



# Natural Sciences Tripos

## Part III/MASt Astrophysics

COURSE GUIDE

2022-2023



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## Aims and Objectives

The Part III course is designed to develop students' analytical, critical, and numerical skills to the point that they are equipped to undertake independent research in Astrophysics. These aims are advanced through taught courses, which develop students' mathematical skills through detailed analysis of topics at the forefront of contemporary research and through the hands-on experience of a substantial research project. The project work encourages students to develop a critical attitude and an innovative approach to problem solving. The more independent working style is developed under the guidance of a supervisor from the Institute of Astronomy.

### Feedback and Consultation Mechanisms

During the first two weeks of Michaelmas Term, students will be invited to elect one representative from their Part III Astrophysics cohort to attend Teaching Committee meetings. Normally, these meetings are held at 2pm on the fourth Thursday of each Full Term.

Students are invited to complete feedback questionnaires for each lecture course. These are relayed to the lecturer. In addition, at the end of the year, there is a general feedback questionnaire on the course as a whole and a feedback meeting with the Course Coordinator and Chair of the Teaching Committee, which takes place at the end of Lent Term. These outcomes are considered by the Astrophysics Teaching Committee.

### Key Contacts

Role	Contact	Phone	Office	Email
Course Coordinator	Vasily Belokurov	37515	Hoyle Rm 20	<a href="mailto:vasily@ast.cam.ac.uk">vasily@ast.cam.ac.uk</a>
Course Administrator	Mahsa Zohhadi	37552	Hoyle Rm 06	<a href="mailto:undergraduate.admin@ast.cam.ac.uk">undergraduate.admin@ast.cam.ac.uk</a>
Teaching Committee Chair	Cathie Clarke	39087	Hoyle Rm 10	<a href="mailto:cclarke@ast.cam.ac.uk">cclarke@ast.cam.ac.uk</a>
Joint Directors	Cathie Clarke	39087	Hoyle Rm 10	<a href="mailto:cclarke@ast.cam.ac.uk">cclarke@ast.cam.ac.uk</a>
	Mark Wyatt	37517	Hoyle Rm 38	<a href="mailto:wyatt@ast.cam.ac.uk">wyatt@ast.cam.ac.uk</a>
Directors' PA	Susan Hatley	37521	Hoyle Rm 48	<a href="mailto:hodpa@ast.cam.ac.uk">hodpa@ast.cam.ac.uk</a>
IoA Librarian	Mark Hurn	37537	Obs Library Office	<a href="mailto:hurnm@ast.cam.ac.uk">hurnm@ast.cam.ac.uk</a>
Public Astronomer	Matt Bothwell	39279	Hoyle Rm 59	<a href="mailto:bothwell@ast.cam.ac.uk">bothwell@ast.cam.ac.uk</a>
IT Helpdesk		66666	Hoyle Rm 42	<a href="mailto:helpdesk@ast.cam.ac.uk">helpdesk@ast.cam.ac.uk</a> <a href="http://helpdesk.ast.cam.ac.uk">http://helpdesk.ast.cam.ac.uk</a>

The Course Administrator oversees the day-to-day administration of the is normally the first point of contact for anything related to the course.

Several course-related items are notified directly by email so you should check your email frequently. Please ensure that the Course Administrator has your up-to-date email address.

## General Information

It is hoped that as a Part III Astrophysics student, you will feel part of the Institute of Astronomy and will participate in some of the activities that maintain its friendly and interactive atmosphere.

### Coffee

The Institute of Astronomy staff have coffee (and tea) in the Hoyle building foyer from about 11 am. Part III Astrophysics students are invited to enjoy coffee with the staff and postgraduate students, although this may on occasions not be possible given the location and timing of Part III lectures. There is no charge for coffee for Part III Astrophysics students.

### Journal Club and Socials

There will be a series of sessions for Part II and Part III students which are designed to build confidence in giving presentations and will also allow socialising between the two-year groups. The sessions are run by enthusiastic PhD students who will offer friendly advice on preparing and giving scientific talks (lecturers do not attend). Further details of these events are to be confirmed.

### Public Outreach

The IoA runs an extremely successful programme of [Public Outreach](#) on Wednesday evenings. Student participation is welcome. More information will be provided during an introductory session (**12:30 Wednesday 5<sup>th</sup> October 2022**), which will be delivered by our Public Astronomer, [Matthew Bothwell](#).

### Food

There are several possibilities for lunchtime food provision. Snacks can be obtained on site from the vending machine located in the Hoyle building. Off-site there are several possibilities for canteen style food (CMS, Cavendish Laboratory and Churchill College) and a full range of meals at the Hauser Forum as well. There is also a bread and cheese lunch held on Wednesdays at 12:30pm, which precedes the Seminar.

### Computing

Part III students are given full access to the Institute of Astronomy Science Cluster, which is based on the Redhat Enterprise Linux operating system. The Science Cluster consists of the desktop computers around the site as well as a number of shared servers. There are also public Linux, Windows and MAC workstations available in the Hoyle Print Room (H30). There are substantial data storage facilities as well as printers and scanners connected at various locations around the site. A wide variety of software is available both for general purposes (producing documents, e-mail, web browsing etc.) and for scientific computing and there is the facility to distribute intensive jobs between computers on the cluster using HTCondor.

A short, compulsory computer orientation course covering practical aspects of Unix and use of the Institute of Astronomy Science Cluster will run in the first two weeks of the Michaelmas term, see [online calendar](#) for timetable.

### Library

The [Institute of Astronomy library](#) holds 8,000 books and 11,000 volumes of astronomical periodicals. Part III students are encouraged to use the library facilities but may not sign out books. If you need any help, ask the Librarian, [Mark Hurn](#), who has an office in the library area in the Observatory building.

