REPORT ON EXAMINATIONS

M.Sc. in Mathematical Modelling and Scientific Computing 2024-25

Part I

A. Statistics

- **Numbers and percentages in each class**

	Number				Percentage			
	2024/25	2023/24	2022/23	2021/22	2024/25	2023/24	2022/23	2021/22
Distinction	14	11	9	7	46.7	31.4	38	39
Merit	9	9	6	7	30	25.7	25	39
Pass	7	14	8	2	23.3	40	33	11
Fail	0	1	1	1	0	2.9	4	5.5
Incomplete	0	0	0	1	0	0	0	5.5

- **Vivas**
  The 30 candidates who submitted dissertations were examined by *viva voce*.

- **Marking of scripts**
  Written examinations were sat in Weeks 0 of Hilary and Trinity terms 2025. Scripts were single-marked by assessors followed by a script check carried out by the Course Director. Finalisation of marks by the examiners took place during an Examiners' Meeting in week 3 of Hilary term and week 4 of Trinity term. Special Topics and Case Studies were double-marked by assessors. In cases where marks varied over the pass/fail borderline, or the difference in marks was greater than ten, the assessors were asked to meet and reconcile their marks. All marks were approved by the examiners during the Examiners' Meetings held in week 7 of Hilary term and week 8 of trinity Term, before being released to the candidates. All dissertations were read and marked by at least two examiners; marks were approved by all examiners at the Final Examiners' Meeting and by confidential correspondence.

B. How candidates are made aware of conventions

The conventions are posted on the course website and electronic copies are circulated to the students. The Course Director discusses the conventions with the candidates and the candidates are reminded of them by email on several occasions during the year. The candidates are notified via email about any changes to the examination conventions and amended conventions are uploaded to the course website.

Part II

A. General comments on the examination

The examiners would like to convey their grateful thanks for their help and cooperation to all those who assisted with this year's examination, either as assessors or in an administrative capacity. In addition, the internal examiners would like to express their gratitude to Prof David Hewett for carrying out his duties as external examiner in a constructive and supportive way during the year, and for valuable input at the Final Examiners' Meeting.

Setting and checking of papers
Following established practice, the questions for each paper were initially set by the course lecturer, with a qualified person involved as checker before the first drafts of the questions were presented to the Chair of Examiners and the External Examiner. The course lecturers also acted as assessors, marking the questions on their course(s).

Determination of University Standardised Marks
The examiners followed established practice in determining the University standardized marks (USMs) reported to candidates for the written examinations. The algorithm converts raw marks to USMs for each paper separately. For each paper, the algorithm sets up a map R → U (R = raw, U = USM) which is piecewise linear. The graph of the map consists of three line segments which join the points (0,0), (P,50), (D,70) and (100,100). The values of P and D are chosen so that the resulting USMs are in line with the mark descriptors in the Examination Conventions. Particular attention is paid to the scripts that lie around class borderlines after the mapping has been applied. The values of P and D for each of the four written examinations in 2024-25 is given in the table below.

Paper	P	D
A1	50	76
A2	46	70
B1	48	70
B2	39	66

B. Equal opportunities issues and sex breakdown
The breakdown of results by sex is given in the tables below. This data is based on the sex recorded against students' records.

	Number							
	2024-25		2023-24		2022-23		2021-22	
	Female	Male	Female	Male	Female	Male	Female	Male
Distinction	6	8	5	6	2	7	2	5
Merit	2	8	2	7	2	4	0	6
Pass	2	4	8	6	4	4	0	2
Fail	0	0	0	1	1	0	0	1
Incomplete	0	0	0	0	0	0	0	2
Total	10	20	15	20	9	15	2	16

	Percentage							
	2024-2025		2023-24		2022-23		2021-22	
	Female	Male	Female	Male	Female	Male	Female	Male
Distinction	60	40	33.3	30	22.2	46.7	100	31.25
Merit	20	40	13.3	35	22.2	26.7	0	37.5
Pass	20	20	53.3	30	44.4	26.7	0	12.5
Fail	0	0	0	5	11.1	0	0	6.25

Incomplete	0	0	0	0	0	0	0	12.5
Total	100	100	100	100	100	100	100	100

C. Candidates' performance in each part of the examination

This course administers examinations internally in January and April, with each student sitting four papers. Each of the two sets of examinations is split into Paper A (Mathematical Methods) and Paper B (Numerical Analysis). Both sets of examinations went smoothly this year, with a good distribution of marks between failure and distinction ranges.

