

# Teaching Committee report to the Faculty Board

## Examinations for Parts IA, IB and II of the Tripos, 2015

### 1 Introduction

The Committee met three times, for two hours each, to consider the 2015 undergraduate Tripos examinations. We looked, for each part of the Tripos, at:

- the examiners' report;
- the external examiners' reports;
- the examiners' comments on their questions;
- the examination statistics;
- the examination papers;
- the analysis of the paper lecture questionnaires;
- the responses to the on-line questionnaires;
- the report from the CATAM assessors (Parts IB and II).

We noted with pleasure that as usual the external examiners, without exception, commented favourably both on the examination process and also on the performance of the candidates. The six external examiners' reports include comments such as:

*The examination was extremely well organised by the Chair and the other Examiners and it ran very well. The academic standards set were very high, the examination questions presenting considerable challenge to the candidates so that there can be differentiation between them. (Part IA)*

*Cambridge's system of compendium examinations papers is appropriate for mathematics and is commendable. We scrutinised in detail a large number of scripts at the class boundaries, and it is particularly heartening to see that the form of the examination papers enables effective discrimination among candidates over a wide range of abilities. (Part IB)*

*The Mathematical Tripos examination system of using end-of-year synoptic papers is envied by mathematicians at other universities. (Part IB)*

*The examination process has worked smoothly and efficiently. The standard of the examination papers was very high, as one would expect of a world-class university. Their scope confirmed my view that Cambridge is second to none in the quality of its applied mathematics education. (Part II)*

*Overall the standards were appropriate for a top university. It should be noted that the first class standard is very high: significantly higher than anywhere except Oxford. (Part II)*

*Intellectual standards on Part II of the Mathematical Tripos are very high, comparing favourably even with those at other departments in Cambridge and with other leading UK universities. This is a course that is of the highest level of intellectual rigour, covering a broad range of topics. (Part II)*

There follows a summary of the points raised in the examiners' reports which the Committee believe need the attention of the Faculty Board. We have not generally highlighted points of a purely administrative nature: that is for the the Chairs of this year's examiners and the Undergraduate Office to pick up rather than the Faculty Board.

## 2 General Matters

### 2.1 Errors

This year nine errors were reported, in a total of about 280 questions: no errors in Part IA; three errors in Part IB; six errors in Part II. This total compares with 7, 9, 9 and 9 errors in the four previous years. The errors, as detailed in the examiners' reports, were largely minor typographical details which did not affect the substance of the question. As usual, examiners made appropriate adjustments when marking these questions, and when considering borderline candidates.

The General Board's Education Committee is much exercised about the number of errors on mathematics papers. Faculty procedures for Parts IA, IB and II already prescribe multiple rounds of checking – by the setter, the checker and the lecturer, and by the exam board, together and in subcommittees, in each of three lengthy meetings. In our experience, examiners make strenuous efforts to clarify wording and eliminate errors during drafting. While we are far from complacent, we do not believe it is realistic to expect a significant reduction from the numbers above. Mathematical questions can include errors in a way that questions in most subjects simply cannot, and in Part II, particularly, the number and specialised complexity of questions is quite unlike any other Tripos. Quite understandably, the majority of the errors in each of the years above have been in Part II, which accounts for 150 of the 280 questions involving highly technical notation and calculations. We **recommend** that GBEC's concerns are communicated to examiners, and that all examiners, in particular those in Part II, are further exhorted to be meticulous in their checking of all draft questions.

### 2.2 Timetabling

A new examination timetable was agreed by Faculty Board for 2015, which was prompted by student comments on the timetable trialled in 2014, and then guided by an electronic poll of current students regarding some alternatives. The new timetable was regarded favourably in this year's end-of-year questionnaire, and it caused no difficulties for the examiners. We **recommend** that the 2015 timetable (as defined relative to the dates of Easter Term) be used from now on.

