

Teaching Committee report to the Faculty Board

Examinations for Parts IA, IB and II of the Tripos, 2009

1 Introduction

The Committee met three times, for two hours each time, to consider the 2009 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 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 level of attainment of students taking the Mathematical Tripos is enviably high, and Cambridge maintains its leading position in the teaching of mathematics in this country. (Part IA)

The examination is of a suitable standard for Part IB... I am satisfied that around 30% of the students are awarded first class honours. (Part IB)

Again this year, at the upper end of the scale, standards are very high and, at the lower end, a small number of students perform poorly. So while the best of Cambridge maths graduates are really excellent, the minimum standard required to get a 2ii or 3 degree is probably no higher than at many other UK institutions. (Part IB)

The Part II course covers a wide range of topics to a high level. The overall quality of the work produced by many of the top students is at a very high level, and that of many others is also of a very good standard. (Part II)

The best candidates produce outstanding performances covering a very wide range of subjects. This year nearly all candidates, even the weakest, produced some good work, even if there was not very much of it. (Part II)

Part II of the Mathematical Tripos is an excellent course at a high level, offering candidates a wide choice in a variety of mathematical subjects. The assessment is based on a challenging examination which provides ample possibilities for the candidates to show their abilities. (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 from the previous year's Examiners' reports. 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 the following errors were reported, out of a total of about 280 questions: one typographical error in Part IA, which was not noticed by candidates; six typographical errors or clarifications ‘of a minor nature’ in Part IB; seven in Part II (no comment in the Examiners’ report about their seriousness). The Examiners reported that the errors caused no detectable problems for candidates.

However, despite assurances by the Part IB examiners that the examination ran smoothly, the response from the students via the on-line questionnaire was not so sanguine: there the number and nature of the errors attracted considerable flak, not least because four occurred on one paper. It was pointed out that the Examiners could not even get the names of the courses right (some questions were labelled ‘Mathematical Methods’ even though there is no course of this name). Part of the students’ ire was occasioned by questions that were said to be unacceptably long and difficult (see later in this report).

We were partly working in the dark here, since the Examiners’ reports for Parts IA and Part II did not specify the corrections required.

We **recommend**, as last year and the year before (but more strongly), that the letter from the Chair of the Faculty Board to Chairs of Examiners asks the Examiners to report on any errors occurring in their papers or in the CATAM projects. We further **recommend** that the corrections be listed in the Examiners’ report.

We believe that reading aloud the examination papers at the meeting at which the papers are finalised can be very beneficial in trapping errors and we **recommend** that this be reiterated to Chairs of Examiners.

2.2 Cover sheets

This year individual examiner cover sheets were pre-printed with question numbers, so that the candidates needed only to circle the questions attempted. Further, machine-readable cover sheets were used. These initiatives were welcomed by all the examiners and so should, if feasible, be continued.

2.3 Mark checking

The difficulty in recruiting mark checkers was raised again this year, this time by the CATAM Director. The problem is that the work is largely clerical, for which there is a University agreed rate; but we use highly qualified graduate students to do the work who are more used to supervision rates.

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.

A number of the External Examiners commented that the system of long and short questions seems to be working well, but some expressed some concern. In previous years, we were able to report that we found no evidence to suggest that this guideline was being ignored, or that the short questions were failing to fulfil their function.

However, we are concerned this year. We noted that the take-up of short questions has declined very significantly as shown in the following tables. (The percentage take-up rate is the number of attempts as a percentage of the theoretical maximum number of attempts; in Part IA, there are four short questions per paper, and there were 247 candidate, so the maximum in 2009 is approximately 247×16 .)

	year	take-up rate (%)	average mark	average beta
Part IA	2009	2047 (51.8%)	6.1	0.38
	2008	2445 (65.0%)	6.5	0.44
	2007	2916 (74.4%)	7.1	0.56
	2006	2677 (71.2%)	6.5	0.44
	2005	2623 (71.0%)	7.2	0.56

	year	take-up rate (%)	average mark	average beta
Part IB	2009	1592 (21.8%)	6.7	0.43
	2008	2378 (29.2%)	6.6	0.44
	2007	2232 (29.7%)	6.9	0.55
	2006	2369 (31.3%)	7.0	0.54
	2005	2408 (30.0%)	6.6	0.45
	year	take-up rate (%)	average mark	average beta
Part II	2009	1105 (12.2%)	6.5	0.43
	2008	1156 (14.0%)	6.3	0.46
	2007	1353 (15.5%)	6.7	0.49
	2006	1425 (16.3%)	7.0	0.54
	2005	1334 (15.8%)	6.9	0.54

As can be seen, the take-up rates of the short questions decrease in Part IA from nearly three-quarters to just over a half in five years, and in Part IB there is a huge fall in take-up from last year.

