

Teaching Committee report to the Faculty Board

Examinations for Parts IA, IB and II of the Tripos, 2005

1 Introduction

The Committee met three times to consider the 2005 undergraduate Tripos examinations. We looked, for each part of the Tripos, at:

- the Examiners' report;
- the External Examiners' reports;
- the Examiners' reports on their questions;
- the examination statistics;
- the examination papers;
- the analysis of the paper lecture questionnaires;
- the e-mail questionnaires;
- the report from the CATAM assessors (Parts IB and II).

In addition, for Part II, we looked at the final report of the Committee for the Structure of Part II and at a statistical analysis prepared by Dr Altham.

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 examiners marked the large number of scripts very carefully and achieved a high level of consistency and accuracy. The standards achieved by the undergraduates are of the highest. Most scripts I saw were neatly and clearly laid out and I saw many excellent solutions from the better candidates. (Part IA)

Overall, the standard of the candidates was high. The borderlines were appropriately placed, and the large proportion of first and upper second class results was fully justified. The candidates and the Faculty should both be congratulated for this outcome. (Part IB)

The examination produced some very strong performances as well as creating a wide spread of marks across the whole group, as intended. Particularly noteworthy is the relatively high percentage of firsts awarded. I am happy that this is a reflection of the high number of very good students in the course who attain the required absolute standard of performance — something Cambridge should rightly be proud of. (Part IB)

The examination is fair and fairly conducted, and broadly equitable in its outcome. I suspect that quite a few students who get upper seconds at Cambridge would, for a similar performance, get firsts from some other universities. (Part II)

Part II of the Mathematical Tripos is an outstanding programme of study. It provides excellent training for a large number of very talented students. The examination process is rigorous and fair. (Part II)

Part II of the Mathematical Tripos is a programme of excellent breadth and quality attracting very able students. The examination process is thorough, efficiently run and provides good evidence for ranking of the students. (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 Chairs of this year's examiners to pick up rather than the Faculty Board.

2 General Matters

2.1 Errors

This year a total of five errors, some insignificant, were reported, in a total of about 280 questions: no errors in Part IA; one minor error (upper case *R* instead of lower case) in Part IB; four errors in Part II (plus two more that were discovered before the start of the examination).

One of the errors in Part II (Paper 2, Q15D, on Cosmology) was corrected incorrectly and a further correction had to be announced. This was understandably the subject of an appeal.¹ One completely avoidable factor was that the examiner responsible for this question could not be located. The reason that the examiner could not be located was not made clear in the Examiners' report. We hope that the Examiners' otherwise very candid discussion of this matter will highlight to future examiners the absolute necessity of being locatable.

2.2 Examinations sat in colleges and in other places

The difficulties highlighted in examiners' reports last year (and in the report of the Teaching Committee) relating to communicating errors to candidates taking examinations in places other than the main examination rooms arose again this year. In Part IB, there were 14 such candidates. This is an administrative matter, but we believe it needs to be tackled urgently. One possible alternative to faxing corrections individually would be to scan the correction and e-mail it to a list provided for each examination.

We **recommend** that the Board of Examinations be asked to review current arrangements

2.3 Personal circumstances of candidates

Two of the External Examiners (Professor Strickland, Part IB and Professor Perkins, Part II) raise the question of the mechanism for taking into account extenuating circumstances of candidates.

Professor Perkins comments (as he did last year) on the lack of such mechanism for candidates who are classed. However a mechanism does exist, via a formal appeal, although it is not applied by the examiners at their final meeting (as we pointed out in our report last year).

Professor Strickland sets out his concerns in detail, taking up the great majority of his report. He also says that he sent an e-mail to the Chairman of the Examiners asking for further information which, although passed speedily to the Board of Examinations, received no response for three months by which time it was too late for Professor Strickland to take the response into account. We believe that (i) Professor Strickland's detailed concerns should be answered in full and (ii) that he should receive an explanation and apology for the lack of timely response to his earlier request for information. We **recommend** that the Faculty Board expresses this view to the General Board.

