Examiners' Reports: Honour Schools of Mathematical Sciences and Mathematics, Part I: Trinity Term 2004

November 17, 2004

Part I of Report on Mathematical Sciences

A STATISTICS

1. **Numbers and percentages in each class**

	Number				Percentages %			
	2004	2003	2002	2001	2004	2003	2002	2001
I	26	29	24	23	25.7	22.8	20.5	19.8
II.1	49	64	63	66	48.5	50.4	53.8	56.9
II.2	18	27	17	14	17.8	21.3	14.5	12.1
III	5	2	12	8	5.0	1.6	10.3	6.9
P	1	4	0	5	1.0	3.1	0	4.3
F	2	1	1	0	2.0	0.8	0.9	0
Total	101	127	117	116	100	100	100	100

2. **Vivas**: Not applicable

3. **Marking of scripts** (of papers which are the responsibility of the Mathematical Sciences Examiners): each Extended Essay (paper o2) and each o14 (History of Mathematics) script was double-marked. As in previous years, all other papers were single marked according to detailed pre-agreed marking schemes.

B NEW EXAMINING METHODS AND PROCEDURES

As previously, University Standardised Marks (USMs) were used as the substantive basis of classification. Sums of squares of marks per question were used for the mathematics papers only for deriving the parameters of the algorithm described in Part II, Section A of the Report. One new paper was offered in Section o this year, namely o14 (History of Mathematics). This was assessed by means of a mini-project, consisting of an essay written at the end of the Hilary Term, and a two-hour written paper. There were eleven candidates.

C CHANGES IN EXAMINING METHODS AND PROCEDURES CURRENTLY UNDER DISCUSSION OR CONTEMPLATED IN THE FUTURE

No changes would be relevant since this was the last examination under the present course structure and regulations.

D COMMUNICATION WITH CANDIDATES

The candidates were given detailed information on the form of the examination and the basis of classification to be used in the 2004 examination. In each of the three terms in 2003-4, circulars were sent in hard copy form to each individual candidate; they were also posted on the Mathematical Institute website. [These circulars are attached.]

Part I of Report on Mathematics Part I

A STATISTICS

79 candidates completed the examination, of whom all but one (1.3%) were awarded Honours. The latter candidate was subsequently given permission to transfer to Mathematical Sciences (notwithstanding the normal requirement to sit a Paper o) and was awarded a Pass in the School.

B–D

[*See corresponding sections of Part I of the report on the Honour School of Mathematical Sciences*]

Part II of Report on Mathematical Sciences and Mathematics Part I

The Examiners record their very warm thanks to:

- the Examiners from the other Honour Schools who set and marked papers for the Honour School of Mathematical Sciences and Mathematics Part I;
- all Assessors, and others who suggested questions in connection with their lecture courses;
- the staff at the Mathematical Institute, particularly Maria Moreno, who assumed administrative responsibility for the examinations, and Catherine Keen for her experience and helpfulness in resolving the trickier problems;
- Elliott Nichol for managing and running the database, and the graduate students who acted as checkers for the marks entry process;
- The staff of the Examination Schools for their help and cooperation in the smooth running of an increasngly complicated examination;
- Examiners from previous years, whose records and guidance were invaluable.

The Internal Examiners record their warm thanks to Professors MacCallum and Rawnsley for their prompt comments on the question papers and for their helpful advice and attention to detail during the classification meetings.

The Chairman thanks all the Examiners for their loyal support throughout the year and for bearing the considerable work load involved with good grace and quiet competence. It goes without saying that without their advice and high level of cooperation, the Examination could not have been conducted properly.

The Internal Examiners met for the first time on 29 September 2003 to elect a Chairman and to distribute responsibilities.

A GENERAL COMMENTS ON THE EXAMINATION

Overview of the Examination

This was the last year in which Mathematics Finals will be held in the present form. Nevertheless, it is hoped that some of our experiences will be of value in the new examination format. Although the basic structure was similar to previous years, there were some changes to the papers on offer and there were numerous new regulations and constraints, all of which add to the labour and pressure of the examining process. In spite of the fact that the timetable was shorter than ever this year; there were no major hitches. The candidates cooperated well and achieved a good standard overall. There was some evidence – as in previous years – that the second halves of many Section b courses (in the Hilary Term) were scoring significantly less credit than the first halves. The need for time to digest material, to work problems and for revision should be recognised in any future changes to the course structure.

Timetable

For Mathematical Sciences the examination began with paper o6 on Tuesday 25 May and for Mathematics Part I with a7, taken on the morning of Saturday 5 June. Both examinations ended on the morning of Thursday 17 June, with papers o14 and b9. As in previous years, most papers were concentrated in the seventh week of Term, with a1 and a2 being sat on the mornings of Monday 7 June and Tuesday 8 June. These papers were taken by all candidates for Mathematical Sciences and Mathematics Part I and were therefore the heaviest papers. It was very helpful that they were scheduled a day earlier than last year.

Unfortunately it proved to be impossible to move another heavy paper, a3, earlier in the schedule than Thursday 10 June; as this was the first paper for one of the markers there was conseqently considerable pressure on the schedule. The time-tabling for the marking was very tight, so that a single day was very significant. This kind of pressure seems to have become worse over the years and it is not conducive to orderly conduct of the examination. It was very helpful that the draft time-tables were sent out considerably earlier this year than last, but it was effectively impossible to negotiate any changes in the light of known pressure points.

Numbers offering the various papers

The numbers of candidates offering each paper (Mathematical Sciences and Mathematics Part I combined) are given below, The Section o papers are restricted to Mathematical Sciences candidates except for papers o10 (Mathematics & Finance) and o11 (Mathematical Modelling and its Applications). Six Part I candidates opted to take o10 and five opted for o11.

Paper	2004	(2003)	(2002)	(2001)
a1 Linear Algebra & Differential Equations	180	(198)	(194)	(182)
a2 Complex Analysis & Geometry	180	(198)	(193)	(182)
a3 Algebra	105	(99)	(97)	(124)
a4 Analysis	106	(93)	(131)	(124)
a5 Non-Physical Applied mathematics	134	(163)	(159)	(154)
a6 Physical Applied mathematics	116	(143)	(116)	(98)
a7 Numerical Analysis	53	(62)	(46)	([o1] 4)
b1 Foundations	53	(48)	(53)	(60)
b2 Algebra	49	(38)	(51)	(51)
b3 Geometry	16	(13)	(20)	11
b4 Analysis	37	(28)	(26)	(25)
b5 Applied Analysis	95	(103)	(94)	(90)
b6 Theoretical Mechanics	25	(37)	(46)	(17)
b7 Mathematical Physics	46	(66)	(58)	(59)
b8 Statistics	25	(34)	(41)	(38)
b9 Numerical Solution of PDEs	6	(17)	(9)	(0)
b10 Approved Subjects	74	(65)	(61)	(84)
o2 Extended Essay	7	(11)	(4)	(9)
o3 Functional Programming & Data Structures & Algorithms	9	(19)	(19)	(14)
o6 History of Philosophy	2	(2)	(6)	(6)
o7 Knowledge & Reality	2	(3)	(7)	(6)
o8 Philosophy of Mathematics	2	(1)	(4)	(6)
o10 Mathematics & Finance	47	(68)	(35)	(42)
o11 Mathematical Modelling & its Applications	16	(12)	(8)	(7)
o13 Actuarial Science	49	(61)	(40)	(26)
o14 History of Mathematics	11	–	–	–
(Mathematics Education)	–	(13)	(15)	(16)

It is hard to discern any consistent trends over recent years: a number of the changes last year would seem to have been reversed. This year there was a slight decrease in the numbers choosing Applied Mathematics options, notably Statistics and Physical Applied Mathematics, and also the essay-based papers; the Philosophy papers in Section o would now seem to be hardly worth putting on. By contrast, the Pure Mathematics options appear to have regained popularity. The History of Mathematics paper made a reasonable entrée, though with fewer entries than Mathematics Education, now no longer available.

Determination of University Standardised Marks

As in the previous year, University Standardised Marks (USMs) were assigned for individual papers, and the profile of USM marks determined the class, according to the rules approved by the Mathematics Teaching Committee and endorsed by the Divisional Board.

Papers o2, o6–o8 and o14 were assigned USM marks directly. There were seven candidates for paper o2 (Extended Essay); these were marked along similar lines to last year, with marks being awarded for content, mathematics and presentation with weights of 1/4, 1/2, and 1/4 respectively. Paper o14 (History of Mathematics) was taken for the first time this year; there were 11 candidates. Assessment was by means of a two hour essay paper and a mini-project, consisting of an essay submitted at the end of the Hilary Term. These two components were given equal weight.

For all papers in Sections a and b and also papers o10, o11 and o13, questions were marked out of 25, and sums of squares of marks (SSQs) were computed. Paper o3 was, as usual, marked by the Moderators in Mathematics & Computer Science; it was taken by nine candidates. Candidates were permitted to answer at most five questions on this paper, and the practical assignments were treated as one additional question. Each question was marked out of 20; the marks were accordingly scaled by 5/4 before the SSQ mark was calculated.

A notional total SSQ mark was calculated for each candidate by summing over the k SSQ papers taken by each candidate (as identified in the previous paragraph) and scaling the sum by $8/k$).

Algorithm for determining USMs

1. In calculating USMs from the initial SSQ marks, the Examiners used the algorithm developed and tested by last year's Examiners and approved, with minor amendments recommended by its developers, by the Mathematics Teaching Committee. This year there were further amendments arising from the requirement by the EPSC that the USM must theoretically be allowed to become zero and that standard rounding be used (previously marks were rounded up at every stage).

