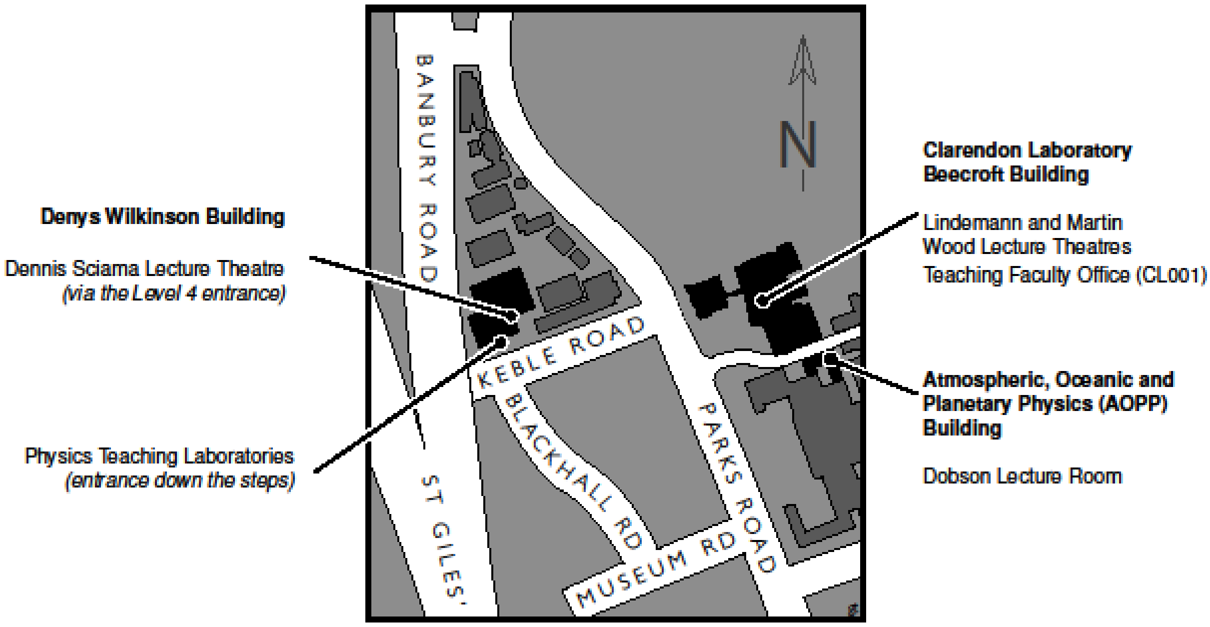
Physics Undergraduate Course Handbook 2020-2021

Third Year (Part B)

UNIVERSITY OF OXFORD

Map of the Department of Physics Buildings



Useful Department Contacts

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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 Course are given in this handbook and in the Part B Practicals course 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 cllege 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 start of full term.

For full and up-to date information on 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 1	Introduction to the Third Year	Mon 09:30	Online only
Week 1	Industrial Projects	09:00	Online only
Week 1	Project Safety for BA students	***	
Week 2	Short Options: S20; S21; S27 and S28		
Week 4	Application for more practical work or vacation placement deadline		
Week 8	Entry for Part B	Fri	*

Hilary Term	Event	Time	Location
Week 4	Industrial Project Presentations	***	***

Trinity Term	Event	Time	Location
Week 1	Hand in BA projects	Mon 12:00	Online submission
Weeks 1- 4	Assessed Practicals	Mon/Tues	To be confirmed
Week 3	Entry for Short Option choices	Fri	*
Week 4	Last day to do practicals	Tues 10:00	
Week 5	Year Group meeting		***
Week 5	Last day to get practicals assessed	Tues 10:00	BY APPOINTMENT ONLY
Week 5	Introduction to Major Options	Wed	***
Week 5	Deadline for completion of Practical Work	Fri 12:00	
Week 6	Hand in extra practical and extended practical reports	Mon 12:00	Online submission
Week 6	Major Option and MPhys project Choice	Fri	Online submission

* 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

Please see the introductory section to the first year handbook for a broader introduction to the Department, the Faculty and lecture theatres etc. if you would like a refresher on those things. Note that due to the current global situation, the computer facilities in the teaching laboratories on level 2 are 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.

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* provides 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 website 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.

Third Year 2020-2021

Introduction to the Third Year

All Physics and Physics and Philosophy third years are **required** to view the Introduction to the third year on Monday morning at 09:30 of 1st week of Michaelmas Term remotely. There you will hear a brief introduction to the third year course.

Aims and Objectives

The first year handbook contains an overview of the course intentions, and includes information about subject benchmark statements, the split of Department and College teaching, expectations of study and workload etc. Please refresh yourself on these areas as appropriate. This handbook focuses on new information needed for the third year of your programme.

The BA and MPhys course: **which course should I do?**

At the start of Michaelmas, you must decide whether you will take the three year course (BA) or the four year course (MPhys). Your tutor(s) will have received the results of your Part A examination over the long vacation, and if you have any doubts concerning which course you should take you should discuss the situation carefully with your tutor(s) in the light of your examination results.

You should bear in mind that the four year course is designed to be challenging and will involve an appreciable amount of advanced work. You will also be expected to work more independently in the fourth year of the MPhys course in comparison to the first three years.

Changing from the MPhys to the BA (**before** 1st week MT)

Students **must make the decision** about doing the BA or MPhys course by the beginning of MT 0th week with a firm deadline of **Friday noon of 1st week**. Students thinking of taking the BA course, but undecided by MT 0thweek, should tentatively sign up for a BA group project so that they can be assigned one at the start of term. Later changes are not normally permitted because of the impact on the BA group projects.

Changing from the MPhys to the BA (**after** 1st week MT)

If you want to change to the BA after the deadline of **Friday noon of 1st week,** you can only exit after publication of the Part B results, normally in July.

During your 3rd year **and** after the publication of your 3rd year, Part B results, you may wish to leave the MPhys course. The classification at the end of year 3 of the MPhys course is the year outcome for the BA should you exit the course before taking Part C examinations or transferring to the MMathPhys.

It is important that you discuss this decision with your college tutors in the first instance and inform the Assistant Head of Teaching. The procedure for the BA exit route is: The student informs their College, normally the Academic or Tutorial College Office, that they are leaving the MPhys 4-year course after year 3 with a BA enabling them to graduate.

This exit route is available to all MPhys students until they complete Part C, but, as you would expect, the award of the BA precludes the possibility of ever taking Part C and obtaining the MPhys. In the *Examination Regulations "*(5) A candidate who has satisfied the requirements for Part A and Part B of the four-year course, but who does not start or enter Part C or who fails to obtain Honours in Part C is permitted to supplicate for the Degree of Bachelor of Arts in Physics (Pass, or Honours with the classification obtained in Parts A and B together, as appropriate); provided that no such candidate may later enter or re-enter the Part C year, or supplicate for the degree of Master of Physics; and provided in each case that the candidate has fulfilled all the conditions for admission to a degree of the University." at www.admin.ox.ac.uk/examregs/

An MPhys classification **does not** have an equivalent BA classification. Once you have taken the MPhys examination, you receive an MPhys degree and are **ineligible** for a BA degree.

Practical Work

Aims of Practical Work

As in Prelims and Part A, 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 examiners' requirement for practical work for Part B is **6** days (regular practicals) + **4** days (mini project), but note that your SPIRe lab record will only show 8 days (6 days + 2 days of credit for the regular practical part of mini-project). Two further days of practical work will be added to your final exam results for the mini project write up.

It is possible to substitute 6 days of extra practical work for a short option.

There is no practical work in Hilary but students should write a report on the mini project they have done. The practical report write-up is part of the training in written communication skills and is organised by your tutor; please see them for further information.

The Examination Conventions show more details.