2.4 Mark processing programs

This year, a new computer program for mark processing was used in all three parts of the Tripos. The Teaching Committee was very pleased to learn that the new program worked well and was a significant improvement. We **recommend** that the Board write to Mr Harris to thank him for his very considerable efforts (in addition to his usual invaluable support) and to congratulate him on their success.

2.5 New scheme for quality marks

A new scheme for assigning alphas and betas to questions was implemented this year (a single alpha or beta is available for Section II questions, and a single beta is available for Section I questions, throughout the undergraduate Tripos). No regrets were expressed by the examiners at the passing of the old scheme, and there were some very positive comments about the new, for example from Dr Scott (Part IA External) who felt that it had led to the examiners setting some shorter and easier questions. Some suggestions were made for improvements and these are dealt with in the next two sections.

There were, however, a number of adverse comments by Part IB students in the e-mail questionnaire, usually to the effect that they were not sure whether it was worth tackling Section I questions.

¹The Examiners' report refers to informal appeals from Directors of Studies. We noted that if the Chairman of Examiners responds to such appeals, the integrity of any later appeal made through official channels may be jeopardised.

2.6 Betas

Two issues concerning betas were raised.

The first issue is whether betas on Section I questions should be distinguished from betas on Section II questions. The Part IA Examiners expressed the view that a Section I beta indicated a better quality answer than a Section II beta and Dr Sankaran (Part II External) makes the same point. Dr Kerswell (Part IB External) believes that it would be very useful to distinguish between the two sorts of betas, and this view is expressed in the Part IB Examiners' report, though in neither case is it explained how the two sorts of beta compare.

The second issue is the number of marks required for a beta on a Section I question. Dr Scott (Part IA External) advocates that 7, 6 or even 5 marks might be a better starting point for a beta than the current 8 marks. Several students also felt that 8/10 was too severe a requirement for a beta. The Faculty Board discussed exactly this issue last year (in response to a suggestion of Dr Scott), and decided on balance that 8 marks should remain the threshold. The main argument against reducing the threshold is that examiners might then be tempted (subconsciously) to maintain the beta standard by increasing the difficulty of the question. On the other hand, as Dr Scott wrote last year, 'it must be made clear to candidates that they should not ignore these shorter questions in a headlong dash for alphas'. He remains of the opinion that reducing the Section I beta threshold would be helpful in this respect. Another possibility would be to increase the credit for Section I betas for candidates well below the 1st/2.1 boundary as a signal that betas can be significant near the lower boundaries. We **recommend** that the Faculty Board reconsiders this issue.

Clearly, the two issues are linked. For example, reducing the threshold for a Section I beta might make the two sorts of betas more closely equivalent and thereby deal also with the first issue (if it is the view that Section I betas are a better indication of quality than Section II betas). However, it might simply be better if the examiners were provided with information about the type of betas each candidate achieved, so that the information could be used to give better definition at the lower borderlines. It might even be helpful, if the relative merits of the two sorts of betas can be agreed, to encode it in the merit mark formula.

2.7 Assignment of alphas

Dr Scott (Part IA External) suggests that a piecewise linear function with increasing gradient might be used to assign alphas to questions (in place of the current step at 15/20) in order to reduce discontinuity and increase the reward for excellent answers. The Part IA examiners also note that the current scheme has strong discontinuities whereby a difference of a single mark can account for a difference of five (*sic*) in the merit mark.

We noted that over the last four or five years the examiners have tried various ways of allocating extra credit for good answers (one year, four different formulae were trialled, including a quadratic formula which more or less fitted Dr Scott's criteria). This led to a great deal of discussion, and extra work for examiners and computing officers, but the Faculty Board was not persuaded that any of the contenders had more advantages and fewer disadvantages than the existing formula as regards reflecting the intentions of the examiners in this matter.