Paper	Number of Candidates	Avg RAW	StDev RAW	Avg USM	StDev USM
A1	28	76.00	11.58	72.07	11.62
A2	29	67.24	13.94	68.38	12.64
B1	28	65.78	11.99	66.36	11.32
B2	29	54.62	14.46	61.03	12.15

The tables that follow give the question statistics for each paper. Examiners' comments for all papers can be found at the end of this document.

Paper A1: Mathematical Methods I

Question	Mean mark	StDev	Number of Attempts
Q1	16.13	4.745	15
Q2	14.45	3.086	11
Q3	18.24	6.131	17
Q4	16.30	4.569	27
Q5	20.79	3.051	28
Q6	19.46	4.516	28

Paper A2: Mathematical Methods II

Question	Mean mark	StDev	Number of Attempts
Q1	16.54	4.14	28
Q2	8.76	3.95	17
Q3	13.42	4.330	24
Q4	11.40	7.31	10
Q5	19.52	4.04	21
Q6	21.12	3.90	26

Paper B1: Numerical Solution of Partial Differential Equations and Numerical Linear Algebra

Question	Mean mark	StDev	Number of Attempts
Q1	9.91	4.954	22
Q2	12.70	4.349	20
Q3	19.04	4.574	25
Q4	17.93	5.203	14
Q5	19.75	2.836	28
Q6	13.50	7.94	8

Paper B2: Numerical Linear Algebra and Continuous Optimisation

Question	Mean mark	StDev	Number of Attempts
Q1	16.25	5.926	12
Q2	14.22	4.242	23
Q3	14.48	4.615	28
Q4	11.96	5.156	23
Q5	11.41	4.973	21
Q6	12.2	5.199	16

Performances on the special topics and dissertations also ranged from pass to distinction level. No student failed the Case Studies in Mathematical Modelling or Scientific Computing. 18 of 29 (62%) of Mathematical Modelling case studies resulted in Distinction grades. 13 out of 29 (44.8%) of Scientific Computing case studies resulted in Distinction grades. Grades for the Special Topics ranged from pass through to distinction. Of the 58 special topics submitted this academic year, 35 (60%) attained a Distinction grade, and 10 (17%) attained a Merit.

D. Distribution of Special Topics

There were no failing grades in Special Topics. Of the 20 topics listed this year, four failed to attract any students.

Special Topic Course	**Number of Students**
Finite Element Methods for PDE	10
Further Mathematical Biology	4
Integer Programming	3
Mathematical Geoscience	2
Mathematical Models of Financial Derivatives	5
Mathematical Physiology	3
Networks	4
Optimal Control	1
Optimisation for Data Science	2

Perturbation Methods	4
Python in Scientific Computing	3
Solid Mechanics	2
Stochastic Modelling of Biological Processes	2
Theories of Deep Learning	11
Viscous Flow	2
Waves and Compressible Flow	2

E. Recommendations for Next Year's Examiners and MMSC Supervisory Committee

The Examiners expressed concern about self-certification extensions pushing them to read dissertations in a short period of time before the viva and suggested that there should be an official cut-off point for late submission after which Examiners are not expected to read the dissertation in that time and the student's viva should be postponed. The Examiners noted that the dissertation guidance did not specify the required font for the dissertation to be written in. As a result, some students were able to write much more in the 54-page limit than others. This should be corrected in the guidance for 2025-26

F. Names of members of the board of examiners

Examiners:
Prof Y. Nakatsukasa (Chair)
Prof C. Cartis
Prof P. Howell
Prof P. Grindrod
Prof. D. Vella
Prof D. Hewett (External Examiner)

