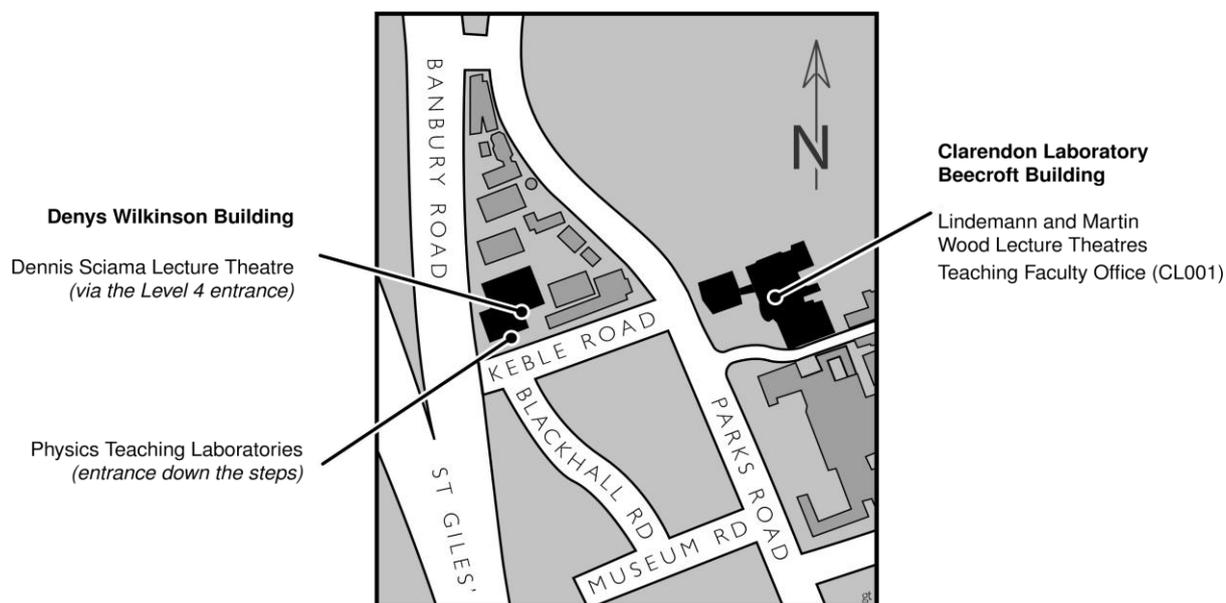


**Physics Undergraduate
Course Handbook
2019-2020**

Second Year (Part A)



Map of the Department of Physics Buildings



Useful Department Contacts

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

These notes have been produced by the **Department of Physics**. The information in this handbook is for the academic year Michaelmas Term 2019, Hilary Term 2020 and Trinity Term 2020.

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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/mps/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 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 Second Year	Mon 09:00	Lindemann Lecture Theatre
Week 1	Teaching Physics in Schools	***	Lindemann Lecture Theatre
Week 2	Short Options: S20; S21and S27		
Week 4	Application for more practical work or vacation placement deadline		
Week 8	Entry for Part A	Fri	*

Trinity Term	Event	Time	Location
Week 3	Entry for Short Option choices	Fri	*
Week 4	Last day to do practicals	Tues	Teaching Laboratories
Week 5	Year Group meeting		***
Week 5	Last day to get practicals assessed	Tues	BY APPOINTMENT ONLY
Week 5	Deadline for marking Practical work	Fri noon	Teaching Laboratories
Week 6	Assessed Practicals	Mon/Tues	Teaching Laboratories
Week 6	Hand in extra practical and extended practical reports	Mon 12:00	Teaching Office
Weeks 7- 8	Part A examination		**

* Students submit their entries via their College Office and Student Self Service.

** See <https://www.ox.ac.uk/students/academic/exams/timetables> for the exam timetables.

*** See <http://www.physics.ox.ac.uk/lectures/> for lecture details.

Introduction to the Department of Physics

The Department of Physics

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 <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.

Second Year 2019-2020

Introduction to the Second Year

All Physics and Physics and Philosophy second years are **required** to attend the Introduction to the second year on Monday morning at 09:00 of 1st week of Michaelmas Term. There you will hear a brief introduction to the second 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 second year of your programme.