2.8 Merit marks

As usual, the question of merit marks is debated at some length in the examiners' reports in all three parts of the Tripos, with varying conclusions. The Faculty Board and its committees have recently expended much energy on the question, the result of which has been a hardening of opinion against mechanistic classing by merit mark and hence against the need for a finely honed merit mark (which should possibly be of a different form at each borderline to reflect the different criteria). The position currently agreed by the Faculty Board is stated in the Schedules booklet (2005/06) for the guidance of this year's examiners and candidates as follows:

In addition to a numerical mark, extra credit in the form of a quality mark may be awarded for each question depending on the completeness and quality of each answer. For a Section I question, a beta quality mark is awarded for a mark of 8 or more. For a Section II question, an alpha quality mark is awarded for a mark of 15 or more, and a beta quality mark is awarded for a mark between 10 and 14, inclusive. A

merit mark, call it M , is calculated for each candidate according to the following formula:

$$M = \begin{cases} m + 10\alpha + 3\beta - 24 & \text{if } \alpha \geq 8, \\ m + 7\alpha + 3\beta & \text{if } \alpha \leq 8. \end{cases}$$

It is used only as a convenience by examiners to produce an initial list in an order which, experience shows, corresponds more closely to the final order than that produced on the basis of marks alone. The class borderlines are not determined by merit mark; rather, the merit mark formula is determined by the class borderlines of previous years.

This is more or less the position taken by the Part IB examiners; in particular, Dr Kerswell (External) says ‘The merit mark continues to offer a convenient provisional ordering for the examiners. Slight tinkering with the definition leads to no significant reordering and I support the continuing use of the present formula.’

The Part II Examiners found that the alternative merit mark:

$$M = m + 12\alpha + 3\beta - 48 \quad (\alpha \geq 8) \quad M = m + 6\alpha + 3\beta \quad (\alpha \leq 8)$$

corresponded more closely to their decisions. They argue that this formula is more appropriate for Part II because they expect candidates with aspirations to a first class to tackle mostly Section II questions (Section I questions being restricted to C-courses).

The Part IA Examiners’ report recommends that ‘the Merit Mark scheme be continued for next year’. Dr Scott (External) comments that the split formula serves no useful purpose and recommends removing the ‘dog-leg’ as an unnecessary complication; though of course the intention of the dog-leg is to give more importance to alphas at the highest borderline. We noted that the recommendation of the Part II Examiners is to further bend the leg of their dog.

There have been major changes both to the structure of examinations (Part IB and Part II) and to the scheme for allocating quality marks in the last two years. We felt that it would be advisable to gain a little more experience before making further changes. We therefore **recommend** that no change is made this year to the merit mark formula.

2.9 ‘Short’ questions

The agreed and advertised description for ‘short’ questions is:

Short questions should be accessible to any student who has studied the material conscientiously. They should not contain any significant ‘problem’ element.

There were various comments to the effect that examiners had followed this guideline more closely than in previous years. However, there is no room for complacency. For example, one Part IB Electromagnetism question (Paper 4, q7H) had only 29 attempts, earning only 3 betas. Given that the crux of the second part of the question was to expand $1/|\mathbf{x} - \mathbf{r}|$ for large \mathbf{x} and manipulate the resulting vectors, areas with which few students feel really comfortable, the response was entirely predictable.

The Methods question on the same paper (124 attempts, 6 betas) could hardly be regarded as a success either.

2.10 Consistent classification

Last year, Professor Laws (External Examiner, Part II) noted that, although he was happy with the placing of the borderlines that year, at each meeting much time is spent in deciding what relative weight to place on marks and quality marks at the different borderlines. He wondered whether a different group of examiners would have made the same decisions and asked whether the Faculty Board could provide more guidance on the issue.

We noted that the wording given in the Schedules booklet relating to this point has this year been made more explicit:

Quality marks as well as numerical marks are taken into account by the examiners in deciding the class borderlines. The Faculty Board has recommended that the number of alphas should be of particular importance at the first/second borderline but that at the lower borderlines alphas, and betas, and total mark should each (individually or together) be regarded as indicators of quality. At the third/ordinary and ordinary/fail borderlines, individual considerations are always paramount. Very careful scrutiny is given to candidates near any borderlines and other factors besides marks and quality marks may be taken into account. The Faculty Board recommends approximate percentages of candidates for each class (30% firsts, 40- 45% upper seconds, 20-25% lower seconds, and not more than 6% thirds and below).

