

# Teaching Committee report to the Faculty Board

## Examinations for Parts IA, IB and II of the Tripos, 2006

### 1 Introduction

The Committee met three times, for two hours, to consider the 2006 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).

In addition, for Part II, we looked at a paper by the chair of examiners entitled 'A commentary on the Merit Mark for Part II, 2006'.

We noted with pleasure that 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:

*My overall impression is that the procedure, which has evolved over a number of years, is very fair, the scripts are generally marked extremely carefully, and the vast majority of candidates achieve an excellent standard of mathematics.* (Part IA)

*My impression without exception was of many high quality students producing good work on demanding courses. I was interested to note that, as at UCL, there is a tail of weaker students and that these are catered for and treated well.* (Part IB)

*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.* (Part IB)

*The Mathematical Tripos remains one of the best, by which I mean most difficult, undergraduate mathematics courses anywhere. It is not without defects but it does not need major structural reform, either in the teaching or in the conduct of the examination. The examination is fairly conducted at an appropriate level.* (Part II)

*The Mathematical Tripos is an outstanding course of study for those interested in, and talented at, mathematics. The examination procedure is tough, but fair. The examination is fair, appropriate and comparable to other quality degree programs.* (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 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. This year, we were pleased that the annual meeting of the directors of studies has requested a copy of this report in time to be able to contribute to the Faculty Board discussion.

## 2 General Matters

### 2.1 Errors

This year six errors were reported, in a total of about 280 questions: no errors in Part IA; three minor errors in Part IB; three very minor errors in Part II (two so minor that they were not detected at all until after the examination).

The examiners reported that the errors caused no detectable problems for candidates, and no appeals were received.

### 2.2 Betas

This year, as last, examiners in all parts of the Tripos expressed the view that it was helpful to be able to discriminate between the two types of beta: those awarded for marks of 8 or more on section I questions; and those awarded for a marks of between 10 and 14 (inclusive) on section II questions. It seems to be generally agreed by examiners in the last two years that ‘short betas’ in particular represent an achievement that should be recognised at the lower borderlines. This being the case, we **recommend** that short and long betas be distinguished in the data given to examiners (as happened this year), in the breakdown given to students and in the summary given to directors of studies. (The information is anyway available both to students and to examiners, but difficult to extract since the breakdowns are by individual question).

### 2.3 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 would surely have to 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 (2006/07) 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.*

Last year’s Part II examiners advocated an alternative merit mark:

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

but this was apparently not found useful this year: Dr Sankaran (Part II external examiner) states that ‘the alternative merit mark was no use to us and should be scrapped’.

The Chairman of Part II (Dr Carne) produced, subsequent to the examination, a very thorough paper on the subject which is appended to this report. We studied this with interest. His analysis of this year’s examination data shows that various plausible alternative merit marks are very highly correlated. He concludes (and this came as no surprise) that no single merit mark can adequately rank all candidates. However, he then considers the possibility of two-dimensional merit marks, with data plotted on two axes one of which might be raw mark and one the number of alphas. This leads to much extra information and we **recommend** that Dr Carne’s paper be made available to this year’s examiners in all parts of the Tripos, subject to his permission.

We were strongly of the view that the merit mark should be used only to provide a preliminary ordering, with individual candidates being classified according to the stated criteria. If this is felt not to be adequate,

then the criteria should be honed. We were not persuaded that more elaborate and complicated methods of representing the data would help this process greatly.

We noted that the second of the two paragraphs from the schedules booklet quoted above could be a little misleading. We **recommend** the following wording: ‘It is used only as a convenience by examiners to produce an initial ordering of candidates; examiners make substantial numbers of promotions and demotions (relative to the merit mark) on the basis of the classification criteria.’

We **recommend** that the Faculty Board reaffirms its position as stated in the schedules booklet (with the modified wording proposed above) and that it emphasises this position to examiners by stating it in the chair of the Faculty Board’s letter to chairs of examiners.

## 2.4 ‘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.*

We found no real evidence to suggest that this guideline was being ignored, though a few short questions were clearly not very successful. It would be helpful if all examiners referred explicitly to the response to short questions in their post-examination comments on the questions; many do.<sup>1</sup>

However, the external examiners made a number of comments about the short questions. Dr Sankaran (Part II) inclines to the view that there should be more short questions and a cap on the number that can be attempted. The number of short questions is chosen so that the total credit on a 24-lecture course (either C or D) is 80 marks, and we believe that it is important to maintain this comparability.

Professor Gregory notes that some candidates (two, in fact) obtained vast numbers of marks by doing large numbers of short questions and parts only of long questions. We disagree with her view that it is impossible to alter the placement of these candidates using the current classification criteria; they clearly state that candidates must produce substantially correct answers to a significant number of more challenging questions. The examiners presumably decided that the failure to meet this criterion could be offset, in exceptional cases, by other factors. We were not persuaded that Professor Gregory’s remedy of capping the number of short questions that may be attempted, or altering the merit mark formula, is required.

