Final Report:

Mathematics Flexible Pre-Major Analysis Project

May 2006

555 SEYMOUR STREET
SUITE 709
VANCOUVER, BC
V6B 3H6
CANADA

TEL: 604-412-7700
FAX: 604-683-0576

EMAIL: admin@bccat.bc.ca
WEB: www.bccat.bc.ca

Prepared for and Funded by the

BRITISH COLUMBIA COUNCIL ON ADMISSIONS & TRANSFER

SUPPORTING BC's EDUCATION SYSTEM

Final Report:

Mathematics Flexible Pre-Major Analysis Project

May 2006

BRITISH COLUMBIA COUNCIL ON ADMISSIONS & TRANSFER

SUPPORTING BC's EDUCATION SYSTEM

Final Report:
Mathematics Flexible Pre-Major Analysis

May 2006

This report was prepared by Leo Neufeld, Mathematics Flexible Pre-Major Analysis Project Contractor, with direction and oversight provided by the Mathematics Flexible Pre-Major Analysis Sub-Committee of the BCcupms, the B.C. Committee on the Undergraduate Program in Mathematics and Statistics.
Assistance from Jennifer Orum in providing project counsel and support is gratefully acknowledged.

709 - 555 Seymour Street, Vancouver, BC V6B 3H6 Canada

Phone: (604) 412-7700
Fax: (604) 683-0576
E-Mail: admin@bccat.bc.ca

Table of Contents

Executive Summary

The BC Committee on the Undergraduate Program in Mathematics & Statistics (BCcupms) formally launched the Mathematics Flexible Pre-Major Analysis initiative at its meeting in May 2005. In October 2005, the BC Council on Admissions & Transfer approved the initiative as a Transfer Innovations Project and a Sub-Committee of the BCcupms was formed to guide the data-collection, analysis and writing processes of the project.

Activities of the Sub-Committee

The grant enabled the full Sub-Committee to meet on three occasions to gain a clear, mutual understanding of the project's aims, to oversee the data-gathering processes, to assist directly in analysing the findings and to formulate recommendations for the Final Report.

Some Findings

- Although diversity exists among the Mathematics Major programs at Receiving institutions in the province, there is also an overall willingness to accommodate students transferring from Sending institutions while lacking one or two lower division courses.

- A large number of Sending institutions offer all the lower division courses required for a Mathematics Major program at several Receiving institutions.

Suggested Mathematics Pre-Major Program

In order to document the observed common elements of Mathematics Major programs, the Sub-Committee agreed on a Suggested Mathematics Pre-Major program (page 13). This program is comprised of Core courses (found in most Major programs) and Additional courses (each found in at least one Major program) from which choices to complete a Pre-Major program would be made.

Recommendations

Three of the Sub-Committee's recommendations are:

1. That those Sending institutions desiring to offer their students the opportunity of transferring to the upper divisions of a Mathematics Major program at any BC Receiving institution attempt as much as possible to offer a program that follows the Suggested Pre-Major Mathematics program in this report.

2. That Receiving institutions take note of the data collected for this project and, when opportunity arises, consider accommodating the Sending institutions in their goal of providing a full lower division Mathematics Pre-Major program for their students through such means as:
   a) Finding ways to assist transferees that may lack only some specialised lower division courses.
   b) Announcing significant changes and adjustments to Mathematics Major program requirements in a timely manner.

3. That those Sending institutions transferring Mathematics students, but not desiring or able to offer a lower division Mathematics Pre-Major program, be encouraged to offer as complete a set of first-year courses as possible.

[The entire set of Recommendations is found on page 15.]

Background and Objectives

1. The BCcupms

The British Columbia Committee on the Undergraduate Program in Mathematics & Statistics (BCcupms) is the post-secondary mathematics and statistics articulation committee for the province. Its activities are conducted under the auspices of the BC Council on Admissions and Transfer (BCCAT). Articulation committees were established to foster and maintain course/program transfer arrangements to assist students in moving easily from one educational institution to another.

Although the BCcupms' activities over the years have centred principally on course to course transfer arrangements, members have at recent meetings expressed a willingness to investigate the composition of educational programs and their transferability.

2. Project Origins

Legislation enabling colleges and university colleges to grant associate of arts (AA) and associate of science (ASc) degrees was enacted in 1987. Although the associate degree concept was not immediately applied at educational institutions, by 2002, Dr. John Dennison, former co-chair of BCCAT, was able to report that the degree had made second-year courses at colleges more attractive to students than previously. This was when the BCcupms began considering a discussion of an Associate of Science degree with a Mathematics emphasis.