### E-mail

Students' correspondence will be delivered via email.

### **Photocopying**

There is a photocopier in the reprographic room (opposite the vending machines), another outside to the right of the stairs to the Sackler Lecture Theatre and one in the main library in the Observatory building. Course-related copying is free of charge. For private copying there is a charge of 3p per A4 sheet.

### **CMS Facilities**

In the CMS, Part III Astrophysics students may use the large Part III Mathematics Room and the associated facilities (TBC). More details may be found in the Part III Mathematics Handbook.

### **Printing at DAMTP**

Part III students are given a free allocation of printer credit for use on the PWF-MATHS printers at CMS. PWF-MATHS credit cannot be spent on UCS or college printers. Similarly, credits purchased at the UCS or in college cannot be used at CMS. If you run out of printer credit, send an email to the [IoA Undergraduate Office](#). You may be asked to explain why the standard allocation proved to be insufficient.

Please note that printing facilities are provided solely for academic use. Please use other printers in college or at the UCS for personal use. Note that non-academic use of printers, or unnecessary waste of paper (including large amounts of output left uncollected), may result in a charge being made.

### **Databases**

**Raven:** The University of Cambridge web authentication server.

You will need your Raven password to log in to the Teaching Information System (q.v.), and to access material, such as past examination papers) on the teaching website from outside the cam.ac.uk domain.

- If you use the Hermes mailstore, you can get your Raven password [here](#).
- If you have lost your Raven password, or you don't use Hermes, contact the University's [IT Support Portal](#).
- If you have a Raven password and your login is rejected by the teaching system, contact the [IoA Undergraduate Office](#), providing your CRSID and we will enable your account.

**CamCORS:** The Cambridge Colleges Online Reporting System

Supervisors use this to report to Directors of Studies and Tutors on the progress of their supervisees, and to claim from the colleges for the supervisions provided. Students can view their supervision reports here directly.

**CamSIS:** The Student Information System

Students use this to enter for exams, and (when the results are uploaded) to check their Tripos results.

**Moodle:** The University's Virtual Learning Environment used by many departments at the University. Students will be enrolled on to the Part III/MAST Astrophysics Moodle site by the Undergraduate Office at the beginning of the Michaelmas Term.

All Part III Mathematics lecture courses will also have their own site on Moodle. Students will be able to self-enrol on these Moodle sites at the start of each term. Further information on how to access lecture resources on Moodle will be provided to students at the Part III Mathematics Introductory Meeting (**Wednesday 5<sup>th</sup> October**). A recording of the lecture material delivered on any given day is expected to be available via the Moodle site at the latest by the end of that day.

**The Teaching Information System (TIS):** A web database system run by the Department of Physics. All physics course resources are provided here. Students *must* register on the Physics TIS in order to

receive important emails from the Teaching Office. Failure to do so will result in not being informed about lecture timing changes due to unforeseen circumstances as well as **supervision allocation**. If you have any difficulty in registering, contact the [IoA Undergraduate Office](#) for assistance.

**[The University's Timetable Tool](#)**: This allows you to create your own timetable of lectures and add to your own electronic calendar.

# Wellbeing

## **Pastoral Support**

Students sometimes encounter personal difficulties during Part III that are not to do with the course itself (for example, there may be financial difficulties or family illness). If such problems arise, you are strongly advised to discuss the situation with your College Tutor as soon as possible. Colleges are used to dealing with such problems, and are experienced in offering advice, help and support. For more on the role of Colleges, [click here](#).

There are also many central University [resources](#) available to students.

## **Medical Problems and Disabilities**

Students with medical problems or disabilities are strongly advised to discuss such problems with their College, who will offer advice and support for medical problems and disabilities.

For more information, please visit the [University Accessibility and Disability Resource Centre](#).

## Lecture Courses

A typical lecture load consists of an average of nine lectures per week during the Michaelmas and Lent terms. It is usual to take more courses than this at the start of each term and then cut down to those of greatest interest. A typical total examination entry of 18 units requires that you prepare fully for examination only about two-thirds of the courses for which you have attended lectures.

### Courses recommended by the Institute of Astronomy

Michaelmas 2022	Lent 2023
Physics of the Earth as a Planet † Dr D. Al-Attar & Dr J. A. Neufeld M.W.F. 09:00 <i>Small LT, Cavendish</i> [3 units] [P]	Formation of Structure in the Universe TBC [2 units] [P]
Relativistic Astrophysics and Cosmology * Dr W. Handley M.W.F. 10:30 <i>IoA HLT</i> [3 units] [P]	Exoplanets and Planetary Systems TBC [2 units] [P]
Particle Physics † Dr C. Lester M.W.F. 12:30 <i>Pippard, Cavendish</i> [3 units] [P]	
General Relativity Dr C. M. Warnick M.W.F. 09:00 <i>MR2</i> [3 units] [M]	Dynamics of Astrophysical Discs Prof. G. I Ogilvie M. W. 09:00 <i>MR14</i> [2 units] [M]
Cosmology Dr B. D. Sherwin M.W.F. 10:00 <i>MR2</i> [3 units] [M]	Black Holes Dr J. E. Santos M.W.F. 10:00 <i>MR3</i> [3 units] [M]
Astrophysical Fluid Dynamics Dr R. Rafikov M.W.F. 11:00 <i>MR11</i> [3 units] [M]	Field Theory in Cosmology Dr E. Pajer M.W.F. 11:00 <i>MR12</i> [3 units] [M]
Structure and Evolution of Stars Dr A.N. Zytkov M.W.F. 12:00 <i>MR11</i> [3 units] [M]	The Life and Death of Galaxies Prof. V. Belokurov M. W. F. 11:00 <i>MR11</i> [3 units] [M]
Extrasolar Planets: Atmospheres and Interiors Dr N. Madhusudhan Tu. Th. 09:00 S. 10:00 <i>MR11</i> [3 units] [M]	Astrophysical Black Holes Dr D. Sijacki Tu.Th. 10:00 <i>MR13</i> [2 units] [M]
Quantum Field Theory Prof. N. Dorey Tu.Th.S. 12:00 <i>MR2</i> [3 units] [M]	
Modern Stellar Dynamics Dr E. Vasiliev Tu.Th. 09:00 <i>MR11</i> [2 units] [M]	