The Teaching Committee agreed to keep the matter under review.

## 2.5 Security

The question of security of questions during the setting process arose this year (though there was no suggestion that security was breached; only that security could have been breached). We note that the Faculty Board has already taken steps to deal with this matter.

## 2.6 Plagiarism

There were a number of cases of plagiarism of CATAM projects in both Part IB and in Part II. We discussed this at some length. We agreed that the explanation in the CATAM booklet, though comprehensive, is not as clear as it might be and that it is not very explicit about the possible penalties of unacceptable collaboration. We also noted that a copy of the statement that the students must sign with their submittal is not included in the CATAM booklet and indeed doesn’t quite match what is said in there. We therefore **recommend** that the Dr Nikiforakis be asked to rewrite this section of the CATAM booklet, with immediate effect for the on-line version, taking into account the comments of the examiners.

We also believe that an e-mail to all candidates from the Chairman of the Faculty Board might be helpful. The e-mail should be two-pronged: it would be explain the guidelines for collaboration (and perhaps include a copy of the statement that they will have to sign) and also mention that several pairs of students have previously faced the prospect of disciplinary proceedings in the University Court of Discipline as well as losing all the marks for the project in question. Accordingly, we **recommend** that such an e-mail be sent to all Part IB and Part II students in the Michaelmas term of each year, and that this be triggered by an entry in the Faculty Secretary’s diary.

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<sup>1</sup>It would also be helpful if every Examiner engaged fully in this part of the examining process, since these comments are used by the following year’s examiners: an extreme case of lack of engagement arose this year when one Part IB Examiner simply wrote that he had no comments.

## 2.7 Classification criteria

Several of the external examiners this year and in the past have commented that examiners do not seem very sure of what the classification criteria should be.

The classification criteria, agreed by the Faculty Board and published in the Schedules booklet, are as follows:

### *The First Class*

*Candidates placed in the first class will have demonstrated a good command and secure understanding of examinable material. They will have presented standard arguments accurately, showed skill in applying their knowledge, and generally will have produced substantially correct solutions to a significant number of more challenging questions.*

### *The Upper Second Class*

*Candidates placed in the upper second class will have demonstrated good knowledge and understanding of examinable material. They will have presented standard arguments accurately and will have shown some ability to apply their knowledge to solve problems. A fair number of their answers to both straightforward and more challenging questions will have been substantially correct.*

### *The Lower Second Class*

*Candidates placed in the lower second class will have demonstrated knowledge but sometimes imperfect understanding of examinable material. They will have been aware of relevant mathematical issues, but their presentation of standard arguments will sometimes have been fragmentary or imperfect. They will have produced substantially correct solutions to some straightforward questions, but will have had limited success at tackling more challenging problems.*

### *The Third Class*

*Candidates placed in the third class will have demonstrated some knowledge but little understanding of the examinable material. They will have made reasonable attempts at a small number of questions, but will have lacked the skills to complete many of them.*

### *Ordinary*

*Candidates granted an allowance towards an Ordinary Degree will have demonstrated knowledge of a small amount of examinable material by making reasonable attempts at some straightforward questions.*

We have four recommendations that should help.

1) We note that the criteria are couched in rather coy language. The code, which is probably well understood by both students and internal examiners, is:

‘straightforward questions’ = section I questions

‘more challenging questions’ = section II questions

‘produced substantially correct solutions’ = obtained alphas or short betas

‘reasonable attempts’ = betas

This circumlocution dates back to the time when alphas were awarded for substantially correct solutions whereas, now that our procedures are considerably simplified and uniform, alphas are for 15 or more marks. We decided that there is a good case for being more explicit about with regard to section I/II, but that that a sentence might be added to the criteria explaining that substantially correct solutions are normally interpreted to be  $\alpha$ -questions in section II and  $\beta$ -questions in section I, and that reasonable attempts are normally interpreted to be  $\beta$ -questions in section II.

We **recommend** that the Faculty reconsiders its presentation of the classification criteria.

2) The second recommendation relates to the additional guidance issued by the Faculty Board:

*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 **recommend** this be included in the letter from the Chair of the Faculty Board to chairs of examiners.<sup>2</sup>

<sup>2</sup>Grace 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 2006, page 217.

3) Dr Sankaran (Part II external examiner) comments that it is still necessary to give clearer guidance, to both students and examiners, on the quality necessary to pass. We wondered if guidance along the lines of: ‘In the last N years, no-one who achieved a mark greater than X was placed below the third class’ would be helpful. We **recommend** that the Faculty Board considers whether a more quantitative classification criterion should be added at this borderline.