We did not have sufficient data to determine the cause. Is it because the stronger students no longer think it worthwhile to tackle short questions? If so, what could have triggered this change? There has been a significant decrease since last year, so the new merit mark formula could have played a role. But there was also a significant decrease between 2007 and 2008. The Part II Examiners reported that a large number of ‘failing candidates’ attempted mainly long questions, with dismal results.

We looked through the short questions, and were of the opinion that there had in fact been a drift towards longer and more sophisticated questions. It couldn’t be said that we made a systematic study. However, the average number of betas per attempt in Part IA has declined from 0.56 to 0.38; and in Parts IB and II is 0.43. We believe that this indicates that the short questions are too difficult. We **recommend** that the chairs of Examiners for 2010 be asked to consider the above data and ensure that short questions are accessible to any student who has studied the material conscientiously and do not contain any significant ‘problem’ element.

2.5 Classification criteria

The new classification criteria came into force in 2009. There was general approval for the scheme. The Part II Examiners initially classified the candidates according to the old scheme (unwittingly, by virtue of the new scheme not having been implemented in the computer programme), promoting and demoting numerous candidates at the borderlines. When they reclassified using the new scheme, almost all of those promotions and demotions were no longer required, which is as good a quality control of the new scheme as one could wish for.

The Part IB Examiners suggest that the explicit formula for merit marks should not be published; they also propose that the formula be overhauled (particularly with reference to the jump of 25 merit marks when passing from 14 to 15). On the other hand, Professor Moss (External Examiner in Part II) recommends keeping the current formula and whole-heartedly concurs with the decision to make the decision known to students. Professor MörTERS (External Examiner in Part II) does not see the need to correct the formula for the merit mark for the next few years. The Part IA Examiners found that the new merit mark formula proved to be exceedingly successful as the primary classification criteria.

The Teaching Committee has discussed merit mark formulae almost every year for the last 10 years. We think that the subject has been aired thoroughly and, as a result, robust and fair classification criteria have emerged.

2.6 Differences in difficulty between courses

This issue arose in Part IB last year and previously in Part II. It is of course the responsibility of the examiners to provide questions of (as close as possible) equal difficulty. The Faculty Board asked the Teaching Committee to consider a paper by Professor Rogers proposing that the Examiners be provided with a statistical measure, based on the response to the current year’s questions, with a view to making adjustments to the ranking of candidates prior to classification. The Teaching Committee reported to the Faculty Board that it was unanimously opposed to this proposal and the Faculty Board concurred.

Professor Joyce (External Examiner for Part IB) suggests that the statistical information should be made available to Examiners, which they would be free to ‘ignore completely if they wish’. We still prefer the current more transparent process whereby the credit obtainable for each question is predetermined and advertised.

Professor Joyce notes that the difference in difficulty between the courses was much less marked this year.

2.7 Design and structure of the examination and course

Professor Joyce (External Examiner for Part IB) presents a detailed discussion from (as he says) the perspective of an outsider. He believes that if we redesigned the course from scratch, we would come up with a very different design. We had a long and useful discussion about this, but we ended up disagreeing with many of Professor Joyce’s premises and therefore with many of his conclusions.

1. We agreed with Professor Joyce that the structure of the examinations is *fairly* complex, having long and short questions with candidates able to attempt (broadly speaking) questions on as many or as few courses as they like. We did not agree that the algorithm for determining classes was either complex or arcane (= ‘requiring secret or mysterious knowledge’).
2. We agreed that a disadvantage of our system is that it does not deliver to the outside world a course-by-course assessment. Professor Joyce takes this to be a disadvantage to all of our students who do not go on to do a PhD in Cambridge (and he says that he himself has less incentive to take even good students from Cambridge for this reason); we disagreed.