Mini-project

The mini project takes place in Michaelmas Term and amounts to 4 days of practical credit: 2 conventional days plus an extra 2 days of work which is then written up as the mini project report. The extra days of mini project credit are not shown on your practical record, so the total credit on the computer record is 8 days. The allocation for the mini project is given below (this is the nominal allocation, please check your record on SPIRe for your group allocation):

Weeks	Groups	Colleges
MT 3-4	A,B	Mansfield, Merton, St John's, Pembroke Balliol, Brasenose, Exeter, Magdalen
MT 5-6	A,B,C,D	Mansfield, Merton, St John's, Pembroke Balliol, Brasenose, Exeter, Magdalen Queens, SEH, Wadham Jesus, St Catherine's, Worcester
MT 7-8	C, D, E,F	Queens, SEH, Wadham Jesus, St Catherine's, Worcester New, Somerville, St Anne's, St Peter's Christ Church, LMH, Oriel, Trinity
HT 1-2	E, F, G,H	New, Somerville, St Anne's, St Peter's Christ Church, LMH, Oriel, Trinity Hertford, Corpus, St Hilda's St Hugh's, Keble, Lincoln, University
HT 3-4	G,H	Hertford, Corpus, St Hilda's St Hugh's, Keble, Lincoln, University

Students normally write their first draft during the Christmas Vacation.

College tutors review the first draft during Hilary Term and provide one set of written and/or oral feedback. Students normally write their second draft during Hilary Term.

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. One Short Option must be offered in Part B.

Short Options offered by other departments of faculties

(a) Language Options

A course is offered in French every year. Courses in German or Spanish are offered in alternate years. The language courses offered this academic year are French and German. The minimum entry requirement is normally an A at GCSE in the relevant language (or equivalent).

The language options will be taught over two terms in Hilary and Trinity Terms. The courses will involve 32 hours (2 hours a week in Hilary and Trinity Terms) of classes together with associated work. It can be used to replace the Short Option paper.

Specific details about the Language Centre presentation arrangements will be circulated to students in Michaelmas Term by e-mail.

There is a preliminary test to determine eligibility to take this option on Canvas, followed by a tutor interview. The *Examination Regulations* reads: “Approval shall not be given to candidates who have, at the start of the course, already acquired demonstrable skills exceeding the target learning outcomes in the chosen language”.

The language options final assessment is based on the syllabus and learning outcomes published by the Language Centre.

Students may offer to do the language option on more than one occasion provided it is a different language. For example a student can do French in their second year and Spanish (or German) in their third year, subject to eligibility.

(b) Pre-approved Alternative Subjects

Several alternative subjects that have been pre-approved and are offered by other faculties or departments can be studied in place of one short option. These are:

(i) Supplementary Subject (History and Philosophy of Science): this is a paper offered within the University by other departments.

S20: History of Science and S21: Philosophy of Physics are examined in the Supplementary Subject (History and Philosophy of Science) paper. S20: History of Science or S21: Philosophy of Physics can be offered as a short option.

(ii) S27: Philosophy of Space-Time and S28: Philosophy of Quantum Mechanics are offered by the Philosophy Faculty. S27: Philosophy of Space-Time and S28: Philosophy of Quantum Mechanics are examined in the Intermediate Philosophy of Physics paper.

If you wish to offer any of the above options, please inform the Assistant Head of Teaching by e-mail at carrie.leonard-mcintyre@physics.ox.ac.uk by 2nd week of Michaelmas Term to ensure that you are entered for these examinations correctly.

Please note: Students must seek permission from their College tutors to study these topics as there will be a financial implication for classes and/or tutorials. The examination dates for the Supplementary Subject (History and Philosophy of Science) and the Intermediate Philosophy of Physics papers **are different** from the Physics Short Option examination date. No examination results will be released before the completion of all the Physics examinations.

(c) Alternative Subjects

Students may request to substitute their short option with another pre-existing course from another department of similar level and workload and where an appropriate pre-existing examination paper or other method of assessment is available. Such requests require the approval of the external department, the Head of Teaching within the Department of Physics and of the College. The assessment mark provided by the other department will be used directly by the Physics Examiners.

Application must be made via the Assistant Head of Teaching by e-mail to carrie.leonard-mcintyre@physics.ox.ac.uk to replace the compulsory Short Option paper in Part B; the deadline is Friday of 4th week Michaelmas Term.

The application will only be agreed if the proposed course and an examination paper already exists within the University, and the alternative subject is considered appropriate. Students will be advised of the decision as soon as possible.

More practical work instead of a short option

There are two ways to do extra practical work instead of a short option; extra practicals, or an extended practical. Extra practicals are simply more of the same experiments carried out for the basic quota, whereas extended practicals are effectively a small project. Permission to do extra practical work can be obtained by emailing labhelp@physics.ox.ac.uk clearly stating which of the options below you wish to apply for.

The application must be made before noon on Friday of 4th week of Michaelmas Term. Applications submitted late will not be considered.

(a) Extra practicals

Extra practicals are an additional six days of standard practicals. You can only book for those practicals allocated to you by SPIRe (Student Practical Information Record). If you want to work out of allocation you must see what is free on the day. Each of the extra practicals must be marked your SPIRe record, and you must write up one of the practicals, selected at random. **Students will be informed which practical to write up by noon on Wednesday of 4th week of Trinity Term**. No tutor input for this report will be allowed. Students must submit an electronic copy (by e-mail attachment) of their report to the Physics Teaching Office (**neither** Examination Schools **nor** the Physics Teaching Laboratories will accept your reports) before noon on Monday of 6th week of Trinity Term. All work submitted will be checked with Turnitin.

- Your work must be identified **only** by your candidate number (which can be found by visiting Student Self-Service). Your candidate number does NOT appear on your University card.
- Your **report** should not contain any other pieces of information that could identify you to the marker of your paper.
- The file name should follow the format: *Candidate number*_Report Title e.g. 1234457_My Ideal Practical.

The six extra days practical work will begin only when the normal practical quota has been completed. They should be booked and grades entered on SPIRe as usual. **If you have done six additional days of practicals in Part A you will not be allowed to repeat this option for Part B.** You may work alone or with a partner. It does not matter which course your partner is registered for or if they are not doing extra practicals.

(b) Extended practicals

Extended practical work must have the support of an appropriate supervisor, and must be equivalent to six days practical work. If you need assistance finding a supervisor, please email labhelp@physics.ox.ac.uk once you have decided which area of physics you would like to work in. Students must submit an electronic copy (by e-mail attachment to labhelp@physics.ox.ac.uk) of their report to the Physics Teaching Office (**neither** Examination Schools **nor** the Physics Teaching Laboratories will accept your reports) before noon on Monday of 6th week of Trinity Term. All work submitted will be checked with Turnitin.

- Your work must be identified **only** by your candidate number (which can be found by visiting Student Self-Service). Your candidate number does NOT appear on your University card.
- Your **report** should not contain any other pieces of information that could identify you to the marker of your paper.
- The file name should follow the format: *Candidate number*_Report Title e.g. 1234457_My Ideal Practical.

Your supervisor may read and comment upon one draft only of your report before submission.

Substituting practical work with vacation placements

It is possible to replace some of the practical quota by a report on Physics-related vacation placements.

Vacation placements

Work carried out during a vacation placement may be submitted for practical course credit. Students wanting to gain credit for vacation work must apply for approval via labhelp@physics.ox.ac.uk after the placement by returning the form AD12 at

http://www-teaching.physics.ox.ac.uk/practical_course/Admin/AD12.pdf. All applications for project substitution for practical work in Michaelmas term must be received before noon on Friday of 4th week of Michaelmas Term. The outcome of these applications will be communicated by e-mail. It is possible to submit vacation work for practical credit in both Parts A and B, providing that the projects are distinct pieces of work.

You may only submit one vacation project per year for practical credit. More information is provided in the Part B Practicals Canvas course.

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.

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.

Major Options

In 5th week of Trinity Term, there will be a general introduction to the Major Options (for details consult the lecture list). By Friday of 6th week you will be required to indicate option choices in order of preference.

Alternative Major Options

It is possible to substitute another subject in place of a Physics Major Option, provided the course and exam already exist and are of sufficient weight. Permission must be sought from the Head of Teaching via the Assistant Head of Teaching by e-mail to carrie.leonard-mcintyre@physics.ox.ac.uk in Trinity Term of your third year.

Fourth Year (MPhys) projects

The *MPhys Projects Trinity Term* handbook published at https://www2.physics.ox.ac.uk/students/undergraduates containing details of the projects for the MPhys will be circulated at the start of Trinity Term of your 3rd year and you must specify your choice of projects by Friday of **6th** week of Trinity Term.

Physics and Philosophy

The physics component consists of **two** (or **four** if your elective paper is in physics) subjects drawn from the following list: **B1** Fluids; **B2** Symmetry and Relativity; **B3** Atomic and Laser Physics; **B4** Nuclear and Particle Physics; **B5** General Relativity; **B6** Condensed Matter Physics; **B7** Classical Mechanics; **B8** Computational Project; **B9** Experimental Project.

