished the CO02 tasks and written summary, follow the instructions in the above links to prepare for marking and get your work marked before the deadline.

Hilary Term

Remember you should have finished CO01 and CO02 in Michaelmas Term (see the deadlines in the important dates table on page 7).

In Hilary Term, you will complete one computing experiment of your choice, CO6x, for two days' credit. As with CO02, you will need to write a concise summary of the aim, method and quantitative results in your logbook. To prepare for assessment, see:
http://www-pnp.physics.ox.ac.uk/~gallas/Lectures/index_1stYear.html which summarises the requirements, how to upload your work to WebLearn, and final preparations for meeting with a demonstrator for assessment (how to book a time and what to bring with you)

CO61 Rocket science
The trajectory of a rocket launched from the Earth on course to the moon is solved for both a stationary and an orbiting moon.

CO62 Projectile motion
The trajectory of a projectile is solved for realistic models. The trajectory is compared to the simplest case where the only force acting on the projectile is gravity.

CO65 Monte Carlo integration
Various integration problems are solved using the Monte Carlo method.

CO66 LCR circuits
The current flowing in a circuit containing an inductance loop, a capacitor, and a series resistor is calculated and plotted. The case of a driving voltage is also investigated.

CO67 Radioactive decay
A Monte Carlo method is used to calculate the percentage constituents of a sample of ^{234}U as it decays through various daughter products.

Working from outside the Computing Laboratory

You can do computing work away from the labs by logging in to the physics system remotely (see our local webpages http://www-teaching.physics.ox.ac.uk/computing) or by doing the problem on your own computer. Instructions on how to work on your own computer are given on our web pages. Student copies of MATLAB are available from the University's IT Services website https://register.it.ox.ac.uk/self/software/. You are encouraged to download and install a copy on your own computer.

Electrostatics and magnetism

Location: Room 212 (Online only for 2020-2021)   Head of Lab: Prof. Pat Irwin
Students will perform two experiments in this laboratory in a three week allocation. i. e. you get one week "off". We recommend you use this week to do Computing.

EM01 Mechanical forces in electrostatic and magnetic situations (Online only)
An electronic balance is used to provide quantitative measurements of electrostatic or magnetic forces. The forces generated between capacitor plates are studied and interpreted via the Principle of Virtual Work. A value is deduced for ε_0, and for ε_r for the dielectric. In the second part, the forces generated between current elements are studied and interpreted in terms of Ampère's law.

EM02 Self and mutual inductance and Faraday's Law of Induction (Compulsory, in person)
Here you will explore the self inductor as a circuit element. Air filled coils are used as well as ferrite core inductors. The relation between self and mutual inductance is explored. A quantitative check of Faraday's law of induction is made.

EM03 Electrostatic charge, field and potential (Online only)
Electrical charges of predictable magnitude are generated by a capacitor whose electrodes can be separated. The interdependences of electric field, electrostatic potential difference and electric charge are studied. Some of the consequences of Gauss' Law are investigated. The forces between charged spheres are measured and compared with electrostatic theory.

Electronics

Location: Room 129   Head of Lab: Prof. Richard Nickerson
It is essential that you obtain a copy of the Electronics Manual to carry out the first year experiments, available from: http://www-teaching.physics.ox.ac.uk/practical_course/ElectronicsManual.pdf .
For the academic year 2020-21, all of these experiments must be prebooked before arriving in the teaching laboratories. You MUST arrive at the time specified and all covid procedures must be followed whilst you are in the teaching laboratories. If you do not follow these procedures you will be asked to leave the teaching laboratories.

It is recommended that you complete the experiments in order but this is not a requirement. You must book EL01/02 (a combined experiment, see the advice on Canvas on how to prepare) and EL03

EL01/02 Excitation of circuits by step emfs and harmonic emfs
EL01: This experiment compares measurements and models of real circuits (called equivalent circuits) when they are excited by emfs which step abruptly from one steady value to another.
EL02: Input and output impedances of oscillators and oscilloscopes are investigated.

EL03 Introduction to digital data processing circuits
Design and construction of some simple combinational and sequential binary logic circuits using CMOS chips.

General Physics

Location: Room 127 (Online only for 2020-2021) Head of Lab: Prof. Paolo Radaelli

You must write a lab report (individually) on one of these experiments. Your report will be assessed via a video call using Microsoft Teams – book for a marking slot on Canvas. You must complete any three experiments from the six listed below.

GP01 Radioactivity and statistics

The first part uses the random nature of the radioactive decay in the study of probability distributions. The second part of the experiment is on the properties of alpha, beta and gamma radioactivity.

