

# Natural Sciences Tripos

## Part III/MASt Astrophysics

COURSE GUIDE

2021-2022



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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 2 pm 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	George Efstathiou	37530	Kavli Rm K15	gpe@ast.cam.ac.uk
Course Secretary	Kate Hardcastle	37552	Hoyle Rm 06	undergraduate.admin@ast.cam.ac.uk
Teaching Committee Chair	Christopher Tout	37502	Hoyle Rm 61	cat@ast.cam.ac.uk
Director	Richard McMahon	37519	Hoyle Rm 49	rgm@ast.cam.ac.uk
Director's PA	Susan Hatley	37521	Hoyle Rm 48	hodpa@ast.cam.ac.uk
IoA Librarian	Mark Hurn	37537	Obs Library Office	hurnm@ast.cam.ac.uk
Public Astronomer	Matt Bothwell	39279	Hoyle Rm 59	bothwell@ast.cam.ac.uk

If you are unsure how to proceed with the course selection, do not hesitate to get in touch with us.

## 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. This equates to about 18 examinable units over the year. The compulsory project accounts for a further 6 units so that 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

(please note that the lecture list is subject to change)

Michaelmas 2021	Lent 2022
Physics of the Earth as a Planet † Dr D. Al-Attar & Dr J. A. Neufeld M.W.F. 10:30 <i>Small LT, Cavendish</i> [3 units] [P]	Formation of Structure in the Universe † Dr N. Laporte M.F. 09:00 <i>Small LT, Cavendish</i> [2 units] [P]
Cosmology Dr B. D. Sherwin M.W.F. 10:00 <i>MR2</i> [3 units] [M]	Field Theory in Cosmology Prof. E. P. S. Shellard & Dr S. Melville M.W.F. 12:00 <i>MR11</i> [3 units] [M]
Formation of Galaxies Prof. N. W. Evans M.W.F. 09:00 <i>MR11</i> [3 units] [M]	Extrasolar Planets: Atmospheres and Interiors Dr N. Madhusudhan M.W.F. 11:00 <i>MR14</i> [3 units] [M]
Astrophysical Fluid Dynamics Dr R. Rafikov M.W.F. 12:00 <i>MR13</i> [3 units] [M]	Astrostatistics Dr K. S. Mandel M.W.F. 12:00 <i>MR5</i> [3 units] [M]
Relativistic Astrophysics and Cosmology * Dr W. Handley M.W.F. 12:00 <i>IoA SLT</i> [3 units] [P]	Black Holes Dr J. E. Santos M.W.F. 10:00 <i>MR3</i> [3 units] [M]
Particle Physics † Dr C. Lester M.W.F. 09:00 <i>Pippard, Cavendish</i> [3 units] [P]	Modern Stellar Dynamics Dr E. Vasiliev Tu.Th. 09:00 <i>MR13</i> [2 units] [M]
General Relativity Prof. H. S. Reall M.W.F. 12:00 <i>MR2</i> [3 units] [M]	Binary Stars Prof. C. A. Tout Tu.Th. 11:00 <i>MR13</i> [2 units] [M]
Structure and Evolution of Stars Dr A.N. Zytkov M.W.F. 11:00 <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]	Exoplanets and Planetary Systems † Prof. D. Queloz Tu. 15:00, W. 10:00, Ryle [2 units] [P]
	Dynamics of Astrophysical Discs Dr H. N. Latter Tu.Th. 12:00 <i>MR13</i> [2 units] [M]

*In addition, attendance at a short computer orientation course, covering practical aspects of Unix and use of the Institute of Astronomy Science Cluster is required.*

Dr R.M. Johnstone, Introduction to Unix and Computing\* – see online calendar for timetable of lectures.

All lectures will be held online or 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]).

The majority of courses you choose for examination must be drawn from the above list. Only one of each of the following pairs may be offered for examination:

- (i) Relativistic Astrophysics and Cosmology or Cosmology;
- (ii) Formation of Galaxies or Formation of Structure in the Universe;
- (iii) Extrasolar Planets: Atmospheres and Interiors or Exoplanets and Planetary Systems.