The BA and MPhys courses

Part A is the same for the BA (3-year) and MPhys (4-year) courses.

Practical Work

The requirement for practical work for Part A is **12** days. It is possible to substitute 6 days of practical work with alternatives.

The *Practical Course Handbook* and the Examination Conventions at <https://weblearn.ox.ac.uk/portal/hierarchy/mps/physics/teaching/undergrads/exammatters> show more details.

Individual Presentations (formerly Oral Skills)

There will be a lecture giving guidance on how to give a talk (see www.physics.ox.ac.uk/lectures) in preparation for the short talk each student will be required to do within Colleges. This talk is usually given in Hilary Term as training in oral communication skills.

The talks should be written to last for 15 minutes, with a further 5 minutes allowed for questions. Topics on any branch of science and mathematics or the history of science may be chosen, but your title must be approved by your College tutor. Your tutor will mark your talk as a percentage.

Physics Department Speaking Competition

The Departmental Competition is held early in Trinity Term. College tutors may nominate one student to enter for this competition.

Each entrant will be allowed a maximum of **ten** minutes for the presentation and up to **two** minutes for questions. Students must provide the Teaching Office with their presentation 24 hours before the competition.

The winner of the Department's competition may be eligible for a prize. Examples of these talks can be found at <https://weblearn.ox.ac.uk/portal/hierarchy/mps/physics/teaching/undergrads/oralskills> to give students an idea of what a good talk should be like. Please note that the talks are meant to be technical and must include scientific or mathematical content.

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.

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.

At least one Short Option must be offered in Part A. A second Short Option may be offered in place of 6 days of practical work. Students electing to take this choice must inform the Assistant Head of Teaching by e-mail at carrie.leonard-mcintyre@physics.ox.ac.uk by the end of Michaelmas Term.

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 first or second 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 A or 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 (or two) 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. Physics students may substitute such a paper instead of two short options. Alternatively S20: History of Science or S21: Philosophy of Physics can be offered as one 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 is offered by the Philosophy Faculty. S27: Philosophy of Space-Time is 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 obtain a mark of at least 2 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 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.

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. **Part A students doing the six additional days of practicals in Part A 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, by taking an extra short option or to take the Teaching and Learning Physics in Schools option.

(a) 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*.

(b) Teaching and Learning Physics in Schools

This popular option is offered to 2nd year physics undergraduates in Hilary Term and is run jointly by the Department of Physics and the Department of Education. The **eight** seminars provide students with an opportunity to explore key issues in physics education, looking at evidence from physics education research and discussing current developments in policy and practice. Students also spend **six** days in local secondary schools, working closely with experienced physics teachers in lessons and gaining valuable insights into schools from the teachers' perspective.

An introductory lecture is given, see the Physics *Lecture list* at <http://www.physics.ox.ac.uk/lectures/> for details. Those wishing to take the option are asked to submit a piece of writing (one side of A4) by a deadline to Dr Judith Hillier (judith.hillier@education.ox.ac.uk) on

(i) why it is important to teach physics and (ii) why the student wants to be accepted onto the option.

A modified version of the course is available for Physics and Philosophy students.

Teaching and Learning Physics can only be offered as a second short option.

Academic Progress

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

Physics and Philosophy

Part A is examined at the end of Trinity Term and consists of three Physics papers: A1. *Thermal Physics* and A3. *Quantum Physics* from Physics Part A with syllabuses given in **Appendix C** and a short paper A2P. *Electromagnetism* from the Physics Prelims syllabus (paper CP2 **without** the topics in circuit theory or optics, see First Year (Prelims) Course handbook). You should also attend the 20-lecture course in Michaelmas Term on Mathematical Methods.

There are no philosophy examination papers in Part A. The philosophy covered in both the second and third years (for details see the *Physics and Philosophy Course Handbook*) is examined in Part B at the end of the third year.

The three Part A papers taken together have a weight for the purposes of the Finals algorithm of 2, made up of $\frac{3}{4}$ for A1 and A3 and $\frac{1}{2}$ for A2P.