Assessors:
Prof R. Baker
Dr M. Banaji
Miss G. Brennan
Prof C. Breward
Prof M. Bruna
Prof H. Byrne
Prof A. Cartea
Prof C. Cartis
Prof S.J. Chapman
Prof S. Cohen
Prof M. Dalwadi
Prof R. Erban
Prof P. Farrell
Dr J. Fowkes
Prof E. Gaffney
Prof M. Giles
Dr K. Gillow
Prof A. Goriely
Prof I. Griffiths
Prof P. Grindrod
Prof J.Hein

Prof D.Hewett
Prof I. Hewitt
Prof P.Howell
Prof S. Howison
Mr S.Jerad
Dr N. Khan
Prof R. Lambiotte
Dr S. Liu
Dr G. Maierhofer
Prof A. Münch
Prof Y. Nakatsukasa
Dr C. Parker
Dr N. Pritchard
Dr M. Sabaté Landman
Dr M. Shirley
Prof E. Süli
Dr M. Suñé Simon
Prof J. Tanner
Prof R. Thompson
Prof D. Vella
Prof S. Waters
Ms L. Yang

G. Assessors' Comments

Paper A1: Mathematical Methods I

Q1.
Students who tried question 1 did quite well on (a), not all got very far with (b). The conservation property was derived correctly by most of the candidates, the computation of the similarity exponents resulted in some algebraic errors. Some did not state the boundary problem at the end of this part. In (b), students often wrote down the conditions but failed to determine α correctly.

Q2. In question 2, parts (a) and (b) were generally done well. Students found (c) hard, few, if any, got the complete answer.

Q3. Students struggled more with this question than I hoped, but there were a number who got through all parts and even got the similarity solution right (or close) in (d). (a) and (b) were done generally well. Some students got the causality wrong for (c), (d). Some found it hard to compute the shock solution and or the similarity solution in (d). It seemed the discontinuous initial data was found challenging by some candidates.

Q4.
Question 4 was by far the most popular question. Most candidates stated Charpit's equations correctly in (a) and also the initial data, though some gave only partial answers (eg one of the possible initial conditions). In (b), a few students struggled with the algebra, but there were also quite a few that got the correct, or almost correct, answer. Of those, some, but (surprisingly not all), got the solution for $u(x, y) = y$ right; some may have just forgotten to do the step from the parametric to the final solution. The domain of definition was done reasonably well, though some got it wrong and a number failed to both sketch and state the solution (e.g. by only presenting the sketch), even though this was explicitly required in the question.

Q5.
Most candidates who attempted this question performed extremely well, making good progress with all sections. Some struggled with section (iii) of part (a). Parts (b) and (c) were answered well, although some candidates struggled with the matching conditions for the Green's function and the algebra in part (c).

Q6.
Most candidates who attempted this question performed extremely well, making good progress with all sections. Part (a) answered well although a few candidates struggled to derive the conditions for the operator to be self-adjoint. Part (b) was a bit more challenging, with a few candidates struggling to determine the eigenvalues and eigenfunctions in section (ii) and/or to correctly determine the eigenfunction $y_0(x)$ associated with λ_0 in section (iii).

Paper B1: Numerical Solution of Partial Differential Equations

Q1 was attempted by a majority of the candidates. Some of the questions appeared to be challenging for many.
(b-ii), for example, was correctly executed via the A^T by rather few candidates.
(a-ii) is bookwork, but the success rate was lower than expected.

Q2 (a-i,ii) are again bookwork; the rest require some thinking, but most attempts were reasonable for part (a). Most of part (b) are doable given a solid understanding of least-squares problems.
The final problems of each question were both intended to be challenging (but not impossible), requiring a good understanding of the materials. There were a few serious (and correct) attempts at them.

Q3.
This question was concerned with the convergence analysis of a finite difference scheme for the numerical solution of a two-point boundary-value problem for a linear second-order differential equation via the discrete maximum principle. Of the 28 students who took the exam, 25 attempted the question. There were 13 almost complete attempts, with 18 of the 25 candidates gaining 18 marks or more, and only 7 of the 25 candidates who attempted the question got 17 marks or less.