The algorithm takes as its starting point the combined list for Mathematical Sciences and Mathematics Part I candidates, ordered by the notional total SSQ. On this list the Examiners set two numbers, $B1$ and $B2$, which are provisional I/II.1 and II.1/II.2 borderlines on the basis of SSQ. Each candidate is then assigned a number G according to the scheme:

$G = 1$ if total SSQ $\geqslant B_1$ (provisional first)
$G = 2$ if $B_1 >$ total SSQ $\geqslant B_2$ (provisional upper second)
$G = 3$ if $B_2 >$ total SSQ (the rest)

2. Next, parameters are chosen for each paper as follows:

N_1 = number of candidates who took this paper and have $G = 1$
N_2 = number of candidates who took this paper and have $G = 2$
N_3 = number of candidates who took this paper and have $G = 3$

The candidates are then ordered by their SSQ on that paper (in descending order) and borderline SSQs are determined as:

$n_1 = N_1$-th SSQ
$n_2 = (N_1 + N_2)$-th SSQ

These are taken to be the SSQ corresponding to a USM of 70 and 60 respectively. The USM is then calculated from SSQ by linear interpolation, first down to a USM of 57, then on a second line leading to a USM of 20 for a SSQ of 0. This second line is used down to a USM value of x (to be chosen at the discretion of the examiners), after which the USM is linearly interpolated down to a USM of zero when SSQ equals zero. This defines the three linear functions:

$F_1(n) = (10n + 60n_1 - 70n_2)/(n_1 - n_2)$
$F_2(n) = 20 + 37n/n_c$
$F_3(n) = xn/n_x$

where $n_c = (13n_2 - 3n_1)/10$, which is the SSQ corresponding to a USM of 57, where the first two lines meet, and $n_x = (x - 20)n_c/37$ which is the SSQ corresponding to a USM of x as defined by F_2.

3. Now the USM m for each candidate is obtained from the SSQ n as

$m = F_1(n)$ if $n \geqslant n_c$
$m = F_2(n)$ if $n_c > n \geqslant n_x$.
$m = F_3(n)$ if $n_x > n$.

The choice of 57 for the first corner follows the proposal of previous Examiners. This figure needs to be well below 60, which is the borderline for a II.1 performance, as otherwise it would distort the distribution at this important threshold; on the other hand, it is desirable to make a uniform choice for all papers, and a value much below 57 produces an algorithm which may not deal, without further intervention, with papers taken by a small number of candidates.

In fact the examiners did intervene in the case of two papers, a7 and b9, by changing the computed values of n_1 and n_2. In the case of a7, the sample size could be increased by looking at the performance of the Maths and Computer Science candidates and the values of n_1 and n_2 from the wider cohort were used. In the case of b9, with just 6 candidates; the computed values $n_1 = 2935$ and $n_2 = 497$ were considerably out of line with other papers and were instead set to $n_1 = 1600$ and $n_2 = 800$.

According to the conventions under which the Examiners were instructed to operate, all USMs were rounded using standard rounding (in distinction to the previous two years in which USMs were rounded up) before being communicated to candidates and colleges, except that any USM above 100 was rounded down to 100. (A small number of unrounded USM marks above 100 were achieved by Mathematics Part I candidates but none by candidates in Mathematical Sciences.)

The table below shows, for each SSQ-marked paper, the average SSQ, and the values of n_1, n_2 and n_c based on the values $B_1 = 11000$ and $B_2 = 5100$ and $x = 35$ which were finally used (see below). The Average USM mark is shown for each paper.

Paper	AvSSQ	N_1	N_2	n_1	n_2	n_c	Av USM All	Av USM MMath	Av USM MathSci
a1	1443	64	83	1739	852	586	65.1	68.5	62.4
a2	1113	64	83	1332	611	160	65.1	68.5	62.4
a3	1782	41	44	2084	1203	939	65.1	68.3	61.3
a4	1274	46	34	1451	821	632	66.0	68.6	63.0
a5	1020	49	63	1244	365	101	65.3	69.3	63.0
a6	879	37	60	1093	385	173	65.3	68.3	63.1
a7	1089	13	27	1300	700	520	65.2	?	?
b1	1205	20	19	1695	1081	897	63.6	66.8	56.3
b2	891	21	20	1066	447	261	65.8	69.9	53.7
b3	1339	9	4	1189	642	478	67.9	67.4	69.5
b4	1531	21	15	1546	703	450	70.3	69.9	73.8
b5	1346	32	47	1538	714	467	65.5	70.2	63.4
b6	1175	9	13	1285	694	517	67.3	68.5	66.0
b7	966	16	24	1062	360	149	67.3	69.0	64.7
b8	1290	5	17	1584	820	591	64.6	68.2	63.4
b9	1675	1	5	1600	800	560	70.4	?	?
b10	1120	25	38	1370	530	278	65.2	67.4	63.2
o3	1659	3	3	2343	1368	1076	58.3		58.3
o10	1355	13	25	1593	882	669	62.8	71.2	61.6
o11	1976	7	8	2118	946	594	68.5	66.8	69.3
o13	1021	14	23	1510	542	252	62.4		62.4

It can be seen from the table that the algorithm automatically makes an adjustment for the relative difficulty of the papers. The Examiners were satisfied that these adjustments were in line with expectations and that the USMs fairly reflected the candidates' performance, except in the case of papers a7 and b9 as previously mentioned.

Classification: Mathematical Sciences

For Mathematical Sciences, AvUSM, the average USM over a candidate's eight papers, has to be calculated in order to determine the degree class. In calculating AvUSM, the USMs before rounding were used and AvUSM then rounded up. Although not an issue this year, it will need to be decided for the future whether USMs above 100 should or should not be rounded down before averaging.

The degree classification is determined from AvUSM according to the rules below. In these, a weak paper is one with USM < 50 and a very weak paper is one with USM < 40.

First Class — AvUSM $\geqslant 70$ with not more than 2 weak papers.

Upper Second Class — EITHER AvUSM $\geqslant 70$ with 3 or more weak papers
OR $70 >$ AvUSM $\geqslant 60$ with not more than 2 very weak papers.

Lower Second Class — EITHER $70 >$ AvUSM $\geqslant 60$ with 3 or more weak papers

	OR $60 > \text{AvUSM} \geqslant 50$.
Third Class	$50 > \text{AvUSM} \geqslant 40$.
Pass	$40 > \text{AvUSM} \geqslant 30$.
Fail	$\text{AvUSM} < 30$.

In arriving at the classification the Examiners adhered to the rules above except for a few cases where individual circumstances were taken into account. In all other cases the notional AvUSM determined the class without invoking the rules on weak and very weak papers.

The choice of the values of B_1 and B_2 from which the algorithm starts fixes the USMs and hence the classification. In deciding what choices to make, the Examiners took into account past precedent in terms of class percentage figures and borderline SSQs at the higher borderlines. SSQ figures for the I/II.1 and II.1/II.2 borderlines in 2004 were, respectively, 11,000 and 5,100; the corresponding borderlines in 2003 were 10,250 and 5,600. The resulting class distributions were evaluated for a number of choices of B_1, B_2 and x. These experimental choices took values of B_1 in the range 10500 to 12000 and values of B_2 in the range 5100 to 6500. In deciding on which values of B_1 and B_2 to determine the agreed Class List, the Examiners scrutinised the full marks profiles of candidates close to the resulting borderlines to see whether the performance of candidates on either side of each borderline matched the qualitative descriptor for the class to be awarded as follows:

First Class: candidates show excellence over a wide range of topics.

Upper Second Class: candidates show very good quality over a wide range of topics.

Lower Second Class: candidates show competence over a good range of topics.

Third Class: candidates show some understanding and competence over a reasonable range of topics; although there may be a few good answers, the majority of the answers will contain errors in calculation and show incomplete understanding of the topics.

Pass: candidates show limited ability, but some grasp of a restricted range of topics, and with large gaps in understanding. There need not be any good quality answers, but there will be indications of some competence.

Fail: little evidence of competence in the topics examined; the work is likely to show major misunderstanding and confusion, coupled with inaccurate calculations; the answers to most of the questions attempted are likely to be fragmentary only.

The Examiners were satisfied that the final choice of parameters, $B_1 = 11000$, $B_2 = 5100$ and $x = 35$, led to a classification which was by and large in line with the descriptors throughout the range, with certain exceptions.

Overall we were satisfied that the use of SSQ marks to determine an initial ranking led to a fair judgement of candidates' relative achievement in a way that unsquared marks would not have done, particularly at the I/II.1 borderline. However it was felt that the use of the sum of squares was a less useful guide at the lower borderlines and we welcome a shift to a system in which there is less dependence on SSQ at these lower borderlines.

It is worth noting, as last year, that it is desirable that database output for a range of choices of values of B_1 and B_2 is obtained in advance of the preliminary classification meeting, in order that the External Examiners can then focus on the scripts of candidates who are most likely ultimately to be borderline cases. Because of our inexperience with the operation of the algorithm, the knock-on effect of a marking and checking schedule that this year was one day shorter than last, and the time taken to obtain output data, we did not have as much data available as early as we would have wished.

Classification: Mathematics Part I

At this stage candidates for Mathematics Part I are only classified as worthy of honours, pass or fail. However, the USMs from this year's exams will contribute to the degree classification under the approved conventions after Part II has been taken in June 2005. The values of the parameters determining class borderlines were set as described above for Mathematical Sciences, USM marks for individual papers for candidates in both Schools following from the algorithm.

B EQUAL OPPORTUNITIES ISSUES AND BREAKDOWN OF THE RESULTS BY GENDER

In the Final Honour School of Mathematics Part I, 57 (73.0 %) of the 78 candidates who were adjedged worthy of Honours passed were male; 21 (27.0 %) were female.