For the experimental requirements in Physics and Philosophy Finals Part A, see the Parts A and B edition of *Practical Course Handbook* for more details.

There will be a lecture in Hilary Term giving guidance on how to give a talk (see the Hilary Term lecture list) in preparation for the short talk each student will be required to do within Colleges. This talk is usually given in Hilary Term as training in oral communication skills and does not count towards your degree.

A modified version of the Physics in Schools option is available to Physics and Philosophy as an alternative to the oral skills training - interested students should attend the introductory lecture in 1st week. The Physics in Schools option cannot replace the compulsory practical work requirement.

You have to attend the 1st year 'Introduction to Practicals' and the Safety Lecture at the beginning of your **second** year. Only students who are recorded as having attended the Safety Lecture are allowed to carry out practicals.

Second 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

Course structure: Three Compulsory Papers A1, A2, A3; Short Option Paper, Individual Presentation and Part A Practical Work.

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

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

Numbers have been generated based on that ratio but there is no recommendation on balance of classes vs tutorials.

Students undertake **12** days of practical work.

Paper		Faculty Teaching	College Teaching
	Term	Lectures	Classes/Tutorial
A1. Thermal Physics	MT	16	~11
Kinetic Theory, Heat Transport, Thermodynamics	HT	24	
Statistical mechanics	TT	3	
A2. Electromagnetism and Optics	MT	20	~10
Electromagnetism and Optics	HT	16	
	TT	2	
A3. Quantum Physics	MT	12	~10
Quantum Mechanics and Further Quantum Mechanics	HT	24	
	TT	12	
Additional lectures	MT	32	~6
Mathematical Methods	HT	1	
Probability and Statistics	TT	2	
S01. Functions of a Complex Variable	TT	12	
S02. Astrophysics: from Planets to the Cosmos (only for TT2020)	TT	12	
S04. Energy Studies	TT	12	
S07. Classical Mechanics	HT	12	
S12. Introduction to Biological Physics	TT	12	
S13. Teaching and Learning Physics in Schools	HT	8	
S14. History of Physics	MT	8	
S20. History of Science	MT	8	
S21. Philosophy of Science	HT	16	
S22. Language Options	HT & TT	2(3) hours per week	
S26. Stars and Galaxies	TT	12	
S27: Philosophy of Space-Time	MT	16	
S29. Exploring Solar Systems	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 A 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 A Examination

The examinations will take place towards the end of Trinity Term.

Physics	Physics and Philosophy
Three Compulsory Papers A1, A2, A3 Individual Presentations Short Option Paper Practical Work	Three Physics Papers A1, A2P, A3 Practical Work

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

Marking Individual Presentations

Individual talks are marked 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

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 A
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 practical 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.

Year Outcome for Part A

Year Outcome	Descriptor
P (Pass)	Pass and allowed to continue to the third year (Part B).

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>

Part A Examination Prizes

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

- Winton Capital prize
- Scott prizes
- Gibbs prizes
- Speaking Competition 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>

Eligibility for MPhys Course

All students will be eligible for the MPhys courses and the only possible result in Part A Physics is “Pass”. However the Examiners will calculate a detailed mark for the year, and the weightings of the contributing papers, practicals, etc. Candidates achieving a mark below a nominal 2:1 classification, that is a mark below 60%, are strongly advised to discuss their options with their college tutors before deciding to proceed to the MPhys course.

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

Should you be undecided as to which course you should be doing, discuss your options with your College tutor. Students should realise that the MPhys course is demanding.

Students will be contacted during the long vacation in order to capture intentions regarding which route they intend to take to enable the Department to plan for volumes of projects etc. This reporting of intentions is not binding, but 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**.

Appendix A Recommended Textbooks – Second Year

(** main text * supplementary text)

Lecturers will give more details at the start of each course

Second Year

Mathematical Methods

See first year list.