All lectures will be held in the Centre for Mathematical Sciences meeting rooms (MR) Clarkson Road except \* which will be held at the IoA, Madingley Road and † in the Cavendish Laboratory (West Cambridge). (Mathematics [M], Physics [P]).

Students may be examined in up to a **maximum of 21 units**, with the compulsory research project accounting for 6 of these units, and a maximum of 15 additional optional units. Quality marks are averaged linearly, weighted by number of units, including 6sixsix units for the project and the best

combination of 11, 12 or 13 units from the exam papers to obtain a final quality mark on which the examiners base their assessment for the class list.

The majority of courses you choose for examination must be drawn from the above list. These courses are worth either 2 or 3 units each and are delivered over 16 or 24 lectures per term, respectively.

You may also choose to be examined in **one additional course** (maximum 3 units) from either the full suite of [Part III Mathematics courses](#) or the [Part III Physics courses](#).

You may not choose the interdisciplinary courses or "Nuclear Power Engineering" from Part III Engineering.

**Please be aware it is your responsibility to ensure that any course not on the recommended counts a maximum of 3 units.** If you choose to be examined in a course not the recommended list, you must contact the [IoA Undergraduate Office](#), who will ensure you have access to both the timetable and Moodle/TIS site for the course.

Please do not hesitate to get in touch if you are unsure how to proceed with the course selection.

## Talks

There are a number of seminars of astronomical interest within various Cambridge departments. Students are encouraged to attend seminars, although the large number of possibilities implies that students need to be selective in those they attend. The Institute of Astronomy has two regular series of talks, one being the Wednesday lunchtime talks at 13:15 and which usually combines 2 half-hour talks on specialised research topics. The Wednesday talks are quite often given by the 2<sup>nd</sup> and 3<sup>rd</sup> year IoA PhD students and would therefore give the Part III/MASt student a good idea of what a research project presentation might involve. The second series is the Colloquia on Thursdays at 16:00 during Michaelmas Full Term. The Colloquia are hour-long talks that generally contain a larger review element, as well as presenting latest scientific results. All IoA students are strongly encouraged to attend the Colloquia weekly. The schedule of talks for the forthcoming week can be found on the [IoA website](#).

In addition, the [Cavendish Astrophysics](#) Seminar takes place at 11:30am on Fridays, and informal lunchtime talks are held at DAMTP (Monday 1 pm for the Cambridge Cosmology and Astrophysics Lunch and Tuesday 1 pm for Astrophysical Fluid Dynamics and Nonlinear Patterns).

Commitments to lecture courses and project work mean that it is essential to be selective about which talks to attend. However, in addition to the benefits of attending a talk containing relevant subject matter, critical assessment of a number of talks offers the opportunity to gain direct experience of what does and does not work when presenting material to a non-specialist audience. Such experience is likely to be of direct benefit when preparing the project oral presentation to the Examiners in the Easter Term.

For full details of the all the Talks and Seminars on offer at the University, click [here](#).

## Calendars

The 2022-23 [Part III/MASt Astrophysics](#) calendar is updated throughout the year as additional events are scheduled. As such, we recommend visiting the calendar regularly.

The 2022/2023 Maths calendar can be found in the Appendix of the [Maths Part III Handbook](#). Whilst some entries are duplicated on the IoA website, it is advisable to check the Maths version, which contains additional entries. In addition to the calendar, you may find the [Lectures/Example classes](#) useful.

## Key Dates: Exam Enrolment

### Mathematics

All Mathematics courses are examined in June. Those of 24 lectures have a 3-hour exam and count 3 units while those of 16 lectures have a 2-hour exam and count 2 units. Mathematics courses timetabled at the same time will be examined at the same time and so only one of each can be chosen for examination.

Students **do not enrol** on CamSIS for Maths exam papers. The Mathematics Faculty requests Part III/MASt Astrophysics students confirm their course choices for examination via a Maths Moodle site. Full instructions on how to do this will be emailed to all students in late April/early May.

### Part III Physics

- i) The Physics Major courses are examined in January. These courses consist of 24 lectures, have a 2-hour exam at the beginning of the Lent term and count 3 units. The courses offered in Part III vary from year to year and students should consult the Part III Coordinator or their DoS for guidance in choosing.

The 2022-23 recommended courses include three Physics major courses:

- Physics of the Earth as a Planet
- Relativistic Astrophysics and Cosmology
- Particle Physics.

Part III/MASt students must enrol for these exams via CamSIS by **4th November 2022**. Students should ensure their Directors of Study have approved their enrolments by **10<sup>th</sup> November 2022** at the latest.

If a student decides to take a Physics Major course that is not on the Astrophysics recommended list, they will need to notify the [IoA Undergraduate Office](#), by **Friday 28<sup>th</sup> October** at the latest to ensure the course is added to CamSIS.

Students should also register for their subject on CamSIS – either the NST3AS (Part III Astrophysics) or MAAS (Master of Advanced Study in Astrophysics) – and also the research project.

