Examiners' Report: Final Honour School of Mathematics Part C Trinity Term 2016

October 20, 2016

Part I

A. STATISTICS

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

  See Table 1, page 1.

- **Numbers of vivas and effects of vivas on classes of result.**
  As in previous years there were no vivas conducted for the FHS of Mathematics Part C.

- **Marking of scripts.**
  The dissertations and mini-projects were double marked. The remaining scripts were all single marked according to a pre-agreed marking scheme which was very closely adhered to. For details of the extensive checking process, see Part II, Section A.

- **Numbers taking each paper.**
  See Table 7 on page 8.

Table 1: Numbers in each class

	Number					Percentages %				
	2016	(2015)	(2014)	(2013)	(2012)	2016	(2015)	(2014)	(2013)	(2012)
I	44	(45)	(45)	(56)	(45)	50.57	(46.39)	(45.92)	(47.46)	(45.45)
II.1	31	(39)	(42)	(41)	(36)	35.63	(40.21)	(42.86)	(34.75)	(36.36)
II.2	9	(13)	(11)	(15)	(15)	10.34	(13.4)	(11.22)	(12.71)	(15.15)
III	3	(0)	(0)	(4)	(3)	3.45	(0)	(0)	(3.39)	(3.03)
F	0	(0)	(0)	(2)	(0)	0	(0)	(0)	(1.69)	(0)
Total	87	(97)	(98)	(118)	(99)	100	(100)	(100)	(100)	(100)
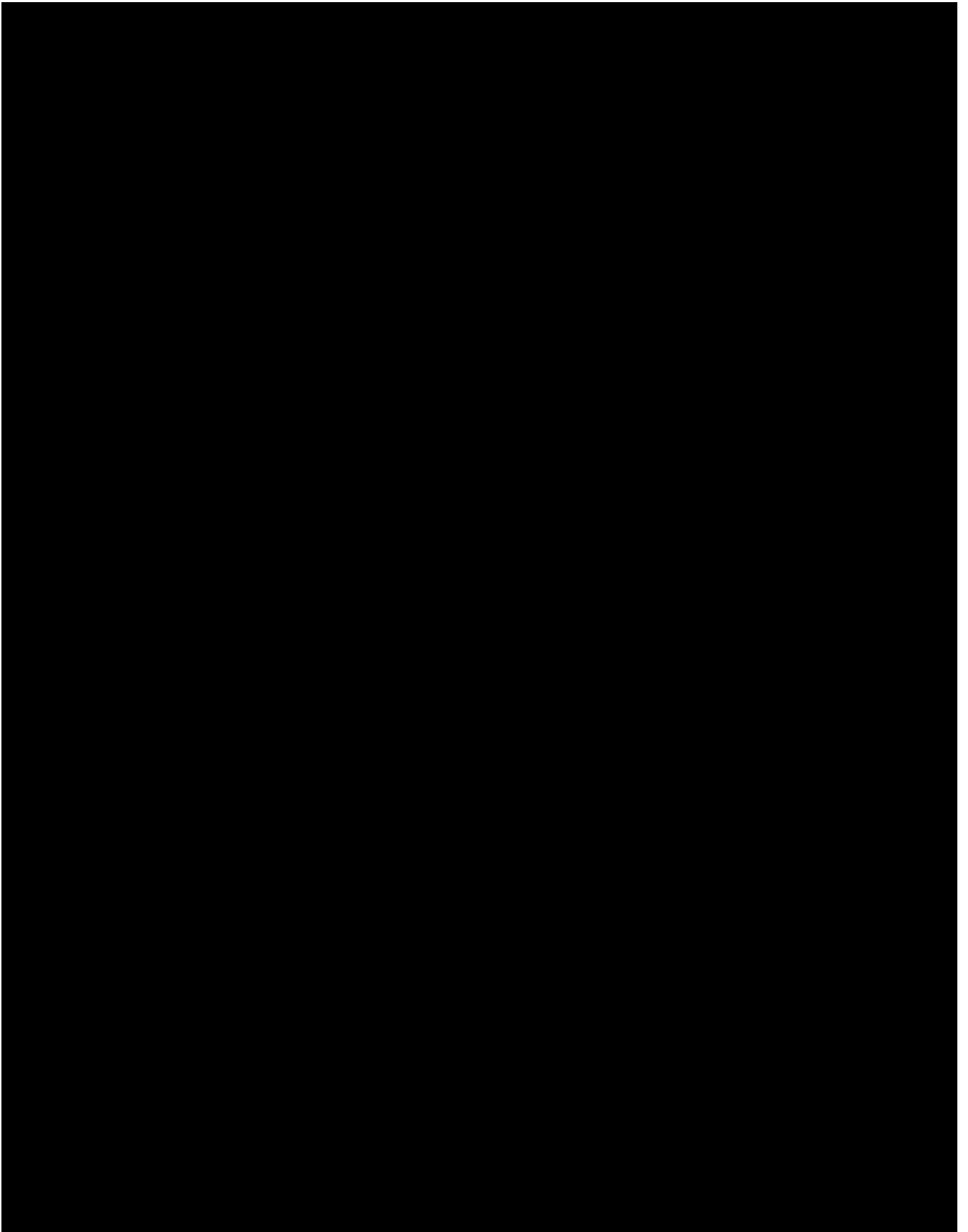
Determination of University Standardised Marks

