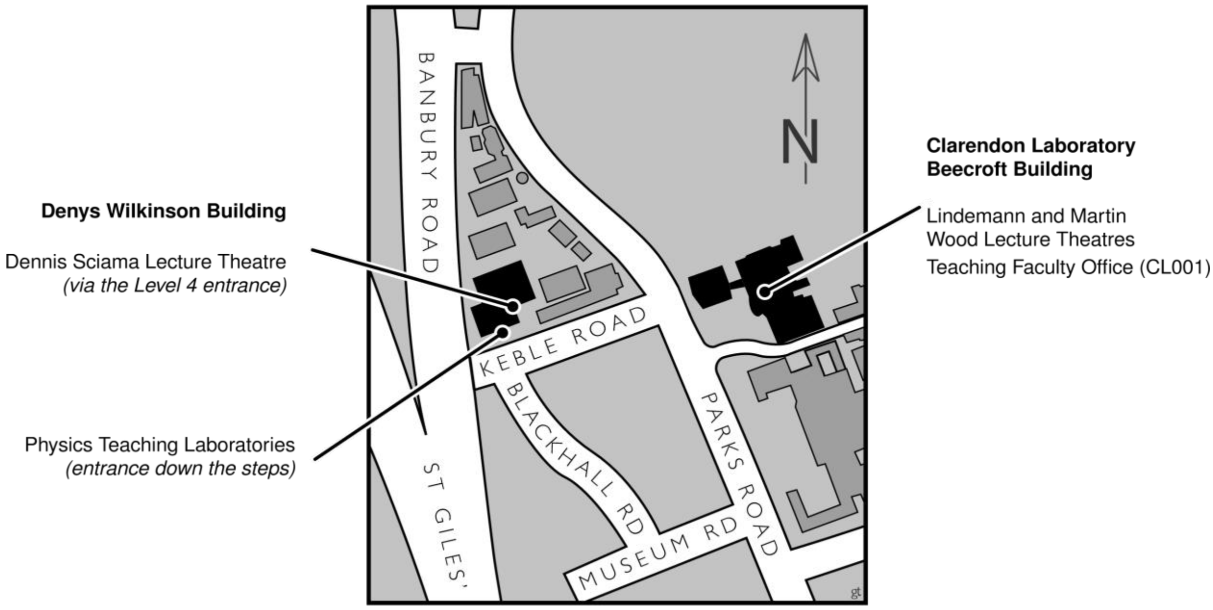
Physics Undergraduate Course Handbook 2020-2021

Second Year (Part A)

UNIVERSITY OF OXFORD

Map of the Department of Physics Buildings



Useful Department Contacts

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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 2020, Hilary Term 2021 and Trinity Term 2021.

Contents

Coronavirus (Covid)

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

Introduction to the handbook

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

Other useful sources of information:

Full details about the Practical Course are given in this handbook and in the Part A Practicals course on Canvas.

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

For particular information about 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 see the lecture timetables.

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

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

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

Important dates and deadlines

Michaelmas Term	Event	Time	Location
Week 1	Introduction to the Second Year	Mon 09:00	Online
Week 1	Teaching Physics in Schools	***	Online
Week 2	Short Options: S20; S21 and 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	To be confirmed
Week 6	Hand in extra practical and extended practical reports	Mon 12:00	Online submission
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. Note that due to the current global situation, the computer facilities in the teaching laboratories on level 2 are closed for the academic year 2020-21. We recommend that all students obtain use of a computer, either their own personal laptop or use of a college computer.

Policies and Regulations

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

Data Protection

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

University Policy on Intellectual Property Rights

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

Copyright

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

Good academic practice and avoiding plagiarism

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

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

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

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

Support for disabled students

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

Student Life, Support and Guidance

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

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

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

Complaints and appeals

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

Opportunities for skills training and development

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

Employability and careers information and advice

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

Departmental representation - The Physics Joint Consultative Committee (PJCC)

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

Opportunities to provide evaluation and feedback

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

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

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

Student representatives sitting on the Divisional Board are selected through a process organised by the Oxford University Student Union (OUSU). Details can be found on the OUSU 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 2020-2021

Introduction to the Second Year

All Physics and Physics and Philosophy second years are **required** to view the Introduction to the second year on Monday morning at 09:00 of 1st week of Michaelmas Term remotely. 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

Aims of Practical Work

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

Thus, our aims are to enable you to:

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

The requirement for practical work for Part A is **12** days. It is possible to substitute 6 days of practical work with alternatives as detailed below and in the Part A Practicals course on Canvas (www.canvas.ox.ac.uk).

