Graduate Program in Mathematics and Statistics

Comprehensive Exam

graduate studies | YORK UNIVERSITÉ UNIVERSITY

Course information
Title Mathematical Modelling
Course number MATH 6931
Semester Fall
Exam is: ☑ Closed-book ☐ Open-Book If open-book, provide a detailed rationale
N/A closed book
Is Exam invigilated? ☑ Yes ☐ No If No, provide a detailed rationale
N/A invigilated
Evaluation method
The written exam will be 5 questions. Non-comprehensive students will choose 4 out of 5 problems to complete. The comprehensive exams will require all 5 problems to be completed.

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Does the duration of exam exceed 3 hours? If Yes, provide a detailed rationale	☑ Yes	☐ No

Since comprehensive students have an additional question to complete, they will be provided an additional half hour making the exam 3.5 hours. They are welcome to finish the exam within the regular 3 hours if they so choose.

Outline of topics to be covered

1. Introduction (philosophy of modelling, structure of a model, scaling and non-dimensionalization)

2. ODE Models (Predator-prey systems, linear stability, disease dynamics, chemical kinetics, inverse modelling and parameter fitting, Euler method.)

3. Stochastic Models (Birth-death processes, Markov Chains, Random Walk, Gillespie Algorithm)

4. PDE Models (Traffic models, characteristics and shocks, conservation laws)

Passing threshold (% of the exam): 65

Faculty	Signature	Date
Name Iain Moyles	Iain Moyles Digitally signed by Iain Moyles Date: 2022.10.18 13:18:36 -04'00'	10/18/22

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Graduate Program in Mathematics and Statistics

Comprehensive Exam

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Course information
Title: Partial Differential Equations
Course number: 6350 3.0
Semester: Fall 2022
Exam is: ☑ Closed-book ☐ Open-Book If open-book, provide a detailed rationale
Is Exam invigilated? ☑ Yes ☐ No If No, provide a detailed rationale
Evaluation method
6 equally-weighted questions from the topics (see below) will have to be answered on examination booklets. Answers have to be written out clearly and jusified fully.

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Does the duration of exam exceed 3 hours? If Yes, provide a detailed rationale	☐ Yes	☑ No

Outline of topics to be covered

Topics: The Convolution, The Fourier Transform, Tempered Distributions, Symbols, Pseudo-Differential Operators, Asymptotic Expansions, The Product of Two Pseudo-Differential Operators, The Formal Adjoint of a Pseudo-Differential Operator, The Parametrix of an Elliptic Pseudo-Differential Operator, L^p-Boundedness of Pseudo-Differential Operators, Sobolev Spaces, Global Regularity of Elliptic Partial Differential Equations, Weak Solutions of Pseudo-Differential Equations

Reference: M. W. Wong, An Introduction to Pseudo-Differential Operators, Third Edition, World Scientific, 2014

Passing threshold (% of the exam): 50%

Faculty	Signature	Date
Name M. W. Wong	M. W. Wong	10/18/22

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Graduate Program in Mathematics and Statistics

Comprehensive Exam

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Course information
Title General Topology
Course number 6540
Semester Fall
Exam is: ☑ Closed-book ☐ Open-Book If open-book, provide a detailed rationale
Is Exam invigilated? ☑ Yes ☐ No If No, provide a detailed rationale
Evaluation method
Written exam. Approximately 6 questions on various topics. Part marks for partial solutions is possible.

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Does the duration of exam exceed 3 hours? If Yes, provide a detailed rationale	☐ Yes	☑ No

Outline of topics to be covered

topological spaces, basis for topology, continuous functions (equivalent def's for metric) product topology (including innite), metric spaces, quotient spaces. complete metric spaces, Baire spaces connectedness, compactness, compactness in metric spaces and applications, generalizations of compactness: countable compactness, sequential compactness, local compactness etc..., countability axioms, separation axioms, normal spaces, Urysohn Lemma and Tietze Extension Theorem, Tychonov Theorem, Urysohn Metrization and Nagata-Smirnov Metrization, compactications including the one-point and Stone-Cech compactication, paracompactness, net convergence, filter convergence, ultrafilters, function spaces, Stone-Weierstrass Theorem

References

[1] Dugundji, James; Topology, Allyn and Bacon series in advanced mathematics. Allyn and Bacon
(Boston) (1966).
[2] Munkres, James R.; Topology, second edition. Prentice Hall (2000)
[3] Willard, Stephen; General Topology, Addison-Wesley (1970).