The Mathematics Teaching Committee issued each examination board with broad guidelines on the proportion of candidates that might be expected in each class. This was based on the average in each class over the last four years, together with recent historic data for Part C, the MPLS Divisional averages, and the distribution of classifications achieved by the same group of students at Part B.

The examiners followed established practice in determining the University standardised marks (USMs) reported to candidates. This leads to classifications awarded at Part C broadly reflecting the overall distribution of classifications which had been achieved the previous year by the same students.

We outline the principles of the calibration method.

The Department's algorithm to assign USMs in Part C was used in the same way as last year for each unit assessed by means of a traditional written examination. Papers for which USMs are directly assigned by the markers or provided by another board of examiners are excluded from consideration. Calibration uses data on the Part B classification of candidates in Mathematics and Mathematics & Statistics (Mathematics & Computer Science and Mathematics & Philosophy students are excluded at this stage). Working with the data for this population, numbers N_1, N_2 and N_3 are first computed for each paper: N_1, N_2 and N_3 are, respectively, the number of candidates taking the paper who achieved in Part B overall

average USMs in the ranges $[70, 100]$, $[60, 69]$ and $[0, 59]$, respectively.

The algorithm converts raw marks to USMs for each paper separately (in each case, the raw marks are initially out of 50, but are scaled to marks out of 100). For each paper, the algorithm sets up a map $R \rightarrow U$ (R = raw, U = USM) which is piecewise linear. The graph of the map consists of four line segments: by default these join the points $(100, 100)$, $P_1 = (C_1, 72)$, $P_2 = (C_2, 57)$, $P_3 = (C_3, 37)$, and $(0, 0)$. The values of C_1 and C_2 are set by the requirement that the proportion of I and II.1 candidates in Part B, as given by N_1 and N_2, is the same as the I and II.1 proportion of USMs achieved on the paper. The value of C_3 is set by the requirement that $P_2 P_3$ continued would intersect the U axis at $U_0 = 10$. Here the default choice of *corners* is given by U-values of 72, 57 and 37 to avoid distorting nonlinearity at the class borderlines.

The results of the algorithm with the default settings of the parameters provide the starting point for the determination of USMs. The examiners have scope to make changes, usually by adjusting the position of the corner points P_1, P_2, P_3 by hand, so as to alter the map raw $\rightarrow$ USM, to remedy any perceived unfairness introduced by the algorithm, in particular in cases where the number of candidates is small. They also have the option to introduce additional corners.

Table 2 on page 5 gives the final positions of the corners of the piecewise linear maps used to determine USMs from raw marks. For each paper, P_1, P_2, P_3 are the (possibly adjusted) positions of the corners above, which together with the end points $(100, 100)$ and $(0, 0)$ determine the piecewise linear map raw $\rightarrow$ USM. The entries N_1, N_2, N_3 give the number of incoming firsts, II.1s, and II.2s and below respectively from Part B for that paper, which are used by the algorithm to determine the positions of P_1, P_2, P_3.

Following customary practice, a preliminary, non-plenary, meeting of examiners was held two days ahead of the plenary examiners' meeting to assess the results produced by the algorithm alongside the reports from assessors. Adjustments were made to the default settings as appropriate, paying particular attention to borderlines and to raw marks which were either very high or very low. These revised USM maps provided the starting point for a review of the scalings, paper by paper, by the full board of examiners.