**Please note:** Raw marks from the Physics Major option papers **will not be released** to Part III/MASt Astrophysics students until after the final examiners' meeting in the summer. This decision has been taken to ensure fairness to those students not taking Physics Major options and who do not receive any indicative marks in advance of exam choices in May.

ii) The Physics Minor courses are examined early in the Easter Term. These courses consist of 16 lectures per term, have a 1.5-hour exam at the start of the Easter term and count 2 units.

The 2022-23 recommended courses include the following Physics minor courses:

- Formation of Structure in the Universe
- Exoplanets and Planetary Systems.

Part III/MAST students must enrol for Physics minor exams via CamSIS by **13<sup>th</sup> February 2023**, Students should ensure their Directors of Study have approved their enrolments by **17<sup>th</sup> February 2023** at the latest.

If a student decides to take a Physics Minor course that is not on the Astrophysics recommended list, must notify the [IoA Undergraduate Office](#) by **7<sup>th</sup> February 2022** at the latest to ensure the course is added to CamSIS.

## Research Projects

A compulsory element of the course is a substantial research project, extending over two terms. This is undertaken with the guidance of a supervisor from with extensive experience in the field. The research project accounts for a third of the total marks available for the course.

Each year the Institute produces a [booklet](#) containing descriptions of the individual projects available. Each entry contains a brief description of the background to the project along with a summary of the type of work involved and several references to where more information can be obtained.

### Project Timetable

#### Formal Supervision

Students will be offered the equivalent of 12 hours formal supervision spread throughout the academic year.

#### Michaelmas Term

An orientation course covering Linux, the Institute of Astronomy Science Cluster, LaTeX (text-processing facility) and information resources available on-line commences during the first few weeks of the Michaelmas Term (see online timetable and [calendar](#)).

It is impossible to form a clear opinion on a project without discussing it with the supervisor. Therefore, supervisors will host project sessions to explain the scientific motivation and give the details of the work involved. These are interactive sessions where both the supervisors and the students attending are encouraged to ask questions. Students are also encouraged to contact the supervisors directly, using the contact details as stated in the project booklet.

Students are required to rank order their top 10 projects by **17:00 BST Wednesday 5 October 2022**. Details on how students should submit their choices will be confirmed by early September. It is expected that students and supervisors will be informed of the project allocations on Wednesday 12 October.

An electronic PDF copy interim progress report, length no more than 1,000 words, bearing the signature(s) of the main supervisor(s) and second supervisor, must be uploaded to the Part III/MASt Astrophysics Moodle site no later than **12:00 Friday 2<sup>nd</sup> December 2022** (the last day of Michaelmas Full Term). The report should be produced with LaTeX, or an equivalent text-processing package and may contain material that can be incorporated in the final project report. The interim report must indicate the progress made so far and show preliminary results. It should also give a clear indication of the project aims and a detailed plan of how these aims will be achieved. This is particularly important where the results of the project depend on data that has yet to be analysed. There is no need for the interim report to reiterate the material given in the Project Handbook. The interim reports do not constitute part of the formal assessment but are regarded as an essential part of the monitoring procedure. The Course Coordinator will assess these reports and provide feedback to students and supervisors.

#### Lent Term

Practice oral presentations, consisting of a 20-minute talk followed by up to 10 minutes of questions, to an audience of Part III Astrophysics students, Project Supervisors and the Project Coordinator will be given on the last Tuesday, Wednesday, Thursday, and Friday of Lent Term (**14<sup>th</sup>, 15<sup>th</sup>, 16<sup>th</sup> and 17<sup>th</sup> March 2023**). A final timetable for the presentations will be provided by e-mail during the previous week. This practice presentation is not formally assessed but offers the opportunity to become familiar with the format of the presentation, to be assessed by the Part III Examiners in the Easter Term. Students are encouraged to attend the practice talks of their peers which will help strengthen their presentation techniques.

### **Easter Term**

A draft of the final project report, generated with LaTeX or an equivalent text-processing package, should be handed to the Project Supervisor no later than **Monday 24<sup>th</sup> April 2023**. The last Supervision, to discuss the draft report, should take place no later than **Monday 1<sup>st</sup> May 2023**.

An electronic PDF copy of the final project report must be uploaded to the Part III/MAS<sup>t</sup> Astrophysics Moodle site no later than **12:00 BST Monday 8<sup>th</sup> May 2023**. Late submissions are very strongly discouraged because you will be left with insufficient time to properly revise for the written examinations. In circumstances in which it is unavoidable you must seek permission in advance and then any late submissions must be submitted via your college Tutor with an accompanying letter of explanation from the Tutor. Your University Examination Number must NOT appear anywhere in the report or on the cover sheet.

A formal, assessed, oral presentation to Part III Examiners will take place at times and dates to be determined by the examiners. Students will be informed by email of the timetable for presentations in the week prior to the project submission deadline. The presentation should consist of a 20-minute description of the project with PowerPoint or equivalent on a laptop computer. The presentation will be followed by up to 10 minutes of questions. The Examiners will allocate approximately 15% of the total marks for the project on the basis of the presentation.

### **Project Report Format and Content**

The report should read as a self-contained document, presented in the style of a scientific research report or paper in a scientific journal. The main sections of the report will describe the work undertaken, the results obtained and an assessment of their significance. An Abstract, Introduction, Conclusions and References should also be included. Supporting Figures and Tables should be used both as an aid in presenting data and results and also to enhance the clarity of the submission. In some circumstances an appendix containing more extensive tabular material/results may be included.

The report **must** be produced with LaTeX, or another text processing package, and **must not exceed 30 pages** in length, including the Abstract, Figures, Tables, References, and any Appendices. The minimum acceptable font size is 11pt with at least single line spacing. The text must be in single column format. Figures must be legible when printed on A4 paper. Projects not meeting these requirements will be returned for revision and a penalty may apply for late submission at the discretion of the examiners. An example template will be made available later in the year.