The table below shows the percentages of male and female candidates for Mathematical Sciences in the various classes.

	Total	Male	Female
I	26 (25.7%)	21 (31.3 %)	5 (14.7%)
II.1	49 (48.5%)	28 (41.8%)	21 (61.8%)
II.2	18 (17.8%)	12 (17.9%)	6 (17.6%)
III	5 (5.0%)	4 (6.0%)	1 (2.9%)
P	1 (1.0%)	1 (1.5%)	0 (0.0%)
F	2 (2.0%)	1 (1.5%)	1 (2.9%)
Total	101 (100%)	67 (66.3%)	34 (33.7%)

C DETAILED NUMBERS ON CANDIDATES' PERFORMANCE IN EACH PART OF THE EXAMINATION

Summary of Statistics

All statistics refer to Mathematical Sciences and Mathematics Part I combined.

Section a

Paper a1— Linear Algebra and Differential Equations

Number of candidates: 180 Average number of questions attempted: 4.72

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	61.93	12.97	91	2	69.43	10.51	91	17
SSQ	1231.63	707.50	3546	9	1775.81	685.29	3536	109

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	120	16.200	7.729	42	45
2	113	10.743	5.979	11	22
3	112	20.125	6.226	70	27
4	113	17.735	6.414	55	27
5	75	12.000	5.948	6	33
6	118	16.136	4.918	9	80
7	85	16.235	5.489	27	30
8	114	18.114	6.640	51	41

Paper a2— Complex Analysis and Geometry

Number of candidates: 180 Average number of attempts: 4.58

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	62.02	14.40	90	1	69.65	11.29	108	22
SSQ	954.43	592.64	2747	4	1350.35	693.35	4001	100

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	60	11.100	8.374	11	15
2	87	9.747	7.870	8	25
3	122	12.516	7.183	17	46
4	147	14.605	5.871	28	69
5	152	15.671	6.200	38	75
6	130	17.069	6.221	48	54
7	98	12.316	6.824	15	35
8	28 15.6%	15.964	5.859	7	13

Paper a3— Algebra

Number of candidates: 106 Average number of attempts: 5.10

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	58.84	16.85	93	8	69.32	9.84	91	45
SSQ	1541.65	891.52	4054	86	2083.18	778.25	3864	625

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	60	13.217	6.732	11	20
2	93	20.699	5.094	57	30
3	94	20.074	6.724	62	15
4	54	11.889	8.042	11	13
5	79	16.848	7.782	35	18
6	79	17.165	5.273	24	42
7	53	17.472	6.075	24	11
8	29	17.345	5.845	11	13

Paper a4— Analysis and Topology

Number of Candidates: 101 Average number of questions attempted: 4.29

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	61.67	13.45	88	32	69.34	11.39	97	42
SSQ	1151.59	595.01	2574	229	1443.40	650.95	3147	360

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	75 16.800	6.388	29	27	
2	51	16.392	6.207	12	27
3	57	11.298	5.158	4	14
4	44	15.159	4.903	6	28
5	63	17.571	6.645	30	20
6	83	19.566	6.202	45	25
7	25	11.240	8.202	6	4
8	35	10.229	7.963	5	11

Paper a5— Non-Physical Applied Mathematics

Number of Candidates: 134 Average number of questions attempted: 4.55

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	65.78	10.15	86	0	69.67	7.77	89	60
SSQ	967.17	636.77	2607	97	1214.57	683.14	2855	303

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	108	9.694	4.184	4	14
2	112	12.339	6.770	18	32
3	66	11.106	8.628	15	15
4	100	14.950	6.708	24	39
5	89	15.933	7.819	34	31
6	41	12.390	7.290	7	12
7	59	15.559	6.944	21	21
8	35	15.657	7.511	13	10

Paper a6— Physical Applied Mathematics

Number of Candidates: 115 Average number of questions attempted: 4.13

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	65.04	10.92	91	10	68.01	6.96	88	58
SSQ	836.77	532.34	2544	19	951.78	492.82	2331	232

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	53	7.755	3.902	0	6
2	63	14.460	6.433	14	28
3	74	15.135	6.080	20	29
4	48	9.875	4.360	0	13
5	30	7.400	4.415	1	1
6	80	15.238	7.313	27	25
7	77	12.208	4.537	4	29
8	50	18.360	5.106	21	22

Paper a7— Numerical Analysis

Number of Candidates: 52 Average number of questions attempted: 4.23

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	63.46	13.53	85	1	68.96	6.36	80	51
SSQ	1021.61	485.28	2157	5	1253.82	335.57	1890	435

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	44	13.432	5.483	4	17
2	46	18.783	5.428	18	22
3	41	14.927	5.140	6	21
4	48	16.479	4.162	8	32
5	18	8.667	7.348	1	5
6	9	9.333	8.062	1	3
7	14	100	7.932	3	1

Section b

Paper b1 — Foundations

Number of Candidates: 48 Average number of questions attempted: 4.08

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	44.49	23.93	73	10	61.40	17.67	98	20
SSQ	842.40	662.63	1829	100	1399.06	728.75	3365	204

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	49	15.531	6.810	14	19
2	33	15.697	7.091	10	13
3	27	9.519	8.327	5	3
4	17	14.176	8.383	5	6
5	2	19.000	1.414	0	2
6	37	15.351	5.584	9	15
7	42	18.333	7.547	23	10
8	13	10.615	9.152	2	3
9	11	10.727	7.295	1	5

Paper b2 — Algebra

Number of Candidates: 38 Average number of questions attempted: 3.87

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	52.64	21.57	74	4	66.59	14.60	93	12
SSQ	553.70	489.54	1300	11	977.13	582.37	2451	34

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	44	16.068	6.036	10	25
2	22	9.227	6.148	1	5
3	22	11.864	8.604	3	8
4	16	14.063	8.079	4	4
5	30	5.767	3.213	0	1
6	36	14.167	9.303	15	3
7	21	13.429	9.009	5	7
8	16	9.375	7.702	2	3

Paper b3 — Geometry

Number of Candidates: 13 Average number of questions attempted: 3.85

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	73.92	8.15	80	62	70.27	19.88	96	27
SSQ	1403.50	445.56	1710	747	1317.08	858.90	2597	144

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	12	19.000	5.689	5	6
2	5	17.800	7.430	2	2
3	6	21.833	5.529	5	0
4	4	12.250	11.325	1	1
5	10	21.700	3.466	7	3
6	6	15.667	5.854	1	3
7	8	18.500	5.043	3	4
8	7	13.000	7.832	1	3

Paper b4 — Analysis

Number of Candidates: 28 Average number of questions attempted: 3.93

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	69.75	13.28	89	58	68.65	12.43	90	24
SSQ	1525.25	1119.91	3104	468	1575.21	756.55	3188	289

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	24	16.167	5.053	4	16
2	12	12.750	6.538	1	6
3	22	16.545	7.130	9	7
4	21	21.762	3.604	16	4
5	32	19.125	5.621	19	9
6	21	13.857	7.384	5	8
7	19	17.421	7.144	9	4
8	18	19.556	3.568	10	8

Paper b5—Applied Analysis

Number of Candidates: 101 Average number of questions attempted: 4.28

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	65.12	10.15	88	23	71.49	7.31	92	59
SSQ	1231.67	661.87	3008	121	1660.97	602.10	3296	602

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	62	12.823	8.849	17	14
2	87	18.471	4.663	33	48
3	47	19.766	6.805	28	13
4	75	9.987	5.855	2	22
5	87	18.770	4.178	38	38
6	39	16.154	6.495	13	17
7	0			0	0
8	19	15.737	6.879	6	7

Paper b6—Theoretical Mechanics

Number of Candidates: 37 Average number of questions attempted: 3.84

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	64.38	13.39	84	40	69.76	5.52	79	60
SSQ	1157	509.54	2085	267	1270.92	326.24	1766	694

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	21	16.619	6.546	6	12
2	18	18.056	5.116	10	5
3	22	14.591	6.146	6	5
4	19	17.579	4.168	6	11
5	8	9.750	7.440	1	2
6	5	8.800	9.094	1	1
7	8	10.750	6.628	1	2
8	4	9.500	5.802	0	2

Paper b7 — Mathematical Physics

Number of Candidates: 65 Average number of questions attempted: 3.92

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	67.87	9.82	90	58	69.41	8.54	101	59
SSQ	912.39	689.36	2458	164	1020.73	599.24	3176	288

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	42	17.952	4.445	14	24
2	20	9.150	5.204	0	6
3	30	16.567	7.473	13	7
4	21	11.381	5.617	2	6
5	21	14.190	6.846	4	10
6	15	15.133	9.471	6	4
7	25	10.720	6.154	2	11
8	1	9.000		0	0

Paper b8 — Statistics

Number of Candidates: 33 Average number of questions attempted: 5.09

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	64.93	8.82	85	38	67.84	6.55	80	60
SSQ	1283.29	528.79	2671	281	1418.83	500.43	2312	769

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	22	15.727	6.189	4	13
2	23	18.696	5.112	9	11
3	19	10.947	6.023	2	4
4	21	14.095	5.467	2	10
5	3	10.333	10.214	1	0
6	2	8.500	2.121	0	0
7	2	11.500	7.778	0	1
8	24	18.917	2.125	6	18

Paper b9 — Numerical Solutions and Differential Equations

Number of Candidates: 17 Average number of questions attempted: 3.53

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	64.26	12.63	78	53	76.48	9.29	87	69
SSQ	1231	893.56	2226	497	2118	742.91	2935	1483

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	6	20.667	5.715	4	1
2	6	20.500	7.609	4	1
3	3	17.667	11.846	2	0
4	4	11.750	9.179	1	1
5	3	9.667	6.658	0	2
6	1	12.000		0	0
7	4	21.500	5.066	3	1
8	1	7.000		0	0

