

A GUIDE TO OUR GRADUATE PROGRAMS
Department of Mathematics & Statistics
Dalhousie University
2015/2016

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Disclaimer: In case of inconsistency between the Faculty of Graduate Studies information and this document; the Faculty of Graduate Studies information takes precedence.

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1 Introduction

Welcome to Dalhousie University and the Department of Mathematics & Statistics. This handbook is written to help graduate students and faculty navigate their way through our programs. Some of the regulations listed here apply only to our department, while others are university-wide regulations designed by the Faculty of Graduate Studies (FGS). Therefore, we encourage everyone to read the FGS Calendar and FGS website (<http://www.dal.ca/faculty/gradstudies.html>) for additional information. In the case of any discrepancy between this handbook and FGS Calendar, the FGS Calendar will have precedence. A list of Mathematics and Statistics faculty and their areas of expertise can be found on our web page (<http://www.dal.ca/faculty/science/math-stats.html>), along with a list of present graduate students and office staff.

This document is a work in progress and will evolve partly in response to the needs of students. Suggested changes and additions can be sent to your graduate coordinator.

We would like to thank the Department of Physics and Atmospheric Science, who generously allowed us to use their graduate handbook as a template for this document.

1.1 Short Checklist for New Students

- *Do you know your Banner ID number (B00 - - - -)?* This would have been provided to you in your letter of acceptance from the Registrar. You will need this number to register, obtain a Dalhousie Student ID card and to set up your Net ID. To obtain your Student ID Card, go to the Dalhousie ID Card Office, located at 6230 Coburg Street (Howe Hall).

To set up your Net ID go to (<https://wa.its.dal.ca/newuser>). Your *@dal.ca* email is the main source of email correspondence at Dalhousie University. All messages sent by Dalhousie University will go to your Dalhousie email address. You can also check the status of your student account, payroll and stipend information once you have set up your Dalhousie Net ID.

- *Have you registered?* All graduate students must register for all three terms (Fall, Winter and Summer) for the upcoming academic year. In addition to any classes you will take during the year, you **MUST** register in REGN 9999. Please see Section 5.9 for more information.

If you are not registered, you will not receive your monthly stipend if you are paid through Dalhousie.

- *Have you checked with the graduate secretary?* Maria Fe Elder is the department's graduate secretary. She will assign you a shared office space, a mail slot in the mail room, a computer account and a code for the front door.
- *Have you met with your graduate coordinator?* Your graduate coordinator will give you information about the program and talk to you about courses and possible supervisors, if you do not already have one. Early in the term you will have to fill out your program form (Section 7.3), and it is therefore important to start thinking about it as soon as possible.
- *Have you returned your "Direct Deposit" form and a void cheque to the Math & Stats Office or Payroll Services?* All payments (including expense and travel reimbursement) to Dalhousie students, faculty and staff are by direct deposit. It is important to provide Payroll Services with your banking information so that you will receive your monthly stipend. Please note that the monthly stipend is deposited at the end of each month.

- *Have you taken care of your Health/Dental and Medical Coverage?* Please see Section 6.5 for details.
- *Have you sent your final transcript stating that you conferred your degree (with date conferred) to the Graduate Secretary?* We need two copies of this final transcript at the beginning of the Fall term.

1.2 Departmental Contact Information

Our department consists of the Mathematics Division and the Statistics Division. Each division has a director and graduate coordinator who are responsible for running the undergraduate and graduate programs, course offerings, admission of graduate students and so on. Both divisions operate under the Department of Mathematics & Statistics, and share the facilities of the Chase Building. The department chair and staff serve both divisions.

The graduate coordinators, with the help of the graduate secretary, are the liaison between the graduate students in the department and the university. They look after the running of the graduate program and make sure all students are taking the appropriate steps towards the completion of their degrees. Students should feel free to bring all concerns and questions to their graduate coordinator in their division. Details of responsibilities of the graduate coordinator can be found at the website of the Faculty of Graduate Studies.

In cases where a conflict of interest prevents a student from approaching the graduate coordinator, students are encouraged to take the matter to the division directors, the department chair, graduate secretary or department administrator and ask for further advice.

- Dr. David Iron: Mathematics Graduate Coordinator (*David.Iron@dal.ca*)
Room 322, (902) 494-2385.
- Dr. Joanna Mills Flemming: Statistics Graduate Coordinator (*Joanna.Flemming@dal.ca*)
Room 103, (902) 494-1268.
- Ms. Maria Fe Elder: Graduate Secretary (*Maria.Fe.Elder@dal.ca*)
Room 219, (902) 494-6909.
- Dr. Bruce Smith: Department Chair (*Bruce.Smith@dal.ca*)
Room 219, (902) 494-6913.
- Dr. Roman Smirnov: Mathematics Director (*Roman.Smirnov@dal.ca*)
Room 324, (902) 494-8854.
- Dr. Hong Gu: Statistics Director (*hgu@dal.ca*)
Room 101, (902) 494-7161.
- Ms. Queena Crooker-Smtih: Department Administrator (*Queena.Smith@dal.ca*)
Room 219, (902) 494-6911.
- Mr. Balagopal Pillai: Systems Administrator (*Balagopal.Pillai@dal.ca*)
Room B004, (902) 494-3204.

2 Preview of Our Graduate Programs

2.1 Admission Requirements

Candidates must satisfy the general requirements for admission to the Faculty of Graduate Studies. For details on admission, fees, course listings and general information see the website (<http://www.dal.ca/admissions/graduate.html>) and also see Section 4 of this document. MSc candidates will normally be expected to hold a degree recognized by Dalhousie University at the equivalent of a Dalhousie Bachelor's degree with Honours. PhD candidates will normally be expected to hold a first-class MSc degree (or equivalent) from a recognized university. To ensure consideration for scholarship funds, applications should be made by January 15, regardless of when during the year you intend to start your program.

2.2 Mathematics and Statistics Programs

The Department of Mathematics & Statistics offers programs leading to the degrees of MSc and PhD in many research areas. You can find a description of our research groups at this website (<http://www.dal.ca/faculty/science/math-stats/research-groups.html>).

Pure and applied mathematics faculty research interests include:

algebra	differential geometry
algebraic topology	functional analysis
applied mathematics	general relativity and cosmology
category theory	graph theory
combinatorics	harmonic analysis
combinatorial game theory	logic
commutative algebra	number theory
differential equations	wavelet theory

Statistics faculty research interests include:

bioinformatics	linear and nonlinear regression
data analysis	robust statistics
experimental design	time series analysis
machine learning	statistical genetics
molecular evolution	statistical inference
multivariate analysis	

Graduate students in the statistics division can also take part in one or more applied projects through their participation in the activities of the statistical consulting service.

2.3 Requirements for a Master's (MSc) Degree

- At least six classes (18 credit hours), not including seminar classes, at the graduate level to be chosen in consultation with a department advisor (i.e. a potential supervisor and/or the graduate coordinator). In addition, students whose preparation in a particular area is deficient will be required to complete appropriate classes which will be designated by the advisor;
- Attendance and participation in seminars;
- A satisfactory thesis;

- Students are required to give an oral presentation (defence) of their thesis and at that time to answer questions about the thesis. This presentation will be made after the thesis is in the hands of the student's committee and will be taken into account when the committee makes its decision;

2.4 Requirements for a Doctor of Philosophy (PhD) Degree

- At least four classes (12 credit hours);
- Comprehensive examinations and thesis proposal— please consult sections 9.3, 9.4 and 9.5 for details about these exams and relevant deadlines;
- Attendance and participation in an appropriate seminar;
- Preparation and defence of a satisfactory research thesis.

2.5 Courses We Offer

2.5.1 Mathematics Courses

Below is a list of the most frequently offered graduate courses. A selection of the following courses will be offered in any given year.

MATH 5010.03: Introduction to Measure Theory and Integration*

MATH 5020.03: Analytic Function Theory*

MATH 5025.03: Commutative Algebra I

MATH 5045.03: Advanced Algebra I*

MATH 5055.03: Advanced Algebra II*

MATH 5065.03: Algebraic Geometry

MATH 5066.03: Advanced Statistical Theory I

MATH 5070.03: Topics in Number Theory

MATH 5135.03: Introduction to Category Theory

MATH 5136.03: Topics in Category Theory

MATH 5140.03: Introduction to Functional Analysis

MATH 5165.03: Mathematical Methods in Physics

MATH 5170.03: General Topology

MATH 5180.03: Introduction to Algebraic Topology

MATH 5190.03: Ordinary Differential Equations

MATH 5200.03: Ordinary Differential Equations - Qualitative Theory

MATH 5220.03: Introduction to Partial Differential Equations

MATH 5230.03: Partial Differential Equations

MATH 5250.03: Asymptotic Analysis

MATH 5320.03: Combinatorial Optimization

MATH 5330.03: Topics in Graph Theory

MATH 5340.03: Discrete Random Structures

MATH 5360.03: Combinatorial Modelling

MATH 5370.03: Combinatorics: Techniques and Structures

MATH 5410.03: Topics in Cosmology

MATH 5500.03: Introduction to Harmonic Analysis

MATH 5530.03: Differential Geometry

MATH 5540.03: Applied Analysis*

MATH 5650.03: General Relativity and Cosmology

MATH 5660.03: Automata and Computability

MATH 5680.03: Topics in Logic and Computation

MATH 5900.03: Combinatorial Game Theory.

* These courses are *core courses*. They are offered most years, and mathematics students can use them to complete their PhD Comprehensive Exam requirement; see Section 9.3 for more details.

2.5.2 Statistics Courses

A selection of the following courses will be offered in any given year.

STAT 5066.03: Advanced Statistical Theory I.

STAT 5067.03: Advanced Statistical Theory II.

STAT 5070.03: Multivariate Distributions.

STAT 5075.03: Multivariate Analysis.

STAT 5090.03: Probability.

STAT 5100.03: Survival Analysis.

STAT 5300.03: Topics in Statistics and Probability.

STAT 5350.03: Applied Multivariate Analysis.

STAT 5360.03: Robust Statistics.

STAT 5370.03: Stochastic Process.

STAT 5390.03: Time Series Analysis I.

STAT 5410.03: Advanced Topics in Time Series Analysis.

STAT 5500.03: Topics in Advanced Statistics.

STAT 5550.03: Longitudinal Data Analysis

STAT 5570.03: Statistical Genetics

STAT 5620.03: Data Analysis.

STAT 5630.03: Statistical Methods in Molecular Evolution.

STAT 5640.03: Advanced Analysis of Complex Survey Data.

STAT 5700X/Y.03: Statistical Consulting Practicum.

STAT 5750.03: Statistical Data Mining.

3 Financial Information

If you are admitted to our programs with full funding, you are guaranteed a minimum level of financial support during the program, so long as you are making satisfactory progress and have met the conditions of financial support. Departmental scholarships will normally be provided for one year to an MSc student and four years to a PhD student. More information appears in this section.

Foreign students must pay a differential fee (see Section 4.5.1). In Mathematics, to help offset this fee the base level of support for foreign students is increased by this amount from departmental sources.