You may also choose to be examined in courses, amounting to a maximum of three units, chosen from any of the full suite of Part III Mathematics courses or from the Part III Physics courses. You may not choose the interdisciplinary courses or "Nuclear Power Engineering" from Part III Engineering. 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. Physics major options have a 2-hour exam at the beginning of the Lent term and count 3 units. Physics minor options have a 1.5-hour exam at the start of the Easter term and count 2 units. The courses offered in Part III vary from year to year and students should consult the Part III Coordinator for guidance in choosing. 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. This applies for the pairs General Relativity and Astrophysical Fluid Dynamics and Astrostatistics and Field Theory in Cosmology.

The lecture courses are supported by Examples Classes organised by the lecturer.

Part III Examples and some Lecture Notes are here:

<http://www.damtp.cam.ac.uk/user/examples/indexP3.html>

## 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 1.15 pm and which usually constitute 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 4.00 pm 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.

*Details regarding the format of the Wednesday Seminars in Michaelmas Term 2021 to follow.*

In addition, the Cavendish Astrophysics Seminar takes place at 2 pm on Tuesdays 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.

The schedule of talks for the forthcoming week can be found on the [loA website](#).

## General Information

It is hoped as a Part III Astrophysics student that 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!). *Events this term are to be decided.*

### Public Outreach

The IoA runs an extremely successful programme of Public Outreach on Wednesday evenings. Student participation is welcome: details available at the introductory session on Wednesday 6<sup>th</sup> October 2021 or email [bothwell@ast.cam.ac.uk](mailto:bothwell@ast.cam.ac.uk).

### 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 Greenwich House) and a full range of meals at the Hauser Forum as well.

*Due to the pandemic, some catering services may remain disrupted.*

### Computing

Part III students are given full access to the Institute of Astronomy Science Cluster. A limited number of bookable dedicated terminals are available in Library Room B at the Institute of Astronomy.

A 5-lecture "Introduction to Unix and Computing" course is given at the start of the Michaelmas Term in order to familiarise students with the operating system and use of the Science Cluster.

### Library

*During Covid 19, only limited access to the library will be possible and borrowing arrangements are modified.*

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.

**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.

**E-mail**

Students' correspondence will be delivered via email.

**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 [undergraduate.admin@ast.cam.ac.uk](mailto:undergraduate.admin@ast.cam.ac.uk). 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.

## Part III/MASt Astrophysics Calendar 2021/22

Please see online calendar at: [https://www.ast.cam.ac.uk/students/undergrad/part\\_iii/calendar](https://www.ast.cam.ac.uk/students/undergrad/part_iii/calendar)

*Please note: details may be subject to change and additions made throughout the year*

**MATHS CALENDAR FOR 2021/2022** – this can be found in the Appendix of the Maths Part III Handbook. Some entries are duplicated on the IoA website and it is advisable to check the Maths version, which contains additional entries.

[Maths Part III Handbook](#) and [Lectures/Example classes](#)

Students offering a **Part III Physics** course for examination must complete and return their College examination forms by the appropriate deadline. Please ensure that one copy of the form is submitted to the Course Secretary in the Institute of Astronomy during Michaelmas Term. Further information about procedures for examination entries will be made available at the beginning of the Michaelmas Term. 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 ask the Astrophysics course secretary at IoA for assistance.

## 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 the Institute of Astronomy. 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. Please read the University's [guidelines on plagiarism](#).

### ***Project Timetable***

Spread across the year, supervisors will offer the equivalent of 12 hours formal supervision.

#### **Michaelmas Term**

An orientation course (5 lectures) covering Linux, the Institute of Astronomy Science Cluster, LaTeX (text-processing facility) and information resources available on-line commences the second week 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 will be required to rank order their top 10 projects by Tuesday 5 October 2021. 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 Monday 11 October.