We do not believe that the job prospects of our students are diminished by lack of information about their examination performance. Our comprehensive supervision reporting system allows us to provide detailed references. It is anyway not correct to say, as Professor Joyce does, that the only information publicly available from the examination is the bare class: we also provide a transcript with an overall mark out of 100.

In case there was evidence that, despite our personal impressions, our students are not doing well in the job and PhD market, we checked the last three years’ destination data. The response rates in the three years were 47%, 60%, 76%, respectively.¹

	2005-6	2006-7	2007-8
Employment	34 (35.1%)	38 (30.2%)	46 (46.9%)
Further study	56 (57.7%)	85 (67.5%)	37 (37.8%)
Still seeking employment or work	5 (5.2%)	1 (0.8%)	8 (8.2%)
Travelling or unavailable for work	2 (2.1%)	2 (1.6%)	7 (7.1%)

3. We did not agree that the examination is in the foreground rather than the background of our system; quite the reverse, in fact. Our system is designed to allow students great flexibility in the number and choice of courses they study over the year which, we believe, provides a good mathematical education. In practice nearly all students study more courses than they prepare for the examination.
4. We did not agree that having the examination questions set and marked by the lecturers would offer significant advantages; again, quite the reverse (and Professor Steiner, External Examiner for Part II points out the advantages of our system).
5. We did not agree that our system is designed for the strongest students; indeed, Professor Joyce says that a ‘small number of students performed poorly’ in the examinations which doesn’t seem consistent with a system aimed at the strongest students. We noted that NSS data shows that the satisfaction rate of students on our course (94%) is the highest of any pre-1992 university mathematics courses.

Professor Joyce advocates an examination system in which candidates take examinations in a fixed number of courses. Members of the Faculty Board will recall that about 10 years ago a working party was formed, under the chairmanship of Professor Beardon, to examine exactly this possibility. After a year’s work the working party produced a report setting out a possible ‘modular’ scheme which initially had the support of some (or even many) members of the Faculty. The report was discussed at an open meeting (to which students) were invited, but there was considerable opposition (especially from the student representatives) and the proposals were not taken further. In view of the thoroughness of the report by Professor Beardon’s working party, we do not wish to recommend that the Faculty resurrects the going-modular debate.

¹<http://www.admin.cam.ac.uk/univ/camdata/utmatx.html>

2.8 What is an alpha?

The Part II Examiners feel that the Faculty Board should discuss the possibility of providing guidelines to help examiners decide at what point in the solutions to their questions an alpha should be awarded. We did not feel that this would be a fruitful discussion. Given the very different nature of pure and applied questions, and the different types of questions within these groupings, we thought that it would not be possible to provide meaningful guidelines; it can only be a matter for the judgement of individual examiners.

2.9 Transferable skills

Professor Steiner (External examiner for Part II) comments (though not overtly as a criticism) on the lack of transferable skills in the curriculum and the absence of combined honours including mathematics.² It is true that there is no examination credit for transferable skills (except for CATAM), but the supervision system provides opportunities for presentational skills and students can take formal language courses (CULP) and attend other lectures as they wish. Our course is deliberately aimed at students who are specialists (and the same can be said of most other subjects in Cambridge), and this means that combined honours programmes are problematic (consider the unsatisfactory arrangements for the Education Tripos).

2.10 Appeals

Professor Kerr (External Examiner for Part II) comments on the number of appeals made by one particular tutor (four, of which one — not none, as Professor Kerr believes — was successful) and the Part II Examiners' report mentions a total of seven appeals. We noted that

1. Under the University regulations (Statutes and Ordinances 2009, p238, regulations 5 and 6), any student can make a representation to the Chairman of Examiners (via the Registry). This can be submitted directly, or by his or her tutor; the latter route is normal, given the rather complex process. It would be difficult for the tutor to refuse any seemingly reasonable request for help in this matter.
2. As the Part II Examiners point out, candidates are not entitled to demand that their papers are re-marked, although examiners in the past have displayed considerable good will in this respect, especially in the case of a candidate not classed.

We wondered whether examiners are being plagued by inappropriate examination appeals and, if so, what can be done about it. As a first step, we **recommend** that Examiners are asked to send a copy of any appeal and response to the Faculty Board so that the situation can be monitored.