'Mathematical Methods for Physicists', Arfken and Weber (Elsevier)

A1. Thermal Physics

Statistical and Thermal Physics

Textbook based on the Oxford course as taught up to 2011:

'Concepts in Thermal Physics,' S. J. Blundell and K. M. Blundell (2nd edition, OUP 2009) **

More undergraduate textbooks:

'Fundamentals of Statistical and Thermal Physics,' F. Reif (Waveland Press 2008) *

'Equilibrium Thermodynamics,' C. J. Adkins (3rd edition, CUP 1997) *

'Statistical Physics,' F. Mandl (2nd edition, Wiley-Blackwell 2002)

'Elementary Statistical Physics,' C. Kittel (Dover)

'Thermodynamics and the Kinetic Theory of Gases,' W. Pauli (Volume 3 of Pauli Lectures on Physics, Dover 2003) *

'Thermodynamics: a complete undergraduate course', A. M. Steane (OUP 2017)

More advanced-level books:

'Statistical Thermodynamics,' E. Schroedinger (Dover 1989) * [a beautiful and very concise treatment of the key topics in statistical mechanics, a bravura performance by a great theoretical physicist; may not be an easy undergraduate read, but well worth the effort!]

'Statistical Physics, Part I,' L. D. Landau and E. M. Lifshitz (3rd edition, Volume 5 of the Landau and Lifshitz Course of Theoretical Physics, Butterworth-Heinemann, 2000) ** [the Bible of statistical physics for theoretically inclined minds]

'Physical Kinetics,' E. M. Lifshitz and L. P. Pitaevskii (Volume 10 of the Landau and Lifshitz Course of Theoretical Physics, Butterworth-Heinemann, 1999)

'The Mathematical Theory of Non-uniform Gases: An Account of the Kinetic Theory of Viscosity, Thermal Conduction and Diffusion in Gases,' S. Chapman and T. G. Cowling (CUP 1991) [the Cambridge Bible of kinetic theory, not a page-turner, but VERY thorough]

'Statistical Physics of Particles,' M. Kardar (CUP 2007)

A2. Electromagnetism and Optics

Electromagnetism

'Introduction to Electrodynamics', 4th Edition, David J. Griffiths **

'Electricity and Magnetism', 3rd Edition, Edward M. Purcell and David J. Morin*

'Classical Electrodynamics', 3rd Edition, John D. Jackson*

'The Feynman Lectures on Physics', Volume II, Richard P. Feynman, Robert B. Leighton and Matthew Sands*

Optics

'Optical Physics' 4th Edition, Ariel Lipson, Stephen G. Lipson, Henry Lipson (Cambridge University Press 2010)**

'Optics', E Hecht, 4th ed (Addison-Wesley, 2002) *

'Modern Classical Optics', G.A. Brooker, Oxford Masters Series (Oxford University Press, 2003)

'Principles of Optics', M Born and E Wolf, 7th ed (Pergamon, 1999)

A3. Quantum Physics

Quantum Physics

'The Physics of Quantum Mechanics', J Binney and D Skinner, (Cappella Archive <http://www.cappella.demon.co.uk/cappubs.html#natsci>) ISBN 978-1-902918-51-8; **

'Introduction to Quantum Mechanics', D. J. Griffiths, (Pearson)*

Modern Quantum Mechanics, J. J. Sakurai and J. Napolitano (Pearson)*

'Principles of Quantum Mechanics', 2nd ed, R. Shankar (Plenum Press)*

'The Principles of Quantum Mechanics', P Dirac (International Series of Monographs on Physics) (OUP paperback) A very beautiful book for those who appreciate mathematical elegance and clarity.*

'Quantum Mechanics: L. D. Landau and E. M. Lifshitz (Elsevier)* A terse classic.

'Quantum Mechanics' (2 vols), C Cohen-Tannoudji, B Diu and F Laloë, (Wiley-VCH 1977) *. A brilliant example of the more formal French style of physics textbook.

'The Feynman Lectures on Physics' 'Vol. 3, R. Feynman, Leighton & Sands A classic but unorthodox QM text. Full of deep physical insight

Short Options

S01. Functions of a Complex Variable

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

'Mathematical Methods in the Physical Sciences', Boas

'Mathematical Methods for Physicists', Arfken

'Complex Variables', Spiegel

S02. Astrophysics: from planets to the cosmos

'Introductory Astronomy & Astrophysics', Zeilek & Gregory
'Universe', Kaufmann & Freedman

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, (Heinemann 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)

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

S32. 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 Second Year (Final Honour School – Part A)

A knowledge of the topics in the syllabuses for the four compulsory physics Prelims papers will be assumed. Emphasis will be placed on testing a candidate's conceptual and experimental understanding of the subjects, apart from explicitly mathematical questions.