The following year Dr. Neil Coburn, Selkirk College, offered to conduct an informal project in which he would gather information from other colleges regarding their interest in establishing an ASc template for Mathematics. In 2004, the BCcupms empowered Neil to assemble a working committee to design a core curriculum for the degree. This group reported to the 83rd meeting of the BCcupms (May 2005) with a recommendation that this initiative change its focus to that of an analysis of a flexible pre-major program in Mathematics.

In May 2005, the BCcupms directed as follows:

Action (Alex Liu and Leo Neufeld): **Write the proposal to BCCAT requesting funding for more detailed research into the feasibility of a flexible pre-major in Mathematics.**

Subsequently, the proposal for a formal Mathematics Flexible Pre-Major Analysis project was accepted by BCCAT in October 2005.

> The Flexible Pre-Major Project arose from the objective of sending institutions to provide a coherent two-year mathematics program for their students. The suggestions and recommendations presented by the Pre-major committee to the BCcupms have advice for both sending and receiving institutions on ways to move closer to achieving that objective.
>
> —David Leeming, University of Victoria

3. Project Objectives

The overall goals of the Mathematics Flexible Pre-Major Analysis Project were to satisfy the wishes of the BCcupms to analyse the Mathematics Major program requirements and transfer program patterns in British Columbia post-secondary educational institutions, and to fulfil the overall Project requirements of BCCAT.

In the project application phase, the specific objectives identified by the proposers were:

- Identify the impediments, both at the 'sending' and at the 'receiving' institutions, to students' ability to transfer directly and fully into a Mathematics Major program.
- Determine whether a Flexible Pre-Major program or some other remedy to these impediments is feasible.
- Recommend means whereby Mathematics departments in 'sending' institutions could implement these remedies.

Although these were initial targets for the project, it became clearer as the process continued that other outcomes might also be realised:

- A Mathematics Pre-Major program template
- An ASc for Mathematics program investigation
- An insight into the availability of on-line course options that could aid students in completing second-year Mathematics programs at Sending institutions
- A listing of Mathematics Major program requirements at Receiving institutions

Process

1. The Project Contract

In accordance with the wishes of the BCcupms, Alex Liu and Leo Neufeld prepared and submitted to BCCAT a proposal for funding to conduct a Transfer Innovations Project under the heading, Mathematics Flexible Pre-Major Analysis. Approval to proceed from BCCAT was received on October 13th, 2005.

2. The Rôle of the Sub-Committee

Besides sharing their knowledge and expertise during project meetings, the members of the Sub-Committee (page 29) served as a resource to the committee and to the Contractor, as communicators with colleagues and, principally, as overseers of the Project. One pre-Project meeting was held and the full Sub-Committee met on three occasions at the Richmond Campus of Kwantlen University College.

We should grab every opportunity to let our students know that we as educators at Sending institutions are here not just to teach them a course or two but to help them reach a better career goal. There are many great career opportunities in Mathematics. A simple and straight-forward Pre-Major template opens the first door.

—Alex Liu, Kwantlen University College

3. Data Collection and Sources

During the Project, post-secondary Mathematics departments at Receiving and Sending institutions were approached for information about their programs and courses. The Receiving institutions' questionnaire was conducted in two stages: a request (1) for Mathematics Program details and Program accommodations available to transferring students and (2) for responses to three specific questions from the Sub-Committee. Sending institutions responded principally to a request for information about course offerings. The response rate in each case was 100%.

Additionally, to determine the availability of and protocols involved in taking Mathematics courses through distance education providers, members of the Sub-Committee informally researched the kind and availability of relevant courses offered by Thompson Rivers University (Burnaby) and via BCcampus.

The Sub-Committee was aware that, besides Mathematics Major programs, BC post-secondary educational institutions offer many related, but not identical, programs in Mathematics. Degree programs like a Major in the Mathematical Sciences, in Pure Mathematics, or Combined Majors with Computer Science, Physics or Statistics exist. It was decided that the Project should focus only on the Mathematics Major program in Science.

As responses from the Receiving institutions was being received, it became evident that the attempt to identify patterns or to quantify the non-Mathematics, -Statistics or -Computer Science courses in these programs would be very difficult at best. Some Mathematics Major programs give students considerable freedom to elect other courses in Arts or Science to complete their programs. Those that do specify particular courses or disciplines from which choices must be made also leave opportunity for some free elective courses. Although the Sub-Committee felt confident in its understanding of the typical course patterns followed by serious Mathematics Major and Pre-Major students, it decided that data collection efforts with respect to these other courses would be a distraction.