2.11 Interpretation of the marks in the Mathematical Tripos letter

Each year, a letter accompanies the mark books stating inter alia roughly where the borderlines are drawn. The wording used in this letter is agreed by the Faculty Board and repeated in the Schedules booklet. Clearly, it must be consistent both with what is done in practice and what is stated elsewhere (for example, as classification criteria).

This year, unfortunately, the wording was not revised when the Faculty Board agreed the new classification criteria. It is true that the Chairs of Part II protested vigorously that his own formulation should be adopted, but this had not been agreed by the Faculty Board and the Chairs of Parts IA and IB did not fully agree. The Chair of the Faculty Board therefore agreed a wording very close to the previous wording.³

The wording previously agreed for the Schedules booklet is:

The following tables show the approximate mark, number of alphas, and number of betas of a typical candidate placed near the bottom of each class. This may be taken as a rough guide for the current year [i.e. the one following the examination] but it is important to realise that borderlines may go up or down. At the lowest borderlines, individual consideration of candidates is always paramount, so there are no typical candidates; very few candidates fail to achieve at least a third class.

²The absence is not complete: the Mathematics option in the Education Tripos, which is mentioned elsewhere in this report, is essentially a combined honours course.

³According to the Part II Examiners, a candidate has made an appeal on the basis of this wording; this appeal is certainly groundless.

This in theory needs no modification: given these data, students can work out the merit mark and hence the borderlines for themselves. However, it would be good to provide more helpful information. Since the merit mark is the agreed primary criterion at the top three borderlines, we **recommend** that the following formulation to be published in the Schedules booklet and in the letter from the Chair of the Faculty Board regarding interpretation of marks.

The merit mark (M) is defined in terms of raw mark (m), number of alphas (α) and number of betas (β) by

$$M = \begin{cases} 30\alpha + 5\beta + m - 120 & \text{for } \alpha \geq 8 \\ 15\alpha + 5\beta + m & \text{for } \alpha \leq 8 \end{cases}$$

The following table shows that approximate borderlines. The first column of data shows the criteria for each class in terms of the merit marks or the numbers of alphas and betas. The second column shows the merit mark, raw mark, number of alphas and number of betas of two representative candidates near the lower borderline.

Very few candidates failed to achieve at least a third class.

2009	Class	Sufficient criteria	Representative candidates
	First	$M \geq 515$	517; 317,9,10 516; 291,11,3
	Upper second	$M \geq 325$	329; 229,3,11 325; 210,6,5
	Lower second	$M \geq 241$	247; 182,1,10 241; 161,4,4
	Third	$M \geq 188$ or $2\alpha + \beta \geq 8$	183; 143,0,8 188; 143,1,6

2.12 Rubric and excess questions

There were 145 attempts that infringed the rubric in Part IA; this figure is larger than last year's (115) but smaller than the previous year's (155).

The advice in the e-mail sent to candidates for Part IA by e-mail a week before the examination was strengthened this year as follows: 'Past examiners have been of the opinion that some candidates have put themselves at a disadvantage by tackling excess questions.' Clearly, this did not have much effect.

We noted that 145 extra questions is not a very large number when compared with the total of 6528 attempts and believe that any attempt to tamper with the marking or classification schemes would be a disproportionate response.

2.13 Marks processing programme

There were various comments about the efficacy of the marks processing programme and the process through which it is updated. We note that this matter is already in hand.

2.14 Faculty Secretary and Computer Officer

All the Examiners' reports remarked on the excellent support given by the staff of the Faculty Office, in particular Ms Sharmeen Irfan. We **recommend** that the Chair of the Faculty Board expresses the appreciation of the Board for her work.

The Examiners in all Parts of the Tripos found the expertise of Mr Mike Rose invaluable; he performed heroically in the face of difficulties that to many would have seemed insurmountable. We **recommend** that the Chair of the Faculty Board expresses the appreciation of the Board for his work.

3 Part IA

3.1 Education Tripos

This year, candidates for the Preliminary Examination for Part I of the newly revamped Education Tripos (*vice Education Studies Tripos*), took courses from Part IA of the Mathematical Tripos, namely Vectors and Matrices, Probability and Numbers and Sets. This year candidates for Part I of the Education Tripos also took courses from Part IA, namely Groups, Differential Equations and Vector Calculus.⁴

⁴Statutes and Ordinances, pp248 and 308.