Passing threshold (% of the exam): 50

Faculty	Signature	Date
Name Paul Szeptycki		10/28/22

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Graduate Program in Mathematics and Statistics

Comprehensive Exam

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Course information
Title Applied Algebra
Course number Math 6121
Semester Fall 2022
Exam is: ☑ Closed-book ☐ Open-Book If open-book, provide a detailed rationale
Is Exam invigilated? ☑ Yes ☐ No If No, provide a detailed rationale

Evaluation method

The comprehensive exam instructions are typically:
This is a 3 hours exam
Give detailed justifications and explanations where appropriate. Attention to detail and clarity of exposition are important.
Total: 6 problems of 10 points; required for passing: 32 points.

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Does the duration of exam exceed 3 hours? If Yes, provide a detailed rationale	☐ Yes	☑ No

Outline of topics to be covered

Linear Algebra (Recall crash course, Graduate level): Direct sum and tensor product has corresponding operations on basis and linear transformations.
Group Theory and representation Theory: Recall: Group, morphism, subgroup, G-sets (and G-morphisms), Isomorphisms Theorems and quotient groups.; Jordan-Holder Theorem; Sylow Theorem;
Representation of finite groups and characters (over C): Maske's Theorem; Schur's lemma; Structure of the space of G-endomorphisms; Structure of the inner space of characters on G Final Theorem: the number of irreducibles representations for G equal the number of conjugacy classes of G
Preliminary notions in ring: definitions; Euclidian domain; Principal ideal domain; Polynomial rings
Grobner basis with emphasis on algorithmic aspect and computational geometry solving polynomial system of equations (with some application to robotics and computational geometry)
Modules over PID (Advanced linear algebra); Chinese Remainder Theorem; Classification of finitely generated modules over PID; Classification of finitely generated abelian groups; rational canonical form; Jordan canonical form;
(1) D. S. Dummit and R. M. Foote, "Abstract Algebra" Willey (2004). ISBN: 978-0-471-43334-7.
(2) T. W. Hungerford, "Algebra", GTM Springer (2003). ISBN: 978-0-387-90518-1.
(3) D. A. Cox, J. Little and D. O'shea, "An Introduction to Computational Algebraic Geometry and Commutative Algebra" UTM Springer (2007). ISBN: 978-0-387-35650-1.
(4) B. Sagan, "The Symmetric Group", Springer-Verlag GTM (2001) ISBN: 978-1-4757-6804-6
Reference (1) and (2) are good for the general material. Reference (3) is for the Grobner basis, and the reference (4) is for the group representation only (chap 1).

Passing threshold (% of the exam): 53.3333

Faculty	Signature	Date
Name Nantel Bergeron	Digitally signed by Nantel Bergeron Date: 2022.10.18 17:42:17 -04'00'	10/18/22

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Graduate Program in Mathematics and Statistics

Comprehensive Exam

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Course information
Title Mathematical Statistics
Course number 6620
Semester F
Exam is: ☑ Closed-book ☐ Open-Book If open-book, provide a detailed rationale
Is Exam invigilated? ☑ Yes ☐ No If No, provide a detailed rationale
Evaluation method
short-answer questions

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Does the duration of exam exceed 3 hours? If Yes, provide a detailed rationale	☑ Yes	☐ No

The final exam for MATH 6620 is three hours long. The comprehensive asks more questions and of greater difficulty, so additional time is warranted.

Outline of topics to be covered

1. probability spaces (e.g. chapter 1 in [S])
2. change of variables: 1-1 or not, univariate or multivariate (e.g. chapter 1 in [S])
3. some fundamental distributions including non central chi-square (e.g. chapter 1 in [S])
4. mathematical inequalities used in statistics (e.g. Jensen, Gibbs) (e.g. chapter 1 in [S])
5. different notions of convergence and convergence theorems (e.g. chapter 1 in [S])
6. sufficiency, completeness, ancillarity (e.g. chapter 2 in [S])
7. exponential families (e.g. chapter 2 in [S])
8. statistical decision theory: loss functions, Bayes' estimators, minimax (e.g. chapter 4 in [S])
9. UMVUE (e.g. chapter 3 in [S])
10. hypothesis testing: UMP, MLR (e.g. chapter 6 in [S])