The submission should be logically structured, clear, and complete, while remaining concise. The reader should be able to understand the context in which the investigation was undertaken, the main features of the project, the results and how they relate to the advancement of the subject. In addition to the descriptive material, questions a report would be expected to address include, "Why were particular approaches adopted?" – back of the envelope calculations will often be helpful and relevant – "What has been learnt?" and "What information/work would have helped us to learn more?" You should take care to demonstrate that you have tested any analysis packages/codes that you use.

It is a fundamental tenet of scientific research that due acknowledgment is given to the work and ideas of others that form the basis of, or are incorporated in, a research presentation. You must always acknowledge the source of an idea or material you use with a specific reference. Plagiarism, including the use of another individual's ideas, data or text, is regarded as an extremely serious disciplinary offence by the University. Please ensure you read the University's [guidelines on plagiarism](#).

It is a requirement that the project investigation and the project report are both the work of the candidate alone and no form of collaboration is allowed.

Each report must be accompanied by a cover sheet that should bear (1) the title of the project, (2) your name, (3) your college and (4) a signed declaration that reads:

*I declare that this project report represents work undertaken as part of the NST Part III Astrophysics Examination. It is the result of my own work and, includes nothing which was performed in collaboration. No part of the report has been submitted for any degree, diploma, or any other qualification at any other university. It's total length, excluding any coversheet and this declaration but including the Abstract, Figures, Tables, References, and any Appendices, does not exceed 30 pages of 11pt single column typescript. I also declare that an electronic file containing this work has been uploaded to Moodle on this date.*

Signed.....

Date .....

If you are in any doubt as to whether you can sign such a declaration, you should consult the Part III Coordinator before submitting your report. In the event that your project report is not collected after examinations the report will be sent to the address provided on the cover sheet.

### **Late Submission**

The Institute of Astronomy expects students to meet the advertised deadlines for the submission of all coursework, to ensure fairness to all students taking the course and allow prompt marking by the Department.

Your Part III Project makes up one third of total available Tripos marks, and is subject to special arrangements. Late submission of this report is a particularly serious matter, and will require your College to apply to the Examination Access and Mitigation Committee (EAMC) of the University to seek permission for any credit to be allowed. If this is not granted, the late work will not be counted.

The College **must** apply to the [Secretary of the EAMC](#) for an extension to a deadline and should **not** approach the Chair or Senior Examiner directly. Applications **must be submitted by Monday 1<sup>st</sup> May 2023 at the latest** (one week before the scheduled deadline) to enable the Secretary to consult the relevant Chair of Examiners or, where applicable, the Senior Examiner. For further information, please see the Natural Science Tripos [statement](#) on late submissions.

### **Guidance on Writing up a Part III Project**

First, you will have read many research papers in the course of your project research. Some of these you will have found easy to read and others less so. You therefore already have a good idea of what makes a good write-up.

It is usual to set out the write-up in sections that include an introduction, a description of methods, results and conclusions. The introduction should set out the problem to be solved, including why it is interesting, and previous work done. The methods section should describe what you have done in sufficient detail that the work can be reproduced by a reader. It is important to make clear what new work you have done yourself in this section. In the results section describe what you have found. Try to make it very clear which are the most interesting outcomes of the project. In the conclusion explain whether or not you have solved the problem you set out to solve. If so, explain how and if not then why not. You can also describe future work that might get closer to or verify your solution. There are some points to particularly bear in mind.

1. Remember that your readers may not be experts in the field of your project. Begin your description from basic physical principles and describe how any observations have been made.

2. Write short sentences. Long and convoluted sentences, with numerous sub-clauses, are hard to read and often grammatically incorrect.
3. Use named references, such as (Eggleton, Fitchett and Tout 1989), in the text. This is the style generally used by astronomers. It is much easier to read than a number reference style that requires continual cross-referencing.
4. Be concise. Well-written reports do not need to fill the page limit.
5. Include a limited number of pertinent figures. A good figure can replace many words, but many similar figures can often be replaced by a few words. Ensure that axes are labelled properly, lines are sufficiently thick, that points and labels are in a large enough font and that the main details of the figure are explained in the caption. Avoid making figures too cluttered and do not include anything that is not relevant to your discussion.
6. Appendices are for additional reading only. The examiners will base their marking on the main report.

A range of courses on academic writing run by participating University training providers can be found on the [University of Cambridge Training system](#).

# Examinations

## Part III Past Exam Papers

Past exam papers for Part III Astrophysics are available from either [DAMTP](#) or the [Physics](#) department.

## Calculators

The use of electronic calculators will **NOT be permitted** in any papers set for the Mathematical Tripos.

For all Part III Physics examinations, the following calculators marked in the approved manner are permitted:

- CASIO fx 991 (any version)
- CASIO fx 115 (any version)
- CASIO fx 570 (any version)

**It is the responsibility of each student to equip themselves with a suitable calculator as described.**

Each such calculator permitted in an examination must be marked by the Department in the approved fashion so that they are clearly identified as being permitted during the examination. No other calculator may be brought into the examination.

## Sale of Approved Calculators

Approved calculators, marked in the approved fashion, will be on sale from the Department of Physics, Bragg Building (Natural Sciences Tripos). Approved calculators bought elsewhere will need to have the approved marking applied by the Department.

## Criteria for Marking

The Part III Mathematics and Physics examination papers are marked by Assessors (who are normally the course lecturers) appointed by the relevant department and these marks are relayed to the Part III Astrophysics Examiners who consider them in conjunction with the marks obtained on the project.