Physics and Philosophy students **must choose** at least two of subjects B2, B5, and B7.

Papers B1-B7 are the same as the core Part B physics papers taken by MPhys students, which are examined in six 2-hour papers. The B7 paper is specially set for P&P students, in the same format as the other physics papers in Part B, and 2 hours in length. You should have tutorials to prepare you for this paper.

The weights assigned to the Part B papers in the Finals algorithm are 1 for each 3-hour Philosophy paper and ½ for each 2-hour physics paper or project.

Third Year Patterns of Teaching

Timetable

The full Physics Undergraduate Lecture Timetable is located at www.physics.ox.ac.uk/lectures. This will show you when lectures are scheduled for all years.

Course structure

The table below indicates the BA and MPhys course structures.

	MPhys			**BA**		
	Option 1	Option 2	Option 3	Option 1	Option 2	Option 3
B4+B6	2	2	2	2	2	2
B1,B2,B3,B5	3	2	1	1	2	1
B8, B9 (projects)		1	2	2	1	
Industrial Project						✓
Short option	✓	✓	✓	✓	✓	✓
Practical work	✓	✓	✓	✓	✓	✓
Mini-project	✓	✓	✓	✓	✓	✓

Please note the total number of lectures is provided as a guide.

Lecture/tutorial ratio: 1 class/tutorial for every 5 lectures. Students undertake 12 days of practical work.

Paper		**Faculty Teaching**	**College Teaching**
	Term	**Lectures**	**Classes/Tutorial**
B1 Fluids	HT	24	~ 5
	TT	2	
B2 Symmetry and Relativity	MT	24	~ 5
	TT	2	
B3 Atomic and Laser Physics	HT	24	~ 5
	TT	2	
B4 Nuclear and Particle Physics	MT	24	~ 5
	TT	2	
B5 General Relativity	HT	24	~ 5
	TT	2	
B6 Condensed Matter Physics	MT	24	~ 5
	TT	2	
B7 Classical Mechanics (MPhysPhil)	HT	12	
	TT	2	
B8 Computational Project	MT	4	
	HT		
B9 Experimental Project	MT	4	
	HT		
Additional lectures	MT	3	
	HT	1	
	TT	3	
S01. Functions of a Complex Variable	TT	12	
S07. Classical Mechanics	HT	12	
S10. Medical Imaging and Radiation Therapy	TT	12	
S14. History of Physics	MT	8	
S16. Plasma Physics	TT	12	
S18. Advanced Quantum Mechanics	HT	12	
S20. History of Science	MT	8	
S21. Philosophy of Science	HT	16	
S22. Language Options	TT	2(3) hours per week	
S25. Climate Physics	TT	12	
S27. Philosophy of Space-Time	MT	16	
S28. Philosophy of Quantum Mechanics	HT	16	
S29. Exploring Solar Systems	TT	12	
S31. Numerical Methods	TT	12	
S33. Entrepreneurship for Physicists	TT	12	

Practical Work

Most of the information you require for the practicals can be found online on the Part B Practicals 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

For the academic year 2020-21, Part B students are able to book individual experiments for in person and as pairs for remote experiments on Mondays and Tuesdays every other week. Your allocated weeks and labs will be shown on your page of SPIRe. In Michaelmas term, non mini project experiments will be available in weeks 2-8, Hilary Term 1-4 and Trinity Term weeks 1-4. Mini project experiments are only available in weeks 3-8 of Michaelmas Term and weeks 1-4 of Hilary Term. You are free to do experiments from any lab; there are no compulsory experiments. Bookings are made on a first come, first served basis.

Practical work timetable: Labs are open 10am-5pm but please check the arrival time on Canvas

Term	**Part B**
Michaelmas	All practicals (and mini project) weeks 2-8
Hilary	All practicals (and mini project) weeks 1-4 No labs or marking (unless by appointment) weeks 5-8
Trinity	All practicals (and assessed practical) weeks 1-4

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 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. **For the academic year 2020-21, all experiments must be pre-booked and turning up to the teaching labs without booking will not be permitted.**

To fulfil the practical work requirements for the third year (Part B) you must complete eight days of practical work (usually three two-day practicals plus a mini-project). The mini-project that you write up in college does not get any credit on your SPIRe lab record, but everyone who completes a mini project write up gets an extra two days of lab credit added to their record at the examination stage, so your transcript will eventually show that 10 days of practical work were completed. You must complete the following days of practicals:

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.

You should prepare for the experiments you choose 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). You must decide in advance which experiment you intend to do next and book it. ***Demonstrators may ask you to leave if you do not show adequate knowledge of the practical at the start of the session.***

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 for the practical work as detailed in this handbook and online on the Part B 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.

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 criterion 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

Your practical work is assessed in several ways. Demonstrators will observe your work and inspect the records in your logbook during the experiment. It is important to be able to present your scientific results clearly, as several write-ups are required. Training in written presentation of your work has been provided by the writing of Part A Computing reports assessed by demonstrators.

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 unless you are instructed otherwise.

Summary of the experiment

When you have finished the experiment and data analysis, you should hand-write a brief (approximately half a page) summary of the work in your logbook. You should state the aims of the experiment, the method, and summarise the results and conclusions, quantitatively if possible. This is to both consolidate your understanding and to provide training in written skills. The ability to concisely report a piece of work by appropriate selection of material is an important skill both in physics and elsewhere. This should be written immediately after the experiment, but before marking.

Mark scheme

At the end of the experiment and a short discussion of your work, the demonstrator will then give you a mark. 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 do the experiment or report again. A mark of 2 is required to pass and obtain the credit for the practical. Once a student has a mark of 2 or higher, they cannot be re-marked 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).

Assessed practical

The assessed practical is compulsory for all Part B Physics students. It is a short oral examination that takes place in Trinity Term.

You must write a short (1 page) report on a marked practical of your choice (not your mini-project or a vacation placement) and take it to a senior demonstrator, with your logbook, for assessment during lab classes in Trinity Term. The report is not marked, and is used to provoke discussion of your understanding of the experiment. The marking will be arranged informally by a sign-up sheet, similar to first year practical write ups. This is arranged on a first come first served basis, so if all slots for your chosen lab are full, then you will need to choose a different one. If you do not produce this write up for marking before the end of the last lab session (Tuesday 1700hrs Week 4 Trinity Term) without good reason, you will get zero. Students must bring **all the logbooks they have used during Part B to the assessment.**

If you miss the assessed practical appointment without good reason you will lose marks.

The Part B 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 Part B can be found in **Appendix E.**

Physics Examinations

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. The Examiners are a committee set up each year under the Proctors. The Finals Examiners include external examiners from other UK universities and may be assisted by a number of Assessors to set and mark some individual papers, projects, etc. In general, papers for Prelims and Part A of Finals 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 final examinations in physics are printed in **Appendix C**.

Examination Entry

Entry for the FHS Part B exam is at the end of 8th week of Michaelmas Term, and 3rd week of Trinity Term for Short Option choices (except for certain alternatives).

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.

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 Final Honours School 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, and penalties for 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.

External Examiner and Examiners' Reports

The names of the External examiners are published in the Examination Conventions. 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**.

Part B Examination

The examination will take place toward the end of Trinity Term.

<table>
<tr><th>BA (3 year course)</th><th>MPhys (4 year course)</th><th>Physics and Philosophy</th></tr>
<tr><td>Option 1:
Three Written papers including B4, B6 and one other, from:
B1,B2,B3,B5
Two Projects: B8 and B9
Short Option Paper
Mini Project
Practical Work

Option 2:
Four Written papers including B4, B6 and two other, from:
B1,B2,B3,B5
One Project: B8 or B9
Short Option Paper
Mini Project
Practical Work

Option 3:
Three Written papers including B4, B6 and one other, from:
B1,B2,B3,B5
Industrial Project
Industrial Group Presentation
Short Option Paper
Mini Project
Practical Work</td><td>Option 1:
Five Written papers including B4, B6 and three other, from:
B1,B2,B3,B5
Short Option Paper
Mini Project
Practical Work

Option 2:
Four Written papers including B4, B6 and two other, from:
B1,B2,B3,B5
One Project: B8 or B9
Short Option Paper
Mini Project
Practical Work

Option 3:
Three Written papers including B4, B6 and one other, from:
B1,B2,B3,B5
Two Projects: B8 and B9
Short Option Paper
Mini Project
Practical Work</td><td>Two subjects in Physics and Four subjects in Philosophy

<u>OR</u>

Four subjects in Physics and Three subjects in Philosophy.