### 2.3 Classification of candidates who were absent for some papers

New Board of Examinations guidelines state that a candidate who is absent or withdrawn from some part of the examination should be classified if possible and 'not classed' (rather than failed) if not. The Part IB examiners ask for guidance on how this applies to candidates who have marks for CATAM, but did not sit any written papers. All three Chairs asked informally for clarification, and preferably for automation, of the procedures for drawing up the provisional class lists. We note that candidates who were absent from any papers, will almost certainly be referred to the Applications Committee, and dealt with appropriately there. We **recommend**

- (i) that a candidate who sits only one paper in Part IA, or only CATAM in Parts IB or II, should automatically be 'not classed' on the grounds that the marks they have obtained have been on only one or two courses;
- (ii) that any candidate who was not present at one or more of the written papers should be listed, together with any not-for-honours candidates, at the bottom of the provisional mark list, and considered for possible classification only after the examiners have decided the class boundaries for the honours candidates who were present for all four papers;
- (iii) the default class boundaries should be calculated using percentiles of the honours candidates who were present for all four papers.

## 2.4 CATAM submission rates and Turnitin

This year, for the first time, students were required to submit electronic versions of their write-ups in order to facilitate checks against plagiarism using *Turnitin*. No cases of plagiarism in either the write-ups or the program code were suspected or detected this year.

The requirement to submit electronic write-ups did not prove to be the disincentive to attempting CATAM that some feared, perhaps because the Directors of Studies asked for graphs showing the contribution of CATAM marks to the total to be circulated to students. The submission rates in Part IB (98%) and Part II (94%) significantly exceeded the respective historic ranges.

## 2.5 CATAM: vivas and plagiarism

The Part IB examiners question whether conducting viva voce examinations of a small number (4 this year) of randomly chosen students fulfils a useful role. Professor Walters (Part II external examiner) suggests instead using vivas in a targeted way, as a means of testing for bespoke plagiarism by candidates with surprisingly high marks compared to Part IB. All of the Part II external examiners, while welcoming the introduction of Turnitin, remained concerned that the University was preventing the Faculty from imposing appropriate sanctions on students found cheating.

The Faculty has been in dialogue with the Student Registry over the summer and negotiated new guidelines for 2015/16 in which CATAM is treated a single piece of work, so that a student found deliberately cheating on one part of CATAM may lose all the marks for CATAM. This is what the external examiners have been advocating for many years, and we can only hope that the University is willing to be sufficiently robust in practice to protect the integrity of its qualifications.

We believe the possibility of vivas was originally intended as a (mild) deterrent against plagiarism. Measures introduced more recently – electronic submission, the possibility of examination interviews and the new robust guidelines – may have removed the need for vivas. We suggest that the Director of CATAM keep this under review as experience of the new measures develops.

## 2.6 Mark processing

This year marks were processed, as well as input, using the new software written by Mr John Sutton. Parallel processing with the old software was used to check the code, and no discrepancies were found. We suggest that the parallel processing checks should be continued for at least one more year.

Two cases came to light where examiners allowed their checkers to make corrections to marks using the online entry system. We are surprised this could be thought appropriate and strongly **recommend** that all guidance regarding mark input and checking be revised to make it very clear that checkers should be given access only to printouts and never the online system.

## 2.7 Marking conventions

Professor Mackay (Part IB external examiner) comments positively on the granularity of mark schemes and the good use by examiners of their mark schemes. In cases where partial marks are awarded, he recommends that there be some indication on the scripts where marks have been lost. The current Memorandum to Examiners emphasises caution that marks on scripts are, in principle, available to candidates under the Data Protection Act, and points towards minimal annotation. We do not see any problem with simply underlining, ringing or putting a cross by deficiencies in answers and **recommend** that this be encouraged in the Memorandum.

## 2.8 Short questions

In Parts IB and II the average success rates for betas on short questions increased slightly to 52% and 51% respectively, approaching the target range of 55–60%. On some courses the success rate fell well short of the target.