Paper b10 — Paper on approved list of subjects

Number of Candidates: 65

Average number of questions attempted: 4.11

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	63.57	10.70	83	28	67	15.76	90	1
SSQ	990.42	589.75	2423	89	1342.97	718.32	2980	1

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
A1	16	17.000	5.820	6	6
A2	15	20.200	5.171	9	5
A3	14	13.786	8.154	3	5
A4	8	17.875	9.203	4	2
B1	25	9.320	6.992	3	4
B2	20	9.350	5.071	1	4
B3	18	13.778	6.924	3	9
B4	12	8.917	3.872	0	3
C1	18	14.000	4.433	1	12
C2	16	19.125	6.469	8	6
C3	16	17.625	5.071	5	9
C4	6	10.167	6.911	0	2
D1	12	16.167	8.579	5	3
D2	8	11.375	6.255	0	4
D3	9	11.111	7.288	0	4
D4	4	5.250	5.315	0	1
E1	15	16.733	7.896	8	2
E2	14	17.571	5.064	5	6
E3	3	8.667	9.815	0	1
E4	12	17.917	3.502	3	8
F1	9	13.556	3.087	1	6
F2	12	17.917	4.680	4	7
F3	11	10.455	5.145	1	0
F4	6	11.500	7.583	1	1
G1	9	14.000	8.515	3	2
G2	8	19.750	4.464	4	4
G3	7	23.571	2.299	6	1
G4	4	9.000	1.414	0	0

Section o

Paper o2 — Extended Essay

	Mathematical Sciences			
	Mean	StdDev	Top	Bottom
USM	67.86	9.35	78	53

Paper o3 — Functional Programming, and Data Structures, and Algorithms

Number of Candidates: 66 Average number of questions attempted: 4.05

	Mathematical Sciences			
	Mean	StdDev	Top	Bottom
USM	59.29	16.59	77	21
SSQ	1659.16	857.78	2979.30	256.25

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	7	17.357	3.051	0	6
2	7	16.357	2.610	0	6
3	7	13.500	2.739	0	5
4	8	9.625	3.652	0	1
5	2	4.500	6.364	0	0
6	2	12.000	0	0	0
7	3	11.667	10.116	0	2
8	3	13.333	8.327	0	2
9	7	15.286	2.360	0	6

Paper o10 — Mathematics and Finance

Number of Candidates: 66 Average number of questions attempted: 4.05

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	62.17	15.02	78	4	76.87	12.43	96	65
SSQ	1283.97	542.16	2126	27	2081.33	883.44	3372	1183

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	29	15.000	7.695	12	6
2	26	18.000	4.299	7	16
3	19	14.474	8.009	6	5
4	9	15.667	9.644	4	1
5	44	17.136	6.801	21	9
6	32	18.188	8.364	18	8
7	25	10.680	7.111	4	4
8	23	15.957	6.547	8	7

Paper o11 — Mathematical Modelling and its Applications

Number of Candidates: 12 Average number of questions attempted: 4.67

	Mathematical Sciences				Mathematics Part I			
	Mean	StdDev	Top	Bottom	Mean	StdDev	Top	Bottom
USM	68.70	5.94	80	60	68.99	7.30	75	58
SSQ	1965.27	696.16	3255	946	1999.60	855.35	2612	602

Individual question statistics

Question	Number of Top	Average Mark Avg	Standard Median	Number of Bottom	Number of StdDev
1	13	19.538	3.455	5	7
2	9	18.667	6.576	6	0
3	15	19.400	6.967	9	4
4	14	20.643	6.295	8	5
5	8	20.500	5.555	6	1
6	7	14.714	7.319	2	1
7	7	20.571	6.528	5	1
8	3	23.000	1.000	3	0

Paper o13 — Actuarial Science

Number of Candidates: 58 Average number of questions attempted: 3.57

	Mathematical Sciences			
	Mean	StdDev	Top	Bottom
USM	62.08	14.20	77	10
SSQ	1045.13	576.82	2171	29

Individual question statistics

Question Number	Number of Attempts	Average Mark	Standard Deviation	Number of Alphas	Number of Betas
1	15	11.267	4.920	1	5
2	44	13.295	6.400	8	18
3	28	11.786	7.295	3	11
4	26	12.692	7.154	3	12
5	40	17.275	6.528	16	13
6	45	16.400	6.351	16	16

Paper o14 — History of Mathematics

	Mathematical Sciences			
	Mean	StdDev	Top	Bottom
USM	55.91	10.21	76	44

D COMMENTS ON PAPERS AND INDIVIDUAL QUESTIONS

Note: These reports are from Assessors and Examiners in their individual capacities; they do not necessarily represent the views of the Examiners as a whole

a1: Linear Algebra

These questions worked well, though (as expected) the triangular form in Q2 caused the most problems. (Triangular form hasn't been set in a good few years, though it is clearly on the syllabus). A lot of candidates wrote FAR too much, both proving things they weren't asked to prove, and giving incredibly long-winded roundabout versions of two line arguments.

Q1: A bog standard question 1, and the first half was done reasonably well. But a surprising number of candidates came unstuck on the simultaneous diagonalization part.

Q2: Most candidates came adrift on the triangular form, though there were a good number of correct solutions. Among the correct proofs I counted 5 different proofs, some of which were new to me.

Q3: Well done on the whole, though a good few candidates got in a muddle proving $(ST)' = T'S'$. I guess the problem is that you need to know what the expressions mean to put the brackets in sensibly, whereas for $(aT)' = aT'$ and $(S+T)' = S'+T'$ more or less anything you write down makes sense.

Q4: The theory was well done, but masses of candidates came unstuck on the example. [I guess they tried to solve it mechanically, instead of looking at the matrix and seeing that it has rank 1, so that 0 is an eigenvalue with multiplicity 2.] Very few candidates bothered to find an orthogonal P as asked. They seemed to think that any old P would do.

a1: Differential Equations

Q5: Relatively few candidates realised that it was necessary to verify that the point $(x, Y_n(x))$ belongs to the rectangle R even though they were explicitly asked to do so. The proof that the limit y is a solution of the initial- value problem was often done only in a sketchy way. Nobody noted that a uniform limit of continuous functions is continuous. Only one candidate realised that the last part of the question follows on comparing y with the solution constructed in the first part.

Q6: Green's functions were well-understood by many candidates. Very few, though, established the uniqueness of solutions in a convincing way.

Q7: This question on the solution of a quasi-linear partial differential equation by the method of characteristics produced some good answers. As ever, the determination of the region in the (X, Y)- plane in which the solution is uniquely defined by the data proved to be the most common stumbling block.

Q8: Many candidates failed to give an acceptable definition of a regular singular point. None the less the rest of the question was often well done. It was distressing to find that some candidates could not correctly identify the sum of the series $\sum_{n=0}^{\infty} x^n \;\; (|x| < 1)$.

a2: Complex Analysis

This was not a particularly easy question, but it was not unreasonably difficult. Questions 3 and 4 attracted a good number of attempts. Candidates found questions 1 and 2 less to their taste.

Q1: A few candidates tried (wrongly) to define the radius of convergence in terms of the ratio of coefficients. Most knew that within the radius of convergence

$$\frac{d}{dz}\left(\sum_{n=0}^{\infty} a_n z^n\right) = \sum_{n=0}^{\infty} n a_n z^{n-1}$$

but a number failed to recognise that they were being asked to establish it. The last part of the question was found to be easy, probably because the answers were given.

Q2: A number of candidates showed that they knew the statement of the Identity Theorem by quoting it, not realising that they were being asked to prove it. Most were able to define f_1 and f_2 but many found it difficult to construct the proof necessary for the last part.

Q3: A common error was

$$\left|\int_{\gamma} g(z)dz\right| \leq \int_{\gamma} |g(z)|dz$$

where candidates failed to recognise that the term on the right hand side was not necessarily real and positive. A number of candidates spent time showing that n^z was holomorphic and were not rewarded for this. Many did not recognise that the final series did not converge uniformly on the whole plane, but that it did so on compact subsets of certain half planes.

Q4: Numerous careless errors were made in locating the singularities of $\tan(1/z)$. The last part elicited errors in logic (particularly from the Maths and Philosophy candidates) where students simply verified that $f_0 + a/z^2$ had the required properties rather than showing that functions satisfying the given properties had this form.

a2: Geometry

Q5: This was a relatively standard but long contour integral question that attracted attempts from 85% of candidates. The first integral proved the most testing and there were widespread computational errors. Most candidates had difficulty spotting an even function. The second part was easier, although many candidates assumed a to be real for at least part of the question.

Q6: This was a very easy Fourier series question that attracted attempts from about 70% of the candidates. Although there were many high quality answers, there were a surprising number of candidates who had difficulty solving $\ddot{y} + p^2 y = 0$.

Q7: About half the cohort attempted this. A problem here was that the lecturer had obviously at some point defined a conformal map to be a holomorphic map with non-vanishing first derivative rather than as a map that preserves angles as in most textbooks. This then made the first piece of bookwork tautological as candidates were asked to prove that a holomorphic map with non-vanishing first derivatives is conformal. Fortunately, few candidates were confused by this and realised what was expected. Most candidates knew what to do in order to find the conformal mapping from the given region to the upper half plane, but relatively few were up to the elementary circle geometry required to get the details right and got the centre and/or radius of the circle wrong.