Physics and Philosophy students must choose at least two of subjects B2, B5, and B7</td></tr>
</table>

The material for the B papers will be covered by lectures, tutorials and classes concentrated in Michaelmas & Hilary Terms.

Full details of the syllabuses for the written papers are given in **Appendix C**.

Marking Mini-projects

College tutors mark the second draft during Trinity Term as a percentage using the University's USM scale:

70%+	1st class	First Class
60-69%	2.1	Upper second
50-59%	2.2	Lower second
40-49%	3rd class	Third
30-39%	Pass	Pass
<30%	Fail	Fail

As in BA and MPhys reports, marking reflects the clarity and rigour of the report, and not the experimental work: a well-documented failure can receive high credit. There is no suggested length for the report, which will in any event vary greatly for different projects. Similarly there is considerable flexibility on questions of style, but a top quality report should include all the usual components: introduction, outline methods, results, analysis of results including errors, and discussion and conclusions. In most cases suitable diagrams will be included to illustrate the results. Students may refer to the script for experimental details, but a good report should include at least an outline description of the underlying method.

Assessment of Practical Work

The practical mark for the second and third year consists of marks for completing experiments and an assessed practical.

Practical Work	**Part B**
Completing Experiments [a]	30
Assessed Practical [b]	20
Total	**50**

The relative marks are made up as follows:

[a] Up to 30 marks as indicated for completing all experiments. Failure to complete the practical quota will attract the following penalty:

(i) A penalty of 5 marks will be deducted for each missed day of experiments.

(ii) If 6 or more days of experiments are missed, the Examiners may penalise the student by lowering the final degree by one class.

[b] Up to 20 marks awarded by the Senior Demonstrator, based on both the quality of the entire logbook and the understanding of the Assessed Practical (chosen at random in advance for Part B) demonstrated by the student.

The precise details of how the practical marks are calculated are published in the Examination Conventions.

Marking of the Assessed Practical

The marks, which will be awarded by a Senior Demonstrator, will be based on **both** the quality of the **entire logbook** and the understanding of the **assessed practical** demonstrated by the student. An average student with an average logbook should expect to achieve ~15 marks.

Specific details pertaining to practical work are published in the Part B Practicals Canvas course. Recommendations to the Finals examiners based on the awarded marks will be used for practical prizes and commendations. These recommendations will be made to the Finals examiners. It is important that students **consult their tutors early** in the event of difficulty with practical work.

More information on how to write up experiments can be found on the Extra Practical Work page of the Part B Practicals Canvas course.

Assessment of extra practicals and extended practicals

The marking of the extra practicals and extended practicals is based upon the following:

- Introduction and abstract
- Description of method/apparatus
- Experimental work/results and errors
- Analysis of results
- Conclusions
- Good argument in the analysis, the use of clear English and writing style. Clear diagrams/plots and references will also be taken into account
- Penalties for late work will be published in the Examination Conventions.

Assessment of Class

How the examiners work is their responsibility, subject to guidance from the Physics Academic Committee, and regulations laid down by the central bodies of the University. However, the following gives some indication of recent practice. Each paper is marked numerically. The numerical marks for each paper may be scaled to remove any first-order effect of a difficult (or easy) paper and these (scaled) marks are combined to give a total numerical mark.

Class	**Descriptor**
Class I (1)	the candidate shows excellent problem-solving skills and excellent knowledge of the material, and is able to use that knowledge in unfamiliar contexts
Class II.1 (2.1)	the candidate shows good problem-solving skills and good knowledge of the material
Class II.2 (2.2)	the candidate shows basic problem-solving skills and adequate knowledge of most of the material
Class III (3)	the candidate shows some problem-solving skills and adequate knowledge of at least part of the material
Pass	the candidate has made a meaningful attempt of at least one question

For the BA degree FHS Parts A and B are approximately weighted 2: 3; for the MPhys FHS Parts A, B, C are approximately weighted 2: 3: 3

Final Degree Classes are assigned on the basis of a careful consideration of the total numerical mark with the project and practical work taken into account.

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 your year. 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.

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

Year Outcome for Part B

The examiners will classify students at the end of year 3 of the MPhys course according to using the University's USM scale

70%+	1st class	First Class
60-69%	2.1	Upper second
50-59%	2.2	Lower second
40-49%	3rd class	Third
30-39%	Pass	Pass
<30%	Fail	Fail

Part B Examination Prizes

Prizes may be awarded for excellence in various aspects of the third year examination

- Scott prizes
- Gibbs prizes
- Project prizes
- 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

MMathPhys

We offer a taught masters course in Mathematical and Theoretical Physics as an alternative to the fourth year of the MPhys course, see http://mmathphys.physics.ox.ac.uk

Appendix A Recommended Textbooks - Third year

(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***

Third Year

B1 Fluids

'Physical Hydrodynamics', E. Guyon, J.-P. Hulin, L. Petit, C. D. Mitescu, 2nd edition, OUP, 2015**
'Elementary Fluid Dynamics', D. J. Acheson (OUP, 1990), ISBN-10: 019859679 **
'Fluid Mechanics', 2nd edition, Volume 6 of Course of Theoretical Physics, L. D. Landau, E. M. Lifshitz, (Elsevier) *
'An introduction to Fluid Dynamics', G. K. Batchelor, (Cambridge University Press *
'Physical Hydrodynamics', 2nd edition E. Guyon, J.–P. Hulin, L. Petit, C. D. Mitescu, (Oxford University Press) **
'Elementary Fluid Dynamics', D. J. Acheson, (Oxford University Press) **
'Fluid Mechanics', 2nd edition, Volume 6 of Course of Theoretical Physics , L. D. Landau, E. M. Lifshitz, (Elsevier) *
'An introduction to Fluid Dynamics', G. K. Batchelor, (Cambridge University Press *

B2 Symmetry and Relativity

Special Relativity

'Relativity made relatively easy', A. Steane (OUP) **
'Classical Electrodynamics', JD Jackson, (Wiley, 1998)*
'Introduction to Special Relativity', W Rindler, (OUP)
'An Introduction to Special Relativity and its applications', F N H Robinson, (World Scientific)

B3 Atomic and Laser Physics

'Atomic Physics', Chris Foot (Oxford Master Series in Physics) **
'Atomic & Quantum Physics', Haken & Wolf (Springer)
'Principles of Modern Physics', RB Leighton (McGraw Hill) *
'Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles', E Eisberg and R Resnick (Wiley)*
'Elementary Atomic Structure', G K Woodgate (Oxford) *
'Atomic Physics', J C Willmott (Wiley) Manchester Physics Series
'Laser Physics', S Hooker and C Webb (Oxford Master Series in Physics) **
'The Physics of Quantum Mechanics' J Binney and D Skinner, (Cappella Archive http://www.cappella.demon.co.uk/cappubs.html#natsci) *
'Principles of Lasers,' Orazio Svelto, (Plenum Publishing Corporation KLUWER ACADEMIC PUBL) ISBN10: 0306457482, ISBN13: 9780306457487
'Laser Physics' Hooker and Webb, ISBN13: 9780198506911, ISBN10: 0198506910

B4 Nuclear and Particle Physics
'Quantum Mechanics', Franz Mandl *
'Quantum Mechanics', Eugen Merzbacher *
'An Introduction to Nuclear Physics', W.N.Cottingham and D.A. Greenwood *
'Nuclear and Particle Physics', W.S.C Williams *
'Elements of Nuclear Physics', W.E.Burcham *
'Introductory Nuclear Physics', Kenneth S. Krane *
'Particle Physics', B.R.Martin and G.Shaw*
'Introduction to Elementary Particle Physics', Alessandro Bettini*
'Particle Physics in the LHC Era', G.Barr, R.Devenish, R.Walczak, T.Weidberg *
'Introduction to High Energy Physics', Donald H. Perkins, *