The Examination Conventions 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 on Canvas 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** and is also available via ORLO (Oxford Reading List Online). 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 Options offered by other departments of faculties

(a) Language Options

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

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

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

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

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

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

(b) Pre-approved Alternative Subjects

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

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

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

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.

(c) Alternative Subjects

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

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

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

More practical work instead of a short option

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

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

(a) Extra practicals

Extra practicals are an additional six days of standard practicals. You can only book for those practicals allocated to you by SPIRe (Student Practical Information Record). If you want to work out of allocation you must see what is free on the day. Each of the extra practicals must be marked 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 an electronic copy (by e-mail attachment) of their report to the Physics Teaching Office (**neither** Examination Schools **nor** the Physics Teaching Laboratories will accept your reports) before noon on Monday of 6th week of Trinity Term. All work submitted will be checked with Turnitin.

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

The six extra days practical work will begin only when the normal practical quota has been completed. They should be booked and grades entered on SPIRe as usual. **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 an electronic copy (by e-mail attachment to labhelp@physics.ox.ac.uk) of their report to the Physics Teaching Office (**neither** Examination Schools **nor** the Physics Teaching Laboratories will accept your reports) before noon on Monday of 6th week of Trinity Term. All work submitted will be checked with Turnitin.

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

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

Substituting practical work with vacation placements

It is possible to replace some of the practical quota by a report on Physics-related vacation placements, 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 Part A Practicals Canvas course.

(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 ¾ for A1 and A3 and ½ 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 individual presentation *formerly* oral skills training - interested students should attend the introductory lecture, see the Physics *Lecture list* at http://www.physics.ox.ac.uk/lectures/ for details. 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] 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 nominally **12** days of practical work, although this can vary as detailed earlier on in this report and in Part A Practicals course on Canvas (www.canvas.ox.ac.uk).

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	
S07. Classical Mechanics	HT	12	
S10. Medical Imaging and Radiation Therapy	TT	12	
S13. Teaching and Learning Physics in Schools	HT	8	

Paper		**Faculty Teaching**	**College Teaching**
	Term	**Lectures**	**Classes/Tutorial**
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	
S25. Climate Physics	TT	12	
S27: Philosophy of Space-Time	MT	16	
S29. Exploring Solar Systems	TT	12	
S33. Entrepreneurship for Physicists	TT	12	

Practical Work

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

Organisation

For the academic year 2020-21, Part A students are able to book individual experiments for in person and as pairs for remote experiments on Mondays and Tuesdays every other week, except in Computing where you can ask for help and arrange to be marked any week the computing lab is open. Your allocated weeks and labs will be shown on your page of SPIRe. In Michaelmas term, Optics/EM and Thermal labs are available in weeks 1-8 and Electronics labs in weeks 3-8. In Hilary term, all labs are open in weeks 1-4 but only Electronics and Computing labs are available weeks 5-8. In Trinity Term, all labs are available but only in weeks 3-4.

Students are allocated at least one session in each laboratory plus two free choice sessions, so there is some flexibility. You are encouraged to do experiments across a broad range of labs (and this will be taken into account when prizes are allocated), but no lab except Electronics is compulsory.

Practical work timetable: Labs are open 10:00 -17:00 (10am- 5pm) but please check the arrival time on Canvas

Term	**Part A**
Michaelmas	Optics/EM, Thermal labs: weeks 1-8 Electronics lab: weeks 3-8
Hilary	Optics/EM, Thermal labs: weeks 1-4 Electronics, Computing labs: weeks 1-8
Trinity	All labs: weeks 3 and 4 only Assessed practicals week 6

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

At the beginning of the academic year, students are allocated to the different laboratories on a rota system. SPIRe will show your allocation and you can only book experiments within your allocation. It is possible to work out of allocation (i.e. at a time not offered to you by SPIRe), though not to book. If you must work at a different time to your allocated slot it is recommended you contact labhelp@physics.ox.ac.uk for advice. **For the academic year 2020-21, all experiments must be pre-booked and turning up to the teaching labs without booking will not be permitted.**