4) We note that the letter sent by the Chair of the Faculty Board makes no mention of the existence of classification criteria. We therefore **recommend** that a reference be made to the relevant page of the schedules booklet.

Finally, we note that if a consistent distinction is to be made between long and short betas, then this must be made clear to students and examiners by means of the classification criteria.

## 2.8 Numbers in the third class

Professor Strickland (IB external examiner) remarks that a very few candidates at the bottom were allowed to progress to Part II, who at other universities would have been held back. He later e-mailed the Chairman of Part IB to emphasise that he did not regard his statement as strong or surprising or significant. Nevertheless, we looked at the fate in Part II of those who obtained thirds in Part IB in the previous year. Not surprisingly, they obtained a variety of results ranging from upper seconds in the Mathematical and other Triposes to failing. We could see no pattern that would help to eliminate (by failing more or giving more thirds in Part IB) those who failed or did badly in Part II. Nevertheless, it is possible that increasing the size of the third class in Parts IA and IB might lead to an increase in standards in the tail in Part II, and we **recommend** that the Faculty Board considers this.

We also discussed the Faculty Board’s guideline that no more than 6% should be placed in the third class or lower and that approximately 30% should be placed in the first class. We recalled that about 10% of our students change Tripos after Part IA and after Part IB, the numbers declining from about 250 to about 200, and that most of those changing come from the lower end of the class list. We **recommend** that the Faculty Board consider whether these percentage guidelines should be finessed to take account of this shift in demography.

## 2.9 Rubric and excess questions

After much discussion over many years, the Faculty Board agreed 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 note that the rubric was this year more or less uniform, being of the form: *Candidates may 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 2007/08 Schedules booklet, replacing ‘should’ with ‘may’ (‘You may attempt at most ...’), and that the letter from the Chair of the Faculty Board to the chairs of examiners alludes to this statement.

The Part IA examiners report that there were again a significant number of (rubric-violating) attempts. It is difficult to judge whether this was in the best interests of individual candidates. However, we **recommend** that the e-mail (below) sent to all first year students contains stiffened advice on this issue, such as ‘Past examiners have been of the opinion that some candidates have put themselves at a disadvantage by tackling excess questions.’

## 2.10 Range of material presented for examination

The schedules booklet contains the following statement (page 2): *the Faculty Board recommends 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 the papers.* This is consistent with the lack of any such requirement in the Aims and Objectives agreed by the Faculty Board. Last year, it was noted that there was an inconsistency between this statement and the classification criteria, and the classification criteria were redrafted accordingly. The Part IB examiners noted this change and wished to reinstate the criterion to the effect that in order to achieve an upper second class, the candidate must show ability across a range of courses.

The Part II examiners state that they were reluctant to award an Honours result to anyone who had only demonstrated skills on a single course.<sup>3</sup>

We **recommend** that the Faculty Board consider whether it wishes to change its policy for 2007/08, and that the policy (new or old) be alluded to in the letter from the Chair of the Faculty Board to the chairs of examiners. We note that any different policy would be quite hard but not impossible to quantify, and that this matter was discussed by the Faculty Board last year.

## 2.11 Sorting of CATAM scripts

External examiners in both Part IB and Part II commented on the inconvenience of the way that CATAM scripts were sorted. We **recommend** that in future these be sorted by candidate number, rather than by topic, (or, if this is not possible, an index be provided).

## 2.12 Availability of CATAM projects

Dr Sankaran (Part II external examiner) wonders why the external examiners were not consulted about the setting of the Computational Projects. We understand that this is not practical, because the projects have to be set long before the external examiners are appointed to be available for students to tackle in the long vacation. However, we **recommend** that the projects booklet be sent to the external examiners, if this does not already happen.

## 2.13 Compulsory CATAM

Professor Gregory is perplexed as to why CATAM is not compulsory. This is a matter that has been discussed many times by the Faculty. In practice, ‘compulsory’ must mean that some threshold mark must be achieved to pass (25%, say) and that if this is not achieved, since there is no provision for re-takes, the candidate fails the examination. There is little or no dissent to the view that this would be undesirable for CATAM to be given this very special status.

## 2.14 Input from lecturers

We believe that in some (probably very few) cases examiners are not paying sufficient attention to the comments of lecturers (see for example the subsections below: Part IA Dynamics and Part IB Quantum Mechanics). We **recommend** that it is clearly stated on the first form that lecturers’ receive that in the event of a potential disagreement with the responsible examiner, the lecturer can discuss the problem confidentially with the chairman of examiners (whose e-mail should be given on the form).

## 2.15 Presentation skills

Professor Gregory (Part II external examiner) regrets the absence of any credit in the Tripos for presentational (or other similar) skills. We recalled that there was a proposal to allow students the option of presenting one of their CATAM projects orally. We **recommend** that the Faculty Board considers whether there should be provision in the Tripos for additional transferable skills of this sort.