Findings and Conclusions

The Sub-Committee agreed to divide the Analysis task into three components: determining the current requirements for earning a Mathematics Major degree at British Columbia's Receiving institutions, getting a sense of the Mathematics transfer courses and programs offered by Sending institutions in the Province and obtaining some preliminary data about the current availability of credit opportunities through on-line and distance learning vehicles.

1. Mathematics Major Programs

In order to obtain a listing of the 2006 lower division requirements for a Mathematics Major program at the various universities and university colleges offering such programs, a questionnaire was sent to the Mathematics Department at each such Receiving institution (page 18). The institutions were asked to respond to this request:

The Flexible Pre-major Analysis team requests that you confirm the current first- and second-year requirements of the Mathematics Major program at your institution, and that you describe briefly any flexibility or accommodation that could be available to a two-year (transferring) 'graduate' lacking some specific course, but desiring to satisfy all your requirements for the Major in the two remaining years of the program.

When program information as available on institutional web sites had been compiled (page 17), the Sub-Committee requested further, direct feedback on three specific questions:

1. That a confirmation of the mathematics, statistics and computer science courses as obtained variously was accurate.
2. That an informal response to the applicability of a Proofs course towards their Mathematics Major program be given. An example (page18) of such a course was provided.
3. That, for those institutions requiring two Discrete Mathematics courses within their lower division, an indication as to what accommodation or provision might be made for those students transferring with only one such course.

The flexible pre-major project promises to be useful for students (and advisors) by making it clear, in a simple way, what students need to take to transfer to one of the BC universities with a minimum of make-up work. It should also be useful to institutions, both sending and receiving because the project gives all institutions a simple framework within which to consider (compare) their first and second year programs.

—Peter Danenhower, Langara College

Each of the eight post-secondary institutions surveyed offers a Mathematics Major degree program. The number of Mathematics and Statistics courses required in the programs varies from 6 and 11. However, there are five courses common to all programs and the following table shows the frequency of occurrence for all of the courses considered:

Mathematics Major Requirements at 8 Receiving Institutions	
Frequency	**Mathematics Major Course(s)**
8	Calculus I, II, III Linear Algebra II Computer Science I
7	Introductory Analysis Computer Science II
6	Discrete Mathematics I
5	Differential Equations
4	Statistics I
2	Abstract Algebra Discrete Mathematics II Mathematical Modeling
1	Statistics II Linear Algebra I Operations Research Computer Science III

In the table, please note that the I, II, III designations usually imply course sequencing, but may also indicate the number of such courses as in the case of Linear Algebra or Computer Science requirements. More information about course names is found on page 23.

To the question concerning the Proofs course, the responses indicated general approval of the course's learning objectives, but respondents felt that it would not be accepted in lieu of either an Abstract Algebra or an Introductory Analysis course. A second Discrete Mathematics course is listed as a second-year course at SFU, and should be taken as soon as possible thereafter. At UNBC, it is at the first-year level, but has a 'recommended' status.

Concerning the Mathematics Major programs extant, the Sub-Committee concluded the following:

- Although there are core similarities in Mathematics Major programs, these programs do have distinctive aspects.
- The differences in existing Mathematics Major programs appear to derive from the specific directions or emphases desired for these programs, e.g. Computer Science, Statistics, preparation for Secondary Mathematics teachers.
- Mathematics Major programs typically offer more required courses in second- than in first-year.

2. Sending Institutions

In order to determine the pattern of course offerings at BC institutes, colleges and university colleges relevant to Mathematics Major programs, the mathematics departments of nineteen such institutions (page 21) were contacted. Each provided the sub-committee with an indication as to their institution's interest in providing a Mathematics Pre-Major program for students, a list of the Mathematics Major-related courses presently offered and a sense of those additional courses they might possibly offer.

Of the 19 Sending institutions surveyed (page 21), twelve desired to offer Mathematics or Mathematics-related programs to their students and three are currently running a Mathematics Associate of Science degree program (page 25 ff). From the survey data, Sending institutions appear naturally to form two groups–those offering a full array of first-year course choices and a significant number of second-year courses (page 22), and those institutions committed mainly to first-year offerings in Mathematics, Statistics and Computer Science courses (page 23). Ten institutions appear in the former group and eight belong to the latter with BCIT, in a developmental mode, offering an ASc-type program having paths to several bachelor degree options. Those institutions limiting their Mathematics offerings mainly to first-year courses do not, at this time, have the resources (financial or student-based) or the intent to offer any kind of Mathematics Pre-Major program.