The Institute of Astronomy Teaching Committee recommends that the degree class be allocated according to the following criteria. An explanation of the marking scheme can be found [here](#).

## First Class Marks

A candidate placed in the first class will be able to demonstrate a full command and a secure understanding of the examinable material. Scripts will contain substantially correct solutions to most of the quantitative parts of a question, showing a good grasp of mathematical skills. For questions of an essay nature, first class marks will be awarded for work which is excellent, both in range and in depth of knowledge and in the argument and analysis that it brings to bear.

A project gaining first class marks will demonstrate an excellent understanding of the methods and results obtained and an ability to argue for the significance of these results in terms of their wider scientific context. Reports awarded first class marks should demonstrate excellent organisation and clarity of thought; an Oral Presentation awarded first class marks should likewise demonstrate outstanding organisation and clarity and the response to questions should exhibit a commanding grasp of the subject matter and wider context.

## Upper Second Class marks, II.1

A candidate placed in the upper second class will be able to demonstrate a good command and some understanding of the examinable material. Scripts will contain solutions to most of the quantitative parts of a question, thereby demonstrating the basic skills involved. For the essay and questions of an essay

nature, II.1 marks will be awarded for work that demonstrates knowledge, but which does not provide as impressive a display of understanding, argument and analysis as those in the first class.

A project gaining an upper second class should demonstrate a good understanding of the methods and results obtained and an ability to synthesise these results in their wider scientific context in a well organised report. Oral presentations in this category should be well organised and attractive. The response to questions should demonstrate that the student has understood the subject material, but would not demonstrate the same critical flair as candidates awarded a first class in this category.

### **Lower Second Class Marks, II.2**

A candidate placed in the lower second class will be able to demonstrate some command of the examinable material but with limited understanding. Candidates should demonstrate the ability to make good attempts at the straightforward parts of questions but limited ability to tackle any of the more challenging topics. Answers to questions of a mathematical nature will show an indication of what is required but fail to proceed sufficiently far into the later parts to demonstrate the skills involved.

A project gaining a lower second class would demonstrate a sound understanding of the methods and results obtained but would not exhibit the same originality of approach or grasp of the connection to the wider field as projects awarded higher class marks. Reports in this category are expected to be reasonably well organised, to clearly set out the work undertaken and to contain appropriate references. Oral presentations in this category will make clear what the student has accomplished but the response to questions may indicate that the understanding is relatively shallow.

### **Third Class Marks**

A candidate placed in the third class will be able to demonstrate some knowledge but have a poor command of the skills expected and very limited understanding of the examinable material.

A project gaining a third class mark would demonstrate relatively poor progress with pursuing the research topic and/or evidence of incomplete understanding of the methods or results obtained. A report gaining a third-class mark may be poorly structured and unable to fully justify and explain the results obtained. Likewise, an oral presentation in this category may be incoherent, with the response to questions indicating a poor grasp of the material.

### **Ordinary/Fail**

A fail mark will be given when a candidate demonstrates little or no knowledge of the material and little or no ability to begin to tackle questions of a mathematical nature.

A project would be awarded a fail mark in the case that the student had failed to achieve any of the significant objectives of the research topic and had failed to provide a reasoned account of why this was the case. A report in this category would provide little evidence of engagement with, or understanding of, the research topic or its relation to the wider field. Likewise, an oral awarded a fail mark would fail to communicate the results and relevance of the project work and the answers to questions would reveal a lack of understanding.

### **Examiners Criteria for Marking the Project Report and Oral Presentation**

The project element of the NST Part III Astrophysics course constitutes one third of the course (equivalent to the marks assigned to two 24-lecture Mathematics Part III lecture courses). Approximately 15% of the marks for the project will be assigned on the basis of the assessed oral presentation that takes place in the Easter Term. The balance of the marks will be assigned on the basis of the written project report.

The Examiners will award marks under three broad headings:

- i) scientific understanding
- ii) quality of the research
- iii) presentational and communication skills.

The format and timetable for submission form part of the Examination process. In their assessment of the project, the Examiners will take account of any breaches of the guidelines, including exceeding the word limit and late submission of the report.

### **Oral Presentation**

The Examiners assessment will take into account the following:

- Visual Material: including relevance, clarity, attractiveness
- Oral Presentation: including overall structure, clarity, time keeping
- Response to Questions: including grasp of subject material, precision of answers

### **Written Project Report**

The Examiners will assess the report under the following headings:

- Overall structure and clarity of the report
- Planning, organisation, and prosecution of the research
- Understanding of the physics and the general scientific content
- Technical proficiency
- Analytical and Interpretational skills
- Significance of the results

### **Classification of the MAST**

As a result of the examination, each candidate is placed in one of the following categories: Distinction, Merit, Pass, Fail or 'Other'. 'Other' may include, for example, candidates who were ill for part of the examination.

**Distinction:** Candidates will have demonstrated mastery over a considerable range of material. Their performance will have been such as would be expected of someone starting PhD research at a leading Astrophysics, or Mathematics, department.

**Merit:** Candidates will have performed at first class level. In the words of the criteria used for a first class in our undergraduate examinations they 'will have demonstrated a good command and secure understanding of examinable material. They will have presented standard arguments accurately and showed skill in applying their knowledge.'

**Pass:** Candidates will have performed at upper second-class level. They will have demonstrated the ability to absorb and understand difficult material but there may remain gaps in their understanding, and they may not always be able to apply their knowledge successfully.

**Fail:** Candidates will have performed at a lower second-class level or below.

### **Special Examination Arrangements & Mitigation**

Any student who believes there are circumstances that require special treatment by the examiners should contact their Tutor as soon as they realise there is a problem, whether this is before, during or after the exams. Your tutor will be able to discuss with you a number of existing mechanisms of support for the examination period. Click [here](#) for full details.