Most of our students hold external scholarships. Even when students start their program with departmental funding, they are expected to apply for external funding during their first year. The purpose is two-fold: external scholarships are prestigious additions to a student's CV, and contribute significantly to the student's success in seeking further funding and postdoctoral positions. Also, every student receiving external funding allows us to reallocate our funding to recruit new students into our graduate program.

3.1 Non-departmental Funding

The most common sources of non-departmental scholarships are listed below. There are several other scholarships that are awarded each year. You can check the list at (<http://www.dal.ca/faculty/gradstudies/funding.html>). We usually send out reminders when these are advertised.

3.1.1 NSERC

NSERC (Natural Sciences and Engineering Research Council) applications are due in the Fall. All eligible students (Canadian citizens and permanent residents) are expected to apply. Applications are sent by the department to the Faculty of Graduate Studies, and candidates are selected university-wide to be nominated for the competition. Please see (<http://www.nserc-crsng.gc.ca/>) for further information on NSERC scholarships.

3.1.2 Killam Scholarships

The department will nominate highly qualified students to apply for Killam scholarships in January. Canadian Citizens may apply for Killam scholarships only if they have applied for NSERC support in the previous fall. Killam scholarships can be awarded to incoming students in both MSc and PhD programs; however, currently registered students may apply for Killam scholarships only if they are enrolled in a PhD program, or if they have been accepted to a PhD program at Dalhousie University. See (<http://killamtrusts.dal.ca/apply/predoctoral/index.php>) for more information on Killam predoctoral scholarships.

3.1.3 Nova Scotia Graduate Scholarships

This new scholarship is open to research graduates at Nova Scotia universities for innovative work aligned with or advancing Nova Scotia priorities. The objectives of this award are to attract and retain top-quality research graduates, as well as to encourage exploration, discovery, and innovation.

Nominations can be made by the department only. More information is available at <http://www.dal.ca/faculty/gradstudies/funding/scholarships/nsgrad.html>.

This scholarship has two rounds of competitions: December and February. To be entered in the December competition, please make sure we have your complete application to our graduate program by mid-November.

3.1.4 The President's Awards

The President's awards are for students starting PhD programs who have a full doctoral scholarship from NSERC (PGSD or CGSD) or Killam (Doctoral). The award will cover tuition – but not international differential fees or other student fees – for up to the first two years for PhD students. Students must have a complete and accurate program form and progress report before the second year award will be paid. The award will be granted for each term that the student is

registered as a full time student;
 paying full tuition (i.e., not continuing fees);
 receiving a full doctoral scholarship from one of the specified agencies;
 tuition is not covered by any other award, agency or government.

For eligible students, the Faculty of Graduate Studies will notify those students and departments following admission. The award will be verified and applied to the student's tuition each term for the duration of the award. Students must have a complete and accurate program form and progress report before the second year award will be paid.

3.2 Departmental Funding

Students without external scholarship support are generally awarded Dalhousie Graduate Scholarships from funds which come to the department from the university and from individual faculty member's research grants. According to FGS regulations, maximum eligibility for FGS scholarships is two Master's years and the first five Doctoral years. The current level of support in our department is as follows.

Division:	Degree	Duration	Amount
Mathematics	MSc	1 year	\$11,000 above tuition costs and differential fees
Mathematics	PhD	4 years	\$14,000 above tuition costs and differential fees
Statistics	MSc	1 year	\$10,000 above tuition costs
Statistics	PhD	4 years	\$13,000 above tuition costs

To see the 2015-2016 tuition and fees, please see Section 4.5.

3.3 Teaching Assistantships (TA)

Students usually receive financial support from Teaching Assistantships (TA) as part of their departmental funding package. TA support is governed by rules of The Canadian Union of Public Employees, Local 3912 (<http://www.3912.cupe.ca/>). TA work is 90 hours for each of the Fall and Winter terms for a total of 180 hours for the 8-month academic year. These hours are assigned for marking, tutoring in our Mathematics & Statistics Learning Centre (<http://www.dal.ca/faculty/science/math-stats/about/learning-centre.html>) or giving first year class tutorials which works out to approximately 7 hours a week.

In order to maintain full-time status and continued scholarship/fellowship support, a student may work no more than 16 hours per week, including a maximum of 10 hours as a teaching assistant/marker/demonstrator. Students registered as part-time are not eligible for scholarship or Dalhousie Graduate Student Scholarship support.

The current TA salary is \$3,870 per academic year. The Centre for Teaching & Learning offers TA support and workshops; please see Section 6.10 for more details.

3.4 Teaching Opportunities

Most PhD students and some MSc students will have the opportunity to teach a course as the main instructor during their program. Typically these openings are for summer courses, but there could be some during the Fall and Winter semesters as well. These job openings are announced by the department via email.

3.5 Scholarship Payments

The procedures for calculating fellowship amounts are complex, and mistakes may occur. Students typically receive a fellowship letter during the summer stating their total rate of pay for the upcoming year. Students are encouraged to discuss this letter with their supervisor, graduate coordinator, or departmental administrator if there is anything about the letter they do not understand. They are also encouraged to monitor their subsequent pay cheques to ensure consistency with their fellowship letter.

Scholarship payments are divided equally over the terms covered by the award, usually Fall (September to December), Winter (January to April) and Summer (May to August). Fees will be deducted at the beginning of each term and the remainder paid in equal monthly instalments. Please note that the monthly payments of scholarships are done near the end of each month.

3.6 Lett Bursary

The Patrick Lett Student Assistance Bursary is a fund with the purpose of giving financial aid to graduate students who are having difficulties getting assistance from other sources.

This bursary is primarily intended for students who have run out of regular funding; this means that students in their first year of an MSc program or in the first two or three years of a PhD program are not usually funded by the Lett Bursary, unless there are special circumstances.

If you think you may qualify, you can find an application form and instructions on the department website under (<http://www.dal.ca/faculty/science/math-stats/programs/financial-assistance.html>), or pick up hard copies from the department office.

There is a similar source of emergency funds called “The Faculty of Graduate Studies Emergency Bursary”. Please see (<http://www.dal.ca/faculty/gradstudies/funding/bursaries/fgs.html>) for more information.

4 Application and Admission

4.1 Language Requirements

All applicants whose first language is not English must receive a sufficiently high mark on an English language proficiency test (TOEFL 580 (written), 237 (computer), 92 (internet); MELAB 85; IELTS 7). The language competency test may be waived if the applicant has completed a degree at a recognized university where the language of instruction is English.

4.2 Deadlines

Graduate programs in mathematics and statistics are designed to start in September, but in some circumstances applicants may start in January or May.

All students applying for funding:

Your application and supporting documents should reach the university by **January 15**.

Canadian students:

Applications should be received by the university no later than June 1 for a September start date (all supporting documents must be received by this deadline). If you are applying for scholarships and departmental funding, your application and documents should reach the university by January 15. Applications received after June 1 are not guaranteed to be processed in time for September admission.

Non-Canadian students:

Your application must be received no later than April 1 for a September start date. If you are applying for scholarships, all documents must reach us by January 15. Applicants who require a student visa and are not funded by the university or an officially-recognized funding agency must provide proof of financial ability with their application. Canadian immigration is increasingly rigorous about requiring proof of sufficient financial support to complete the program of studies. Also, given the length of time some student visa applications can take, foreign students are encouraged to apply early so they can be here for the start of their program.

4.3 Application Package

An application package should at least contain (for details see <http://www.dal.ca/admissions/graduate.html>):

- application forms,
- official transcripts,
- statement of research interests,
- a curriculum vitae,
- at least 2 letters of reference, and
- TOEFL scores or equivalent English Language Competency tests for international applicants (see Section 4.1).

To obtain application information and forms go to (<http://www.dal.ca/admissions/apply.html>). Alternatively, you can request a paper copy of the form to be sent from the Registrar's Office at: admissions@dal.ca or (902) 494-2156. Please allow 2-3 weeks for delivery or 6-8 weeks for overseas

requests. One copy of Part A of the application form along with the application fee must be sent to the Registrar's Office. All supporting materials (including references, official transcripts from all post-secondary institutions attended, official TOEFL scores, etc.) are to be sent directly to the department:

Graduate Secretary
Mathematics and Statistics
Dalhousie University
6316 Coburg Rd.
PO BOX 15000
Halifax, Nova Scotia
Canada B3H 4R2

Note that supporting documents (transcripts, letters of reference, etc.) will be verified for authenticity. Applicants submitting fraudulent documents may have their names published on the listserv of the Association of Registrars of Universities and Colleges of Canada and have their acceptance rescinded.

4.4 Application Fee

The application fee is currently \$100 CDN. This fee is paid to the university (not the department). Payment instructions can be found in the body of the application.

4.5 Program Fees (Tuition and Other Fees)

At Dalhousie, the graduate studies academic year (Sept.1 to Aug.31) is divided into three terms: Fall (September-December), Winter (January-April) and Summer (May-August). The total tuition and fees for one full year are due in three instalments, corresponding to the three terms.

Most graduate programs at Dalhousie University (including Mathematics & Statistics) have a minimum period for program fee payment and residency requirements. For example, a student admitted to a one-year, full-time Master's program is required to pay three consecutive terms of full-time program fees. The student may take two years to complete the MSc, but after the first year, the student will pay only continuing fees.

Students are expected to register for three consecutive terms unless otherwise given permission to take classes or undertake research elsewhere. If admitted to a two-year, full-time program, students are required to pay full-time program fees for 6 consecutive terms.

We normally admit PhD students into a two-year program, and expect them to complete their degrees in four years. This means that for the first two years they pay full program fees and after that they pay continuing student fees until they graduate (see Table 1). There are no part-time PhD programs at Dalhousie.

Mathematics & Statistics degree programs are based on a program fee structure (e.g. a one-year program, two-year program etc.). Fees must be paid for all three terms in a given year, regardless of whether the student is taking courses in all three terms or how many courses are being taken in a particular term. So there are three payment due dates (in September, January and May). Exact dates can be found on the Graduate Studies website. Students who fail to register and pay tuition fees for any term before the degree program requirements have been fulfilled are considered to have withdrawn and will be required to apply for re-admission. Re-admitted program fee students (except those who were withdrawn for academic reasons) must pay fees for the terms in which they were not registered, to a maximum of three terms at the current continuing fee rate.

Please visit Dalhousie's Student Accounts site (<http://www.dal.ca/studentaccounts>) for up-to-date information regarding tuition and fees. Table 1 in this document contains a breakdown of the most up-to-date program fees.

4.5.1 Differential Fees

Students registering at Dalhousie who are not Canadian citizens or permanent residents are required to pay an additional Differential Fee over and above the regular fees. This fee is applied to all graduate degrees in which the student registers, regardless of whether the student has already completed a Dalhousie graduate degree. Table 1 contains the exact amount. For students in our programs the fees are charged for the first two years.

4.6 Residency Requirement

The minimum residency requirement by Dalhousie University is 1 year for the MSc and 2 years for the PhD program. This means that to obtain a degree the fees corresponding to the relevant length of time for each degree must have been paid to Dalhousie University.