Non-examinable topics. Material under this heading will be covered in the lectures (with associated problems). Questions on these topics will not be set in Part A, but general knowledge of the material will be assumed by the 3rd year lectures. Only if these topics appear in the Part B syllabus may explicit questions be set on them in that examination.

Each of the three A Papers is a 3-hour paper in two sections

Section A: Short compulsory questions (total marks 40)

Section B: Answer 3 problems from 4 (total marks 60)

Mathematical Methods

Matrices and linear transformations, including translations and rotations in three dimensions and Lorentz transformations in four dimensions. Eigenvalues and eigenvectors of real symmetric matrices and of Hermitian matrices. Diagonalization of real symmetric matrices; diagonalization of Hermitian matrices. The method of separation of variables in linear partial differential equations in two, three and four variables; and for problems with spherical and planar symmetry. Use of Cartesian, spherical polar and cylindrical polar coordinates (proofs of the form of D^2 will not be required). Eigenvalues and eigenfunctions of second-order linear ordinary differential equations of the Sturm–Liouville type; orthogonality of eigenfunctions belonging to different eigenvalues; simple eigenfunction expansions including Fourier series. Fourier transform, its inverse, and the convolution theorem. Concept and use of the delta function. Solution by separation of variables for problems with spherical and planar symmetry. Steady-state problems, initial-value problems.

Probability and Statistics

Essential properties and applicability of basic probability distributions (Binomial, Poisson, Normal, Chi-squared); The Central Limit Theorem. Covariance and independence. Appropriate application of “Trial penalties” in the case of multiple, independent tests. Simple applications of Bayes’ Theorem. Basic error propagation. Basic notions of likelihood and parameter estimation. *[Non-examinable: Assessment of data/model consistency via probability distributions; maximum likelihood.]*

The above material on mathematical methods, probability and statistics is not attributed to a specific paper.

Short questions on mathematical methods, probability and statistics will be set in one or more of papers A1, A2 and A3. It is expected that the total credit for these short questions will amount to about 15% of the total credit for short questions, as this is roughly the length of the mathematical methods course as a fraction of all courses for papers A1, A2 and A3. One long question on mathematical methods may be set in one of papers A1, A2 or A3.

A1. Thermal Physics

Kinetic Theory

Maxwell distribution of velocities: derivation assuming the Boltzmann factor, calculation of averages, experimental verification. Derivation of pressure and effusion formulae, distribution of velocities in an effusing beam, simple kinetic theory expressions for mean free path, thermal conductivity and viscosity; dependence on temperature and pressure, limits of validity. Practical applications of kinetic theory.

Heat transport

Conduction, radiation and convection as heat-transport mechanisms. The approximation that heat flux is proportional to the temperature gradient. Derivation of the heat diffusion equation. Generalization to systems in which heat is generated at a steady rate per unit volume. Problems involving sinusoidally varying surface temperatures.

Thermodynamics

Zeroth & first laws. Heat, work and internal energy: the concept of a function of state. Slow changes and the connection with statistical mechanics: entropy and pressure as functions of state. Heat engines: Kelvin's statement of the second law of thermodynamics and the equivalence and superiority of reversible engines. The significance of $\int dQ/T=0$ and the fact that entropy is a function of state. Practical realization of the thermodynamic temperature scale. Entropy as dQ (reversible)/ T . Enthalpy, Helmholtz energy and Gibbs energy as functions of state. Maxwell relations. Concept of the equation of state; thermodynamic implications. Ideal gas, van der Waals gas. Reversible and free expansion of gas; changes in internal energy and entropy in ideal and non-ideal cases. Joule–Kelvin expansion; inversion temperature and microscopic reason for cooling. Impossibility of global entropy decreasing: connection to latent heat in phase changes. *[Non-examinable: Constancy of global entropy during fluctuations around equilibrium.]* Chemical potential and its relation to Gibbs energy. Equality of chemical potential between phases in equilibrium. Latent heat and the concepts of first-order and continuous phase changes. Clausius–Clapeyron equation and simple applications. Simple practical examples of the use of thermodynamics.