A large number of Sending institutions offer a full, or nearly complete, lower division Mathematics program. At those Sending institutions committed to a "second-year program", the number of first-year courses in the survey slightly exceed the second-year offerings.

By observing the information obtained from Sending institutions, the following can be concluded:

- All Sending institutions offer the first year Calculus courses of a Mathematics Major program. By having or adding one first-year Mathematics course, the first-year Mathematics requirements for most Major programs could be satisfied.
- With one or two additional courses, at least 10 of the Sending institutions could be able to provide a Mathematics Pre-Major program leading to the upper division of a majority of the Mathematics Major programs in BC.
- Although there are only 3 institutions providing an ASc (Mathematics) program, it appears from the number of relevant second-year courses offered at a few other Sending institutions that their capability or near-capability of mounting such an ASc program exists.

> While there is a fairly wide variety of mathematics programs offered in BC, there are many common elements. With the increased tendency of lower division students to gather courses from several colleges before embarking on degree completion at a university, a template will ease the navigation through different course codes and titles, allowing students at any post-secondary institution to choose with confidence the courses they will need to begin a mathematics program.
>
> —Bruce Kadonoff, Coquitlam College/SFU

3. Flexibility

The Sub-Committee sought to identify those elements of flexibility within reach of institutions or students and those already available to them. Depending on the circumstances, flexibility of one kind or other could be assumed by students, by Sending institutions or by Receiving institutions.

Distance and non-classroom learning provisions are available in British Columbia. Not many of these, unfortunately, have relevance to Mathematics Major programs. Thompson Rivers University (Burnaby) offers Calculus I, II, III and Linear Algebra (I) in a 'distance' format through their Open Learning Division. Also, BCcampus co-ordinates 'distance' learning opportunities for institutions offering such courses. Students register and obtain grades for these courses at their home institution, but the instructional support is administered through the institution originating the course. Although BCcampus lists some Mathematics courses, none have direct applicability to a Mathematics Major program.

On the question of accommodating students transferring into a Mathematics Major program while lacking one or two courses, some Receiving institutions responded that they allow students missing certain courses, usually unique, second-year courses, to take them in third or even fourth year. For example, students lacking an Introductory Analysis course are permitted to complete this course while registered in the upper division of a Mathematics Major program.

Over the years, there has been talk among Sending institutions, particularly on the Lower Mainland, of offering important, low-enrolment courses on a rotational basis. A course like Introductory Analysis could be conveniently scheduled and offered at one institution with student registration from other institutions being encouraged. Scheduling difficulties could also be eased by offering courses on alternate years or during inter-session periods.

Flexibility in the context of programs intended to lead to the upper division of a Mathematics Major program demands conscious effort and, often, creativity and willingness on the part of students, Sending and Receiving institutions.

> A key component to developing a flexible pre-major program that would allow as many sending institutions as possible to provide the first two years of a mathematics degree program is a generic, theoretical mathematics course. Such a course would include an introduction to mathematical proofs, but otherwise its content would not be tied to any specific area of mathematics. It could cover analysis, abstract algebra, or discrete mathematics, or selections of topics from each of these areas.
>
> —Clint Lee, Okanagan College

Suggested Mathematics Pre-Major Program

The following suggests the Core courses and the Additional courses that might be chosen to comprise a Mathematics Pre-Major program for a college student wishing to proceed to the upper division of a Mathematics Major at a British Columbia university. It could also be used by Sending institutions to support the design of such a program.

CORE Mathematics and Computer Science Courses

Calculus I, II, III
Linear Algebra
Discrete Mathematics I
Introduction to Real Analysis
Computer Science I, II

ADDITIONAL Mathematics, Statistics and Computer Science Courses

Ordinary Differential Equations
Statistics I
Abstract Algebra
Discrete Mathematics II
Mathematical Modelling
Statistics II
Operations Research
Computer Science III

CORE English and Science Courses

English I, II
Lab-based Chemistry I
Lab-based Physics I, II

ADDITIONAL Science Courses

Lab-based Chemistry II
Biology

Core Courses are required by 6 or more of the surveyed Receiving institutions in their Mathematics Major programs and can be considered a 'must' for any Mathematics Pre-Major program. The Additional Courses are requirements at five or fewer Receiving institutions. While Sending institutions might wish to design a Mathematics Pre-Major program satisfying local needs, students, who are intent on moving to a particular institution at which to complete their upper division courses, would be wise to choose courses satisfying the requirements at that institution.