PhD	MSc	Qualifying	Tuition
\$8790 \$2,301	\$8412 \$2,301	\$841.20 \$793.20	Tuition full time student (1) Tuition continuing student Fee per 3-credit graduate course Fee per 3-credit undergraduate course
			Incidental Fees (4)
\$216.54 \$270 \$60 \$446.10 \$253.05 \$151.40	\$216.54 \$270 \$60 \$446.10 \$253.05 \$151.40	\$216.54 \$270 \$60 \$446.10 \$253.05 \$151.40	Student Union Fee DSU Health and Dental Plan (2) Society Fee Student Service Fee Facilities Renewal Fee Bus Pass Fee
			International Student Fees
\$6,015	\$6,015	\$4,351.50 \$870.30	International Differential Fee (3) per term differential fees, if taking 3 or more courses per course differential fees, if taking 1 or 2 courses
\$491 \$15	\$491 \$15	\$491 \$15	International Student Health Insurance (2) International Student Society Fee
\$10,367.09	\$ 9,809.09		Total Canadian Student Fees
\$16,888.09	\$16,330.09		Total International Student Fees
\$3,698.09	\$3,698.09		Total Canadian Continuing Student Fees
\$4,204.09 + Applicable Differential Fees (3)	\$4,204.09 +		Total International Continuing Student Fees

Table 1: Breakdown of 2015-2016 Tuition & Fees (to the best of our understanding)

(1) Normally our Master's students pay the full time fees for one year, and PhD students for two years. After that they pay the continuing student fees;

(2) single rate, can opt out if student has other coverage;

(3) payable for 2 years, see the graduate calendar;

(4) Some fees are reduced for students who take less than 3 courses a semester.

Reference: http://www.dal.ca/admissions/money_matters/tuition_fees_costs/fee_schedules.html

and http://www.dal.ca/admissions/money_matters/tuition_fees_costs/incidental_fees.html

5 Acceptance and Registration

5.1 Admission Decisions

Our first round of offers go out in late January and we continue making offers often into April. Our funds keep changing in that period as scholarship competition results are announced, and accordingly, we make new offers all the time. We ask you to please let us know if you are considering other offers and have not yet heard from us. Also, if you have an offer from our department and already know that you will be going elsewhere, we ask you to let us know at the earliest possible so we can admit another student.

If you are coming to Dalhousie with your own external scholarships, your application can be considered at any time, as long as the proper deadlines (application, visa process, etc.) are met so that you can start the program on time.

5.2 Notification

When you are admitted into our graduate program, you will first receive a letter or email from the Department of Mathematics and Statistics, informing you that the department has recommended to the Dean of Graduate Studies that you be admitted (and possibly that you receive funding). It is important to know that this letter or email is not considered an “official” offer; it should be followed by an official admission letter from the Dean of Graduate Studies. In some cases, it is possible for the Dean not to accept the department’s recommendations. Please contact us if you do not receive your official admission letter in a timely manner, and particularly if you have alternative offers to consider from other universities.

You usually have one month to reply to the Dean’s admission letter and accept the offer of admission. If you do not reply by the deadline set out in the letter, your funding may be reallocated.

Once you have made a decision as to whether or not you will be accepting our offer, we request that you let the department know immediately. This helps us greatly in deciding how many students we can admit in a given year.

5.3 Admission Deposit

All students who have been accepted to a graduate program are required to pay a \$200 non-refundable deposit. The deposit will reserve a place for the student in their program and will provide departments earlier confirmation of incoming students. The deposit will be credited towards the students tuition fees once they are registered. Please note, students will not be able to register until the deposit is paid.

Students will have 3 weeks from the day the acceptance letter is issued to pay the deposit through Student Accounts. If the deposit is not paid within one month a decision of “Offer Expired” will be put on their record.

5.4 Qualifying Year (MSc only)

A student applying for admission into the mathematics MSc program but with some deficiency in the particular discipline may be admitted to a Qualifying Year. Qualifying students are required to take specific courses that are chosen in consultation with the graduate coordinator. These courses are chosen from undergraduate classes or a mixture of undergraduate and graduate classes. Qualifying students can study full-time or part-time, and may be required to take as little as one half-credit (0.5) class or as many as ten one-half credit classes.

Qualifying-year students are not eligible for scholarship or bursary support and must apply for admission to the appropriate graduate program in the usual way towards the end of the qualifying period. Qualifying students must pass all classes taken as qualifying students with no grades below a B- and an average of at least B, and fulfill any other requirements in order to be considered for admission.

Students applying to the statistics program are unlikely to be admitted to a qualifying program. Strong preference is given to students who can be admitted directly into the program. Students wishing to improve their application through additional course work can take courses as special students (undergraduate); the undergraduate calendar should be consulted for additional information.

5.5 Special Student Graduate Studies

With permission of the Faculty of Graduate Studies, students are sometimes permitted to take a graduate class without being enrolled in a graduate program. The registration category for non-program students taking graduate classes is Special Student-Graduate Studies (SSGS). Such students may normally take a maximum of four classes (12 credit hours) with the permission of the class instructor and the graduate coordinator. Because all graduate classes must be taught at a consistent standard to graduate level students, non-program students must have records which meet the minimum entrance requirements and follow the same application procedure as for a graduate program. Please see FGS regulations for details.

With permission granted from the FGS, it is possible to receive credit towards a graduate degree for courses completed under SSGS.

5.6 MSc With Option to Transfer to PhD

If you apply to our PhD program, you might be accepted into the Master's program with the option to transfer to the PhD program after one term. This means that you start the graduate program at Dalhousie in, say, September as an MSc student, and at the end of the Fall term, if your performance is deemed satisfactory by the department, transfer into the PhD program effective the Winter term (January). Once transferred, you may receive credit for the courses taken in the Fall term.

5.7 Admission Conditional on ESL

We often conditionally admit students into our graduate program who meet all the admissions criteria but have not satisfied the language requirements of Dalhousie University (Section 4.1). In such cases, the student will have a year to achieve the required scores on an ESL test, and can start the graduate program after that. The list of accepted tests can be found in the University Graduate Calendar under Section 3.4.

5.7.1 Where to Take ESL Courses

The College of Continuing Education (<http://www.dal.ca/faculty/cce/programs/english-as-a-second-language.html>) at Dalhousie University runs (English as a Second Language) ESL courses and administers the tests year-round. It is not required that you take the ESL courses here: you can use any program to obtain the required scores.

5.8 Deferral

Provided you instruct us in a timely manner, we can request a deferral of admittance for up to one year from the Dean of Graduate Studies; however, scholarships cannot be deferred.

5.9 Registration

Graduate students must maintain their registration in all three terms until their program is completed, except in those cases where a formal Leave of Absence has been officially approved by the Faculty of Graduate Studies. In addition to registering for classes, students must add the Fee Generating Course (REGN 9999) for each term. In the Banner registration system, if REGN 9999 is not added for each term, graduate students are not considered registered. Failure to register properly, before the deadline, may result in nonpayment of scholarships and stipends. The deadline for the REGN registration is usually in the middle of August. Students should check the FGS website for the exact date. It is usually more convenient for students to register at this time for the entire year, if they anticipate continuing for an entire year.

All Students

All students must add the Fee Generating Course (REGN 9999) for each term.

	<u>Fall 2015</u>	<u>Winter 2016</u>	<u>Summer 2016</u>
REGN 9999	CRN 12401	CRN 22212	CRN 31245

First Year PhD Students

You should register for Comprehensive Examinations (MATH 9520 or STAT 9520) every semester until you have passed your PhD comprehensive exams.

Continuing Students

Once you have completed all your courses (including MATH 9520 or STAT 9520 in the case of PhD students), you must register for your thesis. Course information is listed below

MATH 9000 - MSc Thesis
MATH 9530 - PhD Thesis
STAT 9000 - MSc Thesis
STAT 9530 - PhD Thesis

For registration details and deadlines, see Graduate Registration Information and Fees:
(<http://www.dal.ca/faculty/gradstudies/tuition-fees.html>).

5.10 Student E-mail Address

The university issues an @dal.ca e-mail address to all students. This address is entered automatically in the Student Information System as the preferred e-mail address; it will be the address to which all general e-mail messages to students will be sent and it will be the address provided to faculty members when they request distribution lists for the sending of messages to students in their classes. A message sent by the university, or a faculty or staff member, to your @dal.ca address will be considered to have been delivered to you. You should visit (<http://www.dal.ca/dept/its.html>) for detailed instructions on how to activate your @dal.ca account.

5.11 Dal Alert & Emergency Phone Text Messaging

Dal Alert (<https://dalalert.dal.ca/index.php>) is an integrated messaging service used to broadcast important information to the Dalhousie community in events like campus hazards, significant campus closures, or other unpredictable events that might affect large groups. Dal Alert uses a variety of messaging media (e.g. email, text messaging, web, etc.) to reach a broad cross-section of the Dalhousie community in a timely fashion.

You can enter your Dalhousie ID and cell phone number to start receiving emergency alerts. A sign-up window/tab has been added to the main page of MyDal (<https://my.dal.ca/cp/home/displaylogin>). This system is an additional but important tool to relay messages to students and employees in emergencies.

5.12 Notification of Address Change

All students must provide Dalhousie with a valid mailing address, and are responsible for keeping this information up-to-date. If your address changes, you must report your new address at Dalhousie Online (<https://dalonline.dal.ca/home.html>). Notifications from the university will be sent to the most recent address on file, and failure to report a change of address is not a valid excuse for missing such notifications.

6 Arrival on Campus

6.1 Housing: Short and Long Term

There are affordable short-term and nightly accommodations available during the summer months at the Dalhousie residences. This is a good option to use when arriving on campus. Please see the website (<http://www.dal.ca/dept/summer-accommodations.html>) for more information.

It can be difficult to find housing if you arrive on campus after classes start. The Residence Office (located at 1443 Seymour St.) has information on university accommodation and off-campus housing. Please view their website (<http://www.dal.ca/residence>) for further information.

A good local source of listings where you can find housing, used furniture and more, is the Kijiji Halifax website (<http://halifax.kijiji.ca/>).

6.2 Dalhousie ID Card (i.e. Student ID or BANNER No.)

On your arrival at Dalhousie (and assuming that you have registered online), one of your first priorities will be to obtain an ID card. New students may obtain their ID card at the DalCard Office located at 1443 Seymour St.

6.3 Departmental Facilities

The graduate secretary will assign each new student an office, a mailbox, a computer account and a code for the front door of the building.

There is a lounge and small kitchen with fridge and microwave on the second floor that is available to all graduate students and faculty for use. Please be respectful of the space and keep it clean and quiet so that everyone can enjoy this common area.

Rooms for seminars and meetings can be booked through the department office.

Photocopier accounts for students are charged to their supervisors. For accounts on the copy machine, please talk to the graduate secretary.

If you need to make on-campus phone calls, please go to the department office and ask one of the secretaries.

6.4 Departmental Computing Facilities

The department provides the following computing facilities to graduate students, faculty, staff and visitors in the Chase Building:

- Office desktops with windows or Linux as available options, if a computer is available;
- accounts that provide storage space with tape backup and space on web server;
- two public heavy duty printers - one in the mail room and one in the basement - plus one color printer in the basement and one color printer in the mailroom. All with unlimited printing.
- a 15 node Linux compute cluster for research computing;
- three sheet-feed scanners and three public computers in room 001.