An interim progress report, length no more than 1,000 words, bearing the signature(s) of the main supervisor(s) and second supervisor, must be submitted to the Course Secretary no later than 12 pm on the last day of Michaelmas Full Term (Friday 3 December 2021). 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 (15, 16, 17 and 18 March 2022). A final timetable for the presentations will be provided by e-mail during the previous week. The 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 25 April 2022. The last Supervision, to discuss the draft report, should take place no later than Monday 2 May 2022.

An electronic copy of the final project report must be uploaded to the Part III/MASt Astrophysics Moodle site no later than 12:00 noon BST Monday 9 May 2022. 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: for further guidance on what constitutes plagiarism, see:

<http://www.admin.cam.ac.uk/univ/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 sent by email (undergraduate.admin@ast.cam.ac.uk) 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.

### **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.

## Examinations

### Course Choices

Students offering courses for examination which are given as part of Part III Physics must complete and return their college examination forms by the appropriate deadline. Please ensure that one copy of the form is submitted to the Course Secretary in the Institute of Astronomy during the Michaelmas Term. Further information about procedures for examination entries will be made available at the beginning of the Michaelmas Term. 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 and **supervision allocation**.

Students are required to submit notification of which courses they will be offering for examination given as Part III Mathematics no later than noon on Thursday, 5 May 2022 **[TBC]**. Three copies of your choice of courses must be submitted, one to your College Director of Studies in College, one to the DAMTP Faculty Office and one to the Course Secretary at the Institute of Astronomy. Your Director of Studies needs to check, approve, sign and forward your nomination form to DAMTP. Make sure you allow your DoS at least 3 weekdays to complete the process.

Students may be examined in up to a maximum of 21 units, including 6 units for the compulsory project. The Examiners will base their decision on 17, 18 or 19 units consisting of 6 project units plus the most favourable combination of examination units. The majority of courses should be selected from the recommended list. Courses amounting to 3 units or fewer may be selected from the full suite of Part III Mathematics courses or the allowed list of Part III Physics courses or a mixture of both.

Results for part III physics options will not be made available before the final examiners' meeting after the summer exams.

Click [here](#) for the report of the External Examiner.

### Calculators

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

### NST Part III Physics – Major and Minor Options

### **Electronic calculators in University examinations, 2021-22 (Cambridge Reporter 7 Oct. 2021)**

For the above 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:

- 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 on page 20.

#### **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.

#### **Special Examination Arrangements**

Any student who believes there are circumstances that require special treatment by the examiners must ensure that this information is communicated to the Course Secretary by their College at the earliest opportunity and well before the project presentations, see

<http://www.admin.cam.ac.uk/students/studentregistry/exams/undergraduate/>

#### **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 2021/22 is £500.

#### **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.

Any complaints or requests for reconsideration must be made in writing by your College (usually via your Senior Tutor) to the Chairman of the Examiners. You should therefore 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 re-marking your papers.

#### **Part III Exam Papers**

Past exam papers for Part III Astrophysics are available from either DAMTP or the Physics department.

## 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.

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; statistical analysis. These skills are developed in the Department through lectures, examples classes, seminars, projects and examinations; and in 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:

#### 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.

#### 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.

#### 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; taking positions of responsibility.

### **Research skills**

Students develop information-acquisition skills from the selection and use of appropriate text books 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. Use of library, electronic and Internet resources to supplement information given in lectures and supervisions; critical analysis of published papers in preparation for Part II essay; 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; 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; 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.