To fulfil the practical work requirements for the second year (Part A) you must complete the following days of practicals:

Requirements for examiners	12 days if taking one short option, including **two** compulsory electronics practicals
	6 days if taking two short options, including **one** compulsory electronics practical
	4 days if taking Teaching and Learning Physics in Schools option, including **one** compulsory electronics practical

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

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

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

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

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

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

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

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

Assessment

Your practical work is assessed in several ways. Demonstrators will observe your work and inspect the records in your logbook during the experiment. It is important to be able to present your scientific results clearly, as several write-ups are required. Training in written presentation of your work is provided by the writing of Part A Computing reports assessed by demonstrators. Remember that for Computing assessment, you must also be prepared to execute your program if the demonstrator asks.

Demonstrators will visit your experiment regularly. They will

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

If your record is satisfactory, the demonstrator will sign your logbook and write a comment on your progress so far. If changes need to be carried out (e.g. extra comments written in), the demonstrator will request that these are done before you continue. Analysis and plotting should be done as you go along unless you are instructed otherwise.

Summary of the experiment

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

Mark scheme

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

Assessed practical

The assessed practical is compulsory for all Part A Physics students. It is a short oral examination that takes place in Trinity Term. The assessed practicals normally take place in the first half of week 6. You will receive an email with an appointment stating the practical to be assessed about a week in advance. The assessed practical is chosen at random from the student's logbook and marked by a senior demonstrator, with a junior demonstrator observing. Marks will be based on both the quality of the entire logbook (including commented code for a computing practical) and the understanding of the assessed practical demonstrated by the student. Students must bring **all the logbooks they have used during Part A to the assessment.** The median mark should be 15 out of 20.

Do not spend time retrospectively "improving" your logbook - this is bad practice, as the logbook is meant to be a contemporary record, and also will not help your marks. Copying logbook material from other students during or after the practical is plagiarism. If you cannot find one of your logbooks, you will not be penalised if you inform the Teaching Laboratory manager of this more than 24 hours before your appointment.

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

Marking

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

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

Physics Examinations

The FHS (Final Honour School in Physics), also called **Finals**, is taken in parts over the final two (BA) or three (MPhys) years of your course. The Examiners are a committee set up each year under the Proctors. The Finals Examiners include external examiners from other UK universities and may be assisted by a number of Assessors to set and mark some individual papers, projects, etc. In general, papers for Prelims and Part A of Finals are not set and marked by the course lecturers; indeed the identity of the examiner for any paper is confidential. The identity of the candidates is hidden from the examiners; no communication between the examiners and the candidate (or the candidate's tutor) is allowed except via the candidate's College's Senior Tutor and the Junior Proctor. The questions are required to be set in conformity with the syllabus, whose interpretation is guided by previous papers except where there has been an explicit change of syllabus. The current syllabuses for the final examinations in physics are printed in **Appendix C**.

Examination Entry

Entry for the FHS Part 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 official examiners' page.

Examination Preparation

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

Past Exam Papers

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

External Examiner and Examiners' Reports

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

Sitting your examination

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

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

Part 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.

Marking of the Assessed Practical

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

Specific details pertaining to practical work are published in the Part A Practicals Canvas course. 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 on the Extra Practical Work page of Part A Practicals Canvas course.

Assessment of extra practicals and extended practicals

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

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

Assessment of Class

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

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

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

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

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

<u>Second Year</u>

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

<u>Short Options</u>

S01. Functions of a Complex Variable

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

S07. Classical Mechanics†

'Mechanics (Course of Theoretical Physics), Vol 1', L D Landau and E Lifshitz (Butterworth Heinemann): Physics the Russian way - first volume of the celebrated 'Course of Theoretical Physics'.

'Classical mechanics', 5th ed, T.W.B. Kibble & F.H. Berkshire – good solid book `Analytical Mechanics' L. Hand + J. Finch – good solid book 'Classical mechanics', 3rd ed H. Goldstein, C. Poole & J. Safko. A classic text. In the US probably plays the same role for classical mechanics that Jackson does for electrodynamics.

For the mathematically erudite: 'Mathematical methods of classical mechanics', V.I. Arnold.