Here is some useful information on how to access the departmental resources:

- ssh to *chase.mathstat.dal.ca* on port 44747 for access to storage space

- Go to www.mathstat.dal.ca/~your-user-name for your web space
- Go to www.mathstat.dal.ca/cluster for compute cluster documentation

Default disk quotas with daily tape backup

400 MB for home volumes on chase.mathstat.dal.ca
400 MB on cluster

Extra storage space on chase/cluster with biweekly tape backup

20 GB (*/temp-1/username*)

Extra storage space on chase/cluster with no backup

5 TB (*/scratch/username*)

For any computing questions in the Chase building, please contact Balagopal Pillai (pillai@mathstat.dal.ca).

6.5 Health and Dental Care

- **Nova Scotia MSI Card (Medical Services Insurance):**

The provincial medical insurance known as MSI is available to Nova Scotia residents at no charge and provides hospital and medical care free of charge. If you have been residing in Nova Scotia for 12 consecutive months and you have not left the province for more than 30 days at a time, you may be eligible for MSI. International Students who have secured positions as teaching or research assistants from a Dalhousie University department or faculty are eligible to apply for MSI immediately and do not have to wait the usual 12 months.

Please note that this is not an extended health coverage plan and prescription drugs, etc. are not covered. To obtain an application and determine your eligibility, please call the MSI office at 902-468-9700.

You will need to get a letter signed by the Dean of the Faculty of Science, so please see the Graduate Secretary who will compose the standard letter for you to take over to the Faculty of Science for the Dean's signature.

- **DSU Health and Dental Plan:** The Dalhousie Student Union Health and Dental Plan (<http://www.dsu.ca/services/health-plan>) is required unless you have alternative coverage (proof required). You must apply to opt out of the plan. Visit their website for more information.
- **International Student Health Plan:** For international students the International Student Health Plan is mandatory if you are not eligible to apply for an MSI card. Please see (<https://www.internationalhealth.ca/dsu/89-plan-information>) for more information on this plan.

International Students who have secured positions as teaching or research assistants from a Dalhousie University department or faculty are eligible to apply for MSI immediately and do not have to wait the usual 12 months. Once you receive your MSI card, you can visit the International Student & Exchange Services office and inquire about opting out of the International Student Health Plan.

Dalhousie Health Services provides health care and services for students. Health Services is located at 1246 LeMarchant Street (between South St. and University Ave). Their phone number is 494-2171.

The Dalhousie Dental Clinic, which is an educational facility, offers a wide range of services to students. Patients accepted for treatment provide clinical experiences for dental students, and at the same time receive quality care at reduced fees. The clinic is located at 5981 University Ave. Phone number is 494-2101.

6.6 Libraries

All mathematics and statistics books are located in the Killam Library. The Killam Library is located across the parking lot behind the Chase Building. Your Dalhousie ID serves as a library card. This also entitles you to use other libraries on campus (e.g. Law or Medicine) or to borrow materials from other local university libraries. Library tours are available. Please consult the front desk at the Killam for further information.

The Graduate Students Centre on the fourth floor of Killam Library is a lounge dedicated to use by graduate students. It contains desks, conference rooms and facilities for study and discussions.

6.7 Bookstore

The university bookstore is located in the basement of the Student Union Building (6136 University Ave). Both new and used textbooks are available, though private sale of graduate texts is more common.

6.8 Student Employment Centre

The Dalhousie Student Employment Centre is on the 4th floor of the Student Union Building (SUB). A student may register full-time and hold a job simultaneously, only if the job involves no more than 16 hours of work per week, including a maximum of 10 hrs as a teaching assistant.

6.9 Student Accessibility & Accommodation

The Office of Student Accessibility & Accommodation, located next to the Killam Library on University Ave., administers the Accommodation Policy for Students.

This office is Dalhousie's centre of expertise for student accessibility and accommodation, based on a disability, religious or other issue. All requests for academic accommodation and non-academic accommodation made by registered students must be directed to this office. Please see their website for details and procedures: (<http://studentaccessibility.dal.ca/>).

6.10 Centre for Learning & Teaching

The Centre for Learning and Teaching (CLT) (<http://www.dal.ca/dept/clt.html>) works in partnership with academic units, faculty members, and graduate students to enhance the practice and scholarship of learning and teaching at Dalhousie University. CLT runs various workshops throughout the year, and offers support to teaching assistants. In particular, they annually host TA Professional Development Days, usually in mid-September.

6.11 Transportation and Parking

The University Bus Pass (U-Pass) is a special transit pass specifically designed for Dalhousie and King's students. If you're a full-time student, the U-Pass lets you ride Metro Transit buses, ferries and Community Transit buses from September to April. The U-Pass is a mandatory program for all full-time students. It costs \$142.50 per year and is automatically assessed in September with your incidental fees.

If you would like information on parking areas/permits, the Security Office is located in the basement parkade of the McCain Bldg. (across from the SUB). Forms must be completed in their office. If you would like information on bus passes, visit the Bookstore (basement of SUB).

6.12 University Closure/Cancellation of Classes

Any decision to close the university (e.g. for a severe snowstorm) is made in the President's Office and announced on Dalhousie's web page (<http://www.dal.ca>) and on local CBC Radio 1 at 90.5 FM.

7 General Program Information

7.1 Supervisory Committees

All members of supervisory committees are Regular, Adjunct or External Scholar members of the Faculty of Graduate Studies. Regular members should constitute no less than 50% of the membership of a supervisory committee. The tables entitled Serving on a supervisory committee, given in Section 9.1 of the Graduate Calendar, define explicitly the permission to serve on supervisory committees. Supervisory committees are selected by the supervisor in consultation with the student. A supervisory committee should complement the expertise available to the student in completing their research program. The membership of all supervisory committees must be recorded in Graduate Studies Information System (GSIS) (<http://www.dal.ca/faculty/gradstudies/currentstudents/gsis.html>), and changes to membership must be submitted on the student's program update form and recorded by the department in GSIS.

7.2 Seminars

Students are required to attend the departmental seminar series most relevant to their area of research, and are encouraged to attend the colloquia in their division. Students who are unable to attend seminars regularly must have the specific agreement of their supervisor or graduate coordinator that this requirement be waived.

Mathematics graduate students are required to give one talk a year in the Graduate Seminar Series (unless they speak in one of the departmental research seminars), on a subject relevant to their area of research, and regularly attend these seminars. This is a good opportunity to give a public talk in an informal environment.

7.3 Program Forms

Program Forms specify the course requirements for an MSc or PhD, and the composition of the supervisory committee. They are normally filled out during the first month of study, in consultation between the student and supervisor. Program forms are submitted online through GSIS. The GSIS Manual for Students is online: <http://www.dal.ca/faculty/gradstudies/currentstudents/gsis.html>.

Once approved, the Program Form constitutes an agreement between the student and the university on the requirements to complete the program. Before graduation, FGS will review the student's Banner record and the Program Form for consistency. The student will not be able to graduate if there are discrepancies. It is the responsibility of the student to ensure consistency between the Banner records and the program form.

Students should only take classes listed on their Program Form. If they take additional classes, they will have to fill out a Program Update Form (see below) or may be required to pay additional fees.

7.4 Program Update Forms

The supervisor and FGS must be notified of any changes in a student's program requirements. These changes include changes in the length of the program, a change from full-time to part-time status, a change in course requirements, a change in supervisor, a change in the supervisory committee, or a change from MSc to PhD. FGS is notified of these changes through a Program Update Form, which is filled via GSIS.

7.5 Progress Reports

Every graduate student in a thesis program is required to submit an Annual Progress Report to the Faculty of Graduate Studies on an annual basis, one month prior to the anniversary of the student's admission date. This means that they are due August 1 for September admissions, December 1 for January admissions, and April 1 for May admissions.

If you hold an NSERC PGSA/B or SSHRC scholarships you must complete a progress report one month in advance of the anniversary date of the start of your award. If the appropriate progress report is not received by the posted deadline, it may result in the award being terminated or a delay in the renewal of the award.

For details on how to fill out this report on GSIS please go to <http://www.dal.ca/faculty/gradstudies/currentstudents/gsis.html>.

7.6 AARMS Courses

The Atlantic Association for Research in the Mathematical Sciences (AARMS) runs a summer school every year. The school takes place at a university in Atlantic Canada. We quote from their website:

“During a four week period every summer AARMS invites highly regarded faculty from around the world to deliver graduate courses in the mathematical sciences and their applications. Our goals are to broaden the education of graduate students and to encourage promising undergraduates to continue their study.”

Many of our students take courses at the AARMS summer school. Depending on the topics, we have two courses in Mathematics (MATH 5001, MATH 5002) and two in Statistics (STATS 5001, STATS 5002) at Dalhousie that you can sign up for to receive credit for the summer school. If you wish to take these courses for credit, please talk to the graduate coordinator in advance to have them approved.

We encourage our students to participate in these schools. For deadlines and all other details, please visit their website (<http://www.aarms.math.ca/summer/index.html>).

7.7 Repeating Cross-listed Courses

If a student has already taken and passed one of our courses at the 4000 level, and wishes to repeat the course at the 5000 level, the 5000 level course will not count towards their degree requirements.

7.8 Taking Courses Outside Mathematics & Statistics

In special cases, such as when the course requirements for a student cannot be satisfied with the current course offerings, the graduate coordinator may permit a student to take a course in a different department.

7.9 Taking Courses Outside Dalhousie

With the approval of the department and FGS, graduate students registered in a Master's or PhD program may take courses for credit at another university, provided the class is not available at Dalhousie. For the Graduate Student Letter of Permission form and guidelines please see (<http://www.dal.ca/faculty/gradstudies/currentstudents/forms.html>). Students may not take classes outside Dalhousie for graduate credit unless prior approval has been given by the Faculty. Classes are not approved retroactively.

The maximum number of classes taken outside Dalhousie University is normally confined to 33% of the class requirements except in cases where a university-level agreement, governing specific cooperative arrangements, has been negotiated and is in operation.

The normal regulations governing grading policy (FGS Regulation 6.6.2) apply to classes taken at other institutions (e.g., a C+ on a graduate class taken elsewhere will be deemed an "F" in the student's program and may render him/her liable to academic dismissal). Students who fail a class may not replace that class as Letter of Permission except by special permission from the Faculty of Graduate Studies.

Dalhousie will normally pay the tuition for students who pay a program fee to take classes offered at other Maritime universities, to the equivalent cost of a Dalhousie course, provided the class is not available at Dalhousie. Any course charges above that amount are the responsibility of the student. Students who are required to take classes at other institutions outside the Maritimes will be considered on a case-by-case basis, e.g. if the class is a necessary component of a student's program. The tuition for an approved class taken at a university outside the Maritimes is normally the responsibility of the student. Students who receive approval to take classes at institutions within or outside the Maritimes for convenience or for non-academic reasons do so at their own expense.