We noted also that the Faculty Board has agreed the statement (given above) that the merit mark is used only as a convenience by examiners to produce an initial list

It is clear from the examiners' reports that there are still divergent views amongst examiners on this matter. For example, Dr Scott (Part IA External) states that only one candidate was moved from the class predicted by the merit mark (once the borderlines had been fixed); whereas the Part IB Examiners introduced a condition for a first on the number of alphas and (it is clear from the final class list) the Examiners of both Part IB and Part II moved quite a number of candidates out of merit mark order.

Although the Faculty Board cannot instruct the examiners with regard to the classing of individual candidates, we believe that stated criteria should be adhered to, especially in this increasingly litigious age, and **recommend** that the Board makes clear to examiners its criteria for determining class lists.²

We note that extracts from the Schedules booklet quoted above were the result of decisions taken by the Faculty Board in the course of last year and were intended to apply to *this year's (2005/06)* examinations. The comments above are not intended as criticism of the classing in any part of the Tripos in 2005.

2.11 Information about past borderlines

Last year, we recommended and the Board agreed that, to assist the examiners in drawing the lowest borderlines, the last page of the mark list for the past five years be made available at the final meetings. This did not happen, so we **recommend** it again.

2.12 Rubric and excess questions

After much discussion over many years, the Faculty Board agreed last year that rubrics should, where appropriate, contain an instruction regarding the maximum number of questions in each section that candidates should attempt, and that the Schedules booklet should explain the precise details of the marking convention (namely that all questions submitted are marked and the best answers consistent with the rubric are counted).

The statement in the Schedules booklet is:

On some papers, there are restrictions on the number of questions that should be attempted, indicated by a rubric of the form 'You should attempt at most N questions in Section I'. The Faculty policy is that examiners mark all attempts, even if the number of these exceeds that specified, and assess the candidate on the best attempts consistent with the restriction. This policy is intended to deal with candidates who accidentally violate the rubric: it is clearly not in candidates' best interests to violate the rubric knowingly.

We **recommend** that this year's examiners bear this in mind when constructing the rubrics. As last year, we **recommend** that the same style of rubric be used in each Part of the Tripos; and we commend the Part IB rubric: *You should attempt at most **four** questions from Section I and at most **six** questions from Section II.*

We further **recommend** that the above statement be repeated in the 2006/07 Schedules booklet.

2.13 Deadline for production of camera-ready copy

The deadline for production of camera-ready copy is creeping earlier and earlier: this year, it was 1st April. This deadline was not adhered to by the Part IB examiners, who make the point that it is of great importance to revisit the papers with a relatively fresh eye after the Easter vacation. We **recommend** that the Faculty Board writes to the Board of Examinations to explain this point and request that a realistic deadlines (which can be adhered to) be set.

2.14 Production of class lists

There was a serious error in the Part IB class list posted on the Senate House: the classes of two candidates with the same surname were exchanged.

After investigation, it emerged that it has been the practice of Student Records (who have responsibility for producing this list and the list in the Reporter) to re-typeset the list provided by the examiners. This year, the process was complicated by the necessity to remove the name of a candidate who did not wish to appear on the list posted on the Senate House; and this apparently led to the error.

²Grace 4 of 24 July 2002 (Reporter, 2001-2, p. 1277) entitles Faculty Boards to issue to Examiners details of the conventions and criteria to be applied in determining class-lists. Stats and Ords 2003, page 216.

The Part IB Examiners invite the Faculty Board to express its view of this episode to the appropriate University body. Since the error must of resulted in considerable distress to the candidates, we **recommend** that this invitation be accepted.