† also for **B7. Classical Mechanics**

S10. Medical Imaging and Radiation Therapy

'Webb's Physics of Medical Imaging', 2nd ed, Flower, ISBN 9780750305730

'Physics in Nuclear Medicine', 4th ed., Cherry Sorenson and Phelps, ISBN 9781416051985

'Introduction to Radiological Physics and Radiation Dosimetry', Frank Herbert Attix, Sep 2008 ISBN: 978-3-527-61714-2

'Fundamental Physics for Probing and Imaging', Wade Allison, Oxford (2006) ISBN 9780199203888 and 9780199203895

Useful resource:

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

S14. History of Physics

'The beginnings of Western Science: the European Scientific Tradition in Philosophical, Religious and Institutional Contexts', D.C. Lindberg, , (Chicago, 1992)

'A History of Natural philosophy from the Ancient World to the Nineteenth Century E. Grant, ', (Cambridge, 2007)

'Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental life', S. Shapin and S. Schaffer, (Princeton, 1995)

'Galileo', J. Heilbron, (Oxford, 2010)

'The Birth of a New Physics', I.B. Cohen, (Norton 1985)

'Discipline and Experience', P. Dear, (Chicago, 1994)

'The Cambridge History of Eighteenth Century Science', R. Porter, ed., (Cambridge, 2002)

'The Maxwellians', B. Hunt, (Ithaca, 1991)

Reading:

'From Watt to Clausius', DSL Cardwell, (Heineman 1971)

'Image and Logic: A Material Culture of Microphysics', P. Galison, (Chicago, 1997)

'Gravity's Shadow: the search for Gravitational Waves', H. Collins, (Chicago, 2004)

S25. Physics of Climate Change

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

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

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

S29. Exploring Solar Systems
“Planetary Sciences”, by Imke de Pater and Jack Lissauer
“The solid Earth”, C M R Fowler

S33. Entrepreneurship for Physicists

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

Appendix B Note on Calculators for ALL Public Examinations*

The regulations are likely to follow recent practice which is:

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

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

Notes:

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

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

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

Appendix C Syllabuses for the 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 $\oint dQ/T=0$ 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. The resolving power of a microscope with coherent illumination. Transverse and temporal coherence.

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; coherence length, as measured using the Michelson Interferometer.

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.

S07. Classical Mechanics*

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

S10. Medical Imaging and Radiation Therapy

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

S14. History of Physics

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

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

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

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

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

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

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

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

S25. Physics of Climate Change

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

S29. Exploring Solar Systems

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

S33. Entrepreneurship for Physicists

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

Inspiration

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

Team Building

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

Creative Thinking & Problem Discovery

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

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

Intellectual Property (IP) & Licensing

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

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

Market Segmentation & Knowing Your Customer

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

Quantifying the Value Proposition & Designing a Business Model

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

The assessment for this course will be as follows:

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

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

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

Appendix D Mark scheme for practicals

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

Criteria for practical marking

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

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

Criteria for report marking

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

Appendix E Summary of Part A experiments

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

Computing

Location: Room 221 (Online only for 2021-21) Head of Lab: Dr. Elizabeth Gallas

Computing must not count for more than half your practical work. Discussions with your colleagues are encouraged, but you must write each line of your own code. Demonstrators are only available when the lab is open (Mondays and Tuesdays Hilary Term and weeks three and four of Trinity Term --- see the table earlier on in this handbook giving details of when the labs are open. Note that for the academic year 2020-21, the computer room in the teaching laboratories will not be available for general use. Assistance will be provided online via Microsoft Teams.

Computing practicals are assessed by writing a report, which you submit online and then meet with a demonstrator. Further information on report writing is available via our website as well as a sample report. To prepare for assessment, see http://www-pnp.physics.ox.ac.uk/~gallas/Lectures/index_2ndYear.html which summarises requirements, how to upload your work to WebLearn, and final preparations for meeting with a demonstrator for assessment (how to book a marking time and what to bring with you).

Note that marking of experiments on Monday and Tuesday of fifth week of Trinity Term is only by appointments arranged in fourth week. Please contact the Head of Lab, Dr Elizabeth Gallas to make an appointment.

The lab is not open for demonstrating or marking in Michaelmas Term but if you would like to do experiment CO20, you can arrange an appointment with Dr Gallas to discuss your plans during Michaelmas Term.

Record keeping for computing experiments

Computing experiments still need logbook entries, although the ability to comment code means that the logbook entry for a computing experiment is likely to be shorter than for other types of experiment. Some experiments require derivations, for instance, which should be written in the logbook. The logbook can also contain, for example, intermediate plots (with appropriate descriptions) especially if they help you confirm that the results from the program are correct. Demonstrators will expect any code that they are shown to be commented.