7.10 Transfer of Credit for Courses Taken Outside Dalhousie

With the approval of the graduate coordinator and the supervisor, a student may transfer up to 33% of their required credits from a different university. The appropriateness of the level and subject of each course will be decided by the graduate coordinator, in consultation with the supervisor.

7.11 Reading Courses

By FGS regulations, students may not register for more than two reading courses and require written approval of their graduate coordinator to do so.

Procedure: each student will be provided with a class outline by the instructor. In order to complete the class satisfactorily, a student must fulfill all the requirements as set down in the class outline. By the end of the first week of class, the Independent Study / Directed Reading / Special Topics form (<http://www.dal.ca/faculty/gradstudies/currentstudents/forms.html>) must be submitted to the Faculty of Graduate Studies in order to be placed in the student's file. Changes to the outline which affect assessment components, the weight of individual assessment components, or examination requirements with a value of ten percent or more must have the approval of the enrolled student(s) in order to be valid and must also be sent to Faculty of Graduate Studies for the student file no later than four weeks after the beginning of the term in which the class is conducted.

When collaboration is included as part of class expectations as in group projects or group assignments, the instructor will provide in the class outline a statement of the degree of collaboration permitted in the preparation and submission of assignments.

7.12 Extensions

The normal upper time limits for an MSc are four years for full time students, and five years for part-time students. The time limit for a PhD student (always full-time) is six years.

A first extension of one year may be granted by the Faculty of Graduate Studies on the recommendation of the department, along with a satisfactory Progress Report form completed and signed by the student and the supervisor. Under no circumstances can a student be registered in a program for more than 10 years.

Requests for one further one-year extension, the final extension, must include a Progress Report form for the previous year together with a detailed plan and timetable for completion of the thesis within the following twelve (12) month period. The student is then expected to defend and submit the approved thesis within that academic year. A further extension will only be given for one term to provide for necessary revisions to the thesis following defence.

7.13 Grading Policy for Graduate Students

Under FGS regulations, all instructors of graduate classes (i.e., designated 5000 and above) at Dalhousie, with the exception of a few classes for which a pass/fail grading scheme has been approved, will use the following grading scheme:

Letter Grade	Percentage Equivalent	Grade Point Value
A+	90-100	4.3
A	85-89	4
A-	80-84	3.7
B+	77-79	3.3
B	73-76	3
B-	70-72	2.7
F	< 70	0

Faculty of Graduate Studies regulations stipulate that graduate students must achieve a minimum, or passing, grade of "B-" in all classes. Any lower grade will be recorded as a failure. A student who fails to meet these requirements (in 3 credit hours) in any year is immediately and automatically withdrawn (academically dismissed) from the program. However, such a student may apply, in writing, to the department for immediate reinstatement, (see FGS regulations, Section 4.2.5, Re-admission of Students). Reinstatement to a program after a failing grade must be supported by the graduate coordinator, and must be approved in writing by the Faculty of Graduate Studies. If re-admitted, any subsequent "F" will result in a final program dismissal. Note that any academic withdrawal and reinstatement will be recorded on the student's official transcript.

7.14 FGS Travel Support

Students are encouraged to apply to FGS for travel support. It is normally given only for presentation of a poster or paper at scholarly meetings. Students are eligible for one travel grant during the period of their graduate degree program at Dalhousie, and should be presenting research related to their thesis. Students should consult the FGS website for more details.

7.15 Dalhousie Math & Stats Graduate Student Society

The Dalhousie Mathematics and Statistics Grad Society organizes the Graduate Seminar Series, and social events for Dalhousie Math and Stats grad students. Events in the past have included martini parties, bowling, game nights and boat cruises.

7.16 Guidelines for the Supervision of Graduate Students

The rights and responsibilities of students, supervisors, and the department are outlined in the FGS Calendar, and can be found in Section 9.4.

8 MSc Program Requirements

8.1 Curriculum Requirements

Students are normally required to complete six half-credits at the 5000 level or higher. Courses are expected to have some relevance to the student's research. The required courses are specified in the Program Form. Upon failure of any course (grade strictly less than B-), a student will be withdrawn from the graduate program and must apply to the department for reinstatement. Reinstatement is at the discretion of the department and Faculty of Graduate Studies, following input from the supervisory committee. If a student fails two courses, re-admission is at the discretion of the Faculty of Graduate Studies and is highly unlikely.

8.2 MSc Supervisory Committee

Each Master's thesis candidate shall have a supervisory committee, comprised of at least two faculty members who have membership in the Faculty of Graduate Studies, and at least one of whom is from the student's graduate department. A sole supervisor needs to have regular full (not Adjunct) membership in the Faculty of Graduate Studies.

Additional full or adjunct members of the Faculty of Graduate Studies may be appointed as appropriate. Additional members of the Committee who are not members of the Faculty of Graduate Studies, including members of the non-university community (such as a practicing profession), may be appointed to the supervisory committee where their particular expertise makes it appropriate. See Section 10.3 of the graduate calendar for more information.

8.3 MSc Thesis

The MSc thesis should report on research by a student on a specific topic. The MSc thesis can contain original theoretical results, or it can be expository. The thesis must demonstrate the student's ability to read, understand and analyze the literature on a specific subject, add their own perspective, and synthesize their findings into a coherent presentation. It can include original observations in the form of computations, applications or discussions. Sometimes an MSc thesis results in a journal publication, and often it is a stepping stone to more in-depth research towards a PhD degree.

Students must familiarize themselves with the Thesis Format Guidelines, available from the FGS website (<http://www.dal.ca/faculty/gradstudies/currentstudents/thesesanddefences/forms.html>). The Thesis Format Guidelines are meant to ensure that high quality manuscripts are produced in a consistent style and that reproduction and reduction in size done by the National Library produce readable copies.

8.4 The MSc Examining Committee

Each Master's thesis shall be examined by an Examining Committee, following the criteria given below:

1. There shall be a Chair, usually the Graduate Coordinator or designate, who is not a participating member of the Supervisory Committee, and whose duty is to ensure that the exam is appropriate and fair and to submit a report as noted below. The Chair is not an examiner.
2. In the case of a thesis with a single supervisor, the minimum set of examiners will consist of the supervisor plus two other readers. If the thesis is co-supervised, the co-supervisors will both act as examiners; there must also be two other readers in this case. The table in

Section 10.3.1B of the graduate calendar summarizes these minimum requirements and the examiner's status with the Faculty of Graduate Studies. Additional examiners, who may or may not be members of the Faculty of Graduate Studies, are permitted beyond these minima.

3. The Faculty of Graduate Studies may appoint an additional Faculty of Graduate Studies representative, if it is deemed necessary.
4. Voting: Only examiners with a Faculty of Graduate Studies appointment may vote on the outcome of an examination and sign the signature page.

8.5 MSc Thesis Defence

The agreement of all supervisory committee members is normally required before a department brings forward a thesis for examination. Notice of an MSc thesis defence, including an abstract, is posted within the Mathematics & Statistics Department several days before the defence. A display copy of the thesis must be made available to the department office for faculty viewing. The MSc Thesis Defence format consists of a 20-25 minute talk by the student, several rounds of committee questions and, if time permits, audience questions. This is followed by deliberations by the examination committee. The MSc thesis defence is open to the public, but the committee deliberations are not. All theses are either approved or not approved. The categories are:

1. approved as submitted;
2. approved upon specific corrections being made (a clear timetable for completion of the revisions must be presented to the student, normally with a maximum of one month to complete the revisions);
3. rejected but with permission to re-submit a revised thesis for re-examination (a clear timetable for completion must be presented, normally with a maximum of one year to re-submit);
4. rejected outright.

Reporting: There are two forms to be filled. Both forms are available at the department office, and the student should make sure to bring them to the defence.

- The Master's Thesis Approval Form, which is typed and sent to FGS, is available at <http://www.dal.ca/faculty/gradstudies/currentstudents/thesesanddefences/forms.html>.
- The Master's Thesis Examiner's Report, which is kept in the student's file, is available in the department office.

In the case of an outright failure or failure with a right to re-submit by a specific date, the Graduate Coordinator must send expeditiously an additional written notification of failure to the Faculty of Graduate Studies.

8.6 MSc Thesis Timeline

Students should check the FGS website for the last dates on which they may submit finished theses to FGS for graduation in May (usually mid-April) or October (usually late August). Students are expected to distribute copies of their thesis to their examination committee at least **3 weeks** in advance of this date. This is intended to give members of the examination committee sufficient time

to read the thesis, and for the student to undertake any minor changes to the thesis as recommended by the examination committee after the defence. It is the responsibility of the student to ensure that the MSc defence is held sufficiently in advance of the final FGS submission date to make any changes that might be required by the examination committee. Deadlines for the submission of the copies of the thesis to FGS in order to be eligible to graduate in May or October are final in all cases.

Intent to Graduate forms should be submitted to the Registrar's Office by late November, for May convocation and by late June for October convocation. Dates and forms are available on line from the Registrar's Office website, and the form can be filled on Dal Online.

8.7 When to Submit Your Thesis

Your stipend will be discontinued at the end of the month in which your degree requirements are met and the final submission of your thesis is received in FGS, but the balance of the fees you paid for that term will not be refunded to you. Therefore, it would be wise to time the submission of your thesis appropriately. As one of our former students put it: "Don't hand in your thesis until the final month of your program."

Please consult the FGS website <http://www.dal.ca/faculty/gradstudies/currentstudents/thesesanddefences/submission.html> for deadlines of submission in order to make it to convocation.

8.8 Required Paper Forms for Thesis Submission

Specific paper forms are required by FGS before the online submission of a thesis can be completed. The original signed forms are kept in the student's file. These forms are available from <http://www.dal.ca/faculty/gradstudies/currentstudents/thesesanddefences/submission.html>.

- Master's or PhD Thesis Approval Form
- Dalhousie Thesis License Agreement
- Student Contribution to Manuscript form (if applicable)

8.9 Electronic Submission of Final Approved Theses

All final, approved Master's and PhD theses – that is, after examination and approval of any required changes – are submitted directly to the Faculty of Graduate Studies as PDF/A files via DalSpace. These files are termed electronic theses or E-theses. The procedures for E-theses approval and submission can be found on the Faculty of Graduate Studies website at: <http://www.dal.ca/faculty/gradstudies/currentstudents/thesesanddefences/submission.html>. It is the student's responsibility to meet Faculty of Graduate Studies formatting requirements for the thesis and to ensure that the thesis has been converted into a compatible PDF/A version. Electronic submission of the thesis must be accompanied by original paper forms, which are retained on file at the Faculty of Graduate Studies. These include: Library and Archives Canada Theses Non-Exclusive License Form with original signature, the title page of the thesis, the signature page (Page ii) with original signatures (the E-thesis does not contain signatures), the copyright page (Page iii) with original signatures of the student, the ethics pages, the copyright permission and student contribution to manuscripts form (if applicable).