B5 General Relativity
'General Relativity: An Introduction for Physicists', M. Hobson, G. Efstathiou and A. Lasenby (Cambridge, 2006)
'Gravitation,' C. Misner, K. Thorne, J. Wheeler (Princeton, 2017)
'Spacetime and Geometry,' S. Carroll (Cambridge, 2019)
'Gravitation and Cosmology', S. Weinberg (Wiley, 1972)
'Gravity: An introduction to Einstein's Theory of General Relativity', James Hartle (Addison-Wesley, 2003)
'Introduction to Cosmology,' B. Ryden (Cambridge, 2017)
'Black Holes, White Dwarfs, and Neutron Stars,' S. Shapiro and S. Teukolsky (Wiley, 1983)
(Cambridge, 2007)

B6 Condensed-Matter Physics
'The Oxford Solid State Basics', Steven H Simons (OUP, June 2013) ISBN-10: 0199680779 | ISBN-13: 978-0199680771
'The basics of crystallography and diffraction', C Hammond (OUP)
'Introduction to Solid State Physics' C Kittel (Wiley) *
'Solid State Physics', N W Ashcroft and N D Mermin (Saunders)
'Solid State Physics', H Ibach and H Luth (Springer)

<u>Short Options</u>

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

S07. Classical Mechanics†

'Mechanics (Course of Theoretical Physics), Vol 1', L D Landau and E Lifshitz (Butterworth Heinemann): Physics the Russian way - first volume of the celebrated 'Course of Theoretical Physics'.
'Classical mechanics', 5th ed, T.W.B. Kibble & F.H. Berkshire – good solid book `Analytical Mechanics' L. Hand + J. Finch – good solid book 'Classical mechanics', 3rd ed H. Goldstein, C. Poole & J. Safko. A classic text. In the US probably plays the same role for classical mechanics that Jackson does for electrodynamics. For the mathematically erudite: 'Mathematical methods of classical mechanics', V.I. Arnold.
†also for **B7. Classical Mechanics**

S10. Medical Imaging and Radiation Therapy

'Webb's Physics of Medical Imaging', 2nd ed, Flower, ISBN 9780750305730
'Physics in Nuclear Medicine', 4th ed., Cherry Sorenson and Phelps, ISBN 9781416051985
'Introduction to Radiological Physics and Radiation Dosimetry', Frank Herbert Attix, Sep 2008 ISBN: 978-3-527-61714-2
'Fundamental Physics for Probing and Imaging', Wade Allison, Oxford (2006) ISBN 9780199203888 and 9780199203895

Useful resource:
'3D Conformal Radiation Therapy - A multimedia introduction to methods and techniques', Springer ISBN 978-3-540-71550-4

S14. History of Physics

'The beginnings of Western Science: the European Scientific Tradition in Philosophical, Religious and Institutional Contexts', D.C. Lindberg, , (Chicago, 1992)
'A History of Natural philosophy from the Ancient World to the Nineteenth Century E. Grant, ', (Cambridge, 2007)
'Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental life', S. Shapin and S. Schaffer, (Princeton, 1995)
'Galileo', J. Heilbron, (Oxford, 2010)
'The Birth of a New Physics', I.B. Cohen, (Norton 1985)
'Discipline and Experience', P. Dear, (Chicago, 1994)
'The Cambridge History of Eighteenth Century Science', R. Porter, ed., (Cambridge, 2002)
'The Maxwellians', B. Hunt, (Ithaca, 1991)
Reading:
'From Watt to Clausius', DSL Cardwell, (Heineman 1971)
'Image and Logic: A Material Culture of Microphysics', P. Galison, (Chicago, 1997)
'Gravity's Shadow: the search for Gravitational Waves', H. Collins, (Chicago, 2004)

S16. Plasma Physics

'Plasma Dynamics', R.O. Dendy (OUP)
'Introduction to Plasma Physics and Controlled Fusion: Volume 1, Plasma Physics' Francis F. Chen (Plenum)

S18. Advanced Quantum Mechanics

"Quantum Mechanics", L.D.Landau and E.M.Lifshitz,(Pergamon Press, 1965)
"Advanced Quantum Mechanics", J.J.Sakurai, (Addison Wesley, 1967)
"Modern Quantum Mechanics", 2nd edition, J.J.Sakurai and J.J.Napolitano, (Addison Wesley, 2010)
"Intermediate Quantum Mechanics", H.Bethe and R.Jackiw, (Addison Wesley, 1986)
"Scattering Theory", J.Taylor, (Dover, 1972)
"Scattering Theory of Waves and Particles", R.Newton, (McGraw-Hill, 1966)
"Quantum Mechanics: Selected Topics", A.Perelomov and Ya.B.

S25. Physics of Climate Change

For a very accessible overview: D. Archer, "Global Warming, Understanding the forecast", 2nd Ed., (Wiley) For a deeper look, but pitched at the right level for this course: R. T. Pierrehumbert, "Principles of Planetary Climate", (CUP)

For a compact summary for the busy undergraduate: S. J. Blundell and K. M. Blundell, "Concepts in Thermal Physics", 2nd Ed., Chapter 37
For a bit more detail: D. G. Andrews, "An Introduction to Atmospheric Physics", 2nd Ed. (CUP), Chapters 2 & 8 or J. Marshall and R. A. Plumb, "Atmosphere, Ocean and Climate Dynamics, An Introductory Text", (MIT), Chapters 2, 3, 9 & 12.

And for a highly influential, albeit controversial, take on climate change economics: W. Nordhaus, 'The Climate Casino: Risk, Uncertainty and Economics for a Warming World', (Yale), Chapters 13-16 & 18.

S29. Exploring Solar Systems

"Planetary Sciences", by Imke de Pater and Jack Lissauer
"The solid Earth", C M R Fowler

S31. Numerical Methods

'Computer Simulation using Particles', R.W. Hockney and J.W. Eastwood, Taylor and Francis (1988)
'Numerical Methods in Astrophysics', Bodenheimer, Laughlin, Rozyczka and Yorke, Taylor and Francis (2007)
'Riemann Solvers and Numerical Methods for Fluid Dynamics ', E.F. Toro, Springer (2009)
'Finite Volume Methods for Hyperbolic Problems', R. LeVeque, Cambridge University Press (2002)
'Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-dependent Problems', R. LeVeque, Society for Industrial and Applied Mathematics (2007)

S33. Entrepreneurship for Physicists

The Mom Test by Rob Fitzpatrick
Business Model Generation by Alexander Osterwalder
Mullins, John (2017) *The New Business Road Test*, Pearson 5th edition
Disciplined Entrepreneurship by Bill Aulet

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 Third Year (Final Honour School – Part B)

A knowledge of the topics in the syllabuses for the four compulsory physics Prelims papers and the compulsory material for Part A will be assumed. Emphasis will be placed on testing a candidate's conceptual and experimental understanding of the subjects. The word 'qualitative' indicates that the treatment of the topic will outline the physical principles involved, may include order of magnitude estimates, but will not be a full mathematical treatment.

Each of the physics B papers is a 2-hour paper,
Answer 2 questions from 4 in each section offered; with each question worth 25 marks.

B1 Fluids

Fundamental definitions, conservation principles.
Eulerian and Lagrangian descriptions.
Ideal fluids: Euler and vorticity equations, Bernoulli theorem (steady flow).
Surface waves: dispersion relation, group velocity, gravity-capillary waves.
Sound waves (linear treatment).
Potential flows, irrotational flow past an obstacle: complex potential, Kutta-Joukowski lift theorem.
Concept of stress in a continuous medium, stress-strain relationship.
Viscous flows: Navier-Stokes equation, no-slip condition, Reynolds number, examples of elementary viscous flows, dynamical similarity, very viscous flows.
Instabilities: Kelvin-Helmholtz, Rayleigh-Bénard, Rayleigh-Taylor; transition to turbulence.
Boundary layers: 2D laminar boundary layer equations, boundary layer separation.
Stratified fluids: buoyancy, internal gravity waves.

B2 Symmetry and Relativity

Concept of symmetry, groups and representations.
Examples of symmetries and applications.
Relativity in four-vector form and Lorentz transformations (Lorentz group), including Compton scattering and application to formation, collision, annihilation, and decay of particles.
Four-forces and simple motion problems.
Electromagnetism in four-vector and tensor formulation, including the Maxwell field tensor, the energy-momentum tensor of the electromagnetic fields, and their transformations.
Relativistic electrodynamics and radiation (field of an accelerated charge, retarded potentials, radiated power and Larmor's formula).
Concept of gauge invariance.