### **Examination Results**

Examinations are a University matter and covered by strict regulations. Whether you have a complaint or not, **you should not, under any circumstances, seek to discuss your examination result with your examiners.** The University has a [standard procedure](#) for dealing with complaints about examination results.

The various steps in the procedure are **time-limited** and you should therefore immediately discuss the matter with your College Tutor, who will advise you further. You should note that any investigation by the University will usually confine itself to seeing that the examiners acted correctly (for example that all the marks you received were entered into the mark book) and not try to second-guess the examiners by remarking your papers.

### **Institute of Astronomy Prize**

The Institute of Astronomy Prize is awarded annually to that candidate for Astrophysics in Part III of the Natural Sciences Tripos or a Master of Advanced Study in Astrophysics candidate who has in the judgement of the Examiners shown the greatest distinction in that examination, provided that his or her work is of sufficient merit. The value of the Prize for the academic year 2022/23 is £500.

## Transferable Skills

All students in the University are encouraged to engage in personal development planning. The Astrophysics courses are designed to provide all students with opportunities to develop a wide range of transferable skills. The University also offers plenty of opportunities to acquire skills outside the curriculum particularly in College-based activities and in numerous specialist interest clubs and societies. Students also have access to the [University of Cambridge Training system](#), which hosts a wide range of courses run by participating University training providers.

The Institute of Astronomy has identified the following set of skills and attributes which all undergraduates can reasonably expect to acquire during their university career. These skills enhance students' academic performance, can be used beyond university, and are valued by employers.

This note sets out the ways in which transferable skills are acquired through the teaching programme offered by the Institute. The Part II and Part III Astrophysics courses overlap with courses provided by the Departments of Physics and Applied Mathematics and Theoretical Physics and so the transferable skills policy statements of those departments are also relevant.

### Intellectual Skills

The most important intellectual skills which our students learn are abilities at quantitative and qualitative reasoning in the exact physical sciences and the application of this understanding to problem-solving. Examples include development of models of phenomena, mathematical analysis of models, appropriate approximation, and statistical analysis. These skills are developed both the IoA through lectures, examples classes, seminars, projects and examinations and your College through supervisions involving discussion, reasoning, problem solving, and critical analysis.

### Communication Skills

All students develop their communication skills as part of the teaching and assessment programme. In Part II essays and Part III projects credit is given for the quality of the student's communication skills. The principal elements of the training involve the following:

#### i. Writing

- Department: Guidance notes provided by the Department on the preparation and presentation of Part II essays. Individual guidance by supervisors of Part III research projects, encouraging a critical attitude and an innovative approach to problem solving.
- College: Supervisions involving the discussion and written solution of problems.

#### ii. Oral

- Department: Oral presentations of project work in Part III (also including software presentation packages and visual aids).
- College: Supervisions involving oral explanations and discussion with supervisors and other students.

#### iii. Non-verbal (development of an argument using mathematical concepts or symbolic language)

- Department: Computational projects, essays, and examples sheets.
- College: Supervisions involving problem solving.

### Organisational and Interpersonal Skills

Students develop self-discipline in the management of a complex work programme of lectures, supervisions, examples classes, projects, literature reviews and examinations with strict deadlines.

Interpersonal skills and self-expression are developed through constant interaction with peers, supervisors, lecturers and working within a research group as part of a Part III project.

- Department: Provision of a framework within which the students carry out their work programme with clear deadlines. Advice on organising the programme of work in the Course Guide.
- College and University societies: Oversight of the students' programmes is maintained by Directors of Study and Tutors. Advice on organisation of the work programme through supervisions. Living, working, and socialising in a diverse community and taking positions of responsibility are important contributors.

### **Research Skills**

Students develop information-acquisition skills from the selection and use of appropriate textbooks to the sourcing and assimilation of scientific literature particularly for essays and projects.

- Department: Development of all aspects of research skills involving the application of understanding of concepts to new problems by use of the library, electronic and Internet resources to supplement information given in lectures and supervisions, critical analysis of published papers in preparation for a Part II essay and the Part III research project. Appreciating how to access the experience and knowledge of expert scientists.

### **Numeracy and Computing**

Success in Astrophysics is dependent on a high level of numeracy and computing skills, all of which are highly transferable to other spheres.

- Department: In earlier years of the Natural Sciences Tripos students will have followed courses in mathematics. All Astrophysics courses contain mathematical elements. Lectures and examples classes are provided in mathematical methods and statistical Astrophysics, daily use of mathematics and computational methods for study and problem solving and data analysis in essays and projects. CATAM courses are specifically focussed on programming skills, many at a very advanced level.
- College: Supervisions in all courses. Computing resources for the above such as e-mail and Internet access. Word processing is used for all aspects of written communication.

### **Foreign Language Skills**

Students have access to the University's [Language Centre](#) and extensive opportunities for self-teaching in foreign languages.

# Appendix I

## Part III Examination Assessment

Each Part III Mathematics paper is marked by an assessor who is usually the lecturer. Assessors give a quality mark alpha+, alpha, alpha-, beta+, ..., gamma- to the whole paper. Individual questions are not assigned quality marks so there is no extra weight given to answers to more complete questions though assessors can, and often do, assign more marks to problem solving parts of questions than to book work. Paper quality marks alpha+ to beta+ are given to papers of first class standard (alpha+ to alpha- are of distinction standard and beta+ is of merit standard for the MAST) and beta and beta- are of II.1 standard (pass for the MAST). The project is assigned a similar quality mark by the Part III Astrophysics examiners. Physics papers are assigned a quality mark appropriate to the numerical mark assigned by the physics examiners. Quality marks are averaged linearly, weighted by number of units, including six units for the project and the best combination of eleven, twelve or thirteen units from the exam papers to obtain a final quality mark on which the examiners base their assessment for the class list.