The Board will remember that last year the Chair wrote to the Faculty Board of Education to express concerns about the poor performance of the Education students and to suggest that entry to the Education with Mathematics Tripos should be conditional on STEP. The Faculty Board of Education supported this suggestion, but the first students to have cleared such a hurdle (if there were any) will have been admitted in October 2009; the candidates examined in 2009 will not have had to clear the hurdle.

It is no surprise, therefore, that the Examiners report a situation similar to last year's. If the marks of the nine Education candidates are scaled (and this may or may not be a reliable guide), only one achieved even the level of a third class.

In view of the new admission policy (which we hope has been implemented by colleges), we do not recommend any further action this year.

3.2 Capacity of examination rooms

The examiners are concerned that the examination rooms are close to capacity. We noted that conditions in some rooms were cramped this year. Although it seems unlikely that the number of mathematicians taking Part IA will increase much, it should be remembered that those offering the Mathematics option in the Computer Science Tripos (only 9 this year) might well increase.

We **recommend** that the Board of Examinations be asked to look into this issue.

3.3 Distribution of questions on Relativity and Dynamics

This year, Special Relativity was introduced into the Dynamics course. The on-line questionnaire revealed some disquiet about the number of long questions on Special Relativity: there were two long questions. There are 100 marks available for each course in the examinations. There are nominally 7 lectures on Special Relativity (though only one examples sheet out of four). One might expect that between 6/24 and 8/24 of the marks would be attached to Special Relativity, i.e. between 25 and 33 marks: perhaps one long and one short question; or two long questions if one tested also some material from the Newtonian Dynamics section. Clearly, since this was the first year of the new course, the Examiners wanted to emphasise the importance of the new material, but probably this pattern should not be repeated every year. We **recommend** that this be brought to the attention of this year's Examiners.

4 Part IB

4.1 Difficulty of the examination

The strong consensus in the on-line questionnaire was that this year's examination was particularly hard; in particular, opprobrium was heaped on Examiner B (with Methods and Quantum Mechanics questions being singled out). We noted that two alphas fewer this year were required for a first than last year, though the marks were comparable. It seemed to us that many of the questions this year were unreasonably long or difficult. We **recommend** that this be brought to the attention of this year's Examiners.

5 Part II

5.1 CATAM marks

The CATAM director notes that fractional quality marks are awarded for CATAM.⁵ These quality marks are rounded up or down to whole numbers. Since quality marks play such an important role, particularly at the highest borderline, he proposed that they are not rounded, but instead given to one decimal place. The merit mark would be calculated using the same formula as before. This has the support of the Part II Examiners and we **recommend** this procedure.

⁵Three alphas are available for candidates who take 30 units; for candidates who take fewer units, the quality marks they receive are scaled in proportion to the number of units they take.

5.2 Schedules

The Examiners state that the schedules for the Number Fields course are ambiguous and suggest improvements. We are not of the opinion that the schedules are ambiguous at all, and do not wish to recommend either of the suggested improvements.

5.3 Number Fields: off-schedule question

One question on this course was set on non-examinable material. It generated several complaints, one of which went through official channels. All attempts at this question were investigated in the final meeting and, for one candidate, an adjustment was made.

The Examiners explain in their report the lecturer did not provide the questions until ‘many weeks’ after the deadline, by which time it was too late to guarantee that the questions could be checked fully. They also point out that the range of expertise of the pure examiners was rather narrow and that this might have been a contributory factor.

We had two thoughts about this. First, given that two questions on another course were found (in time) to be off-syllabus, we **recommend** that when lecturers in Part II are asked to propose questions they are sent the schedule for their course and asked to ‘provide questions on the topics in attached schedule’. Second, in view of the fact that late questions can derail the setting process, we **recommend** that the relevant Head of Department be asked to investigate the situation and take whatever steps he believes will ensure that it does not recur.

5.4 Number of pure examiners

The examiners point out that the marking load of the pure Examiners was nearly double that of the applied Examiners and more than double that of the applicable Examiners, and recommend that in future an additional pure examiner be appointed. We **recommend** that the Head of DPMMS considers this.

Catherine Cutts	Ewa Bieniecka	Keith Carne	Thanasis Fokas	Imre Leader	
Richard Samworth	John Lister		Colm Caulfield	Tom Fisher	Stephen Siklos (Chair)

December 1, 2010