Q8: This was a straightforward geometry question it but didn't attract many attempts $\sim 10\%$ of candidates) probably because it comes at the end of the course. There were many good attempts, but many were let down by poor calculational skills.

a3: Algebra I

All four questions worked pretty much as designed. Although Question 3 ("not" Burnside's Lemma) was popular, it wasn't overwhelmingly so, and still attracted a good spread of marks. Candidates found the applications in questions 1 and 2 hard, and had most difficulty with question 4 on Cauchy sequences.

a3: Algebra II

Q5: This was a popular question with over 70% of students submitting attempts. Many students did well on this question, with two thirds of students achieving an α or β. Of note is that a large number of students achieved full marks, over 20% of students.

Q6: This standard bookwork question was also popular with over 70% of students submitting attempts. The majority completed the question competently and there were few poorly scoring students; less than 20% of students failed to achieve a β. Marks were evenly distributed above 10 marks, with slightly fewer students achieving the highest marks.

Q7: This question was less popular with half of students submitting answers. Several students spent a large amount of time and energy on the first part of the question, describing ruler and compass constructions. However this question on the whole was tackled well with over 69% of students achieving an α or β.

Q8: This question was either perceived to be difficult or was not a topic that many students had revised, as only a quarter of students attempted it. Answers enumerated many different statements of the Primary Decomposition Theorem, few of which were correct. Nearly all proved that: $\ker(fg) \subset \ker(fg) + \ker(g)$ but lost two marks for overlooking the obvious reverse inclusion. However the marks were fairly evenly distributed with few attempts scoring poorly.

a4: Integration

This paper contained a good number of straightforward questions and candidates who had mastered the material had no difficulty in finding questions on which they could score highly.

Q1: A popular, familiar, straightforward question but many students failed to notice that the sign of $g(x)$ depended on whether $a < \frac{1}{2}$ or $a > \frac{1}{2}$.

Q2: A number of different proofs were offered for the continuity of F; many students failed to appreciate that a continuous function on a compact set is uniformly continuous and as a result gave incomplete proofs.

Q3: Most candidates tried to establish the integrability of the various examples using Tonelli's theorem and evaluating the multiple integrals, whereas most could be decided by more abstract observations. They appeared to lack practice and experience of such problems, which are at the heart of the subject.

Q4: A successful question. The change of period, and evaluation of the series at a 'jump' point gave a good test of understanding.

a4: Topology

Q5: A straightforward question on which many candidates scored close to full marks.

Q6: Another straightforward question on which candidates scored highly.

Q7: A less popular question. A number of candidates simply picked off several definitions and left it at that. But there were some complete answers.

Q8: Not popular. This question was rather different from those set previously on metric spaces. The part that caused most difficulty was proving that $V_{m,\epsilon}$ was open. Most candidates attempting the question failed to notice the misprint in $(iii), (b)$ where a '+' appeared instead of a ','. This caused no confusion.

a5: Probability

Q1: Chebyshev's inequality etc. The basic inequality was meat and drink to nearly all. The rider about possible strict inequality was a cut-down version of the original question ('Consider a fixed $\mu, \sigma^2 > 0$ and ϵ,...') and students did not seem to know what was expected. I changed the mark scheme by moving one mark from this part to the basic proof, and marked generously. The part about $Z_1, Z_2, \ldots$ independent but not necessarily i.d. tripped up more than expected. The last part caused serious problems. It is not hard, though a better hint would have been to say that the rv T with mean μ has non-zero variance if and only if $P(T = \mu) < 1$. Few spotted that symmetry gives $E[Y_i] = 1/2$.

Q2: This was a replacement question that was intended to give fair representation to the distribution theory part of the syllabus. It should have been quite short and easy, but it required a little thought, as opposed to routine manipulation, and many candidates lost easy marks.

Q3: Random walk with steps of 0,1 and 2. Many good solutions but also many fragments. There was some confusion about finding first that $E[T_1] = 1/(p - 2r)$ (implicitly assuming that the expectation is finite), then deducing that since the formula gives a finite answer, the expectation is finite and so we must have T_1 finite with probability 1.

Q4 Markov chain: Parts (a) and (b) were well done generally (though finding the stationary distribution (uniform) caused surprising grief). Part(b) was simply there to help with part (c) but this help was spurned by all but a handful, and almost all essentially repeated the calculations. Also, only 2 or 3 students said that the expected time to return to 1 is $1/(\pi_1) = 5$: again they did calculations.

a5: Statistics

Q5: This was the most popular of the Statistics questions (which were as usual less popular than the Probability). It was a straightforward question on what should have been familiar ground since Mods and it attracted a fair proportion of alphas.

Q6: This was an easy example of the GLRT but this is a difficult topic that should arguably be deferred to later in the course and there were relatively few good attempts. It required some arithmetic but this did not appear to upset a significant number of students.

Q7: The first part was fundamental bookwork, the last an attempt to make candidates use it in an interesting way. It required some understanding to do the arithmetic correctly; this was rather more challenging and relatively few of those who started pushed it through to an alpha.

Q8: This was new material to a5 and again it is arguable that it takes things too far. It attracted relatively few attempts, but a good proportion were alphas.

On the whole, this paper worked quite well.

a6: Classical Mechanics

Overall the candidates found this section hard. Questions two and three were of a standard form and attracted many good attempts, but they were nevertheless rather long and required calculational dexterity that only the best were endowed with. Nevertheless, there were a good number of alpha and beta attempts for these questions. Questions 1 and 4 were non-standard and only attracted fragmentary attempts; there were no alphas for either question.

Q1: 40% attempted this question with no alphas and about 12% of attempts getting a beta. The bookwork in this question was hard to get completely right by obtaining a completely explicit expression for $\ddot{q}^i$ in terms of q^i and $\dot{q}^i$. The rest was a non-standard question in which candidates were expected to perform the change of variables on the equation of motion, but most did so to the Lagrangian, which did not give the right answer.

Q2: A popular question with roughly half of all candidates attempting it, approx 20% getting alphas and 50% betas. The bookwork had been mostly well learnt and the most frequent problem was in the correct identification of the kinetic term of the Lagrangian (many/most candidates omitted the vertical translational part).

Q3: 60% of candidates attempted this, with 23% of those acquiring an alpha and 53% a beta. This was mostly a routine question, except that the correct identification of the Lagrangian was again a problem, particularly that of the potential energy contained in the elastic string.

Q4: 40% attempted this question with no one achieving an alpha and just 25% of attempts achieving a beta. The second piece of bookwork was non-standard with very few correct answers. The principal difficulty in the rest was in applying rotating frames (or some correct direct method) in order to obtain the Lagrangian in the first place and so the point of the question could not be arrived at.

a6: Fluid Mechanics

Q5: This question, which was concerned with radial flow in 3-D, was not popular and it produced very few complete, or even nearly complete answers. Not many candidates understood why the velocity potential has to have the form $f(t)/r + g(t)$ and not many could correctly write down the kinetic energy of the fluid as an integral.

Q6: A question on line-vortices and streamlines which produced many answers of good quality.

Q7: Nearly all who attempted this question were able to derive Blasius' formula for the net force on unit length of the cylinder. Further progress was often impeded by a lack of understanding of two areas of Complex Analysis, namely inverse points in relation to a circle and the calculus of residues.

Q8: The setter had attempted to lighten the formulae involved in the discussion of the propagation of surface waves by taking the fluid to have infinite depth. Nonetheless many candidates had evidently met the case of finite depth h in lectures or textbooks and they insisted on treating that case first and then at the end taking limits as $h \to \infty$. All this made for answers more lengthy and complicated than they need have been. The discussion of particle paths was not always convincing.

b1: Set Theory

All four questions worked successfully, producing a very wide spread of marks. The top 10% of candidates performed extremely well, showing an excellent grasp of the content and methodology of the course. The weakest 10% by contrast showed lack of knowledge of even the most basic facts, notwithstanding plenty of opportunity to display this, and some of these students wrote answers which were hyper-naive. A substantial number of candidates, even some who otherwise performed well, were careless over important details, in particular omitting to state that sets were non-empty where this was obviously necessary.

Q1: Very popular and a good discriminator.

Q2: Also very popular. Only (b) and (c) of the bookwork parts caused any major difficulties. Most solved the last part successfully; a few used, unwittingly, a [ZFC] result.

Q3: Candidates had either learned accurately some proof of the core bookwork or appeared totally unaware it was bookwork and wrote screeds of nonsense. The last part discriminated well.

Q4: A few sought cheap marks for definitions only. Otherwise most attempts were creditable, with quite a number of candidates making a good stab at the last part, which demanded mastery of harder parts of the course.

Mathematics & Philosophy: It was striking, and disappointing, that the Maths/Phil candidates performed significantly less well in general than the mathematicians.

b1: Logic and Further Logic

As always the candidates concentrated their efforts on Questions 6 and 7, although I had attempted to make the questions on the later part of the course equally accessible. I thought that the overall quality of the answers was good. There were good answers from candidates in all the Honour Schools. I was surprised that there were candidates in the FHS of Mathematics & Philosophy who attempted no logic questions.

Q5 Computability: Very few attempts, of varying quality.

Q6 Propositional Lagrange Valuations: A very popular question. The last part was not well done; many got the idea that they were to manipulate the DNF using the results established in (ii), but couldn't write it out properly. As to the answers, many tried to give the same answer as last year, and some asserted that every formula was expressible with only $\rightarrow$ and $\wedge$. I accepted $\sum_{k=0}^{n}\binom{n}{k}$ as the answer to part (iii).

Q7 Propositional Calculus: There is a spurious initial "(" in the scheme $(L2)$ for which I apologise. The candidates found the parts (i)–(iii) straightforward. The last part depends more crucially on how it is approached than I had realised. Those who fared best asserted that the proof of the DT is a re-write procedure, checked that the number of replacement lines never exceeded 5, and were home. A few set up careful inductions. Most tried to argue by induction; I gave most credit to those who noticed that one couldn't be too simplistic, even if they didn't get it technically correct.