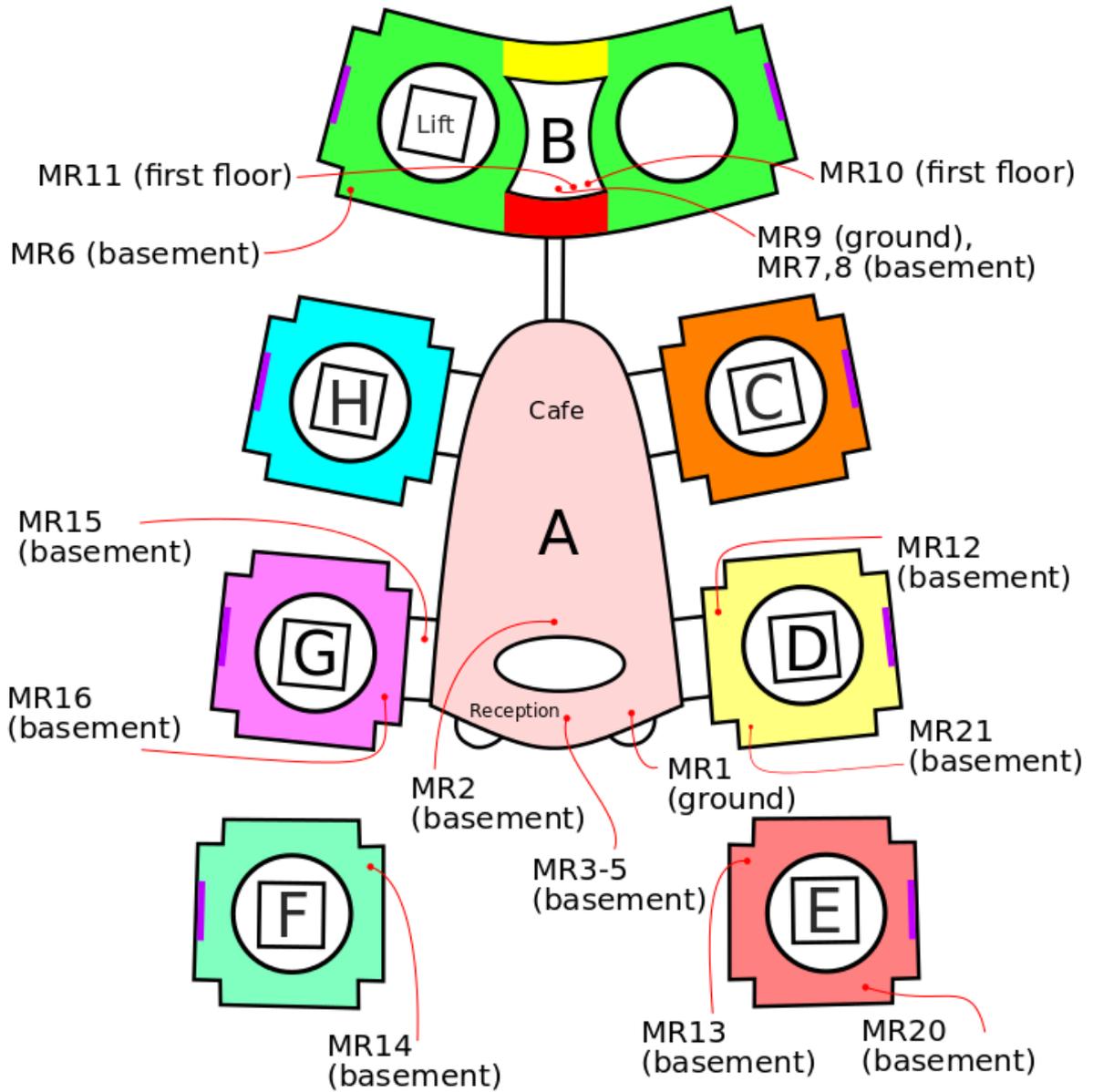
Christopher Tout

Chair, Institute of Astronomy Teaching Committee

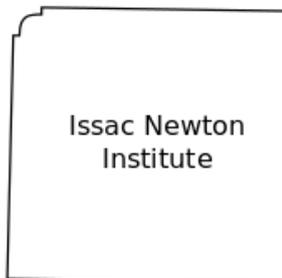
15 March 2012

# Welcome to the Institute of Astronomy





Access to MR1-5, MR13-16 is via reception in Pavilion A; disabled access is via lift in Pavilion D.



Issac Newton Institute

All pavilions except A have one lift each, marked above with squares.



Gatehouse



Betty & Gordon Moore Library

UNIVERSITY OF CAMBRIDGE

INSTITUTE OF ASTRONOMY

# Safety Manual

## Action if you discover a fire

### Operate alarm

Using nearest break-glass unit

**Call Fire Brigade:** dial 1999

**Tackle fire** with hand-held extinguishers **if safe to do so** without personal risk

Or

**Evacuate building** by nearest exit

Do not stop to collect belongings

Do not re-enter building

## Action when fire alarm sounds

Leave by nearest available exit

Assemble on Thorrowgood Lawn (between Observatory and SPO buildings)

## University Security Control Centre

24-hour number 31818

Emergency number 101

## Accidents

For Ambulance dial 1999

### First Aiders

Cormac O'Connell 07801707058 or 37505

Monica Gamboa 37548

Mark Hurn (Library office) 37537

Debbie Peterson (H12) 66643