Our default language is Matlab, though you may code in any language in Part A. If you wish to use a language other than Matlab, please check with a computing demonstrator first or email the Head of Lab, Dr Elizabeth Gallas .

CO03 Strange mesons from proton-antiproton collisions at the CDF experiment

In this practical, the student will analyze charged-particle track data at the CDF experiment, a proton-antiproton collider experiment that took data at the Fermilab Tevatron until 2011. MATLAB will be used to display collision events, calculate track intersections, and, ultimately, reconstruct strange mesons from their decay to two pions. Using special relativity, the lifetime of the strange meson can also be estimated from the data, which has kindly been provided courtesy of CDF and Fermilab.

CO20 Computing project

This is an open-ended piece of work to develop and implement a program in an area of your own interest. If you have an idea for a project, you MUST contact the Head of Lab to discuss it and plan the work before you start.

CO22 Schrödinger's equation

This problem requires you to find the solution of the time-independent Schrödinger equation for the quantum harmonic oscillator, a good example of a stiff differential equation.

CO23 Soliton

In this experiment you will solve a non-linear wave equation whose solution can have particle-like properties (hence the name soliton). The exercise also illustrates wave steepening and breaking as well as computational instability if the time-step constraints are not met.

CO24 Chaos (1 day)

This illustrates the use of Runge-Kutta techniques on the non-linear set of Lorenz equations. You will investigate the presence of stable and unstable stationary points, the presence of a strange attractor and chaotic behaviour. The relevance to weather forecasting is also demonstrated.

CO25 Laplace (2 days for normal practical + optional 1 extra day)

The solution of Laplace's equation by successive over-relaxation is found for a square domain, and compared with the analytic solution. The solution is then found for Poisson's equation.

CO28 Ferromagnetism

The Ising model is a simplified model of a ferromagnet. Its properties such as the magnetic moment and the transition temperature can be studied using a method of random sampling of the configurations.

CO31 Structure of white dwarf stars

The structure of white dwarf stars is a balance between gravitational forces, which act to compress the star, and electron-degeneracy pressure, which acts to resist the compression. In this practical you will investigate the structure of white dwarf stars by integrating the equations defining this equilibrium state.

CO32 Fourier optics (2 days for normal practical + optional 1 extra day)

In this practical you will be investigating a particular form of the Fourier Transform that is particularly suited to computational physics, the Discrete Fourier Transform, and using it to investigate diffraction patterns.

Electronics

Location: Room 129 (Online only for 2021-2021) **Head of Lab: Dr. Georg Viehhauser**

Students doing the full practical quota of 12 days must do two out of the three practicals: EL20, EL21 and EL22. Those doing a half quota of 6 days, or the Teaching and Learning 4 day quota, must do one out of these three.

EL20 Introduction to bipolar transistors

This practical teaches you (1) how to use bipolar transistors in amplifier circuits, (2) how to build an op-amp using transistors, (3) about the functional groups in an op-amp and (4) about performance parameters of real op-amps.

EL21 Digitization and sampling

In this practical you will learn about the transformation of analogue signals to digital information and the errors introduced by this process. You will build a comparator circuit and use this in a time-to-digital converter (TDC) and an analogue-to-digital converter (ADC). Then you will sample analog signals and use digital Fourier transform to understand effects like aliasing or leakage. Finally, you will learn how to reconstruct a sampled signal.

EL22 Introduction to the computer

The hardware and programming of a simple 8-bit machine are studied. You will first have to implement a missing instruction in the instruction set of the machine using a network of logic components. When the machine is complete it is used to solve a number of problems. Initially programs are written in machine code, later an assembler language is used.

EL23 Amplifiers

This practical explores different negative feedback amplifier circuits based on op-amps. You will use these circuits to amplify different types of inputs to generate output voltages or currents. It is recommended to do this practical only after EL20.

EL24 Analogue computing

Integrator, adder and multiplier modules are combined to make a small analogue computer. Solutions of linear simultaneous and differential equations are investigated. A predictable non-linear problem (rabbits and foxes) and an equation with chaotic solutions are also examined. It is recommended to do this practical only after EL20.