I don't think it's a problem that many scored high marks: they showed they understood and could handle a key part of the subject. One negative comment: a small minority of the Maths & Philosophy and Maths & Computer Science candidates showed they were unable to distinguish 'proof' from 'truth'.

Q8 First Order Lagrange Models: There is a random "{" at the end of θ_5 for which I apologise. Most of those who attempted this got somewhere. Despite the clear instruction in part (i) many candidates wasted time in telling me what the answer would have been to different questions.

Most answers for part (ii) were presented as more or less random occurrences of $\theta_i \models \theta_j$ on the page. Only one candidate set out a 6×6 table. I accepted minimal explanation, but very few dealt with all cases.

One candidate who asserted that (iii)(a) is ambiguous offered two answers; I gave full credit for the correct one. Another candidate must also have misunderstood the question, and wrote down the ZF Axioms, and tried to add sentences to ensure the objects were of size n. I think that the question is phrased in the traditional way, and can't in fact bear the meaning the candidate gave it.

Q9 Predicate Calculus: For most who tried this it was either the last resort, or an attempt to acquire a few more marks. I did not think 'By the Soundness Theorem' is a satisfactory answer to (i)(a); nor did most candidates. But I wish I had reversed (a) and (b). Part (ii)(a) was set so as to flush out the notation being used by the candidates: almost all answers were defective, not restricting the use of Gen either in the notation or the statement of the Deduction theorem. One or two carried out a careful analysis for (ii)(d).

b2: Algebraic Structures

Q1: The majority (nearly 90 %) of students attempted this question. Good results were generally obtained, with three quarters of students winning an α or β. Most students dealt competently with the bookwork parts of this question. However the final parts, involving calculation, were successful in differentiating the better candidates.

Q2: Fewer than half of students attempted this question and generally low marks were obtained; over 70% of attempts failed to score a β. In retrospect it is clear that these poor results are due to the excessive length of the question.

Q3: This question again attracted less than half the students. Marks were lower than expected due to a lack of familiarity with the specific subject matter, a result of disruptions to the course lectures this year. The results were fairly uniform with half of students scoring above β and half scoring below.

Q4: Less than a third of students attempted this question. This would be because teaching concentrated on the application of Smith Normal Form whereas the question concentrated on the theory. (The lecturer was different from the setter). Again results were uniform with half the students above a β and half below.

b2: Finite Groups and Galois Theory

Q5: This question attracted quite a large number of attempts but candidates found everything after the first two parts very difficult. Most attempts included a satisfactory proof of Cauchy's Theorem.

Q6: This was a popular question and there were a number of good answers. There were still a surprising number of errors made by candidates when calculating the degrees of splitting fields.

Q7: A reasonable number of good attempts at this question; when answering the last part of the question, candidates often lost their way in setting out the different parts that had to be proved and overlooked a part.

Q8: It was not a popular question and those who attempted it found it surprisingly difficult. It is obvious that even those specialising in Algebra find calculation in finite fields difficult.

b3: Geometry of Surfaces

Q1 Topology of Surfaces: This, as usual, was the most popular question, though some candidates were thrown by the inclusion of the Gauss map and its relationship with orientability.

Q2 Geodesics: Many candidates appear to have been put off by the apparent length and unfamiliarity of this question, but of the four serious attempts two were near perfect and two were beta quality.

Q3 Gauss-Bonnet: This question was straightforward and mostly very well done.

Q4 Hyperbolic plane: This question was all either bookwork or seen in problem sheets, but it was a long question and there were only two serious attempts.

In general these questions were rather long, and appeared even longer than they were (especially questions 2 and 4). However they were well answered in nearly all cases.

b3: Projective Geometry

There were 16 candidates, 2 of whom returned empty cover sheets.

Q5 Pappus/general position: was popular with 10 attempts and 7 alphas. The bookwork was done well. One or two candidates got into trouble with the calculations of (ii), and a few failed adequately to treat the degenerate (i.e. non-general position) case in (iii). Most candidates seemed comfortable with the use of projective invariance/general position ideas to reduce the generic case of the theorem to the calculation in (ii).

Q6 Quadrics: This proved the least popular question, with 6 attempts and only one alpha. Several candidates omitted to say that a quadric was defined by a SYMMETRIC bilinear form. General position arguments were applied well in (ii). Part (iii) was not well done, although one candidate got a perfect score.

Q7 Klein correspondence: This was fairly popular with 8 attempts and 3 alphas (there were also some high betas). Several candidates were too sketchy in their discussion of the Klein map. Some did not show it was well-defined and many failed to show injectivity. Part (ii) was reasonably well done, but only a few candidates managed (iii)

Q8 Cross-ratio: This had 7 attempts and only one alpha. The bookwork was fairly well done, but only one candidate solved (iii), despite the hint and the fact that the calculation was short. Possibly the appearance of a differential equation put people off.

b4: Banach Spaces

Q1: This was reasonably popular and produced a fair spread of marks. Some solutions were unnecessarily long (generally because of a failure to see how to use the operator S in part (ii)).

Q2: This question started with an entirely standard density theorem and application. This was done well by all who attempted it. Many also got the idea that the last bit was about "unbounded norms" even if they failed to sort out the details perfectly.

Q3: This question was quite similar to something that occurred on a problem sheet and was well handled.

Q4: Questions about the spectrum have proved unpopular in recent years. This one seems to have been sufficiently accessible to attract a good number of attempts with a high success rate.

b4: Hilbert Spaces

General Comments. Forty-three candidates sat the paper, a substantial increase upon the previous year. Every question attracted a reasonable number of attempts, question five being the most popular. The standard of work produced was high, an indication that this option is chosen by the most able candidates. Indeed, thirty-eight of the candidates were either MMath or Mathematics and Philosophy undergraduates.

Q5: This question was very well done and produced few difficulties for those attempting the question. Of the thirty-six attempts there were twenty alphas and eight betas. A common mistake in the proof of the Cauchy-Schwarz inequality was that of not considering the case when one of the elements is equal to zero.

Q6: This question produced twenty-four attempts, of which eight were of alpha standard and eight of beta standard. There were many reasonable attempts at the first part of the question. However, a common mistake was the failure to give a proper proof that the mapping $f \mapsto y_f$ is surjective. There were fewer attempts to the last part of the question and of these many did not prove uniqueness of the norm-preserving extension. This is the trickiest part of the problem, the existence of the extension being guaranteed by the Hahn-Banach Theorem, or, more easily, directly from the formula.

Q7: This question produced twenty-one attempts, eleven of which were alphas and four of which were betas. Some candidates thought that condition (ii) was the definition of maximality of an orthonormal set and hence that (i) and (ii) provided a tautology. The definition of maximality of an orthonormal set is that of not being contained in a larger orthonormal set. Whilst the equivalence of (i) and (ii) is very easy to prove, they are not quite the same statement. This omission only carried a very small penalty. Possibly guided by question five a gratifying number of candidates chose the correct function to provide the solution to the last part of the question. One candidate chose a completely different function that led to the result required.

Q8: This question produced twenty-one attempts, eleven of which scored alpha marks and eight of which scored beta marks. Common omissions were the proof of boundedness of the mapping $x \mapsto \langle Tx, y\rangle$ and the proof that $\|T\| = \sup\{|\langle Tx, y\rangle| : \|x\| \leq 1, \|y\| \leq 1\}$.

b5: Integral and Differential equations

Q1: This question on Schmidt's solution of an inhomogeneous integral equation with symmetric kernel produced many good answers. Some mistakenly believed the kernel to be degenerate and went astray at the outset.

Q2: Candidates were asked to derive Euler's equation for the externals of a variational problem and to make a straightforward application of the theory. Failure to complete the question was often a consequence of being unable to write down correctly the area of the surface of revolution.

Q3: Many candidates produced good quality answers to this question about a singular Sturm-Liouville problem and Hermite Polynomials.

Q4: This was an easy question on plane autonomous systems (the Lotka-Volterra equations) and candidates would have seen much of it before. Not many managed to find the period of small oscillations about the critical point - something they ought to have been able to do had it been set as a problem in the first-year Dynamics course.

b5: Partial and Differential equations

Question 5 (Charpit's Methods) was answered by almost all candidates, with a typical mark of 18-22. The last part (graphical) was completed in very few cases, but the usual bookwork and simpler problem solving was done well. In contrast, questions 7 (on Green's functions) was attempted by (effectively) no-one, while questions 6 and 8 had nearly equal shares of answers, and were completed successfully to β level. Thus it appears that most candidates are choosing 2 PDE questions to work on, in conjunction with their ODE choices. The work on various Green's functions, and associated identities has proved a little too much for this second year course, while the solution methods by characteristics and similarity variables (using ODE's) remain popular and understood.

b6: Viscous Flow

In general the candidates did very well on these straightforward questions.

Q1: Most people handled the bookwork very well. I was disappointed more didn't get the final calculation right. It was not difficult.

Q2: The slightly unusual thing about this question was that the plate was at a shallow angle so that gravity appeared in both the x and y momentum equations. Nobody was fazed by this, presumably because the equations you were trying to derive were given in the question. There was a small typo in the question - the subscript y in the equation $p_y = 0$ should have been a capital. Nobody was confused by this.

Q3: Good answers in general. Nobody remembered to include an integral condition on the similarity solution, although many checked that it was compatible.