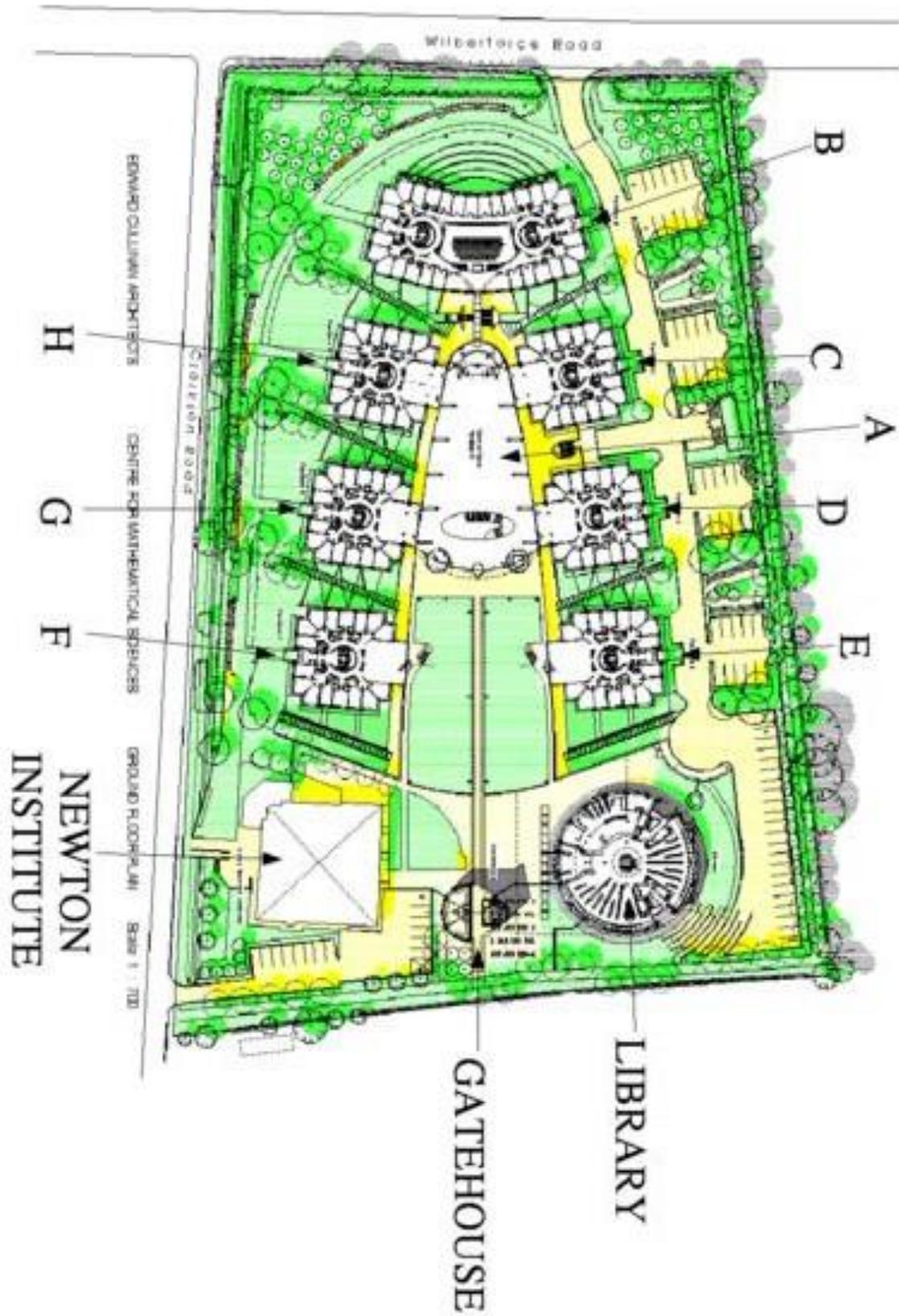
Christopher Tout

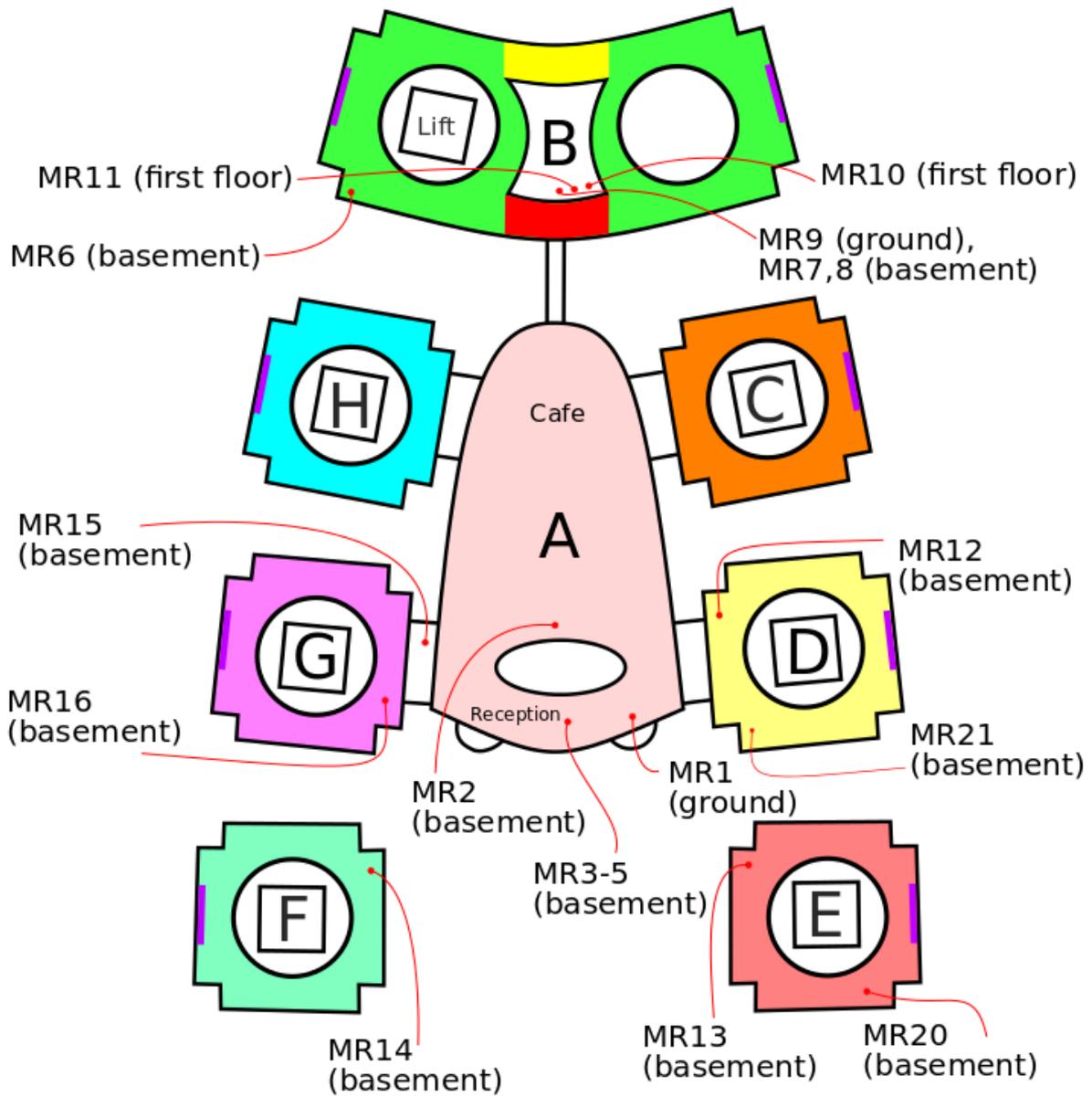
Chair, Institute of Astronomy Teaching Committee

15 March 2012

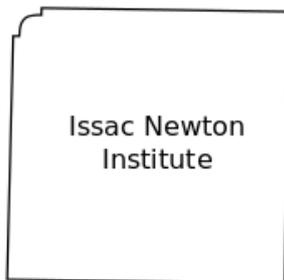
# Welcome to the Institute of Astronomy







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