REFERENCES:

[S] Mathematical Statistics by Jun Shao (Springer Text in Statistics)
[CB] Statistical Inference by Casella and Berger (Duxbury Advanced Series)

Passing threshold (% of the exam): 60

Faculty	Signature	Date
Name Hanna Jankowski	Hanna Jankowski	11/1/22

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Graduate Program in Mathematics and Statistics

Comprehensive Exam

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Course information	
Title	Applied Statistics I
Course number	6630
Semester	Fall 2022

Exam is: ☑ Closed-book ☐ Open-Book

If open-book, provide a detailed rationale

Is Exam invigilated? ☑ Yes ☐ No

If No, provide a detailed rationale

Evaluation method

The exam will be comprised of a 3-hr closed book written test and a 1-hr online crowdmark test using computing program to implement an algorithm.

The 3-hour theory exam will be administered in person and will be invigilated. The online part is open book and open notes. The online part is administered in the evening (8-9 pm) on the same day of the theory exam. There is no invigilation and students complete the online programming test using their own computer at home.

Twenty percent of the overall grade is the online programming part.

The passing threshold is 60% of the overall grade combining the theory and the online part.

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Does the duration of exam exceed 3 hours? If Yes, provide a detailed rationale	☑ Yes	☐ No

The comprehensive exam has an online test in computing in addition to the written test in theory.

Outline of topics to be covered

The exam will cover the topics in applied statistics including:
Maximum likelihood estimation using numeric method including continuous and discrete optimization
EM algorithm for missing data
Monte Carlo simulation methods
Markov Chain Monte Carlo methods
Bootstrap and Jackknife methods
The reference for the exam will be:
1) Chapters 1,2,3,4,6, 7, 9 of Computational statistics, Geof Givens and Jennifer Hoeting, Wiley

Passing threshold (% of the exam): 60%

Faculty	Signature	Date
Name Xin Gao	Xin Gao Digitally signed by Xin Gao Date: 2022.10.19 10:54:17 -04'00'	

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Graduate Program in Mathematics and Statistics

Comprehensive Exam

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Course information	
Title	Complex Analysis
Course number	6300
Semester	Fall 2022

Exam is: ☑ Closed-book ☐ Open-Book

If open-book, provide a detailed rationale

Is Exam invigilated? ☑ Yes ☐ No

If No, provide a detailed rationale

Evaluation method

There will be a closed book in-person written exam of 3 hours scheduled during the final exam period..

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Does the duration of exam exceed 3 hours? If Yes, provide a detailed rationale	☐ Yes	☑ No

Outline of topics to be covered

Complex differentiability, power series, Cauchy-Riemann equations, Cauchy integral theorem, harmonic functions, residues, contour integration, theorems of Liouville, Jensen, Morera, Rouch\'e, Hurwitz, meromorphic functions, Weierstrass products, Montel's theorem, Riemann ζ-function, Weierstrass $\mathfrak{P}$-function, Riemann mapping theorem

Passing threshold (% of the exam): 60%

Faculty	Signature	Date
Name Peter Gibson		10/24/22

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Graduate Program in Mathematics and Statistics

Comprehensive Exam

graduate studies | YORK UNIVERSITÉ UNIVERSITY

Course information	
Title	Differential Dquations
Course number	6340
Semester	Winter 2023

Exam is: ☑ Closed-book ☐ Open-Book

If open-book, provide a detailed rationale

Is Exam invigilated? ☑ Yes ☐ No

If No, provide a detailed rationale

Evaluation method

The compressive exam will have 6 questions, total marks 120.
I will consider 60%, or equivalently, 72 a pass.