Q4: No problems with this question. Good answers in general.

b6: Waves and Compressible Flow

This half of the paper was not popular and 12 out of 25 candidates did not attempt any of these questions. The marks recorded on questions 5, 6 and 7 had a reasonable spread. For Q8, which was on work covered in the last 2 weeks of HT, there were only 3 attempts, none very successful.

b7: Quantum Theory

Q1: There were 44 out of 47 attempts to this question. The average mark was 17.6. Several excellent solutions and attempts. Almost all students that attempted this question did the bookwork correctly. The students also showed a good understanding of the matching conditions at the boundaries. Some students did not get the correct answer for the transmission coefficient, mainly due to algebraic mistakes in solving for the coefficients in the general solution of the Schroedinger's equations. Many failed to do correctly the last part of the problem, that is, to find the value of the transmission coefficient in the limit where the energy of the particle tends to the value of the potential.

Q2: This was not a very popular problem and there here were 20 out of 47 attempts to this question. The average mark was 9.2, which is low, considering that this problem was taken from the problem sheets. The expectation was that at least 10 marks would be obtained from the separation of variables procedure and stating properly the boundary conditions of the problem. However in many of the attempts the students got confused precisely here and therefore they were not able to continue to find the values for the energy.

Q3: There were 30 attempts out of 47 to this problem. The average mark was 16.6 and, as in problem 1, there were many excellent solutions. Some students had trouble showing that the eigenvalues of the number operator N were non-negative integers. In the last part of the problem, many students did not realize that they could find the wave function for the ground state readily from the fact the operator A on this state is zero, and instead tried to solve Schroedinger's equation.

Q4: There were 22 attempts to this problem and the average mark was 11.5. Most of the marks, around 10, were obtained from bookwork. Some attempts were good though with a few excellent solutions. Students were confused about the eigenvalues of the operator A, mainly not realizing that zero is also an eigenvalue. The last part of the problem, which was worth 9 marks, was attempted by only a handful of students.

b7: Relativity and Electromagnetism

There were 47 candidates entered for this paper in the three schools. Of these, 14 returned empty cover sheets for this section and a further 11 attempted only one question. Since the questionnaires at the time I gave the course gave no sign of major dissatisfaction, I think this is a sign of the Michaelmas vs. Hilary effect, combined with a belief that the quantum mechanics questions are easier. I set the questions following the pattern which had become standard.

Q5: The Lorentz transformation question, with a rider which was easy for those who understand the subject. More than half the candidates attempted this one. There were three essentially perfect answers, another alpha and ten betas so that it was not a hard question.

Q6: A question on the hyperbolic world-line, which was treated in lectures and appeared on the problem sheets. Fewer attempts but again three essentially perfect answers and three more alphas. Again, an easy question for those who revised this material.

Q7: A conservation of 4-momentum question, precisely this situation was treated in lectures, with a slightly different last line. With 27 attempts, this was the most popular question, possibly because it was familiar in appearance. However scoring was lower as many didn't use the key idea (solve in centre-of-mass frame and then transform to laboratory frame).

Q8: The electromagnetism question, which is always unpopular. This one was very close to a question on the problem sheets but still only attracted one attempt.

b8: Statistics

This paper was set in two parts but marked as a whole. The first four questions were much the most popular, the last three attracting attempts by only 4 candidates (out of 26 in DMAT and DMAS).

The failure of questions 5-7 to attract attempts needs to be addressed by the Sub-Faculty. It may result from the timing of the second part of the course, or the more advanced character of the material examined, much of which arguably belongs more properly in a postgraduate course. One feature of the material is that inevitably the questions require more discursive answers. Given these difficulties, the questions themselves looked fair and reasonable.

From the Examiners' point of view, the popularity and approachability of the first four questions meant that there should be no difficulty in adjudicating on this paper. The questions were, however, rather obviously highly related to class-work; the question on GLM's in particular was clearly done largely from memory (including an inevitable and telling error) and it is arguable that this material - which used to appear in Section c - is too advanced for this course.

Q1 Rejection method: This was a popular question, but quite tricky. A surprising number of candidates made a good start, presumably because they had seen this approach before. Few got out the last, rather difficult, part at the end, though there were a few muddled answers suggesting that they had seen something very similar.

Q2 Linear model: The most popular and straightforward question, albeit with rather heavy algebra that prevented most candidates from getting it out completely (though it was leniently marked in this respect.)

Q3 GLM: Absolutely standard bookwork throughout. Virtually no candidate defined a canonical link correctly. In apparently uncomprehending reproduction of mathematics, mistakes were penalised and, although there were 19 attempts, only two candidates obtained alphas.

Q4 ANOVA and residuals: The first half is fairly straightforward algebra and arithmetic, testing understanding of ANOVA. The rest is fairly qualitative and requires reproduction of standard qualitative information on residuals. Popular, with 21 attempts, but not scoring high marks, with only 2 alphas.

Q5 Non-parametric tests: Only 3 attempts with one alpha. Much of the underlying mathematics of this topic is off-limits in an undergraduate course and it is very hard to set an exam question at this level that is reasonably mathematical.

Q6 Robust estimation: An even more chatty question attempted by only two candidates, neither of whom got even a beta.

Q7 Non-parametric smoothing: It is possible to cover some interesting mathematics for this topic, but in fact the question was fairly qualitative and undemanding. It was attempted by only two candidates, one of whom managed a beta.

The Practical projects were inspected: they were well designed and carefully marked and a lot of work for the students (quite disproportionate to one eighth of the paper). The marks were high - as is usual in practical work. They were nevertheless well deserved.

b10: A Elementary Number Theory

About 25 alphas out of about 70 attempts - a rather higher proportion than in past years perhaps. All 4 questions were popular, and all 4 attracted a good number of good answers. The "tail" of candidates seems to have been smaller than in the recent past, but nonetheless the questions had enough harder material to discriminate at the top end.

b10: B Mathematical Ecology & Ecology

The fact that candidates no longer are at ease with algebraic manipulation and curve sketching had an overall impact here because they chose some very long-winded ways to do questions and therefore penalised themselves time-wise.

B1: Some very poor attempts to sketch curves. In part (iv) a number of candidates really struggled to solve a simple difference equation.

B2: No one did the stability correctly for part (i). Only one person showed properly that there was a threshold effect and sketched u and v as functions of t. No-one got the long time dynamics.

B3: Well done in general, although some candidates went to enormous trouble to show that W was equivalent to 1, when they could simply substitute that value into the equation for W (which virtually everybody got). Most struggled with the phase plane at the end.

B4: Few attempts at this question. Some candidates had real difficulty with non-dimensionalisation. A number of candidates quoted the conditions for diffusion-driven instability in a Turing system for part (v) but this is not a Turing system.

b10: C Non-Linear Systems

C1 Bifurcation analysis of a 3rd order system: Some candidates did the bookwork for a 2nd order, instead of a 3rd order system; most got the equilibria; most got the pitchfork bifurcation. Only 1 or 2 candidates looked for Hopf bifurcations for all 3 equilibria. Some errors in the derivations of the cubic characteristic equations had consequences for the stability curve calculations and the frequencies; in lectures, we had gone through the equivalent analysis for the Lorenz equations.

C2 Normal form for an example with a Hopf bifurcation: Bookwork was well answered; derivation of the transformed equations was well answered, although some candidates forgot to transform the nonlinear term. Application of bookwork to remove the non-resonant terms was well answered. One candidate did the Centre Manifold reduction of the system, instead of the Normal Form reduction.

C3 Nonlinear cubic map example: Bookwork was well answered; nearly all the candidates found the fixed points, analysed their stabilities and identified the bifurcations correctly. Some failed to get the subcritical bifurcation for $\beta < 0$; few candidates obtained the period 2 cycle equation, even though a verification would have been acceptable. Most candidates identified which were the period 2 cycles, but no-one got the stability range for the more complicated pair.

C4 Multiple scales example: The least popular equation. One candidate used the Poincare-Lindstedt method, instead of what the question asked for. First part, identifying a Hopf bifurcation, was well answered as was the derivation of the hierarchy of problems. Derivation of the secular term removal, caused algebraic difficulties. Consequently, few candidates reached the end of the question.

b10: D Communication Theory

D1: Most of the 16 attempts at this question were quite good, some half a dozen very good. Few tailored the syndrome decoding algorithm as recalled in its general outline to the specific code given in the question (the binary Hamming code), and, likewise, few calculated the probability of correct decoding of a word explicitly in (iii) and (iv), only quoting a general remembered result from which the answer might have been found.

D2: This must have appeared to be a difficult question for there were only 11 attempts, and most of these half-hearted, 9 marks being the unhappy mean. All answers ground to a halt by the time part (iii) was reached, some four succeeding in an honourable performance up to the end of (ii). It is uncertain whether part (iii) was the most off-putting (despite its possibly helpful hint), or whether a struggle with parts (i) and (ii) led to exhaustion upon reaching (iii).

D3: Part (i) was straightforward bookwork, well done. Part (ii) should have been easy but caused trouble. Part (iii) was rather hard, and needed the answer to (ii) (namely $H = H' + p_z H(q)$): it would have been better to give this result and ask the students to prove it. The last part was an easy application of part (iii).

D4: Channel capacities. This was rather hard, and attracted few attempts.

b10: E Applied Probability

I am impressed by students' performance in b10 Applied Probability There was a high number of empty cover sheets for the Mathematical Sciences candidates (8 out of 15), and all 4 Mathematics and Philosophy cover sheets were empty, too. Also, the discrepancy between Mathematical Sciences and Part I candidates is high, about 4 marks on average (14.2 vs. 18.1). One candidate scored 87 marks (2 alphas and 2 very good betas).

E1: This was a popular question with many excellent answers. A few students did not remember the trick of splitting the population in two independent parts, for part (iii), despite the hint, and some couldn't do the calculus for part (iv).

E2: This was another popular question with many very good answers. Some students had not learned the bookwork for part (i). The last part only found very few correct answers, but some reasonable attempts.