Within one week of submitting the E-thesis to the Dalhousie Institutional Repository (DalSpace) it is reviewed by the Faculty of Graduate Studies. If it is not approved as complete it will be returned

to the student once for corrections. Once it is approved as complete it is then committed to the institutional repository and then harvested by Theses Canada, sent to the National Library, Ottawa and listed in Dissertation Abstracts International or Master's Abstracts International. The National Library can then circulate such copy according to the International Inter-Library Loan Code, with full copyright protection for the author. Similarly, E-theses are also stored by DalSpace where they are searchable and available to the public via the internet. Where protection of intellectual property is a concern, the thesis may, with Faculty of Graduate Studies approval, be retained for a maximum of one year before publication and distribution.

Faculty of Graduate Studies will not accept or bind paper copies of theses. Students wishing to obtain bound copies for themselves, supervisors, departments, or other parties, are free to do so. Contact information for some thesis binderies may be found at the website above.

9 PhD Program Requirements

9.1 Curriculum Requirements

Students are normally required to complete four half-credits at the 5000 level or higher. Courses are expected to have some relevance to the student's research. Supervisors have the right to require additional courses beyond these numbers. The required courses are specified in the Program Form. Upon failure of any course (grade strictly less than B-), a student will be withdrawn from the graduate program and must apply to the department for reinstatement. Reinstatement is at the discretion of the department and Faculty of Graduate Studies, following input from the supervisory committee. If a student fails two courses, re-admission is at the discretion of the Faculty of Graduate Studies and is highly unlikely.

9.2 PhD Supervisory Committee

Within the first year of their program, all Doctoral students must have a formally constituted supervisory committee, consisting of the thesis supervisor and at least two other members of the Faculty of Graduate Studies who are knowledgeable in the field of research. Membership of all Doctoral supervisory committees must be approved formally by the Faculty of Graduate Studies.

Supervisory committees should meet during the thesis research period; FGS recommends at least twice a year.

9.3 Mathematics Comprehensive Examinations

As part of the Mathematics PhD program, each student must successfully pass three examinations. A PhD student must register for MATH 9520 (Comprehensive Examinations) each term until they have completed all three examinations and received a passing grade. These exams consist of:

1. Two non-specialist examinations to be chosen from the following list of areas:

- Algebra
- Analysis
- Combinatorics and Graph Theory
- Differential Equations
- Differential Geometry
- General Relativity
- Number Theory
- Numerical Analysis
- Probability
- Statistics
- Topology (General and Algebraic).

2. An examination in the candidate's area of specialization;

Syllabi for some of these comprehensive examinations can be found in Section 10 of this handbook. Copies of the others are available from the graduate secretary.

9.3.1 Non-specialist Examinations

1. *There will be no overlap in the syllabus of any two non-specialist comprehensive examinations a student takes.*

2. *At least one of the examinations must be in either Algebra or Analysis.*

The syllabi for the Algebra and Analysis exams closely follow those of the mathematics core courses MATH 5045, MATH 5055 for Algebra and MATH 5010, MATH 5020, and MATH 5540 for Analysis. Comprehensive exams for these two subjects are given in conjunction with the final exams for these courses. To receive credit for the comprehensive exam in

- Algebra the candidate may write and pass the two exams given in conjunction with the courses MATH 5045 and MATH 5055;
- Analysis the candidate write and pass the exams set in conjunction with two of the three courses MATH 5010, MATH 5020 and MATH 5540.

These comprehensive exams are written in the same period as the final exams for these courses. At the discretion of the instructor, the comprehensive exam may contain different questions than the final exam for the course. The level required for the comprehensive exam may be different than that of the final exam, and the length will be three hours. The setting and grading of the comprehensive exam at the end of these courses will be overseen by a second faculty member.

Banking Comprehensive Examinations for MSc Students: MSc students taking the core courses mentioned above are allowed to, with the permission of the graduate coordinator, take the corresponding comprehensive final exam for the course, and bank their passing grade so that it could be used once they are enrolled in the Mathematics PhD program at Dalhousie. This option is only available if there is no gap between the MSc and PhD programs for the student. MSc students wishing to avail themselves of this option must inform the graduate coordinator and the course instructors of this at the beginning of the term in which they take the courses.

3. *The exams must be taken for the first time within 12 months and successfully completed within 16 months of registration in the program.*

Usually, the non-course-based exams are scheduled within a few days of each other, and typically at the end of the summer following a September start date (or December for a January start date).

9.3.2 Specialist Examination

The specialist examination is a combination written and oral exam **to be completed within 24 months of entry into the PhD program**. The written portion of the specialist exam is to consist of a written report prepared in advance by the student outlining the students proposed thesis research. The oral examination will be on the content of the written report together with a syllabus prepared by the student's supervisory committee prescribing a selection of published sources relevant to the student's proposed thesis research. The examiners for the oral exam will be the student's supervisory committee and a departmental representative appointed by the chair.

9.3.3 Procedures

1. The candidate selects a specialty area and an advisor from this area, and obtains the advisor's consent. (Normally this advisor becomes the research supervisor.)
2. The candidate and the advisor in consultation select the two non-specialty areas and inform the graduate coordinator of these areas.

3. The graduate coordinator, in consultation with the advisor and the candidate, appoints a comprehensive examination committee of two for each examination (normally including the advisor for the specialty examination), and obtains the consent of these committee members. Committee members must be members of the Dalhousie Faculty of Graduate Studies.
4. It is the responsibility of the comprehensive examination committee to interpret the prepared syllabi. The candidate should consult with the appropriate examiners if clarification of the syllabus is required.
5. The graduate coordinator and examination committee will schedule the examinations.
6. The official notification of the results of each examination will always come from the graduate coordinator.

9.3.4 Oral Examinations

Oral examinations are 60 to 90 minutes long, and it begins with a 20 minute presentation by the student followed by two or more rounds of questions from the committee. All members of the examining committee must be present at an oral examination. The graduate coordinator will assign an observer to an oral examination session who makes sure that the candidate, within the designated time-frame of the examination, has been given sufficient time to consider each question. Details of how each session is to proceed will be set ahead of time with the candidate, examination committee, observer and graduate coordinator.

Reporting: The Report on Oral Specialist Exam form is available in the department office. After the examination, this form is filled and signed by each member of the committee and the observer, and will be filed with the graduate coordinator.

9.3.5 Written Examinations

Written examinations are three hours in length, are marked by the examination committee and filed with the graduate coordinator.

9.3.6 Evaluation

The comprehensive examination committee will notify the graduate coordinator of its decision, in writing, that:

- (i) the candidate has passed the comprehensive examination; or
 - (ii) the candidate has failed the comprehensive examination; or
 - (iii) the candidate should repeat the comprehensive examination.
- A candidate who fails exactly one of the three examinations must be given the chance to repeat that examination.
 - A candidate who fails all three examinations will not be allowed to repeat the examinations and is no longer eligible to continue in the PhD program.
 - No examination may be repeated more than once.

9.3.7 Grievances

The candidate should bring any grievance or complaint regarding the implementation of their comprehensive examinations to the attention of the graduate coordinator as soon as any such matter arises. It is necessary that we have a transparent system for the examining committees as well as the candidate.

9.3.8 Practising for Comprehensives

Old comprehensive exams are available at the department office. Please see the graduate secretary to receive copies.

9.4 Statistics Comprehensive Examinations

As part of PhD requirements, students must pass two 3 hour exams. Both are written on the same week in May of the year of admission. The first examination covers material on Statistical Inference and Linear Models. The second examination covers material on Probability and Multivariate Analysis. Students will be provided with a detailed syllabus for the examinations when they enter the program.

Syllabi the statistics comprehensive examinations can be found in Section 11 of this handbook.

9.5 Statistics Thesis Proposal

As part of PhD requirements, within 12 months of successful completion of comprehensive exams, students must submit a written document to thesis committee members as a PhD proposal. This proposal will summarize the relevant literature related to their proposed thesis research topic. It should also outline a plan for successful completion of the project. The proposal needs to be defended orally approximately one week after submission.

Committee members will decide whether the proposal constitutes a viable plan for an eventual successful PhD thesis. Failure occurs when and if committee members decide that the proposal is unlikely to lead to a successful thesis or does not contain enough information to make a clear judgement. In such cases, students will be granted the opportunity to provide a new proposal within one month of the original oral exam.

To complete this requirement, students must register in Stat 9500 for the term in which the proposal takes place.

9.6 PhD Thesis

The PhD thesis should report original research of such value as to merit publication in a refereed scientific journal and be in a satisfactory and consistent form. Students must familiarize themselves with the Thesis Format Guidelines which are available from the FGS website (<http://www.dal.ca/faculty/gradstudies/currentstudents/thesesanddefences/format.html>). The Mathematics Thesis LaTeX Template is available at this link. The Thesis Format Guidelines, which allow for the incorporation of scholarly articles into the thesis, are meant to ensure that high quality manuscripts are produced in a consistent style and that reproduction and reduction in size done by the National Library produce readable copies. Students are strongly advised to show their thesis to the Thesis Clerk well in advance of final submission dates to ensure that there is enough time for any changes to be made.

9.7 The PhD Examining Committee

The examining committee consists of the research supervisor or co-supervisors, at least two additional members (Readers who shall normally have been members of the supervisory committee), and the external examiner who shall be from outside the University. A departmental representative (the chair of the department or a designate) is included as a non-voting and non-examining member of the committee. All members of the examining committee must have current membership in the Faculty of Graduate Studies (see Section 1 of the graduate calendar.)

9.8 PhD Internal Defence

The Department of Mathematics and Statistics requires that students publicly defend their thesis within the department before being allowed to submit their thesis to FGS. This defence consists of a 20 minute talk by the candidate followed by several rounds of questions by the examiners. Following questions by the examiners, questions by the public are considered. Immediately after the question period, a closed-room meeting with the examining committee results in one of the three recommendations that the candidate

- (1) be permitted to submit the thesis to FGS,
- (2) be permitted to submit the thesis to FGS after specific changes,
- (3) be asked to make major changes to the thesis and resubmit to the internal examination committee at a later date.

When the internal defence is passed successfully, the internal examining committee signs the PhD Thesis Submission form and the department chair or director signs the PhD Examination Information form- both forms are available from <http://www.dal.ca/faculty/gradstudies/currentstudents/thesesanddefences/forms.html> – so that the candidate can submit them to FGS along with the final version of the thesis.

9.9 FGS Regulations Regarding PhD Examinations

The following regulations have been copied from Faculty of Graduate Studies Regulations and somewhat edited to fit our department's procedures.

9.9.1 Deadline for Graduation

For thesis students the published deadlines for the submission of the copies of the thesis to the Faculty Office in order to be eligible to graduate in May or October are final in all cases.

9.9.2 Regulations for the Defence of a Doctoral Thesis

All Doctoral theses must be examined in a public oral defence, to be conducted by an examining committee recommended by the department and approved by the Faculty of Graduate Studies. A candidate shall not be permitted to proceed with the oral defence and examination until all of the following requirements have been met:

- (i) all required classwork completed successfully;
- (ii) comprehensive examination passed;
- (iii) examining committee established;

- (iv) the style and format of the thesis meets the requirements of the university and appropriate copies of the thesis have been submitted as per regulations and deadlines in paragraphs 1-10 below.