Statistical mechanics

Boltzmann factor. Partition function and its relation to internal energy, entropy, Helmholtz energy, heat capacities and equations of state. *[Non-examinable: Quantum states and the Gibbs hypothesis.]* Density of states; application to: the spin-half paramagnet; simple harmonic oscillator (Einstein model of a solid); perfect gas; vibrational excitations of a diatomic gas; rotational excitations of a heteronuclear diatomic gas. Equipartition of energy. Bosons and fermions: Fermi–Dirac and Bose–Einstein distribution functions for non-interacting, indistinguishable particles. Simple treatment of the partition function for bosons and fermions when the particle number is not restricted and when it is: microcanonical, canonical and grand canonical ensemble. Chemical potential. High-temperature limit and the Maxwell–Boltzmann distribution. *[Non-examinable: Simple treatment of fluctuations.]* Low-temperature limit for fermions: Fermi energy and low-temperature limit of the heat capacity; application to electrons in metals and degenerate stars. Low-temperature limit for boson gas: Bose–Einstein condensation: calculation of the critical temperature of the phase transition; heat capacity; relevance to superfluidity in helium. The photon gas: Planck distribution, Stefan–Boltzmann law. *[Non-examinable: Kirchhoff's law.]*

A2. Electromagnetism and Optics

Electromagnetism

Electromagnetic waves in free space. Derivation of expressions for the energy density and energy flux (Poynting vector) in an electromagnetic field. Radiation pressure.

Magnetic vector potential. *[Non-examinable: The change of E and B fields under Lorentz transformations in simple cases.]*

Dielectric media, polarisation density and the electric displacement D. Dielectric permittivity and susceptibility. Boundary conditions on E and D at an interface between two dielectrics. Magnetic media, magnetisation density and the magnetic field strength H. Magnetic permeability and susceptibility; properties of magnetic materials as represented by hysteresis curves. Boundary conditions on B and H at an interface between two magnetic media. Maxwell's equations in the presence of dielectric and magnetic media.

Electromagnetic wave equation in dielectrics: refractive index and impedance of the medium. Reflection and transmission of light at a plane interface between two dielectric media. Brewster angle. Total internal reflection. *[Non-examinable: Fresnel equations]* The electromagnetic wave equation in a conductor: skin depth. Electromagnetic waves in a plasma; the plasma frequency. Dispersion and absorption of electromagnetic waves, treated in terms of the response of a damped classical harmonic oscillator.

Treatment of electrostatic problems by solution of Poisson's equation using separation of variables in Cartesian, cylindrical or spherical coordinate systems.

Theory of a loss-free transmission line: characteristic impedance and wave speed. Reflection and transmission of signals at connections between transmission lines and at loads; impedance matching using a quarter-wavelength transmission line.

[Non-examinable: Rectangular loss-less waveguides and resonators.]

Optics

Diffraction, and interference by division of wave front (quasi-monochromatic light). Questions on diffraction will be limited to the Fraunhofer case. Statement of the Fraunhofer condition. Practical importance of Fraunhofer diffraction and experimental arrangements for its observation. Derivation of patterns for multiple slits and the rectangular aperture using Huygens-Fresnel theory with a scalar amplitude and neglecting obliquity factors. (The assumptions involved in this theory will not be asked for.) The resolving power of a telescope. Fourier transforms in Fraunhofer diffraction: the decomposition of a screen transmission function with simple periodic structure into its spatial frequency components. Spatial filtering. *[Non-examinable: The Gaussian function and apodization.]* The resolving power of a microscope with coherent illumination.

Interference by division of amplitude (quasi-monochromatic light). Two-beam interference, restricted to the limiting cases of fringes of equal thickness and of equal inclination. Importance in modern optical and photonic devices as illustrated by: the Michelson interferometer (including its use as a Fourier-transform spectrometer); the Fabry–Perot etalon (derivation of the pattern, definition of finesse).