Table 2: Position of corners of piecewise linear function

Paper	P_1	P_2	P_3	Additional corners	N_1	N_2	N_3
C1.1	(14.59,37)	(25.4,57)	(43.4,72)		4	4	3
C1.2	(12.24,37)	(21.3,57)	(33,72)		3	4	2
C1.3	(8.96,37)	(15.6,57)	(27.6,72)		9	8	2
C1.4	(9.77,37)	(17,57)	(32,72)		5	9	3
C2.1	(13.04,37)	(22.74,57)	(33.5,72)		8	0	1
C2.2	(9.77,37)	(17,57)	(32,72)		9	5	1
C2.3	(18.79,37)	(33,70)			3	0	0
C2.4	(8,37)	(17,57)	(25,72)		2	3	0
C2.5	(16.49,37)	(28,57)	(39,72)		5	0	0
C2.6	(21.37,37)	(33,57)	(45,70)		4	2	0
C2.7	(7.7,37)	(19,57)	(35.5,72)		8	6	1
C3.1	(11.55,37)	(20.1,57)	(28,72)		5	4	0
C3.2	(9.59,37)	(17,57)	(29,72)		5	0	0
C3.3	(14.42,37)	(20,57)	(33,72)		5	2	0
C3.4	(11.89,37)	(27,57)	(37.2,72)		7	7	0
C3.5	(10,37)	(23,57)	(35.4,72)		3	1	1
C3.6	(14.99,37)	(26.5,57)	(41,72)		4	7	0
C3.7	(12,37)	(24,57)	(37,72)		8	9	1
C3.8	(10.34,37)	(24,57)	(34,72)		7	11	1
C4.1	(6.32,37)	(22,57)	(36,72)		7	9	1
C4.2	(8.5,37)	(19,57)	(30,72)		5	7	0
C4.3	(6.15,37)	(20,57)	(30,72)		4	3	0
C4.4	(11.32,37)	(22,57)	(30,72)		3	0	0
C4.5	(10.57,37)	(23,57)	(36.4.72)		4	6	0
C4.6					3	0	0
C4.7					1	2	0
C5.1	(15,37)	(29,57)	(40,70)		2	14	0
C5.2	(8,37)	(25,57)	(36,72)		5	12	0
C5.3	(10.51,37)	(18.3,57)	(32,72)		1	4	0
C5.4	(23,37)	(56,57)	(70,72)		7	9	1
C5.5	(8,37)	(21,57)	(35,72)		7	16	1
C5.6	(11.6,37)	(22,57)	(31,72)		7	6	0
C5.7	(10.4,37)	(19,57)	(37.6,72)		6	10	0
C5.9	(10,37)	(22,57)	(36,72)		1	7	0
C5.11	(12,37)	(19,57)	(35,72)		2	7	0
C5.12	(12.29,37)	(23,57)	(36,72)		4	16	2
C6.1	(8.67,37)	(25,57)	(39,72)		2	9	3
C6.2	(10.46,37)	(21,57)	(36,72)		2	10	3
C6.3	(17,37)	(27,57)	(40,70)		1	11	4

Paper	P_1	P_2	P_3	Additional corners	N_1	N_2	N_3
C6.4	(17.41,37)	(31,57)	(40,70)		6	13	4
C7.3	(13,37)	(23.8,57)	(36,72)		1	4	0
C7.4	(18.44,37)	(32.1,57)	(40,70)		0	6	1
C7.5	(16.09,37)	(30,57)	(39,72)		1	3	0
C7.6	(13.44,37)	(25,57)	(37,72)		1	3	0
C8.1	(16.2,37)	(28.2,57)	(37.2,72)		7	3	0
C8.2	(13,37)	(22,57)	(35,72)		6	2	0
C8.3	(12.52,37)	(25,57)	(40,70)		13	17	4
C8.4	(10.23,37)	(22,57)	(38,72)		14	13	5
SC1	(14.25,37)	(26,57)	(40,70)		9	13	1
SC2	(10.91,37)	(23,57)	(42,72)		4	15	2
SC3	(11.2,37)	(23,57)	(32,72)		1	5	0
SC4	(10.91,37)	(21,57)	(30,72)		3	13	3
SC5	(7.58,37)	(20,57)	(35,72)		3	13	1

Table 4 on page 6 gives the rank of candidates and the number and percentage of candidates attaining this or a greater (weighted) average USM.