Normally a candidate proceeds to oral defence with the approval of the supervisor and supervisory committee. A candidate may proceed without the consent of the supervisor and committee but a signed declaration included on the Thesis Submission Form is required by the Faculty.

9.9.3 FGS Doctoral Defence Procedures

1. Appointment of External Examiner: The Chairperson of the Department (or Graduate Coordinator where appropriate) shall recommend to the Associate Dean of the Faculty of Graduate Studies three names (with C.V. for the first choice), listed in order of preference as submitted by the thesis supervisor (and approved by the supervisory committee). The appointment of an external examiner should preferably occur three months before the anticipated date of defence. The persons suggested should be acknowledged experts in the field or discipline of the research being examined in the thesis, must not have been directly involved in the student's research in any way, should possess a Doctoral degree or equivalent, and should have demonstrated experience of Doctoral supervision to degree completion and examination. Evidence of these qualifications must be explicit in the C.V. submitted for the first external candidate. The choice of the external examiner must be approved by the Faculty of Graduate Studies. If the first choice is unacceptable to the Faculty or if that person is unavailable, then the other names will be considered in order of identified priority. The Graduate Coordinator may then confirm the availability of the external examiner and proposed date and time for the defence. Once the date and time have been confirmed by the department then the formal invitation to the external examiner is issued by the Faculty of Graduate Studies (see para. 6. below).
2. Copies of Thesis Required for Examination: A minimum of five copies of the thesis are required, more if the Examining Committee is larger than the minimum Faculty requirements. The candidate shall submit one unbound paper copy of the completed thesis and an electronic copy (via *thesis@dal.ca*) to the Faculty of Graduate Studies Office, together with the
 - Thesis Submission Form,
 - PhD Examination Information Form, and
 - the candidate's C.V.

The thesis will then be given a preliminary check for formatting and style. The deadlines for submitting unbound PhD theses to departments (see the Schedule of Academic Dates in the Faculty of Graduate Studies calendar under July, November and February) are also the deadlines for submission of the unbound and electronic copies (with completed PhD Thesis Submission Form) to the Faculty of Graduate Studies (see also para. 5. and 6. below). The paper copy is then sent to the External Examiner by the Faculty of Graduate Studies office once a date and time of defence are determined. At that time the candidate shall provide

- a copy of the abstract page from their thesis and
- a brief biographical sketch for publication in a public notice of the defence

(this material must be submitted in Word compatible format and emailed to the Faculty of Graduate Studies Office at *thesis@dal.ca*).

3. Committee and Department Copies: The other four (or more as required) copies of the thesis will be submitted by the candidate to the departmental Graduate Coordinator, who will distribute them immediately to local members of the examining committee. One copy is held in the departmental secretary's office for use by other interested faculty and students.
4. No arrangements will be made for the oral examination until all these requirements are fulfilled. **The examination will be held no earlier than four weeks after submission of the thesis**, thereby allowing adequate time for the thesis to be read by the external examiner. Wherever possible the Coburg Board Room in the Mona Campbell building will be used.
5. The Faculty of Graduate Studies will establish the place for the examination.
6. The Associate Dean of Graduate Studies will issue a formal invitation to the external examiner and will send a copy of the thesis (see paragraph 2 above) to him/her at least four weeks before the examination, with a request to submit a written appraisal (the Examiner's Report - see paragraph 7) of the thesis no later than one week prior to the date of the defence.
7. The external examiner will submit by mail, fax, or email, a constructively critical and analytical report (the External Examiner's Report) to the Faculty of Graduate Studies Office at least one week prior to the scheduled date of the defence. A copy will be sent to the department Chair or Graduate Coordinator. The Examiner's Report must include a recommendation on whether or not the thesis should proceed to defence. Where the recommendation is not to proceed, the report should indicate what, if anything, would be required to make the thesis acceptable. Note that a decision to proceed to defence does not imply that the thesis is approved, only that it is acceptable for defence. The external examiner (and the examining committee) will have questions that must be answered to their satisfaction, and a thesis can be rejected as a result of the defence. The Examiner's Report must not be disclosed to the candidate or the supervisory committee prior to the defence (however, see para. 8. below). Normally the external examiner will attend the defence. A request for remote participation must be approved by the Associate Dean of the Faculty of Graduate Studies. The department will make every effort to arrange for alternative facilities (such as video- or teleconferencing) if they are appropriate to provide for the external examiner to participate in the defence even though he/she cannot be there in person. In the rare event of the external examiner not attending, a separate written report with opinion for grading, accompanied by detailed questions to be read at the defence on the external examiner's behalf should be submitted to the Faculty one week before the defence. Where this is not possible the defence should be rescheduled to permit participation of the external examiner.
8. The defence will only occur if the External Examiner states that the thesis may proceed. The report of the External Examiner must contain a clear indication whether the thesis is ready to defend or not. If the External does not recommend that the thesis proceeds to examination, then within 12 months, a revised thesis may be resubmitted and sent to either the original external examiner or to a new external examiner, as deemed appropriate by the Faculty of Graduate Studies. A doctoral thesis may be submitted to the Faculty of Graduate Studies for examination no more than twice.
9. If the external examiner recommends that the thesis proceed to defence, notice of the public defence of the thesis will be published and sent to all relevant departments by the Faculty of Graduate Studies. All interested faculty, students, and members of the public will be welcome to attend.

10. Variation of the regulations outlined above may be permitted only with the written permission of the Faculty of Graduate Studies.

9.9.4 Oral Examination

The oral examination of a Doctoral thesis is the culmination of the candidate's research program. It exposes the work to scholarly criticism and gives to the candidate the opportunity to defend the thesis in public.

1. **Chair of the Defence:** The Examination is chaired by a member of the Panel of PhD Defence Chairs.
2. **Examining Committee** The examining committee consists of the research supervisor or co-supervisors, at least two additional members (Readers who shall normally have been members of the supervisory committee), and the external examiner who shall be from outside the University. A departmental representative (the chair of the department or a designate) is included as a non-voting and non-examining member of the committee. All members of the examining committee must have current membership in the Faculty of Graduate Studies. (see Section 1 and Section 10.6.1 of the graduate calendar)
3. The Departmental Representative attends the public and in camera sessions of defence. The role of the Departmental Representative is to ensure departmental expectations are adhered to and reports such to the Defence Chair.
4. Order of Examination Proceedings:
 - (a) the Chair of the Defence opens the proceeding with a brief description of the protocol;
 - (b) the candidate is questioned on the thesis following a summary presentation no longer than 20 minutes;
 - (c) the Chair will give priority to questions from the external examiner and then from the other members of the examining committee in some pre-arranged order;
 - (d) the audience will then be invited to ask questions;
 - (e) the Chair adjourns the examination when the examining committee decides that further questioning is unnecessary, and the candidate and all members of the audience are required to leave the room;
 - (f) the Chair then presides over the examining committee during its deliberations in camera;
 - (g) following the in camera session, the candidate is invited back into the room and is informed of the decision of the committee;
 - (h) the Chair oversees the completion of the signature sheet as appropriate and completes the Defence Report and returns it immediately to the Faculty of Graduate Studies Office.
5. **In camera Deliberations and Grading:** The decision of the Examining Committee is based both on the thesis and on the candidate's ability to defend it. No thesis shall be approved without the agreement of an external examiner, except that a negative opinion of an external examiner who does not attend the examination should not prevail over the unanimous opinion of the other examiners present and voting.

The thesis is graded "approved" or "not approved". A thesis can be accepted by the Examining Committee as submitted; accepted on condition that specific minor corrections are

made; rejected with permission to submit a revised thesis and re-defend within 12 months; or rejected outright with no possibility of re-submission. No thesis shall be approved if major modifications are required. Theses can be rejected on grounds of form as well as content. If specific minor corrections are required, the thesis will be returned to the candidate with a time limit for the completion of all corrections, normally no more than one month. Specific corrections will usually be left to the satisfaction of the research supervisor.

6. **Proceedings in the Case of Rejection:** If the thesis is rejected with permission to submit a revised thesis (within 12 months of the first defence), the revised thesis will be re-read by an Examining Committee, at least two of whose members were on the original committee. The thesis shall be submitted to an external examiner who may be the original external examiner if the Associate Dean of Graduate Studies considers this to be desirable. The candidate shall defend the thesis before an Examining Committee in the usual way. If the thesis is rejected again, there will be no third examination. Such a student will be academically dismissed without the possibility of reinstatement.
7. Variation of the procedures stipulated above may be permitted only with the written permission of the Faculty of Graduate Studies.

Anomalies or deviations from the procedures or actions detailed above will be dealt with solely by the Dean of the Faculty of Graduate Studies. The dean(s) of the faculty in which the student is enrolled cannot intercede in matters related to the defence of a thesis (Master's or PhD).

9.10 PhD Defence Timeline

The timeline is usually dictated by the date at which the candidate must submit the completed version of the thesis to graduate in May or October. The timeline below is based on the assumption that any changes to the thesis recommended after the Internal and FGS defences are minor. It is the responsibility of the student to initiate the defence process sufficiently in advance of all deadlines to ensure sufficient time for changes to the thesis to be made. The timeline below is intended to complement the PhD timeline given on the FGS web site (<http://www.dal.ca/faculty/gradstudies/currentstudents/thesesanddefences/defense.html>).

3 Months in Advance of the FGS Defence:

Supervisors should supply the graduate coordinator with the names of at least three potential external examiners. The graduate coordinator requires this information to submit the Request to Arrange Oral Defence of a Doctoral Thesis form. The supervisor should confirm with the recommended external examiner that he/she is willing to participate in the FGS Defence prior to giving this list to the graduate coordinator. The other two names on the list are to be used only if the recommended external examiner is not available, and do not need to be contacted. External examiners should have a PhD, hold an appointment at a university that grants PhD degrees, and have experience examining and supervising PhD students. To ensure arms length status, they should not be employed in Nova Scotia, not have a degree from Dalhousie, not have been involved with the student's research, and not have co-published with the supervisor. More detailed information on the qualifications of external examiners is given in the Request to Arrange Oral Defence of a Doctoral Thesis form.

10 Weeks Before Submission of the Thesis to FGS:

The candidate must apply to graduate on dalonline (see the FGS calendar for the exact date).

8 Weeks prior to FGS Defence and 2 weeks prior to Internal Defence:

The candidate distributes copies of the thesis to the supervisory committee plus graduate coordinator and the departmental office for faculty viewing.

At least 6 weeks prior to the FGS Defence:

Internal Defence.

5 to 6 weeks prior to FGS Defence:

- (a) Make sure that there is sufficient time between the Internal Defence and the date for final submission to FGS to make any revisions requested by the supervisory committee after the Internal Defence.
- (b) Have a format review of your thesis done by FGS before your thesis goes out to the external examiner.
- (c) Complete all changes required by the format check.
- (d) Deliver to FGS
 - the completed PhD Thesis Submission Form,
 - PhD Examination Information Form,
 - your current CV,
 - one unbound copy of your thesis for your external examiner, and
 - email one pdf version of your thesis to *Thesis@dal.ca*.
- (e) Deliver at least four unbound copies of your thesis to your departmental graduate coordinator to be distributed to your internal examining committee members.
- (f) Send your abstract (max 350 words) by email to FGS at *thesis@dal.ca*

2 to 4 Weeks Prior to FGS Defence:

Book necessary A/V equipment through Instructional Media Services at 494-6471. This must be done by a staff/faculty member, so ask your supervisor or graduate secretary to do this on your behalf.

or

Book equipment through FGS. Fill out Request to Borrow Equipment from FGS for Doctoral Defence. This form must be signed by student and department head/chair and delivered to FGS.