Distinction between completely polarized, partially polarized and unpolarized light. Phenomenological understanding of birefringence; principles of the use of uniaxial crystals in practical polarizers and wave plates (detailed knowledge of individual devices will not be required). Production and analysis of completely polarized light. Practical applications of polarized light.

Basic principles of lasers and laser action: population inversion, Einstein coefficients, pumping.

[Non-examinable: Properties of laser radiation; brightness compared to conventional sources; coherence length measured using the Michelson Interferometer. Measurement and use of transverse coherence. Propagation of light in optical fibres.]

Electronics

Non-ideal Operational amplifiers with finite, frequency dependent gain. Bipolar Junction transistors and simple one-transistor amplifiers. Extension to long-tailed pairs and current mirrors.

A3. Quantum Physics

Probabilities and probability amplitudes. Interference, state vectors and the bra-ket notation, wavefunctions. Hermitian operators and physical observables, eigenvalues and expectation values. The effect of measurement on a state; collapse of the wave function. Successive measurements and the uncertainty relations. The relation between simultaneous observables, commutators and complete sets of states.

The time-dependent Schroedinger equation. Energy eigenstates and the time-independent Schroedinger equation. The time evolution of a system not in an energy eigenstate. Wave packets in position and momentum space.

Probability current density.

Wave function of a free particle and its relation to de Broglie's hypothesis and Planck's relation. Particle in one-dimensional square-well potentials of finite and infinite depth. Scattering off, and tunnelling through, a one-dimensional square potential barrier. Circumstances in which a change in potential can be idealised as steep; *[Non examinable: Use of the WKB approximation.]*

The simple harmonic oscillator in one dimension by operator methods. Derivation of energy eigenvalues and eigenfunctions and explicit forms of the eigenfunctions for $n=0,1$ states.

Amplitudes and wave functions for a system of two particles. Simple examples of entanglement.

Commutation rules for angular momentum operators including raising and lowering operators, their eigenvalues (general derivation of the eigenvalues of L^2 and L_z not required), and explicit form of the spherical harmonics for $l=0,1$ states. Rotational spectra of simple diatomic molecules.

Representation of spin-1/2 operators by Pauli matrices. The magnetic moment of the electron and precession in a homogeneous magnetic field. The Stern–Gerlach experiment. The combination of two spin-1/2 states into $S=0,1$; *[non-examinable: Derivation of states of well-defined total angular momentum using raising and lowering operators]*. Rules for combining angular momenta in general (derivation not required). *[Non-examinable: term symbols.]*

Hamiltonian for the gross structure of the hydrogen atom. Centre of mass motion and reduced particle. Separation of the kinetic-energy operator into radial and angular parts. Derivation of the allowed energies; principal and orbital angular-momentum quantum numbers; degeneracy of energy levels.

Functional forms and physical interpretation of the wavefunctions for $n < 3$.

First-order time-independent perturbation theory, both non-degenerate and degenerate (questions will be restricted to systems where the solution of the characteristic equation can be obtained by elementary means). Interaction of a hydrogen atom with a strong uniform external magnetic field. The linear and quadratic Stark effects in hydrogen.

Exchange symmetry for systems with identical fermions or bosons; derivation of the Pauli principle. Gross-structure Hamiltonian of helium. Implications of exchange symmetry for wavefunctions of stationary states of helium; singlet and triplet states. Estimation of the energies of the lowest few states using hydrogenic wavefunctions and perturbation theory.

The variational method for ground-state energies; application to helium.

The adiabatic and sudden approximations with simple applications.

Time-dependent perturbation theory. The interaction of a hydrogen atom with an oscillating external electric field; dipole matrix elements, selection rules and the connection to angular-momentum conservation. Transition to a continuum; density of states, Fermi's golden rule.

[Non-examinable -Classical uncertainty in quantum mechanics: pure and impure states. The density matrix and trace rules. Time-evolution of the density matrix. Measurement and loss of coherence.]

S01. Functions of a complex variable

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

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

S02. Astrophysics: from planets to the cosmos

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

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

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

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, selfassembly, 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.

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.

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>).