E3: This was an unpopular question, clearly because renewal theory was new on the syllabus with no old exam questions available. Two students collected a few marks for quoting a theorem in part (i). Two other attempts led to good and very good answers to all parts.

E4: This was another popular question with most answers scoring alphas or high betas. A mistake in the last formula caused some surprise, but apparently little confusion. That part was not completed by many candidates, but for different reasons (not remembering the pdf of a gamma variable or not applying Tonelli's theorem, or alternatively not realising that they could have used mgf methods not requiring the gamma pdf).

b10: F Combinatorial Optimisation

F1 Scheduling, Moore's algorithm: Parts (a) and (b) were well done. Part (c) was bookwork but not well done.

F2 General matchings: Quite easy for good students, but the example seemed to sort out those who did not fully understand the method.

F3 Bipartite matchings, matroids: Part (a) was straightforward. There were few good attempts at parts (b) or (c).

F4 Minimum cost flows: Mainly bookwork but not popular.

b10: G Stochastic Processes

The candidates did well this year. The average mark was 17, and there was a good proportion of well-answered questions, demonstrating a good understanding of the important ideas. As usual, the "Time Series" question was relatively unpopular, being very much an "outlier" in the syllabus.

o10: Mathematical Models of Financial Derivatives

This year the questions were generally well done. The question with the most alphas was question 1 but the highest percentage of alphas was on question 4. There was at least one attempt worth full marks on each question. As usual there were a number of candidates who had not grasped the most basic ideas in the course and performed poorly on these questions.

Q1: This question was well done in general and produced a lot of alphas. Most candidates could solve the basic SDE and could make some progress with the calculation of probabilities and the put price. A number of people did not read the question carefully enough and computed the put price incorrectly. Those that really struggled appeared to have a poor grasp of basic probability. The final part was not well done, with few realising the implications of the two results obtained earlier.

Q2: This question came in two parts. Many were able to do the first binomial model part and could correctly derive the Black–Scholes PDE in this setting. The final part proved tricky, with most not seeming to realise that if the instalments were cancelled then the option value was 0. This meant that there were a lot of high beta scores.

Q3: This question was mostly a standard barrier options question. Many people struggled to show that the reflected solution satisfied the Black–Scholes equation. After that it was bookwork with a slight twist in the tail.

Q4: Not many attempted this question but those who tried it generally did well, with 50% gaining an alpha. The forward start option was standard but the other two put-call parity results were new. With the hints these unseen parts were not found to be too hard.

o10: Decision Mathematics

Candidates found the 2003 questions on this subject difficult, so there was a concerted effort to make the questions easier this year. Candidates did seem to find this year's questions easier: there were lots of attempts; most of these were reasonably successful, and there were plenty of very good answers.

Q5: This was the most popular question and most attempts got at least half marks. Several attempts got full marks, and plenty of others scored highly.

Q6: This was a standard type of question. Most candidates who attempted it knew how to go about it, and marks were generally high.

Q7: This was also a fairly standard type of question and was reasonably popular. However few candidates took sufficient care with the proofs required and relatively few attempts got good marks.

Q8: Most attempts at the interchange argument were successful, and most who tried the second part of the question were able to get somewhere with it.

o11: Introduction to Mathematical Modelling

Q1: This question was fine. Only one correct last part.

Q2: This was fine.

Q3: This was O.K.

Q4: This was O.K., arguably a bit easy, although algebraically challenging.

o2: Extended Essay

Seven candidates took this paper; this was down on last year. There was some cause for concern over the variable standards of the essays submitted. This resulted partly from the variable suitability of the topics. The essays also proved difficult to mark, with most requiring significant reconciliation.

o11: Mathematical Modelling Case Studies

The vast majority of answers to these fairly simple questions were very good. Overlaps are inevitable in Case Studies and the marker has twice given credit for one question when the work was contained in the answer to the other question (asterisked on mark sheets). Question 5 contained 2 small and obvious misprints but no candidate was upset by them – they either didn't notice or corrected them. Misprints:
1) First equation, second term on RHS should have $\overline{T}_s$ not T_s.
2) Last equation, last term on RHS should have $\overline{T}_g$ not $\overline{T}_s$.

o13: Actuarial Science

Students' performance in o13 Actuarial Science has improved on last year's, but not as much as I would have expected, given that the questions were (meant to be) easier and shorter. Some students haven't even understood the very basics and only learnt to apply some methods, if any. Others are too selective in what they prepare. They are confounded by bringing inflation in a fund setting, and default with taxation. The very low scores pull the means downwards in Q2 and Q3. Ignoring scores 0-2, their means are 14 or higher.

Q1: This was the least popular question, rather long, but based on the first few lectures only. Surprisingly, many of those who attempted it did not get much further than part (ii) and nobody solved part (vi). Taking out part (vi), there were three very good answers, though.

Q2: This was mostly a standard question on funds, very popular with many good answers. Some students had gaps on the inflation part, and the last part required some thinking. Many students lost marks on the interpretation or explanation of results.

Q3: This was a standard question on taxation attracting some very good answers. Again, a non-negligible number of students did not get further than (ii)(a), and again the last parts required some thinking, with disappointingly few answers.

Q4: was the life assurance question and, as last year, it was not a popular question. However, more students attempted it this year and several made good attempts. Part (ii) was clearly a problem and only one student successfully answered it. One other student started out on the right track but everyone else was completely confused by it.

Q5: was generally very well done and there were many alpha scripts. Having seen some scripts and looking again at the wording of part (ii), I realise that it is equivocal: it does not specify to what the 3% refers. The model solution and most of the scripts took it to mean 3% of the 100 redemption price. However, some scripts took it as 3% of the purchase price of 95. People who adopted this latter position were not penalised. Part (viii) was not well done on the whole. Many people trotted out the bookwork without applying it to the question.

Q6: was also well done. Again quite a number did not really answer the question in parts (i) and (ii) – trotting out bookwork without covering the "how" and "why" parts of the question. Some students gave a more elegant solution to part (v) than in the model solution.

o14: History of Mathematics

o14 Hilary Term miniproject: Complex numbers

Seven students attended this course and wrote the project. Writing styles were very variable, most passable, one very good. Use of sources and evidence was also very variable. Only one candidate showed much originality. Others relied mainly on one main source, supplemented with notes and comments from other sources. Only two candidates understood the connection between the 'real' and 'complex' versions of the Fundamental Theorem of Algebra. Only one of these offered a passable proof.

o14 Hilary Term miniproject: Fermat's Little Theorem

Four students attended this course and wrote the project. Again, writing styles were variable. One candidate showed little knowledge of grammar. Another's style was very obscure. Three of the four essays were more about the mathematics than its history. Two candidates presented material from the web (mainly—a little from books) that was far beyond their comprehension. Only one candidate made a serious attempt to answer a historical question by evaluating the evidence.

o14 Trinity Term written paper: Two Extracts (worth 25 marks each)

Eleven candidates took the 2-hour written paper. Three produced first class papers. Sadly, two of these had performed less well on their miniprojects. The overall standard was encouraging and showed that all the candidates had really learned something. Nevertheless, some were not fully in command of facts; others not fully in command of context and significance.

Q1: Extract from Newton's *Principia* 1687: Five answers; mark range 12–19. The five responses were all very different. The main error was the assertion that Newton required the inverse square law of force whereas in fact only a general centripetal force is required.

Q2: Extract from Berkeley's criticism of Newton 1734: Nine answers; mark range 10–23. This was by far the most popular question. Several candidates lost marks by being rather vague in their treatments of responses to Berkeley's criticism.

Q3: Extract from Lagrange on equations 1770: Four answers; mark range 11–22. One good answer.

Q4: Cauchy on definition of continuity 1821: One answer.

Q5: Cayley on Cayley–Hamilton theorem 1845: Two answers.

Q6: Jourdain 1915 on Cantor 1874: One answer. A disappointing response since this was a subject the students should have been able to address well.

o14 Trinity Term written paper: Essays (worth 50 marks)

Again the overall standard was encouraging and confirmed both that the students had learned some non-trivial history of mathematics and that most could structure an essay competently.

Q7: Transition from geometry to algebra *c.* 1600–1720: Two answers.

Q8: Euler's contribution to at least two topics: One answer.

Q9: Developments in probability 1713–1812: Two answers.

Q10: Changing standards of proof 17th–19th centuries: Six answers; mark range 19–35. Although several candidates gave attractive descriptions of changing standards of proof, and some gave quite good examples, none treated their examples in the detail that the examiners were hoping to see.

In general, and to our slight surprise, we felt that the standards achieved on the written paper were higher than on the miniproject. This was perhaps because in researching the miniproject candidates overloaded themselves with information that they could not properly digest, whereas writing from memory and their own understanding, they did rather better.

F EXAMINERS AND ASSESSORS

Examiners:

C J K Batty, J F Bithell (Chairman), W A Day, G L Luke (*vice* Batty in the Trinity Term), M A H MacCallum (External), L J Mason, D G Quillen, J Rawnsley (External), M R Vaughan-Lee.

Assessors: (for papers under the aegis of the Department of Mathematics):

P Clark, S J Chapman, P J Clifford, A Dancer, X de la Ossa, C M Edwards, R Flood, A C Fowler, A Goodall, B M Hambly, R Haydon, D R Heath-Brown, F C Kirwan, N Laws, A D Lunn, C J H McDiarmid, P K Maini, I Moroz, P Neumann, J Norbury, H Ockendon, J R Ockendon, H Priestley, J Stedall, W B Stewart, D R Stirzaker, G Stoy, P Tod.

Assessors: (for o2 essays):

R J Wilson, M Winkel, J Hein, T Browning, I Sobey, D Acheson, G McVean, A Wilkie, A Wathen.