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<sup>3</sup>We noted that had the examiners actually put this reluctance into practice, there would almost certainly be grounds for a legal challenge: had such a candidate known that he or she was to be penalised in this way, he or she might have (and would certainly have claimed that he or she would have) adopted a different strategy.

## 3 Matters for the Board of Examinations

### 3.1 Examinations sat in colleges and in other places

As usual, a number of candidates sat their examinations in their colleges or in the central facility now provided for straightforward extra time candidates. No problems were reported. However, it was noted that the FAX machine in Mill Lane is exceedingly antiquated and there would be problems if a significant amount of faxing had to be done. We **recommend** that the Faculty Board draw this to the attention of the Board of Examinations.

### 3.2 Mill Lane: overcrowding

The Part IA examiners were concerned about overcrowding in rooms 6 and 7. We **recommend** that the Board of Examinations be made aware of this concern.

### 3.3 Invigilation: starting the examination

It was noted by the Part IA examiners and also by several students responding to the on-line that some invigilators allow candidates to start immediately and others gave 5 minutes reading time. We **recommend** that the Faculty Board bring this to the attention of the Board of Examinations.

### 3.4 Faculty Secretary and Computer Officer

All the examiners' reports remarked on the excellent support given by Ms Louise Hall. We **recommend**, especially as this was her first year, that the Chair of the Faculty Board expresses the appreciation of the Board for her work.

As always, the examiners in all Parts of the Tripos found the expertise of Mr David Harris was invaluable; we noted that this was the last examination season before his retirement.

## 4 Part IA

### 4.1 Mathematics with Computer Science option

We noted the Part IA examiners' view that the arrangements for examining this option did not create significant complications.

### 4.2 Dynamics

The statistics on the examinations and the response to the on-line questionnaire reveal that there are problems with this course that are not related to the lecturer (in fact, may be disguised by the quality of Dr Hunt's lectures). First, there seems to have been a mismatch between the questions set in the examination and those discussed in the lectures and on the examples sheets, which was responsible for a very low take-up (not much more than half the take up of the other applied courses). We strongly **recommend** that this year's examiners work closely with the lecturer to ensure that more suitable questions are set this year.

We also **recommend** that the Head of DAMTP be asked to set up a working party to consider how this course might be changed to provide a better introduction to university level mathematical physics. We note that this might have ramifications for other courses in Part IA.

## 5 Part IB

### 5.1 Complex Methods/ Complex Analysis

Although the examiners explicitly state that the 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) worked satisfactorily this year, a number of the students responding to the on-line questionnaire complained, this year as last, that the shared questions were biased towards Complex Methods.

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.

We note that the problem, if there is indeed a problem, will be exacerbated this year now that the schedules for these two courses have further diverged (with the removal of Fourier transforms from Complex Analysis) and could be solved by setting the shared questions in either/or form, the alternatives being questions from the two courses, and we **recommend** that this year's (2006/07) examiners consider this possibility.

## 5.2 Quantum Mechanics

The response to the questions on this mainstream course was dismal: the average mark on the long questions was 6.6 out of 20. We looked at the questions and saw that they were very non-standard and off-centre for the course. We believe that this might have been avoided if more attention had been paid to lecturers' criticisms.

# 6 Part II

## 6.1 Courses in need of attention

Dr Sankaran comments that Mathematical Biology and perhaps Cryptography appear to need attention. We investigated the examination data for Coding and Cryptography, from which it can be seen that the questions were popular but the average marks per question were somewhat low. The on-line and paper questionnaire response is very good, so we believe that, rather than the course requiring attention, the examination questions must have been a little on the tough side. We noted that (if our recommendation above is followed) the examiners this year will be able to take appropriate action. We note that both Mathematical Biology, and Geometry and Groups, are receiving and have received attention (including new lecturers).

Professor Gregory believes that the Cosmology questions failed to discriminate sufficiently between candidates; this is an area in which Professor Gregory is an expert and she says that she will be extra vigilant next year.

## 6.2 Difficulty/length of questions

Last year, the examiners expressed concern about the difficulty of examination questions in one particular subject area. A statistical analysis was undertaken by Dr Altham which distinguished candidate effect from question effect and showed that there were indeed grounds for concern.

This year, the examiners conducted a similar analysis and found that the variations between courses were much less significant.

We **recommend** that this analysis (or a summary) be sent to all Part II lecturers.

## 6.3 CATAM marking

Dr Sankaran expressed the view that the basis on which the computational projects is marked is still unsatisfactory. It is difficult to understand how the effect to which he refers could arise, given the pro-rata nature of the marking scheme. Professor Gregory also mentions the same point, but concludes that it was not unreasonably out of line. Nevertheless, we **recommend** that the CATAM Management Committee be asked to consider Dr Sankaran's remarks.

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

December 8, 2006