Table 4: Percentile table for overall USMs

Av USM	Rank	Candidates with this USM or above	%
92	1	1	1.15
91	2	2	2.3
88	3	3	3.45
84	4	6	6.9
83	7	10	11.49
82	11	12	13.79
79	13	13	14.94
77	14	16	18.39
76	17	20	22.99
75	21	22	25.29
74	23	28	32.18
73	29	35	40.23
72	36	39	44.83
71	40	40	45.98
70	41	44	50.57
69	45	46	52.87
68	47	48	55.17
67	49	52	59.77
66	53	56	64.37
65	57	61	70.11
64	62	66	75.86
63	67	68	78.16
62	69	73	83.91
61	74	74	85.06

Av USM	Rank	Candidates with this USM or above	%
60	75	75	86.21
59	76	76	87.36
58	77	79	90.8
57	80	80	91.95
56	81	82	94.25
54	83	83	95.4
53	84	84	96.55
49	85	86	98.85
44	87	87	100

B. Breakdown of the results by gender

Table 6, on page 7 shows the performances of candidates broken down by gender.

Table 6: Breakdown of results by gender

Class	Total		Female		Male	
	Number	%	Number	%	Number	%
I	44	50.57	10	41.67	34	53.97
II.1	31	35.63	10	41.67	21	33.33
II.2	9	10.34	4	16.67	5	7.94
III	3	3.45	0	0	3	4.76
F	0	0	0	0	0	0
Total	87	100	24	100	63	100

C. Detailed numbers on candidates' performance in each part of the exam

Data for papers with fewer than six candidates are not included.

Table 7: Numbers taking each paper

Paper	Number of Candidates	Avg RAW	StDev RAW	Avg USM	StDev USM
C1.1	11	33.91	11.4	65.45	17.53
C1.2	9	27.44	10.25	63	18.49
C1.3	19	25.68	6.97	69.21	9.91
C1.4	17	26.47	7.05	66.88	8.51
C2.1	9	34.22	9.83	73.67	16.29
C2.2	15	31.2	9.52	72.07	14.15
C2.3	3	-	-	-	-
C2.4	6	14.67	8.98	47.83	23.79
C2.5	5	-	-	-	-
C2.6	6	45.17	3.71	77.67	12.09
C2.7	15	30.2	10.75	67.4	14.76
C3.1	10	24.8	4.83	65.3	7.39
C3.2	6	23.17	5.27	64.83	6.62
C3.3	7	35.57	9.14	77.57	13.75
C3.4	14	36.29	8.04	72.71	14.66
C3.5	5	-	-	-	-
C3.6	12	38.83	6.93	72.42	11.65
C3.7	19	33.84	6.99	69.11	10.2
C3.8	20	31.25	8.1	68.55	13
C3.9	2	-	-	-	-
C4.1	16	31.75	9.31	68.81	12.01
C4.2	12	23.92	10.67	62.67	16.23
C4.3	6	24.33	11.36	63.33	16.49
C4.4	3	-	-	-	-
C4.5	10	32.8	8.13	69.5	12.27
C4.6	3	-	-	-	-
C4.7	3	-	-	-	-
C5.1	16	36.56	10.15	69.19	17.29
C5.2	17	33.47	7.68	69.82	11.91
C5.3	5	-	-	-	-
C5.4	18	62.06	14.15	64.28	12.89
C5.5	22	30.91	7.44	68.86	10.37
C5.6	13	30.62	6.17	70.92	9.56
C5.7	16	32.5	7	69.25	8.13
C5.9	8	32	7.71	68.62	9.93
C5.11	9	29.22	8.71	65.56	12.24
C5.12	22	31.18	5.46	66.86	7.67
C6.1	13	31.92	12	66.23	16.16
C6.2	16	27.69	7.36	64	8.77
C6.3	16	36.38	8.02	70.19	14.16