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Does the duration of exam exceed 3 hours? ☐ Yes ☑ No If Yes, provide a detailed rationale

Outline of topics to be covered
• General properties of Differential Equations Existence, uniqueness, dependence on initial data and parameters, extensibility. • Linear Systems and Stability General theory of linear systems, Periodic coefficients and Floquet Theory, Stability of linear and nonlinear systems. • Nonlinear Systems: Local Theory Linearization, Invariant manifolds, Hartman-Grobman Theorem, Normal form theory. • Nonlinear Systems: Global Theory Limit sets and attractors, periodic sets and limit cycles; Poincare map, Poincare-Bendixson Theory, Lotka-Volterra system, Liénard systems. . • Bifurcation theory of nonlinear systems: Saddle-node bifurcation, transcritical bifurcation, pitchfork bifurcation, Hopf bifurcation, homoclinic-bifurcations, co-dimension 2 bifurcations. • Nonlinear dynamics and applications in physics, biology and finance.
Passing threshold (% of the exam):

Faculty	Signature	Date
Name Huaiping Zhu		10/30/22

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Graduate Program in Mathematics and Statistics

Comprehensive Exam

graduate studies | YORK UNIVERSITÉ UNIVERSITY

Course information
Title Functional Analysis I
Course number 6461
Semester F22
Exam is: ☑ Closed-book ☐ Open-Book If open-book, provide a detailed rationale
Is Exam invigilated? ☑ Yes ☐ No If No, provide a detailed rationale
Evaluation method
The usual (the students work on the assigned problems for three hours, and I grade them afterwards`

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Does the duration of exam exceed 3 hours? If Yes, provide a detailed rationale	☐ Yes	☑ No

Outline of topics to be covered

Topological vector spaces. Normed spaces.

Banach spaces. Baire Category Theorem. Closed Graph Theorem. Open Graph Theorem. Classical Banach spaces ($C(X)$, c_0, ℓ_p, ℓ_∞, $L_p(X,\mu)$, $L_\infty(X,\mu)$). Hilbert space.

Local convexity. Hahn--Banach theorems.

Weak topologies. Compactness. Dual spaces. Riesz representation theorems. Krein-Milman theorem. Stone-Weierstrass theorem.

Bounded linear operators. Operators on Hilbert space. Spectral theorem for compact, self-adjoint, operators.

Passing threshold (% of the exam): 60%

Faculty	Signature	Date
Name Ilijas Farah	*Ilijas Farah*	October 19, 2022

This form must be submitted electronically by email to: gradmath@yorku.ca.

Graduate Program in Mathematics and Statistics

Comprehensive Exam

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Course information
Title Advanced Numerical Methods
Course number MATH6651
Semester Fall 2022
Exam is: ☑ Closed-book ☐ Open-Book If open-book, provide a detailed rationale
Is Exam invigilated? ☑ Yes ☐ No If No, provide a detailed rationale
Evaluation method
The comp exam of MATH 6651 is three-hour and in-person exam, and will be invigilated. The exam is closed-book. Students are allowed to bring "a formula sheet" (two letter pages but only two sides, for formulas that you prepared, wrote or typed) and a calculator is also allowed. Passing threshold is 60% of the comprehensive exam.

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Does the duration of exam exceed 3 hours? If Yes, provide a detailed rationale	☐ Yes	☑ No

Outline of topics to be covered

Chapter 1. Optimization Methods
Section 1 Search Methods in One Dimension (Golden and Fibonacci Methods)
Section 2 The Simplex Search Method in Two Dimensions
Section 3 The Steepest Descent Technique and Newton's Method in Multi-dimensions

Chapter 2. The Preconditioned Conjugate Gradient Methods
Section 1 The Gradient Methods and The Conjugate Direction Method
Section 2 The Conjugate Gradient Method
Section 3 The Preconditioned Conjugate Gradient Method
Section 4 The Nonlinear Conjugate Gradient Methods

Chapter 3. Numerical Methods for Initial Value Problems of ODEs
Section 1 The Euler's Method and Higher-order Taylor's Methods
Section 2 The Runge-Kutta Methods
Section 3 The Multistep Methods
Section 4 Stability Analysis
Section 5 Adaptive Step Technique
Section 6 Applications to Systems of ODEs and Higher-Order Equations

Chapter 4. Approximation Theory
Section 1 Orthogonal Polynomials and Least Squares Approximation
Section 2 Chebyshev Polynomials and the Economization
Section 3 Pade approximation
Section 4 Fourier Approximation and Fast Fourier Transforms

Chapter 5. Numerical Methods for Boundary-Value Problems of ODEs

Passing threshold (% of the exam): 60/100

Faculty	Signature	Date
Name Dong Liang	Dong Liang Digitally signed by Dong Liang Date: 2022.10.28 20:47:47 -04'00'	Oct 28, 2022

This form must be submitted electronically by email to: gradmath@yorku.ca.