The Teaching Committee is concerned that a similar error should not occur in future. We understand that the results for Part IA of the Natural Science Tripos are not re-typeset by Student Records, but are printed out from an electronic version supplied by the examiners; we **recommend** that steps be taken to implement a similar scheme for the class lists of the Mathematical Tripos, the technology for which is by now well understood.

Dr Kerswell is firmly of the opinion that candidates should not have the opportunity to disrupt the process by opting out of the published class list and suggests that the issue should be dealt with (if at all) by using only candidate numbers as is done at his institution. This is probably not a decision for the Faculty Board, but we hope the suggestion will be considered by the appropriate body. We noted, however, that the ceremonial reading of the Part II results in the Senate House would become not only decidedly bizarre but also even more of a challenge with regard to accurate presentation than it apparently was this year.

2.15 Instructions to checkers

The duties of checkers were mentioned a number of times in the various Examiners' reports. We **recommend** that this year's Chairs of examiners collectively consider whether the guidelines for checkers need amending.

2.16 Warning letters

Two matters were raised regarding the letters relating to special circumstances of individual candidates that are sent to Chairs of examiners.

There seems to have been some inconsistency in dealing with dyslexic/dyspraxic/dysgraphic candidates. Candidates with these disabilities were not flagged to the Part IA examiners prior to marking 'as accuracy is an inherent part of mathematics'. We understand that in other parts of Tripos, such candidates were flagged to examiners before marking so that due allowance could be made. We believe that guidelines on this matter are issued by the Board of Examinations; we **recommend** that examiners follow the guidelines if they are prescriptive or, if not, agree a policy common to all parts of the Tripos.

The Part IA examiners ask that the Board of Examinations provide warning letters based on the candidate number as well as the candidate's name. This seemed sensible to us and we **recommend** that the Faculty Board makes this suggestion to the Board of Examinations.

2.17 CATAM

This year, at the request of the Faculty Board, the recipients of the e-mail questionnaires were asked specifically for views on CATAM. These, with the exception of the question of allocation of quality marks which is discussed below, will be considered at a later meeting of the Teaching Committee.

2.18 Faculty Secretary

All the Examiners' reports remarked on the excellent support given by Ms Katheryn Ayres. We were dismayed to hear that Ms Ayres is leaving shortly, and we wish her every success in her new post.

3 Part IA

3.1 E-mail to students

This year, Teaching Committee again provided the text of an e-mail to explain the rubric which was sent to all Part IA students by the Faculty Office. This year's Examiners request that students should be e-mailed again next year, with an addition to the e-mail to discourage students from binding together all the individual examiner bundles. The Teaching Committee **recommend** that this should be done and that a prompt for doing so be added (if necessary) to the Faculty Secretary's diary.

3.2 Credit for Papers 5 and 6

We were confused by the statement in the Examiners' report that 'only the $m + 7\alpha + 3\beta$ contribution was used in establishing an effective merit mark for Paper 5 and 6 candidates'. However, after consulting the Chairman of Examiners, we were reassured that this referred only to the allocation of alpha counts on papers 5 and 6, and that the usual dogleg formula was then applied to all candidates for the overall merit mark.

4 Part IB

4.1 Complex Methods/ Complex Analysis

Although the Examiners make no comment about the novel arrangement for examining these two courses (three Section I and three Section II questions, with two of the Section II questions and one of the Section I questions shared) a number of the students responding to the e-mail questionnaire found this unsatisfactory: it was said, for example, that the shared questions were really Complex Methods questions.

The rationale for shared questions is clear: without this arrangement, or something similar, candidates could obtain sufficient marks from these two closely related courses alone to obtain second class.

The problem, if there is indeed a problem, could be solved by setting the shared questions in either/or form, the alternatives being questions from the two courses, and we **recommend** that next year's examiners consider this possibility.

4.2 Level of difficulty of questions: Markov Chains

Take-up levels and success rates on individual questions on the various courses varied, but the success rates on three of the four Markov Chains were very low. We considered whether the questions were a bit too sophisticated, given that the course is now only 12 lectures; but inspection of the questions suggests that this is not the case. Nevertheless, we **recommend** that the IB examiners for 2005/06 be alerted to the poor response to this year's questions.