Thermal physics

Location: Room 127 (Online only for 2021-2021)   Head of Lab: Prof. Robin Nicholas

GP32 The latent heat of evaporation of liquid nitrogen (1 day)
The rate of evaporation of liquid nitrogen as a function of heat input is determined by a flow meter, calibrated with gas produced electrolytically.

GP47 Ultrasonic interference and diffraction
The objective of this experiment is to demonstrate in a quantitative way the diffraction and interference patterns from a number of different objects and to show how these are related to one another.

GP49 Thermal waves
The aim of this experiment is to study the transport of heat along a copper bar. The heat input at one end of the bar can be varied with time and the temperature profile along the bar recorded both as a function of position and time. Solution of the heat conduction equation gives predictions for the dispersion and thus the group and wave velocities.

Electromagnetism and Optics

Location: Rooms 209 and 210   Head of Lab for Part A: Prof. Alexander Lvovsky
For the academic year 2020-21, all of these experiments must be prebooked before arriving in the teaching laboratories. You MUST arrive at the time specified and all covid procedures must be followed whilst you are in the teaching laboratories. If you do not follow these procedures you will be asked to leave the teaching laboratories.

EM07 Wave phenomena on electrical transmission lines
The propagation and the reflection of electrical signals on coaxial transmission lines are studied. Using directional couplers, a quantitative study is made of the amplitude and the phase of reflected pulses. When driven by a sinusoidal signal the impedance matching properties of a quarter-wave line are investigated.

EM09 Total internal reflection and the evanescent wave (1 day)
Total internal reflection can occur as light passes from glass to air if the angle of incidence is too large. The angle of transmission would then exceed 90 degrees. Under these conditions, is there any electromagnetic wave in the second medium? These phenomena are studied at a wavelength of 3cm, enabling distances comparable with the wavelength of the electromagnetic wave to be measured easily.

EM10 Electrodynamic Confinement
In this practical you will investigate the use of oscillating electric fields to confine ions in an "ion trap". These traps are widely used in industry for mass spectrometry, and in research into quantum computing.

OP21 Two slit interference

A standard two slit (Young's slit) interference arrangement is set up using a red laser as the light source. The light source is changed to a green lamp and a similar interference pattern is observed but with changed spacing between the maxima. The light intensity is now reduced so that photons pass through the apparatus one at a time (i.e. the probability of two or more photons is very small). Since this photon must go through either one slit or the other can an interference pattern be produced? Find out.

OP22 The Michelson interferometer as a spectrometer

The use of the Michelson as a Fourier transform spectrometer is explained. The width of the mercury green line and the separations of the resonance lines of the alkalis Na, K, Rb and Cs are measured.

OP24 Emission spectrum of sodium (plane grating spectrograph)

Various lines in the sodium spectrum are examined and identified. These are mostly lines which connect to the lowest P level (principal, sharp and diffuse series). The results can be used to locate the energies of a number of S, P and D levels. A limitation is that only a few lines of each series are observed.

Additional work can be carried out by comparing the one-electron spectra of several elements (Na, K, Rb, Cs, and H lamps are available); with different alkali atoms, different features of the energy level diagram are made available for investigation.

OP25 Stern-Gerlach experiment (1 day)

There have been many surprising results in the history of physics, but few can have been quite so unexpected as that which Stern and Gerlach obtained in 1921 when they tried to measure the magnetic moment of silver atoms by deflecting them in an inhomogeneous magnetic field. The atoms split up into two well-defined beams, the first direct evidence of space quantisation.

Not only that, the fact that the number of beams was even suggested that there could be half-integral quantum numbers. It was four years before anyone realised that this was associated with the intrinsic spin of the electron. In this experiment, you verify these remarkable findings for yourself.

OP26 The Faraday effect (1 day)

Measurement of the rotation of the plane of polarization of light traversing glass in a longitudinal magnetic field. Illustrates ideas from the classical theory of dispersion and of the Zeeman effect.

OP27 Analysis of polarized light

Polarisation patterns of light: linear, circular, elliptical. Preparation, manipulation and measurement of these patterns. Primary optical elements for polarisation control: polarisers and wave plates. Fresnel equations and Brewster angle. Effect of external and total internal reflection on the polarisation.

Appendix F Complaints and Appeals

Complaints and academic appeals within the Department of Physics

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

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

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

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

Complaints

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

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

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

Academic appeals

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

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

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