B3 Atomic and Laser Physics

Multi-electron atoms: central field approximation, electron configurations, shell structure, residual electrostatic interaction, spin orbit coupling (fine structure).
Spectra and energy levels: Term symbols, selection rules, X-ray notation, Auger transitions.
Hyperfine structure; effects of magnetic fields on fine and hyperfine structure.
Two level system in a classical light field: Rabi oscillations and Ramsey fringes, decaying states; Einstein A and B coefficients; homogeneous and inhomogeneous broadening of spectral lines; rate equations.
Optical absorption and gain: population inversion in 3- and 4-level systems; optical gain cross section; saturated absorption and gain.

B4 Nuclear and Particle Physics

Knowledge of the special relativity in the Prelims paper CP1 will be assumed

Scattering in quantum mechanics to first order, concept of a scattering cross section, form factors, propagators, virtual particle exchange.
Resonant scattering, decay widths, Breit-Wigner formula.
Nuclear mass, binding energy, the semi-empirical mass formula, stability, radioactivity, alpha and beta decay.
Basic fission and fusion reactions.
Quark model of hadrons: the light meson and baryon multiplets and quarkonium.
The Standard Model: quark and lepton families, fundamental interactions, Cabibbo mixing.
Strong interaction, a qualitative discussion of confinement, the concept of colour.
Weak interaction, parity violation, properties and decays of the W and Z bosons.

B5 General Relativity

Gravity as a geometric concept, equivalence principle, tensor formulation of special relativity.
Gravitational redshift.
Tensor calculus, general covariance, affine connection, metric tensor, covariant derivatives. Newtonian limit/gravitational redshift connection. Parallel transport.
Geodesic motion in covariant form. Riemann and Ricci curvature tensors. Bianchi identities and Einstein Field Equations.
Classical tests of GR: light deflection, advance of Mercury's perihelion, Shapiro delay.
Black holes via Schwarzschild solution. Stellar hydrodynamic equilibrium.
Simple treatment of gravitational radiation. Binary orbit decay by gravity wave emission. Detections of gravitational waves.
Expanding universe dynamics. FRW metric. Accelerating universe, cosmological constant as vacuum energy.

B6   Condensed Matter Physics

Structure and types of condensed matter. Chemical Bonding.
Crystal structure: lattices, unit cells and basis, reciprocal lattices, Brillouin zones.
X-ray and neutron diffraction: Bragg and Laue equations, structure factor, atomic form factor and nuclear scattering length.
Vibrations in lattices: monatomic and diatomic chains, phonons, heat capacity, Einstein and Debye models.
Free-electron theory of metals: Fermi energy and Fermi surface, density of states in 1, 2, and 3 dimensions, heat capacity, electrical conductivity.
Band structure: nearly free electron model for electron dispersion in a periodic potential, tight binding model, band gaps, distinction between metals, semiconductors and insulators.
Direct and indirect gap semiconductors, optical absorption, donor and acceptor impurity doping. Mobility and Hall effect, temperature dependence of carrier concentration.
Magnetic properties of matter: diamagnetism, paramagnetism and Hund's rules, Pauli paramagnetism, exchange interactions, ferromagnetism and Curie-Weiss law, domains.

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.

S07. Classical Mechanics*

Calculus of variations: Euler--Lagrange equation, variation subject to constraints.
Lagrangian mechanics: principle of least action; generalized co-ordinates; configuration space. Application to motion in strange co-ordinate systems, particle in an electromagnetic field, normal modes, rigid bodies. Noether's theorem and conservation laws.
Hamiltonian mechanics: Legendre transform; Hamilton's equations; examples; principle of least action again; Liouville's theorem; Poisson brackets; symmetries and conservation laws; canonical transformations.
*[Non-examinable: Hamilton--Jacobi equation; optico-mechanical analogy and derivation of Hamilton's principle from path integral. Action-angle variables.]******
Note: the above Classical Mechanics syllabus is also that for the Physics and Philosophy paper B7: Classical Mechanics but includes the non-examinable material.

S10. Medical Imaging and Radiation Therapy

The physics that is applied in imaging, diagnostics, therapy and analysis in medicine: Interaction of X-rays with matter (Photoelectric, Compton, Pair Production); X-ray imaging (scintillation and diode detection) and Computed Tomography; Magnetic resonance fundamentals, basic imaging & slice selection, functional imaging (diffusion-weighted imaging, dynamic contrast-enhanced imaging, spectroscopy); Ultrasound and its application to imaging, including Doppler imaging; Use of radioisotopes: Gamma cameras, SPECT, PET & radionuclide therapy; Radiotherapy: microwave linacs, bremsstrahlung, beam collimation, portal imaging; Introduction to radiotherapy planning: CT simulation, conformal therapy, IMRT, charged particle therapy; Radiation Dosimetry (ionisation chambers, film, diodes, TLDs); Safety considerations; Comparisons between imaging methods.

S14. History of Physics

Medieval natural philosophy: the basic Aristotelian scientific views that dominated learned thought until the Seventeenth Century, and why the system became increasingly implausible by the end of the Sixteenth Century.

The instrumental origins of the Scientific Revolution: how in the first three decades of the Seventeenth Century there was a transformation in the way that researchers understood nature, such that for the first time it became conceivable that experiments and scientific instruments could give improved evidence about the natural world.

The Mathematization of Nature: the introduction by Galileo and Newton of new and immensely powerful mathematical approaches to nature, the ways in which they argued for these approaches and the response to them.

The Evidential Basis of the Newtonian system: the experimental and observational corroboration of the Newtonian system in the Eighteenth Century, including the shape of the Earth, the prediction of the return of Halley’s comet in 1759, and the triumph of celestial mechanics.

Electromagnetism from Oersted to Maxwell: the work of Oersted, Faraday, Maxwell and Heaviside, and resulting contemporary technological innovations.

Carnot’s Inheritance and the Creation of Thermodynamics: Carnot’s analysis of Watt engines, his idealisation of a perfect engine by means of the Carnot cycle, and the later work of Joule, William Thomson, and Clausius leading to the concept of energy.

Small Particles and Big Physics from Marie Curie to CERN: the twentieth century elaboration of the structure of matter, from the pioneering work of Wilson, JJ Thomson, and Rutherford, the work of Marie and Pierre Curie, Moseley’s use of X-Ray spectroscopy to demonstrate the physical foundation of the Periodic Table, to the beginnings of particle physics

Einstein’s Universe: Finding Evidence for the General Theory of Relativity from Eddington to LIGO.

S16. Plasma Physics

Saha Equation. Heat Capacity of a Plasma. Debye Length.

Plasma frequency. The plasma parameter and 'good' plasmas. Single particle motion: Larmor orbits, guiding centre drift, drift of particles in electric and gravitational fields, grad-B drift. First adiabatic invariant. Analysis of subset of electrostatic and electromagnetic waves in unmagnetized and magnetized cold plasmas. Coronal Equilibrium. Plasma dispersion and Faraday Rotation and application to simple astrophysical problems.

Concept of collisionless plasmas and collective effects. Collision times and the Coulomb Logarithm. The fluid approximation, Bohm-Gross frequency. The Vlasov equation and Landau damping (integration in the complex plane not required). The Lawson criterion. Simple concepts of magnetic confinement fusion. Inverse bremsstrahlung absorption.

Rayleigh-Taylor Instability and simple concepts of inertial confinement fusion.

S18: Advanced Quantum Mechanics

Introduction to scattering theory. Classical and quantum scattering. Differential cross-section and the scattering amplitude. One dimensional scattering. The S-matrix. Green's functions methods. The Lippmann-Schwinger equation. Perturbation theory and the Born series. Scattering by a central potential. Method of partial waves, the phase shift. Unitarity and the optical theorem. Relativistic wave equations: the Klein-Gordon equation, the Dirac equation, their properties and solutions.

S25. Physics of Climate Change

This course outlines the basic physics underlying our understanding of how the global climate system responds to increasing greenhouse gas levels and its implications for the future. We cover: the distinction between weather and climate in a chaotic system; planetary energy balance; atmospheric temperature structure and its role in the greenhouse effect; forcing, feedbacks and climate sensitivity; the role of the oceans in the transient climate response; the global carbon cycle; simple coupled ODE models of global climate change; how we use observed climate change to quantify what is causing it and to constrain climate projections; simple climate change economics, including the principles and pitfalls of benefit-cost maximisation; and the prospects and risks of geo-engineering. In addition to the lectures, participants will be asked to undertake a small-group exercise using a simple (Excel-based) Integrated Assessment Model, devise their own global climate policy and defend it to the rest of the class.