While the beta threshold for short questions in 2015/16 has been reduced from 8/10 to 7/10, the target success rate for betas has been raised from 55–60% to 65–70%. Hence it is important that the short questions be made no harder and no longer than previously and, in many cases, we **recommend** that pressure is maintained in the opposite direction.

## 2.9 Draft solutions

Professors MacKay and Willerton (Part IB External Examiners) both comment that the draft solutions provided by examiners vary greatly in style, purpose and detail from a minimal hand-written outline to a fully LaTeXed exposition that includes all possibilities and ramifications. This makes it difficult to compare the length and difficulty of questions, or to judge what a student is expected to write. We agree with their **recommendation** that a draft solution should mean what a good student should write down under exam conditions to obtain full marks. If LaTeX is used, the answer should still have the same content and detail as a hand-written answer would.

## 2.10 Illegible handwriting

The Part IA examiners asked for clarification of the policy regarding illegible handwriting: specifically, should examiners attempt to do their best without transcription, or should they routinely ask for transcription (for which the Board of Examinations provides a mechanism), or should they feel free not to do their best because, in the words of the rubric, the candidate has placed themselves at a grave disadvantage.

The Teaching Committee agreed that an ability to lay out a solution clearly and legibly is one of the skills that should be acquired in a mathematical education (through supervisions and input from Directors of Studies) and therefore a valid part of the assessment. We **recommend** that examiners should normally do their best without transcription and if an answer, or part of an answer, is indecipherable then it should not be awarded the relevant marks. Exceptions should be made, where appropriate, for candidates with disabilities or diagnosed specific learning difficulties.

## 2.11 Format of mark list and Director of Studies list

The examiners in Parts IB and II commented very positively on the experimental use of a provisional mark list in which the question numbers and examiner letters for each attempt on the various papers are replaced by three-letter subject codes. (A similar scheme is not possible in Part IA, because there is more than one long or short question of a given subject on each paper.)

We **recommend** that the three-letter coding be made the default format for the provisional mark list in Parts IB and II, and also that a similar coding be used (in all Parts) in the mark list issued by the Faculty to Directors of Studies.

## 2.12 Administrative and Computer Officer support

The examiners' reports remarked on the excellent support given by Ms Amy Dittrich and Mr John Sutton, in particular, and the administrative staff more generally. We **recommend** that the Chair of the Faculty Board expresses the appreciation of the Board for their hard work.

# 3 Part IA

## 3.1 Difficulty of Examination

We commented last year that the marks for long questions on Probability were lower than desirable (a 35% alpha rate). The marks this year were even lower (a 24% alpha rate), way out of line with both the Faculty guidelines and the other course on Paper 2. In the interests of fairness, we **recommend** that this year's examiners consider previous years' statistics carefully when aiming to set questions of a uniform standard to the Faculty guidelines.

## 3.2 Short questions

The examiners note that their 42% beta rate (on average) on short questions fell well short of the Faculty guidelines of 55–60% (on each course), and even seemed to think that such a high target might be unachievable. The Teaching Committee certainly does not share this view, and we observe that last year’s examiners hit the upper end of the target (on average) with 60% betas.

## 3.3 Classification criteria

The IA Examiners suggested that performance on short questions might form an explicit part of the classification criteria at the 3rd/Fail boundary. The Teaching Committee was unpersuaded that it was desirable to quantify a difference between long and short betas at this boundary.

## 3.4 Gender balance of examiners

We welcome the breakdown of Tripos results by gender in this year’s report. The Teaching Committee, particularly its female members, did not believe that the gender balance of the examiners was relevant to the performance of the candidates.

## 3.5 Rubric

The Examiners note that the rubric statement “Complete answers are preferred to fragments” might be considered misleading for candidates taking Computer Science with Mathematics. The Computer Science examiners actually only use the raw marks from the Mathematics papers and are not interested in quality marks, but the CST documentation is not particularly explicit on this point. We did not wish to complicate our own, already lengthy, rubric. We **recommend** that our Schedules should include a comment that, unless the official documentation for the Computer Science Tripos states otherwise, candidates taking Computer Science with Mathematics should expect to be assessed on the basis of their total raw mark on Papers 1 and 2, with no account of quality marks.

