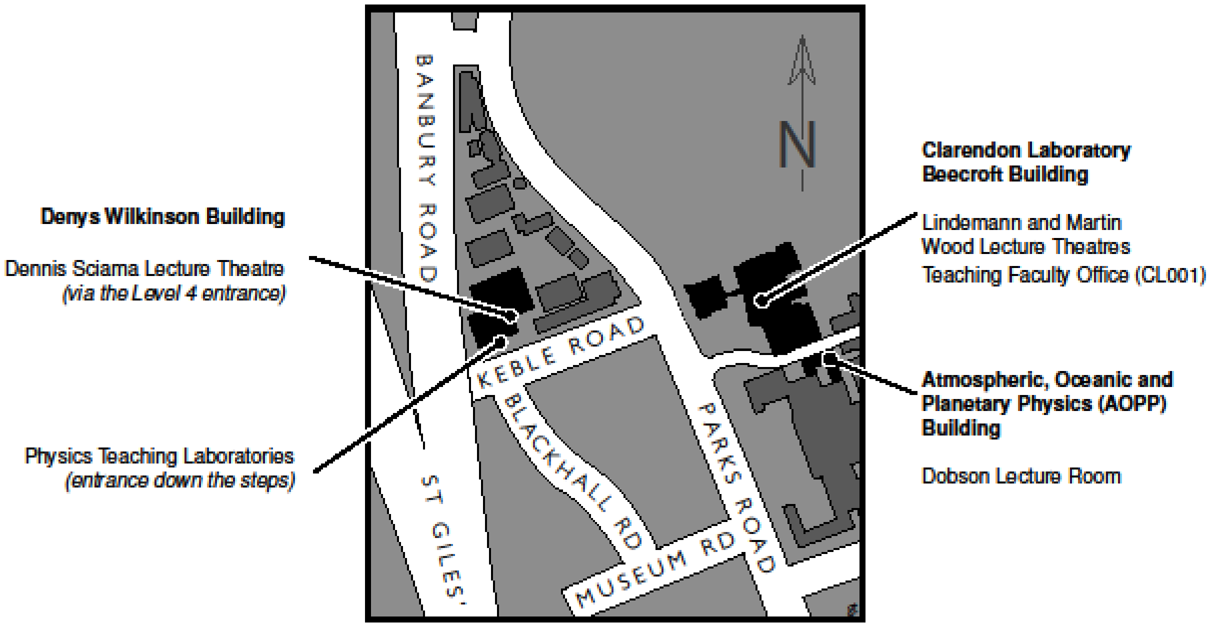
Physics Undergraduate Course Handbook 2019-2020

Third Year (Part B)

UNIVERSITY OF OXFORD

Map of the Department of Physics Buildings



Useful Department Contacts

Head of Teaching	Prof H Kraus hans.kraus@physics.ox.ac.uk	
Assistant Head of Teaching	Mrs C Leonard-McIntyre carrie.leonard-mcintyre@physics.ox.ac.uk	72407
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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 2019, Hilary Term 2020 and Trinity Term 2020.

Contents

Introduction to the handbook

A handbook is provided for each year of the programme, you may find it useful to read the handbooks on topics available in later years. This handbook contains, amongst other things, comprehensive book/reading lists; 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 the *Practical Course Handbook* at http://www2.physics.ox.ac.uk/students/undergraduates

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

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

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

For full and up-to date information on lecture timetables, see www.physics.ox.ac.uk/lectures.

The examination times given in this handbook are based on information available in September 2019. These may be altered and the definitive times are those published by the examiners; these will be posted on the official examiners' web page.

The Examination Regulations relating to this course are available at https://weblearn.ox.ac.uk/portal/hierarchy/mpls/physics/teaching/undergrads/exammatters. 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 mailto:carrie.leonard-mcintyre@physics.ox.ac.uk.

The information in this handbook is accurate as at **7 October 2019**, 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	Lindemann Lecture Theatre
Week 1	Industrial Projects	09:00	Dennis Sciama Lecture Theatre
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	Examination Schools
Weeks 1- 4	Assessed Practicals	Mon/Tues	Teaching Laboratories Sign up on paper sheets outside the relevant lab in advance.
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	Teaching Office
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.

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 D**, 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 http://www.ox.ac.uk/students/academic/guidance/skills.