S29. Exploring Solar Systems

The planets in our Solar system in context and with other solar systems, basic concepts including overview of orbits. Description of data sources (types of space missions, ground based observations, remote sensing and in-situ measurements). Solar system formation, planetary interiors, connection to observed terrestrial planetary surfaces, magnetic field (presence of dynamos), impact and cratering processes, introductory concepts in seismology. Planetary atmospheres, including basic derivations of thermodynamic concepts such as lapse rates, thermal structure, introduction to radiative transfer. Clouds and basic dynamics/ thermal wind equation. Applications of key concepts to exoplanets, next steps in planetary science, future exploration.

S31. Numerical Methods

Types of partial differential equations (elliptical, hyperbolic, parabolic); finite difference approximations for partial differential equations: discretization on a grid, Taylor series and accuracy of discretization, stability analysis of linear PDEs (one-dimensional heat conduction equation, scalar advection equation), physical meaning of stability criterion.

Collisionless N-body dynamics: Poisson-Vlasov system; Monte-Carlo approach to N-body dynamics; Time integration schemes for advancing positions and velocities of particles (e.g. explicit Euler method, Runge-Kutta methods, leapfrog method); symplectic integration schemes; gravitational force calculation: direct summation, particle mesh methods (mass assignment schemes, Fourier methods, relaxation solvers), tree algorithms.

Lagrangian versus Eulerian hydrodynamics; Smooth Particle Hydrodynamics: kernel interpolation; constructing derivatives from discrete tracer points; basic equations of smooth particle hydrodynamics; artificial viscosity and shock capturing.

Grid-based hydrodynamics: Euler equations as a set of hyperbolic conservation laws; conservative versus primitive variables; solution to linearized Euler equations and Riemann problem; solving non-linear conservation laws: shocks and rarefaction waves.

S33. Entrepreneurship for Physicists

The course comprises 12 hours direct teaching with a significant coursework element as the basis of assessment. It has been designed by experts in the Saïd Business School and Oxford Foundry specifically for Physics undergraduates.

Inspiration

Students will receive a series of short talks from ex-Physicists turned entrepreneurs (emphasis on founders of Hard Tech Start-ups), current academics who have their own spin-outs, and academics who license technologies to companies. Examples of start-ups could include those supported through the OXFO L.E.V8 accelerator programme that have been founded by ex-Oxford Physics students such as See-Through Scientific and Veratrak. Showcasing a combination of current academics who have spin-outs and Oxford Physics alumni that have created start-ups will show students that they do not need to leave academia to be enterprising.

Team Building

A leadership coach will help students form diverse high-performing teams of 2-4 people using Belbin team formation methodology. The exercises will help students gain a greater self-understanding of their strengths and how to manage their weaknesses, enabling them to better contribute to a team. Students will form teams made up of a diverse mix of Belbin team roles.

Creative Thinking & Problem Discovery

Students will be provided with an introduction to design thinking to help them understand what creative problem solving is and how it can be used for innovation. A common pitfall that scientists face when developing products is starting with a solution and looking for a problem.

Design thinking is a powerful methodology to helping students engage with actual customer needs and work towards building insightful and efficient solutions where there is a market opportunity. Students would be shown case studies of Hard Tech companies related to Physics and be tasked with applying the concepts of design thinking to generate an idea for a product or service and begin the process of developing the idea for the people they are designing for.

Intellectual Property (IP) & Licensing

Students will be introduced to the principles of IP and why IP is so critical to new businesses.

The session will cover IP as a value driver for start-ups, how to monetize IP and various methods to protect your IP. Speakers will have a background in managing IP and technology transfer and draw upon their experiences of working with companies. Students will have the opportunity to get first-hand accounts on how business strategy is formed around IP, what opportunities and challenges companies have to face and how to maximise the value of IP.

Market Segmentation & Knowing Your Customer

Students in their newly formed teams will explore how to choose the market segment for their chosen product or service and the methods of "seeing the problem through the customers' eyes." Students will learn and apply the concepts of market segmentation, explore the foundations of primary market research, and develop a customer persona.

Quantifying the Value Proposition & Designing a Business Model

Students will learn how to estimate the quantified value proposition for their team's product or service and gain an understanding of existing business models of companies across industries where disruptive technologies have had a significant impact (e.g. Biotech and Quantum computing) to help students capture some of the value their product or service brings to the customer. Students will be guided through how to use the Business Model Canvas to map and design a business model for their product or service.

The assessment for this course will be as follows:

25% Group presentation: Assessed based on an oral presentation of a business idea/plan.

25% Group written assessment: Student groups will be asked to submit an executive summary of no more than 1000 words, and a slide presentation of no more than 10 slides.

50% Individual Feasibility Study: Individual students will be asked to write a portion (1000 words max) of a document assessing the feasibility of a potential business venture, from one of the following perspectives: the potential market (demand-side), the potential competition (supply-side), and the skill-base of the team.

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 AY 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 Part B experiments

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

Optics

Location: Rooms 209 and 215 **Head of Lab for Part B: Prof. Alexander Lvovsky**

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.

Mini-projects are indicated with (mp) after the practical title. Mini-project bookings are for two consecutive weeks; in the first week you do, and are marked for, the basic experiment. In the second week you do the more open ended mini-project part.

OP31 Absorption spectrum of sodium (quartz prism spectrograph) (1 day online only)

With a complicated spectrum, one can isolate those transitions which connect to the ground state by observing the absorption spectrum. Here sodium is observed in absorption, and the spectrograph (quartz prism and lenses) operates far enough into the u.v. for a number of lines in the principal series to be identified. Results are analysed in terms of a quantum defect formula; values can be obtained for the ionisation energy of sodium and the quantum defect.

OP32 Isotope shift and fine structure in hydrogen

A photographic study of detailed structure in the Balmer lines using a Fabry-Perot etalon. Basic atomic physics is investigated by high resolution spectroscopy.

OP33 Hyperfine structure of cadmium (mp)

A study of hyperfine structure using a Fabry-Perot etalon. The results can be used to determine the nuclear spin of ^{111}Cd and ^{113}Cd. In the first instance, measurements are made both by photographing the interference fringes and by pressure scanning of the fringes with photo-electric recording.

OP34 The Zeeman effect (mp)

The Zeeman effect (both normal and anomalous) is studied in the spectral lines of cadmium using a Fabry-Perot etalon. We examine the polarization of the split spectral lines perpendicularly to the magnetic field and parallel to it. Basic atomic physics is combined with high resolution spectroscopy techniques. The mini-project component is a study of the splitting in the mercury spectrum.

OP35 The helium-neon laser (mp)

In this experiment a helium-neon (He-Ne) laser is built from a discharge tube and a variety of cavity mirrors, and the properties of the laser investigated. The requirements on the cavity mirrors to achieve a low-loss mode are established theoretically and confirmed by experiments. Measurements of the transverse profile of the lowest-order cavity mode are compared with theoretical expectations, and operation on a higher-order mode is demonstrated. Lasing on transitions in addition to the familiar transition at 632.8 nm is demonstrated by introducing dispersive elements into the laser cavity.

OP36 Image formation in the microscope

A coherently illuminated object is imaged by a lens. In the focal plane of the lens there appears the Fourier transform of the object. By blocking out certain parts of this plane (i.e. by filtering out certain Fourier components) one can change the image dramatically. Simple spatial filters can remove a raster to demonstrate the Abbe theory of microscope resolution, and to demonstrate phase contrast, dark-ground microscopy and Schlieren.

Condensed matter physics

Location: Room 127 Head of Lab: Prof. Robin Nicholas

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.

Mini-projects are indicated with (mp) after the practical title. Mini-project bookings are for two consecutive weeks; in the first week you do, and are marked for, the basic experiment. In the second week you do the more open ended mini-project part.

SS03 Hall effect in semiconductors (online)

The Hall coefficient and resistivity of both p-type and n-type InSb are measured between 77 K and 300 K. This experiment clearly illustrates many concepts covered in the third year lectures, including mobility, minority carriers, effective mass and the two carrier Hall effect; in the past it has been used as the basis of a number of finals questions! Experiment now 2 days.