Paper	Number of Candidates	Avg RAW	StDev RAW	Avg USM	StDev USM
C6.4	24	38.38	5.59	69.83	11.05
C7.1	2	-	-	-	-
C7.3	4	-	-	-	-
C7.4	5	-	-	-	-
C7.5	4	-	-	-	-
C7.6	4	-	-	-	-
C8.1	8	36.75	4.8	72.25	8.92
C8.2	6	31.67	9.44	69.5	14.11
C8.3	31	35.1	8.58	68.71	13.09
C8.4	27	31.56	9.19	66.63	12.18
SC1	13	40.23	6.52	76	12.01
SC2	10	31.4	9.67	66.4	14.01
SC3	1	-	-	-	-
SC4	9	27.56	4.5	67.67	7.47
SC5	4	-	-	-	-
CCD	32	-	-	74.69	6.354
COD	7	-	-	74	9.06
CCS1	2	-	-	-	-
CCS2	1	-	-	-	-
CCS3	3	-	-	-	-

The tables that follow give the question statistics for each paper for Mathematics candidates. Data for papers with fewer than six candidates are not included.

Paper C1.1: Model Theory

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	15.9	15.9	6.9	10	0
Q2	7	7		1	0
Q3	18.82	18.82	4.92	11	0

Paper C1.2: Gödel's Incompleteness Theorems

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	11	11	4.24	4	0
Q2	15.67	15.67	6.63	9	0
Q3	12.4	12.4	5.37	5	0

Paper C1.3: Analytic Topology

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	13.05	13.05	3.99	19	0
Q2	11.78	12.41	4.21	17	1
Q3	14.5	14.5	12.02	2	0

Paper C1.4: Axiomatic Set Theory

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	13.57	13.57	4.93	14	0
Q2	10.83	10.83	5.04	6	0
Q3	13.93	13.93	3.85	14	0

Paper C2.1: Lie Algebras

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	17.71	17.71	6.05	7	0
Q2	16.29	16.29	4.61	7	0
Q3	14	17.5	8.92	4	1

Paper C2.2: Homological Algebra

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	13	15.6	7.85	5	1
Q2	13.08	14.45	5.28	11	2
Q3	16.5	16.5	5.81	14	0

Paper C2.4: Infinite Groups

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	8.67	8.67	6.06	6	0
Q2	6.8	6.8	3.11	5	0
Q3	2	2		1	0

Paper C2.6: Introduction to Schemes

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	23	23	3.08	5	0
Q2	22	22		1	0
Q3	22.33	22.33	2.5	6	0

Paper C2.7: Category Theory

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	13.9	14.78	6.72	9	1
Q2	16	16	4.76	10	0
Q3	13.31	14.55	6.74	11	2

Paper C3.1: Algebraic Topology

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	10.11	11.57	6.17	7	2
Q2	9.17	10.25	3.25	4	2
Q3	14	14	2.35	9	0

Paper C3.2: Geometric Group Theory

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	16	16	3.61	3	0
Q2	11.8	11.8	3.35	5	0
Q3	8	8	2.71	4	0

Paper C3.3: Differentiable Manifolds

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	16	16	6.48	4	0
Q2	19.4	22.75	8.02	4	1
Q3	15.67	15.67	5.35	6	0

Paper C3.4: Algebraic Geometry

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	18	18	5.26	14	0
Q2	18.63	18.63	4.24	8	0
Q3	17.83	17.83	2.64	6	0

Paper C3.6: Modular Forms

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	18.6	18.6	4.97	10	0
Q2	19.7	19.7	4.47	10	0
Q3	18.4	20.75	5.81	4	1

Paper C3.7: Elliptic Curves

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	19.47	19.47	3.59	17	0
Q2	12.69	13.58	6.2	12	1
Q3	16.56	16.56	3.81	9	0

Paper C3.8: Analytic Number Theory

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	17.44	17.44	3.93	18	0
Q2	14.77	16	6.17	12	1
Q3	11.9	11.9	6.03	10	0

Paper C4.1: Functional Analysis

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	19.06	20.33	7.24	15	1
Q2	12.5	12.5	6.76	12	0
Q3	10.6	10.6	4.22	5	0

Paper C4.2: Linear Operators

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	13.33	13.33	5.69	12	0
Q2	12.22	12.22	4.87	9	0
Q3	8.5	8.5	4.95	2	0