Employability and careers information and advice

The University Careers Service (at 56 Banbury Road) provides careers advice for both undergraduates and graduates (see http://www.careers.ox.ac.uk). 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 2019-2020

Introduction to the Third Year

All Physics and Physics and Philosophy third years are **required** to attend the Introduction to the third year on Monday morning at 09:30 of 1st week of Michaelmas Term. 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 than during your 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

The examiners' requirement for practical work for Part B is **6** days + **4** days (mini project), but note that your SPIRe lab record will only show 8 days, since 2 are awarded 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 *Practical Course Handbook* and the Examination Conventions at https://weblearn.ox.ac.uk/portal/hierarchy/mpls/physics/teaching/undergrads/exammatters 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):

MT Weeks	Groups	Colleges
1-2	A,B	Mansfield, Merton, St John's, Pembroke Balliol, Brasenose, Exeter, Magdalen
3-4	C,D	Queens, SEH, Wadham Jesus, St Catherine's, Worcester
5-6	E,F	New, Somerville, St Anne's, St Peter's Christ Church, LMH, Oriel, Trinity
7-8	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 Option: 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 Spanish. 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.

There will be a presentation for those interested in taking a language option at the Language Centre, 12 Woodstock Road. See the Physics *Lecture list* at http://www.physics.ox.ac.uk/lectures/ for details.

There is a preliminary test to determine eligibility to take this option on Canvas followed by 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.

Short Option: Alternative Subject

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.

Short Option: 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 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.

Anyone wishing to do the S20: History of Science course should attend the first lecture, see the Physics *Lecture list* at http://www.physics.ox.ac.uk/lectures/

It is especially important to be present at the first lecture, immediately after which tutorial groups for the term will be arranged. More details can be found at http://course.chem.ox.ac.uk/history-and-philosophy-of-science-mt.aspx

(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.

More practical work

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 at least S on 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 one printed copy and 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.

Please ensure you write your candidate number **ONLY** on the report and **NOT** your name/college so that the reports can be marked anonymously.

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 one printed copy and 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.

Please ensure you write your candidate number **ONLY** on the report and **NOT** your name/college so that the reports can be marked anonymously.

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

Alternatives to practical work

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 *Practical Course Handbook.*

Textbooks

A list of the books recommended by the lecturers is given in **Appendix A**. 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

Please note: the course structure for the third year in 2019-2020 is different from previous years.

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	
S04. Energy Studies	TT	12	
S07. Classical Mechanics	HT	12	
S12. Introduction to Biological Physics	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	
S26. Stars and Galaxies	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	
S32. Chaos, Random Processes and Predictability	TT	12	

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* are 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 Examination matters webpage at https://weblearn.ox.ac.uk/portal/hierarchy/mpls/physics/teaching/undergrads/exammatters.

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 at https://weblearn.ox.ac.uk/portal/hierarchy/mpls/physics/teaching/undergrads/exammatters. 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 Examination matters webpage at https://weblearn.ox.ac.uk/portal/hierarchy/mpls/physics/teaching/undergrads/exammatters 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 10.3..." at http://www.admin.ox.ac.uk/examregs/2016-17/rftcoue-p10dopatuow-p-ccaominexam/ 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 A) demonstrated by the student.

The precise details of how the practical marks are calculated are published in the Examination Conventions at
https://weblearn.ox.ac.uk/portal/hierarchy/mpls/physics/teaching/undergrads/exammatters

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 *Practical Course Handbook*. 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 in the *Practical Course Handbook*.

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 **
Physical Fluid Dynamics, D. J. Tritton (CUP, 2nd edition, 1988), ISBN- 10: 0198544936*
Fluid Dynamics for Physicists, F E Faber, (CUP, 1995), ISBN-10: 0521429692*

B2 Symmetry and Relativity

Special Relativity

'Six not-so-easy pieces: Einstein's relativity, symmetry and space-time', R P Feynmann (Allen Lane, 1998)
'Introduction to Special Relativity', W Rindler, (OUP) **
'Einstein's miraculous year', J Stachel (Princeton, 1998)
'The Special Theory of Relativity', Muirhead (Macmillan)
'An Introduction to Special Relativity and its applications', F N H Robinson, (World Scientific)**
'Introducing Special Relativity', W S C Williams (Taylor & Francis, 2002) ISBN: 9780415277624
'Relativity made relatively easy', A. Steane (OUP) **

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)
‘Gravitation and Cosmology’, S. Weinerg (Wiley, 1972)
‘Gravity: An introduction to Einstein’s Theory of General Relativity’, James Hartle (Addison-Wesley, 2003)
‘Cosmology’, S. Weinberg (Oxford, 2007)
‘Introduction to Cosmology,’ B. Ryden (Cambridge, 2017)
‘The Cosmic Century’, M. Longair (Cambridge, 2006)
Black Holes, White Dwarfs, and Neutron Stars, S. Shapiro and S. Teukolsky (Wiley, 1983)