SS05 The magnetophonon effect (online)

Introduces phonons, the quantised vibrations of the ions in a solid (sound waves are low energy phonons), the quantum-mechanical equivalent of cyclotron motion of electrons in a magnetic field, and the use of computers to record data. Measurements carried out at 77 K plus a little numerical processing allow the effective mass of electrons in InSb to be deduced.

SS07 The quantum Hall effect (mp) (online)

This experiment demonstrates that the Hall resistance of two-dimensional electrons is quantised very exactly. Hall effect data acquired using a high-field superconducting magnet and a computer data-acquisition system are used to determine the fine-structure constant to an accuracy of one part in 1×10^5.

SS08 Superconductivity (online)
Superconductors have an immeasurably small (or zero) electrical resistance. This experiment demonstrates this property, plus phenomena such as persistent currents and the Meissner effect. It also provides an introduction to data acquisition and processing using computers.

SS09 Superconducting quantum interference device
This experiment explores a Superconducting Quantum Interference Device (SQUID) as a means of performing sensitive measurements of magnetic fields, and of converting frequency into voltage through the 'Shapiro Step' effect.

SS12 Paramagnetic resonance (mp)
Magnetic resonance is used widely in medicine, biology, geology etc. The experiment explores electron spin resonance at 10 GHz. Aspects of second year statistical mechanics and quantum mechanics lectures are covered and topics from third year solid state lectures can be studied.

SS14 Nuclear magnetic resonance (1 day)
Nuclear magnetic resonance (NMR) is used widely in medicine and biology. In this experiment, a simple NMR spectrometer running at 10 MHz – 20 MHz is used to study H and F nuclei and to illustrate the basic principles of the technique.

SS16 X-ray diffraction (mp)
The study of the lattice structures of crystals using X-ray diffraction techniques. A range of experiments are undertaken using new X-ray sets, which allow computer controlled acquisition of X-ray spectra and powder diffraction using photographic film.

SS20 Adiabatic demagnetization (online)
The attainment and measurement of temperatures down to \SI{0.3}{\kelvin} using liquid helium and the adiabatic demagnetisation of a paramagnetic salt.

Nuclear physics

Location: Room 230 (Online only in 2020-2021) Head of Lab: Prof. Giles Barr

Due to the use of radioactive sources in this laboratory, a senior demonstrator must be present at all times. For this reason, the lab usually shuts at lunchtime.

Mini-projects are indicated with (mp) after the practical title. Mini-project bookings are for two consecutive weeks; in the first week you do, and are marked for, the basic experiment. In the second week you do the more open ended mini-project part.

NP03 γ-ray spectroscopy (mp)
A GeLi spectrometer is calibrated with sources of known energy and then used to investigate the γ-ray spectra associated with the β-decay of ^{108}Ag (simple) and ^{110}Ag (complicated).

NP08 Muon lifetime measurements

Muons are heavy electrons which decay into an electron (and two neutrinos) with a mean lifetime of 2 μs. Muons produced as a result of cosmic radiation interactions in the upper atmosphere filter down to DWB level 2 and some stop in a cylinder of plastic scintillator. Set up an electronic trigger for stopping muons and measure the distribution of time intervals between muons stopping and the decay electron.

NP10 search for mesons containing b-quarks (mp) (Online only)

In this experiment, you will use software tools to analyse real data from the CDF high energy physics detector at the Fermilab Tevatron to search for elementary particles. You will be using muons, which are relatively long-lived, to try to reconstruct what happened at the interaction vertex.

Physics of atmospheres and oceans

Location: Room 129 (Online only in 2020-2021) Head of Lab: Dr. Anu Dudhia

Mini-projects are indicated with (mp) after the practical title. Mini-project bookings are for two consecutive weeks; in the first week you do, and are marked for, the basic experiment. In the second week you do the more open ended mini-project part.

AP03 Remote sensing from satellites (mp) (Online only)

An infrared image of the Earth recorded by the geostationary Meteosat satellite is analysed using a computer. Standard techniques of image registration and radiometric calibration are investigated to determine sea-surface, land, and cloud top temperatures.

Astrophysics

Location: Room 221 (Online only in 2020-21) Head of Lab: Prof. Michele Cappellari

The Astrophysics experiments are computer based, carried out singly and are marked via a sign up on Canvas the week after you carry out the experiment.

Astrophysics experiments MUST be pre-booked on SPIRe - if you do not book and then turn up to be marked you may be turned away.

Doing Astrophysics practicals on one's own laptop is strongly discouraged because of the IT support issues. If your laptop even slightly differs from the settings on the computer room Macs it can be complicated to set up the required software, and the Physics Department will not be able to support this.

When doing the experiments, you will need to make a remote connect to the Macs in the teaching laboratories computer room. Computers will be allocated to students on the first morning of the practical when you connect to the relevant channel on Microsoft Teams. Instructions for connecting to the machines are on Canvas. You will only have access to the Mac for the week(s) you are booked into the lab and should not attempt to connect to the same Mac on a different week.

Mini-projects are indicated with (mp) after the practical title. Mini-project bookings are for two consecutive weeks; in the first week you do, and are marked for, the basic experiment. In the second week you do the more open ended mini-project part.

AS33 The mystery transiting exoplanet

The goal of this experiment is to measure the mass, radius and temperature of a 'mystery' transiting exoplanet, in order to identify it and to infer a crude estimate of its bulk composition.

AS35 Colour-magnitude diagrams of open clusters (mp)

In this experiment, you will use observations taken with the Philip Wetton Telescope to study the colour-magnitude diagram of an open stellar cluster. The practical uses a range of software tools and introduces techniques to calibrate the raw data, reduce the science images and carry out aperture photometry. Isochrones are then used to fit the photometric data and deduce the physical properties of the cluster.

AS37 The Hubble diagram for type Ia supernovae

Constraints on the values of cosmological parameters are determined by statistical analysis of a sample of type Ia supernovae. Results present one of the key pieces of evidence in favour of a non-zero Cosmological Constant. Best-fitting values of the energy density in matter and in dark energy are derived together with their statistical uncertainties.

AS38 Gas and Star Formation in Spiral Galaxies

Molecular insterstellar gas is the prime ingredient used by galaxies to form their stars. While the specific process of converting gas into stars depends on many parameters, the rate at which a galaxy forms stars should be directly proportional to its molecular gas mass. In this practical you will use spectral image maps from the Atacama Large Millimetre Array (ALMA) in Chile to measure the molecular gas content of a spiral galaxy. The stellar content of the same galaxy will be determined through analysis of near-ultraviolet and mid-infrared data taken from Space Telescopes. These measurements will enable you to investigate the complex process by which galaxies form their stars out of their molecular gas reservoir and determine the uncertainties involved in such measurements.

Biophysics

Rooms 214 and 216, DWB   Head of Lab: Prof. Sonia Contera

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.

Mini-projects are indicated with (mp) after the practical title. Mini-project bookings are for two consecutive weeks; in the first week you do, and are marked for, the basic experiment. In the second week you do the more open ended mini-project part.

Experiments are designed to introduce students to some of the techniques of modern biophysics, and to some biological systems that can be studied with these techniques.

BP01 Light microscopy (mp)

Image formation in a microscope is essentially an interference phenomenon. Spatial filtering of images will be explored and the Abbe theory of microscope resolution tested. Fluorescence microscopy and phase-contrast methods including differential interference contrast (DIC) will be used to observe and record images of plant and animal cells with a CCD camera. Various physical and biological microscopic phenomena will be observed and measured using different forms of microscopy.

BP02 Optical tweezers

A single-beam optical trap or optical tweezers allows micron-sized transparent particles to be held in a focused laser beam by forces on the order of a few piconewtons. The position of the particle can be measured with nanometre accuracy by measuring the displacement of the beam. A simple optical trap with position detection will be demonstrated and the force and displacement calibrated by measurement of the Brownian motion of the particle. The trap will then be used to observe the rotation of a living, molecular, rotary electric motor; the bacterial flagella motor.

BP03 Atomic force microscopy (AFM) (Might not be offered every week)

The atomic force microscope is a new technique that allows individual atoms to be resolved on flat surfaces. It is also becoming a powerful tool for the examination and manipulation of single biological molecules. The basic principles and operating modes of the AFM will be explored and simple specimens such as vinyl records and compact discs will be imaged. If possible, the practical will also include the imaging of single DNA molecules on mica surfaces and investigations of the properties of different kinds of DNA molecule.

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).