## 3.6 Schedules

We **recommend** that some specific suggestions in the Examiners’ report for changes to Schedules be referred to the Curriculum Committee.

## 3.7 Substantial revisions

There is a clear requirement for questions that have been substantially revised to be resubmitted to the relevant lecturer for comment. In response to a question from the Part IA examiners, we believe that there is, and should be, no requirement to resubmit them to the external examiner and, indeed, there may not be time to do so.

## 3.8 Typesetting conventions

The Part IA examiners recommend that some typesetting conventions, for example an obscure distinction between uses of (i), (ii), (iii) and (a), (b), (c), are not well known and in need of revision. The Chair of the Teaching Committee intends to produce a short online summary of common conventions.

# 4 Part IB

## 4.1 Difficulty of questions, Methods

The percentage of attempts on long questions gaining alphas was 49% for Pure, 50% for Statistics and 44% for Applied, representing a good overall balance between the major subject areas, though

there were much larger variations within subject areas than is desirable.

In particular, Professor MacKay (External Examiner) comments in his report that the alpha rate on Methods was only 27%, that some of the Methods questions took up a full page and had solutions twice as long as others and, most disturbingly, that he had commented at the draft stage that he felt that these questions and their solutions were too long. The Teaching Committee thought several questions went beyond topics covered in lectures or mentioned in the Schedules (Fredholm integral equations, the fundamental solution of the Helmholtz equation, shock formation in nonlinear hyperbolic equations). The end-of-year student questionnaires were full of complaints about the questions on this course.

The letter from the Chair of the Faculty Board to Examiners is clear about the importance of having as uniform a standard of questions as possible, and about the collective responsibility of the Examiners for the whole examination. Part IB is much more difficult to get right than Part IA, and we **recommend** that this year's examiners make full use of statistics from several previous years, comments from the External Examiners and consultation with lecturers, as well as their own collective wisdom.

## 4.2 Difficulty of question, Variational Principles

Professor MacKay (External Examiner) notes that a short, supposedly bookwork, question on the brachistochrone received only 1 beta from 62 attempts, and asks that the causes be investigated. The relevant lecture notes cover various problems and follow this one as far as the first integral of the Euler–Lagrange equation, but they then just state the parameterised cycloidal solution without actually solving the differential equation. The examination question did not provide the answer to aim for, and most candidates got stuck on the (slightly old-fashioned) integration. Neither lecturer nor examiner anticipated this would be such a sticking point. We note that the other questions on Variational Principles were answered well, and regard this question as an isolated and unfortunate glitch.

## 4.3 Easter Term courses

We agree with the **recommendation** that draft questions on the Easter Term courses, which students may attend in their first or second years, should be shown to the relevant lecturers from both years, if they differ. (We thought this was already the recommended practice.)

## 4.4 Timing of meetings

The Teaching Committee notes again that the IB examiners only have two meetings where they consider the draft questions, whereas the examiners in Part IA and II have three meetings. We wonder whether a third meeting might improve the robustness of the setting process against errors and divergences in difficulty.

## 4.5 Availability of paperwork

Professor Willerton (External Examiner) notes that he would have found it useful to have some of the paperwork, such as the statistics on questions, available the evening that the external examiners arrive in Cambridge, before they spend a day examining the scripts. The timetable is very tight (and even more so in Part IA because of Physics) and sometimes careful cross-checking between the scripts, the cover sheets and the mark list is still in progress. Nevertheless, if they are ready, we **recommend** that the papers be sent electronically to the external examiners before their day of examining scripts.