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)

Short Options

S01. Functions of a Complex Variable
‘Mathematical Methods for Physics and Engineering: A Comprehensive Guide’, K F Riley, M P Hobson and S J Bence (CUP, 2002), ISBN 0521-81372 7 (HB), ISBN 0521-89067 5 (PB) **
‘Mathematical Methods in the Physical Sciences’, Boas
‘Mathematical Methods for Physicists’, Arfken
‘Complex Variables’, Spiegel

S04. Energy Studies
‘Energy Science’, John Andrews and Nick Jelley (OUP 2013) **
‘Renewable Energy Resources’, Twidell & Weir (E&FN Spon)
‘Energy’, a guide book, J Ramage
Sustainable Energy- without hot air,’ David MacKay, http://www.withouthotair.com/
‘Elementary Climate Physics’, F W Taylor, OUP
‘Beyond Smoke and Mirrors’, B. Richter, CUP

‘Farewell Fossil Fuels – Reviewing America’s Energy Policy’, Borowitz

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**

S12. Introduction to Biological Physics

‘Biochemistry’, D. Voet and J. Voet (Wiley)
‘Molecular Biology of the Cell’, B. Alberts et al. (Garland)
‘Mechanics of Motor Proteins and the Cytoskeleton’, J. Howard (Sinauer)

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.

S26. Stars and Galaxies
“Astrophysics for Physicists”, Chouduri
“Galactic Dynamics”, Binney & Tremaine
“An introduction to Modern Astrophysics” by B. W. Carroll & D. Ostlie (2nd edition Pearson/Addison Wesley 1987)

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)

S32. Chaos, Random Processes and Predictability
Strogatz “Chaos” (MIT press)

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 http://www.admin.ox.ac.uk/examregs/2019-20/rftcoue-p10dopatuow-p-ccaominexam/ 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.

S04. Energy Studies

Historical development of power generation, global issues. Conservation laws. Application of thermodynamic reasoning to power generation.
Physical principles of thermal power plant. Generation from mechanical sources (hydro, tidal, wave, wind), Solar energy (PV and solar thermal), Biomass, Nuclear fission reactors. Fusion power. Energy storage. Risk assessment. Environmental and economic issues. Future trends.

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.

S12. Introduction to Biological Physics

Introduction to biological molecules, the structures and processes of life: organisms, organs, cells, molecules and molecular machines. DNA and RNA; the double helix, the "central dogma" and DNA code, DNA processing in cells, genes, inheritance. Proteins; the importance of water, amino acids and their properties, forces in protein folding, primary, secondary, tertiary and quaternary structure, methods of structure determination, proteins as catalysts and machines. Lipid bilayer membranes; self-assembly of lipids, vesicles, electrical properties, ionic solutions and Nernst potential. Biological membranes; ion channels and other membrane proteins.

Proteins as nanotechnology: importance of thermal energy, self assembly, examples of protein nano-machines.

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.

S26. Stars and Galaxies

Measurement of physical properties of stars and galaxies. Parallax and the distance ladder. Magnitude systems and their relationship to quantitative measurements of luminosity and effective temperature. Observational properties of stars and galaxies: the H-R diagram, stellar clusters, basic description of the structure of the Milky Way; the Hubble classification of galaxies; galaxy luminosity functions.

The equations of stellar structure: hydrostatic equilibrium, virial theorem, convection and energy transport. Structure of main sequence stars; use of scaling relations to derive relationships between stellar masses, luminosities, radii and lifetimes. The Chandrasekar limit and degenerate stellar cores; introduction to post-main sequence evolution.

Galaxies treated as systems of stars in spherically symmetric gravitational potentials. The Collisionless Boltzmann Equation; Jeans' equations; moments of distributions. Stellar velocity dispersions and their use to infer the potential. Influence of a point mass at the centre of the potential; observational evidence for supermassive black holes in normal galaxies.

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.

S32. Chaos, Random Processes and Predictability

The geometry of dynamical systems; fixed points and stability; properties of the Jacobian; limit cycles; control parameters and bifurcations; phase portraits; conservative versus dissipative systems; three-dimensional systems and the Poincare-Bendixon theorem (qualitative account only); the Lorenz system; phase-space volume contraction; strange attractors and fractals; introduction to random processes; distinguishing between low-dimensional chaos and linear stochastic processes; predictability and error growth; Liapunov exponents.

Appendix D 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, **Mrs Nicola Small**. 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).