5 Part II

Overall, the examination for this first year of the new-style Tripos seems to have gone very well. There were no significant criticisms from examiners or students of the structure of the examinations; indeed, there was general approval.

5.1 Ambiguity in the Schedules booklet: distribution of Section I questions

We noted that the ambiguity referred to in the Examiners' report (regarding the distribution of the four Section I questions on each course amongst the four papers) has been settled in the current Schedules booklet.

5.2 Advice to candidates

Professor Perkins (applied External) regretted the lack of concrete advice given to candidates about the requirements for each class. This was a consequence of the newness of the arrangements. This year's students have been given last year's borderlines as a guideline (as has been the practice in all parts of the Tripos in recent years).

5.3 Difficulty/length of questions

The Examiners (para 2 and 3 of their report) worried about the length of Section II questions. Having examined the statistics for the examination, we believe that, overall, they got it about right this year and that, since this year's questions will inform examiners in future years, no further guidelines from the Faculty Board are required.

However, Professor MacPhee (applicable External) believes that while the pure questions seemed generally of consistent and appropriate level, and the applied questions were on average of appropriate level (but with too much variation), the applicable questions were too difficult and the same point is made by Professor Perkins (applied External).

Professor Sankaran (pure External) makes this point as well and recommends that some form of statistical analysis be available. He does not advise that this analysis should be used to modify marks gained by individual candidates.

At the suggestion of the Faculty Board (on the recommendation of the Committee for the Structure of Part II), Dr Altham was asked to provide a statistical analysis designed to compare the difficulty of the questions on each course after factoring out the ‘student effect’. This analysis shows clearly that the concerns of the External Examiners set out above have substance.

We noted, however, that this sort of statistical analysis is not sufficiently robust to give more than a strong indication of the level of difficulty. For example, a C course has only two Section II questions, and one question set on an unpopular part of the course (material from the last four lectures, say) could result in the statistics giving a false picture.

We **recommend** that the results of Dr Altham’s analysis of the 2005 examination (with suitable explanation) be made available to all current Part II lecturers and to the Part II examiners for 2006, and that lecturers in particular be exhorted to take into account this analysis when proposing questions.

5.4 Breadth of course

Professor MacPhee (applicable External) comments that some second and third class candidates attempted questions on a disappointingly small range of subjects. This point has been considered by the Faculty Board a number of times. Its current policy is stated in the Schedules booklet, namely that *no requirement is placed on candidates to produce answers on a range of mathematical material beyond that imposed by the distribution of questions on papers*. Implementing a different policy, should the Faculty Board now decide that this was educationally desirable, would require either a fundamental change in the structure of the examination or fairly precise definitions of acceptable range. This matter was discussed by the Faculty Board last year and also by the Committee (for the Structure of Part II) that proposed the new arrangements for Part II. We are not keen to see the matter reopened at this early stage.

5.5 CATAM merit marks

In Part IB, candidates may attempt four projects, each of which is marked out of 20 with one quality mark available. In Part II, projects of different lengths are available, measured in terms of ‘units’, and the candidates may obtain credit for up to 30 units. This means that assigning quality marks, which is straightforward in Part IB, requires a non-trivial algorithm.

The current algorithm is clearly a product of carefully thought, but the result is somewhat arcane (some might describe it as labyrinthine or even Byzantine); and it turns out to have a rounding anomaly. This point is discussed by Professor Sankaran (pure External).

We wondered whether a simpler algorithm might be helpful; for example, one in which betas or alphas are assigned for each project according to the usual thresholds (half marks, three-quarter marks), scaled according to the length of the project and added. We **recommend** that the CATAM Management Committee be asked to consider this.

Alice Thompson	Tom Sutherland	Tom Körner	
Thanasis Fokas	Imre Leader	Douglas Kennedy	John Lister
Ruth Williams	Gabriel Paternain (on leave)	Stephen Siklos (Chairman)	

September 27, 2006