GP03 Resonances and harmonics

This experiment studies standing waves on a wire, investigates nodes and antinodes and measures the velocity of sound waves on the wire.

GP04 Driven harmonic motion

The amplitude and phase of a driven harmonic oscillator are studied as a function of driving frequency and compared with the theory of transient and resonant behaviour.

GP06 Harmonic motion and normal modes

The vibration of masses coupled by springs on a 'frictionless' air-track are studied for the case of one, two or five masses. The positions of the masses are recorded by an ultrasonic ranger connected to a computer.

GP08 Rotational dynamics

An experiment to investigate aspects of the rotational dynamics of rigid bodies, using an apparatus based on a rotational motion sensor and a low friction pulley. Investigations focus on (a) the conservation of angular momentum and energy, and (b) factors which contribute to the moment of inertia of objects of differing shapes and sizes.

GP14 The electron, particle and wave

The particle and wave characteristics of the electron are investigated. Its charge to mass ratio is estimated from the bending of an electron beam in a magnetic field; its wave nature is used to estimate the atomic spacings in graphite and evidence for discrete energy levels in atoms is examined in the Frank-Hertz experiment.

Optics

Location: Room 210 (Online and in person for 2020-2021) Head of Lab: Dr. Matthias Tecza

For the academic year 2020-21, all of these experiments must be prebooked before arriving in the teaching laboratories. You MUST arrive at the time specified and all covid procedures must be followed whilst you are in the teaching laboratories. If you do not follow these procedures you will be asked to leave the teaching laboratories.

You will complete either OP11 OR OP14 plus OP13 online. You must write two reports (individually) on both of the experiments you complete. Your reports will be assessed via a video call using Microsoft Teams – book for marking on Canvas.

OP11 Lloyd's mirror

A study of two-beam interference fringes produced by wavefront division, which brings out the importance of practical considerations such as size of source slit, non-localization of fringes and measurement techniques using Moiré fringes.

OP13 Grating monochromator (Online only)
Spectral lines of mercury are used to obtain an accurate calibration. The Balmer lines of atomic hydrogen are investigated, and the Rydberg constant obtained.

OP14 Fraunhofer diffraction and resolving power
Investigates the most important type of diffraction. Simple quantitative relationships can be verified, and the resolution of optical systems is investigated.

Appendix F Complaints and Appeals

Complaints and academic appeals within the Department of Physics
The University, the **MPLS Division** and **Department of Physics** all hope that provision made for students at all stages of their course of study will result in no need for complaints (about that provision) or appeals (against the outcomes of any form of assessment).

Where such a need arises, an informal discussion with the person immediately responsible for the issue that you wish to complain about (and who may not be one of the individuals identified below) is often the simplest way to achieve a satisfactory resolution.

Many sources of advice are available from colleges, faculties/departments and bodies like the Counselling Service or the OUSU Student Advice Service, which have extensive experience in advising students. You may wish to take advice from one of those sources before pursuing your complaint.

General areas of concern about provision affecting students as a whole should be raised through Joint Consultative Committees or via student representation on the faculty/department's committees.

Complaints
If your concern or complaint relates to teaching or other provision made by the **Department of Physics**, then you should raise it with the Head of Teaching, **Prof Hans Kraus**. Complaints about departmental facilities should be made to the Head of Administration. If you feel unable to approach one of those individuals, you may contact the Head of Department, **Prof Ian Shipsey**. The officer concerned will attempt to resolve your concern/complaint informally.

If you are dissatisfied with the outcome, you may take your concern further by making a formal complaint to the Proctors under the University Student Complaints Procedure (https://www.ox.ac.uk/students/academic/complaints).

If your concern or complaint relates to teaching or other provision made by your college, you should raise it either with your tutor or with one of the college officers, Senior Tutor, Tutor for Graduates (as appropriate). Your college will also be able to explain how to take your complaint further if you are dissatisfied with the outcome of its consideration.

Academic appeals
An academic appeal is an appeal against the decision of an academic body (e.g. boards of examiners, transfer and confirmation decisions etc.), on grounds such as procedural error or evidence of bias. There is no right of appeal against academic judgement.

If you have any concerns about your assessment process or outcome it is advisable to discuss these first informally with your subject or college tutor, Senior Tutor, course director, director of studies, supervisor or college or departmental administrator as appropriate. They will be able to explain the assessment process that was undertaken and may be able to address your concerns. Queries must not be raised directly with the examiners.

If you still have concerns you can make a formal appeal to the Proctors who will consider appeals under the University Academic Appeals Procedure (https://www.ox.ac.uk/students/academic/complaints).