Paper C4.3: Functional Analytical Methods for PDEs

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	15.67	15.67	4.41	6	0
Q2	9	9	8.29	4	0
Q3	8	16	11.31	1	1

Paper C4.5: Ergodic Theory

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	19.6	19.6	5.27	10	0
Q2	14.71	14.71	3.95	7	0
Q3	9.5	9.67	4.51	3	1

Paper C5.1: Solid Mechanics

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	17.53	19.23	7.81	13	2
Q2	14.17	19.13	7.93	8	4
Q3	15.85	16.55	5.93	11	2

Paper C5.2: Elasticity and Plasticity

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	12.5	15.33	7.72	3	1
Q2	16.53	17.56	5.22	16	1
Q3	16.13	16.13	4.45	15	0

Paper C5.5: Perturbation Methods

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	14.39	15.06	5.7	17	1
Q2	15.71	16.25	4.63	16	1
Q3	13.75	14.91	4.61	11	1

Paper C5.6: Applied Complex Variables

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	17.33	17.33	1.8	9	0
Q2	12.38	12.38	3.54	8	0
Q3	14.7	15.89	6.38	9	1

Paper C5.7: Topics in Fluid Mechanics

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	15.14	15.14	2.04	7	0
Q2	15.21	15.21	4.15	14	0
Q3	18.27	18.27	4.36	11	0

Paper C5.9: Mathematical Mechanical Biology

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	16	20	9.62	4	1
Q2	12.2	12.2	5.45	5	0
Q3	16.43	16.43	2.99	7	0

Paper C5.11: Mathematical Geoscience

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	11.5	11.5	4.8	4	0
Q2	17.22	17.22	4.76	9	0
Q3	12.4	12.4	6.43	5	0

Paper C5.12: Mathematical Physiology

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	16.78	16.78	2.41	18	0
Q2	14.85	14.85	3.48	13	0
Q3	14.69	14.69	4.09	13	0

Paper C6.1: Numerical Linear Algebra

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	13.82	14.8	5.76	10	1
Q2	17.91	17.91	7.45	11	0
Q3	12.29	14	6.24	5	2

Paper C6.2: Continuous Optimization

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	14.38	14.38	4.06	16	0
Q2	12.67	12.67	6.74	6	0
Q3	13.09	13.7	4.64	10	1

Paper C6.3: Approximation of Functions

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	19.2	19.2	4.48	15	0
Q2	17.27	18.77	5.57	13	2
Q3	12.2	12.5	3.7	4	1

Paper C6.4: Finite Element Methods for Partial Differential Equations

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	18.81	19.74	4.26	19	2
Q2	18.62	18.6	3.06	20	1
Q3	17.4	19.33	7.43	9	1

Paper C8.1: Stochastic Differential Equations

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	15.5	15.5	3	4	0
Q2	17.25	17.25	2.22	4	0
Q3	20.38	20.38	4.14	8	0

Paper C8.2: Stochastic Analysis and PDEs

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	15.25	15.25	7.37	4	0
Q2	14.8	17	6.42	4	1
Q3	15.25	15.25	5.74	4	0

Paper C8.3: Combinatorics

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	18.6	18.6	4.58	30	0
Q2	16.74	16.74	4.91	23	0
Q3	16.11	16.11	4.91	9	0

Paper C8.4: Probabilistic Combinatorics

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	15.48	15.48	4.76	27	0
Q2	16.27	16.27	4.83	26	0
Q3	11	11		1	0

Paper SC1: Stochastic Models in Mathematical Genetics

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	20	20	2.96	9	0
Q2	21.36	21.36	2.69	11	0
Q3	18	18	5.1	6	0

Paper SC2: Probability and Statistics for Network Analysis

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	15.56	15.56	5.68	9	0
Q2	14.6	18	8.25	8	2
Q3	8.75	10	3.3	3	1

Paper SC4: Statistical Data Mining and Machine Learning

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	18	18	2	5	0
Q2	11.71	12.67	3.55	6	1
Q3	11.5	11.71	2.51	7	1

Paper SC5: Advanced Simulation Methods

Question	Mean Mark		Std Dev	Number of attempts	
	All	Used		Used	Unused
Q1	16.25	16.25	3.1	4	0
Q2	12	12	4.24	2	0
Q3	10.5	10.5	2.12	2	0