## 4.6 Access to administrative staff

Professor Willerton (External Examiner) comments that he would have welcomed the opportunity to meet with the administrative staff. There is certainly no intention to keep them hidden behind

the scenes, but we are uncertain that it would be particularly useful. We suggest that all Chairs offer the opportunity to meet with Amy Dittrich and/or John Sutton, and see whether other external examiners find that useful.

## 5 Part II

### 5.1 Difficulty of questions

The examiners observe that the alpha rate was significantly higher than the Faculty recommendations in a number of courses (exceeding 65% in Algebraic Geometry, Algebraic Topology, Coding & Cryptography, Galois Theory, Number Fields, Riemann Surfaces and Cosmology; reaching 82% in Number Fields). Moreover, we note that the variations between subjects, as revealed by the bar charts of *adjusted* marks, was rather greater than usual, and that, even after adjustment for student effect, 5 of the 6 lowest scoring courses were Applied while the 4 highest scoring courses were Pure.

We **recommend** that this year's examiners make every effort to reduce differences in difficulty between questions on various courses, and that they try to inform the relevant lecturers of last year's issues and the desired direction of travel.

### 5.2 Submission of questions

If the internal examiners are to have time to get the draft questions into reasonable shape before sending them to the external examiners, then it is essential that lecturers provide drafts on time. The internal examiners felt this had worked better this year than in 2014, though Professor Hydon (External Examiner) thought there was still room for improvement. We **recommend** that Faculty Board continue to make robust use of the threat of 'naming and shaming' those who are late.

### 5.3 CATAM credit

Professor Hydon wonders whether CATAM may have more influence at the upper end of the rankings than appropriate. Almost all candidates near the 1st/2.1 border do well in CATAM so that, while the CATAM mark makes a significant contribution to their overall credit (compared with not doing it), the differences in the CATAM marks are very much smaller, and thus we do not consider this to have an inappropriate influence on the rankings.

### 5.4 3rd/Fail boundary

Professor Walters comments that marks here are low and judgement is consequently difficult. While we agree that marks are low, the candidates seem to us well spaced by merit mark allowing distinction between them.

### 5.5 Question checking

Professor Walters wonders whether having a designated checker for each course (not an examiner) would reduce the number of mistakes. We are not persuaded. Firstly, we think it would dilute the sense of responsibility, which should be fairly and squarely on the examiners to get things right. Secondly, it would introduce a further step, and time delay, into the process, and would work against what we believe to be the main priority area for good quality questions: getting draft questions from the lecturers by the deadline at the start of the Lent Term so that examiners have plenty of time to consider them.

## 6 Summary of recommendations

(The exact recommendation is described in the section indicated.)

- 2.1 Meticulous question checking.
- 2.2 Use the 2015 timetable from now on.
- 2.3 A procedure for dealing with candidates who were absent from one or more papers.
- 2.6 Checkers should never have access to the online marks system.
- 2.7 Examiners to indicate where marks have been lost.
- 2.8 Pressure maintained to keep short questions genuinely short.
- 2.9 Draft solutions to be what a good student should write down to obtain full marks.
- 2.10 Transcription not to be used for illegible scripts (except where appropriate in cases of disability or SpLD).
- 2.11 Use of three-letter codes for subjects in mark lists.
- 2.12 Thank Ms Amy Dittrich and Mr John Sutton for their efforts last year.
- 3.1, 3.2, 4.1, 5.1 Examiners to actively consider previous years' statistics and adjustments necessary to achieve a more uniform level of difficulty.
- 3.5 Add a comment on Computer Science with Mathematics to our Schedules.
- 3.6 Referral of suggested Schedule changes to the Curriculum Committee.
- 4.1 Part IB examiners to make use of all available information when aiming to set questions at a uniform level across all courses.
- 4.3 Draft questions on Easter Term courses to be shown to previous and current year's lecturers.
- 4.5 Paperwork to be sent out electronically if available in time.
- 5.1 Faculty Board to be robust with Part II lecturers.

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November 12, 2015