10 Days prior to the Date for last day of Submission of Thesis to FGS for May/October Graduation:

This is the last day to conduct the FGS Defence. This is intended to allow sufficient time for minor corrections of the thesis to be made.

9.11 When to Submit Your Thesis

Please see Section 8.7.

9.12 Required Paper Forms for Thesis Submission

Please see Section 8.8.

9.13 Thesis Submission

Please see Section 8.9.

10 Syllabi for some Mathematics Comprehensive Examinations

10.1 Syllabus for Non-specialist Comprehensive Exam in Algebra

(Updated: September 2014)

To pass the non-specialist examination in Algebra, a student has to pass **both of the following options**. Please note that each of these topics correspond to the syllabus of a course that is listed next to it. To pass the examination in each subject, the student may choose to pass the corresponding course, following procedures outlined in the Graduate Handbook.

Abstract Algebra I (MATH 5045)

Topics

1. Rings and ideals
(Chapters 7.1–7.5 of Dummit & Foote)
2. Modules, including the structure theorem for finitely generated modules over a PID.
(Chapters 10 and 12.1 of Dummit & Foote)

Abstract Algebra II (MATH 5055)

Topics

1. Basic group theory.
(Chapters 1, 2, 3.1–3.3, 4.6 of Dummit & Foote)
2. Galois Theory.
(Chapters 13, 14 of Dummit & Foote)

Suggested References

- Artin, E. *Galois Theory*, Notre Dame (QA171 A79)
- Dummit, D. & Foote, R. *Abstract Algebra*, Prentice Hall (QA162 D85)
- Jacobson, N. *Basic Algebra I*, Freeman (QA154.2 J32)
- Lang, S. *Algebra*, Addison Wesley (QA154 L27)

10.2 Syllabus for Non-specialist Comprehensive Exam in Analysis

(Updated: January 2011)

To pass the non-specialist examination in Analysis, a student has to pass **TWO out of the following three options**. The exact combination of the three options that can be used to satisfy comprehensive requirements should be decided by the grad coordinator in consultation with the student and supervisor. Please note that each of these topics correspond to the syllabus of a course that is listed next to it. To pass the examination in each subject, the student may choose to pass the corresponding course, following procedures outlined in the Graduate Handbook.

Real Analysis (MATH 5010)

Topics

1. Measure spaces: σ -algebras; measures; measurable functions.
2. Construction of measures: *either* locally compact Hausdorff spaces and the Riesz representation theorem, *or* outer measures and Carathéodory's theorem; construction of Borel measures on the real line; Lebesgue measure on the real line.
3. Lebesgue Integration: integrals of real- and complex-valued functions; monotone and dominated convergence theorems; product measures, Fubini and Tonelli theorems; Lebesgue integral in $\mathbb{R}^n$.
4. Signed Measures: Lebesgue-Radon-Nikodym theorem.
5. Elementary Banach space theory; L^p , L^∞ spaces; Hölder's and Minkowski's inequalities; completeness; relations between L^p spaces; duality and L^p spaces.

Suggested References

- G. B. Folland, *Real Analysis: Modern Techniques and their Applications*, John Wiley, 2nd ed., 1999.
- H. L. Royden, *Real Analysis*, Prentice Hall, 3rd ed., 1988.
- W. Rudin, *Real and Complex Analysis*, McGraw-Hill Science/Engineering/Math; 3rd ed., 1986.

Complex Analysis (MATH 5020)

Topics

1. Holomorphic functions: Cauchy and Morera theorems.
2. Residues, contour integration including branch cuts.
3. Liouville's theorem, maximum modulus principle, Schwartz lemma.
4. Rouché's theorem, argument principle.
5. Conformal mapping, Möbius transformations, Riemann Mapping theorem, applications.

Suggested References

- L. V. Ahlfors, *Complex Analysis*, McGraw-Hill Education, 1980.
- J. B. Conway, *Functions of One Complex Variable*, Springer-Verlag, 2002.
- J. E. Marsden, *Basic Complex Analysis*, W. H. Freeman & Company, 3rd ed., 1998.
- W. Rudin, *Real and Complex Analysis*, McGraw-Hill Science/Engineering/Math; 3rd ed., 1986.

Applied Analysis (MATH 5540)

(Updated May 2015)

Topics

1. Dynamical Systems: Classification of planar systems, nonlinear systems, equilibria, global nonlinear techniques, closed orbits and limit cycles.
2. Calculus of Variations: Functionals, necessary conditions for an extremum, Euler-Lagrange equation, second variations, sufficient conditions for an extremum, principle of least action, Lagrangian and Hamiltonian systems, completely integrable systems, Hamilton-Jacobi theory, applications.

Suggested References

- J. K. Hale and M. Kocak, *Dynamics and Bifurcations*, Springer Verlag, 1991.
- I. M. Gelfand and S. V. Fomin, *Calculus of Variations*, Prentice- Hall, 1963.

10.3 Syllabus for Non-specialist Algebraic Topology Comprehensive Exam

(Updated September 2014)

Topics

1. Homotopy and the fundamental group
2. Covering Spaces
3. Chain complexes
4. Singular and Simplicial Homology
5. Eilenberg-Steenrod Axioms
6. Homology of CW complexes
7. Higher Homotopy Groups
8. Classification of surfaces
9. Cohomology and the cup product
10. Kunneth and Universal Coefficient Theorem
11. Poincar Duality Theorem
12. Fixed Point Theorems

Suggested References

- M.Harper, J.Greenberg, *Algebraic Topology, a first course*, Benjamin, 1981.
- W. Massey, *A basic course in algebraic topology*, Springer GTM v. 127, 1991.
- J. Junkers, *Elements of algebraic topology*, Addison-Wesley, 1984.

10.4 Syllabus for Non-specialist Comprehensive Exam in Differential Equations

Please see (<http://mathstat.dal.ca/~tkolokol/decomp/>) for the most up-to-date version.

11 Syllabi for Statistics Comprehensive Examinations

11.1 Comprehensive Examination in Statistical Inference, Linear and Generalized Linear Models

Part I - Inference

1. Distribution Theory. Conditional probability, conditional expectation and conditional variance.
2. Statistical Models and Families of Distributions
3. Point Estimation
4. Hypothesis Testing
5. Interval Estimation
6. Decision Theory
7. Bayesian Inference

Principal reference

- Bickel, P.J. and Doksum, K.A. (2001) *Mathematical Statistics*, Volume 1, 2nd edition, (relevant chapters are 1-6, appendices A,B).

Additional references which cover the material at the level of this exam

- Casella, G. and Berger, R. (1990) *Statistical Inference*. Wadsworth & Brooks/Cole. (relevant chapters are 1-10).
- Kalbfleisch, J. (1985) *Probability and Statistical Inference vol. II* Springer Verlag.
- Rao, C.R. (1973), *Linear Statistical Inference and It's Applications*, Wiley.
- Bickel, P. and Docksum, K. (1977) *Mathematical Statistics: Basic Ideas and Selected Topics*. Holden Day.

Part II - Linear and Generalized Linear Models

Linear Models

1. Simple and multiple linear regression
2. Model adequacy and transformations
3. Regression diagnostics (influential points and multicollinearity)
4. Model building and variable selection
5. Analysis of variance.
6. Fixed, random effect and mixed models.
7. Factorial and nested designs.

Principal references

- Montgomery D.C., Peck, E.A. and Vining, G.G. (2001). *Introduction to Linear Regression Analysis* (third edition or higher). Wiley. (relevant chapters are 1-10, 12)
- Montgomery D.C. (2005). *Design and Analysis of Experiments*, 6th Edition. Wiley. (relevant chapters are 3, 5, 13 and 14)

Additional references which cover the material at the level of this exam

- Weisberg, S. (1985) *Applied Linear Regression*. Wiley. (chapters 1-9).
- Scheffe, H. (1959) *The analysis of variance*. Wiley. (appendix VI on Cochran's theorem).
- Casella, G. and Berger, R. (1990) *Statistical Inference*. Wadsworth & Brooks/Cole. (chapters 11,12).
- Montgomery, D.C. (1997) *Design and Analysis of Experiments*. Wiley. (chapters 3-6,11)
- Miller, R.G. (1981) *Simultaneous Statistical Inference*. Springer-Verlag. (chapters 1 and 2)
- Rawlings, J.O. (1988) *Applied Regression Analysis - A Research Tool*. Wadsworth & Brooks/Cole. (chapter 6).

Generalized Linear Models

1. Maximum likelihood and quasi-likelihood
2. Tests of hypotheses
3. Binomial, count and multinomial data
4. Over-dispersion
5. Random effects
6. Model checking

Principal reference

- McCullagh, P. and Nelder, J. A. (1989). *Generalized Linear Models*, Second Edition, John Wiley & Sons. (Relevant chapters are 1-12, appendices A and C).

Additional references which cover the material at the level of this exam

- McCulloch, C. E. and Searle, S. R. (2001). *Generalized, Linear and Mixed Models*, John Wiley & Sons. (Relevant chapters are 5, 8-10).
- Faraway, J. (2006). *Extending the Linear Model with R*, Chapman & Hall. (Relevant chapters are 1-8 and appendix A).

11.2 Exam in Probability and Multivariate Analysis

Part I - Probability

1. Axioms of probability. Probability of events.
2. Distribution functions.
3. Random variables. Expectation. Independence.
4. Conditional probability and expectation.
5. Random variables and their distributions
6. Distribution functions, joint probability distribution of functions of random variables,
7. Modes of convergence of random variables.
8. Weak and strong laws of large numbers.
9. Central limit theorem.
10. Generating functions.
11. Poisson process,
12. Markov chains

Principal references

- Ross, S.M. *Introduction to probability models*, 7th ed. Prentice Hall. Chapters 1-9.
- Grimmet, G.R. and Stirzaker, D.R. (1990) *Probability and Random Processes*. Oxford. (relevant chapters are 1-4, 5.1, 6 and 7.1-7.5)

Additional reference which covers the material at the level of this examination

- Derman, C. Gleser, L. and Olkin, I. *Probability Models and Applications*, Prentice Hall.

Part II - Multivariate Analysis

1. Matrix algebra, random vectors, sample geometry, random sampling.
2. Multivariate normal distribution..
3. Inferences on means. Multivariate linear regression models.
4. Principal components and factor analysis.
5. Discrimination and classification.

Principal Reference

- Johnson, R.A. and Wichern, D.W. (2002) *Applied Multivariate Statistical Analysis*. Prentice-Hall. (chapters 1-8, 10 and 11)

Additional reference which covers the material at the level of this examination

- Morrison, D. G. *Multivariate Statistical Methods*. McGraw-Hill.