Q4.
The question asked the candidates to construct a finite difference scheme for a boundary-value problem for the biharmonic equation with a source term, by rewriting it as a system of two second-order elliptic boundary-value problems, followed by performing a stability analysis of the resulting finite difference scheme using discrete energy estimates. There were 14 attempts, and a wide range of marks. There was one complete solution and another 5 almost complete attempts. Only 9 of the 14 candidates who attempted the questions gained 18 marks or more. Most of those who received less than 18 marks struggled with the proof of the inequality stated in part (b) of the question, or failed to prove it altogether.

Q5.
This question was concerned with the Fourier analysis of an explicit finite difference scheme for an initial-value problem for the heat equation, and was generally well done. All 28 candidates who took the exam attempted the question. There was one complete answer to the question, and another 10
candidates gained between 21 and 24 marks. 23 candidates gained 18 marks of more. 14 candidates did not attempt the nonstandard but completely straightforward part (a) of the question.

Q6.
The question was concerned with the derivation of a discrete maximum norm bound and a discrete total variation norm bound on the first-order upwind finite difference approximation of a first-order scalar nonlinear hyperbolic equation. The first two parts of the question were standard variation on
bookwork, while the last two parts were extensions of bookwork to the derivation of a discrete total variation norm bound. Only 8 candidates attempted the question; 3 of them managed to answer the question completely, gaining 25 marks. The remaining 5 attempts were weaker, gaining 15 marks or less; these candidates rarely got beyond part (a) of the question.

Paper A2: Mathematical Method II

Question 1 was attempted by most of the candidates, who demonstrated good understanding of the material in their answers, with the average mark being 16.54/25 = 66.2%. Some candidates did some unnecessary calculations, which would be fine to solve the question algorithmically using A computer, but they should avoid such calculations in a pen-and-paper exam.
For example, some candidates attempted to find 2-cycles in part (a)(iii) by solving a quartic equation, which did not require any further calculations to be solved. Successful candidates

observed that all four roots of the quartic equation have already been discovered in parts (a)(i) and a(ii), giving that there is only one 2-cycle {1, 2}.

With most of the candidates choosing to submit Question 1 for the assessment, Question 2 was naturally explored by less candidates. Part (a) included calculations of eigenvalues and (generalized) eigenvectors, where some candidates decided to get some raw marks on the bookwork analysis of a linear system, while not attempting parts (b) and (c). A few candidates continued further and analyzed the nonlinear system in parts (b) and (c).
Some again did some unnecessary calculations which could be avoided by transforming the coordinates using the eigenvalues of the linear system found in part (a).

Q3 (24 responses) was significantly more popular than Q4 (10 responses). Both questions generated a very wide spread of scores. Both questions were probably on the more difficult side.

Q3a: generally answered accurately, with occasional (minor) algebraic errors. Some students generated a lot of algebra on what was meant to be a short part, but most were able to get the stated result in a page or so (which was the intended length).
Q3bi: generally answered well. Mistakes here involved in correctly identifying the constants of integration.
Q3bii: only seriously attempted by around half the students. Here, no-one correctly calculated the final constant of integration with several different algebraic errors.
Q3ci: attempted by most students, but only a handful were able to correctly deal with the compact support specified in the question. Q3cii: not generally completed well. A small number of students had the correct intuition, but no-one showed the result mathematically.
Q3d: generally well done when attempted.
4a: answered well in general, though several people described them mathematically rather than physically, as requested in the question. Some students erroneously interpreted ‘$\beta = 0$’ to mean ‘ignore the boundary condition involving β’.
Q4b: A wide discrepancy between solutions, with stronger students solving with ease.
Q4c: Around half the students attempting this question did not answer this or the following parts. Of those that attempted it, a small number struggled with the concept of transforming variables even before the small K limit was taken.
Q4d: Strong solutions when attempted.
Q4e: Only a small number of students answered this question. A couple of very good answers, but algebraic mistakes meant that the final result was not obtained by anyone.

Q5-6: No comments for inclusion on examiner’s report.

Paper B2 Numerical Linear Algebra and Continuous Optimisation

Although the intended solution for 2-a-(iv) was to find a case where the GMRES residual stagnates at a nonzero value (as in a problem sheet), some said once it reaches 0 it stays that way (for which partial credit was awarded).
Question 3 was more accessible than Questions 4, 5, 6 and was attempted by most students; many of them did well on Question 3.