It is unrealistic to expect Sending institutions to offer all sixteen of the Mathematics, Statistics and Computer Science courses listed above. However, those institutions committed to second-year courses are already on average presently offering 11.6 such courses and some report (page 24) being willing to add further courses in order to round out a program. Given that 20 courses over two years is considered to be a typical program course load, demanding that 11 or 12 of these be central requirements of the program does seems reasonable.

The schematic below lists those Additional Mathematics, Statistics and Computer Science courses beyond the Core courses that are required at each of the Receiving institutions in our study. The course numbers at respective Receiving institutions are indicated in parentheses.

Recommended CORE plus ADDITIONAL Courses at Each Receiving Institution

UBC Additional Differential Equations (215) Computer Science [Confirm that Core CPSC courses transfer to UBC]	**UBC (OK) Additional** Differential Equations (225) Statistics I (230)	**SFU Additional** Discrete Mathematics II (201) Statistics I (270) Math Modelling (202)
UCFV Additional Differential Equations (255) Statistics I (270) Math Modelling (235)	**Core Courses** **Calculus I, II, III** **Linear Algebra II** **Discrete Mathematics I** **Introductory Analysis** **Computer Science I, II**	**UVic Additional** Differential Equations (201) Abstract Algebra (233C) Statistics I (260) Statistics II (261)
TWU Additional none	**TRU Additional** Statistics I (200) Computer Science III (123)	**UNBC Additional** Linear Algebra I (220) Discrete Mathematics II (142) Differential Equations (230) Abstract Algebra (224) Operations Research (221)

Sending institutions need to articulate their courses to several institutions, not just to one, so changes made at one receiving institution can have profound impact on the whole system of transferability. I applaud the mathematics group for addressing this issue, and for establishing a working group to analyze the feasibility of a common core at the lower level of a baccalaureate degree.

—Brian Carr, Dean of Science & Mathematics, Kwantlen University College

Recommendations

The following general Recommendations are respectfully offered by the Mathematics Flexible Pre-Major Analysis Sub-Committee to the BCcupms and to BCCAT for their consideration:

1. That those Sending institutions desiring to offer their students the opportunity of transferring to the upper divisions of a Mathematics Major program at any BC Receiving institution attempt as much as possible to offer a program that follows the Suggested Pre-Major Mathematics program given in this report.

2. That Receiving institutions take note of the data collected for this project and, when opportunity arises, consider accommodating the Sending institutions in their goal of providing a full lower division Mathematics Pre-Major program for their students through such means as:
   a) Finding ways to assist transferees that may lack only some specialised lower division courses.
   b) Announcing significant changes and adjustments of Mathematics Major program requirements in a timely manner.

3. That those Sending institutions transferring Mathematics students, but not desiring or able to offer a lower division Mathematics Pre-Major program, be encouraged to offer as complete a set of first-year courses as possible.

4. That Mathematics Major and Pre-Major program designers consider weighting more-equally the mathematics program components of first- and second-year.

5. That Sending institutions, struggling to balance student course-loads with Mathematics Pre-Major program demands, consider scheduling one or two appropriate courses during inter-sessions, on alternate years or by some indirect instructional modality.

6. That those institutions offering a Mathematics associate degree program strive as possible to imbed in it the elements of a Mathematics Pre-Major program.

Appendix

Part A - Data - Receiving Institutions

Appendix Part A contains the following Mathematics Major program and Receiving Institution Questionnaire response information:

- A listing of the Mathematics, Statistics and Computer Science course requirements (and course numbers) for Mathematics Major programs at each of the Receiving institutions.
- The questions asked of Receiving institutions in the Follow-up Questionnaire.
- An outline of the "Proofs" course mentioned in the questionnaire.
- A summary of the responses from Receiving institutions to the Follow-up questionnaire.

Mathematics, Statistics and Computer Science Requirements in Mathematics Major Programs

Math Major Requirements	UBC	UBC(OK)	SFU	UVic	UNBC	TRU	TWU	UCFV	Common
1st Yr									
Calculus I	100	100	151	100	100	114	123	111	✔
Calculus II	101	101	152	101	101	124	124	112	✔
Linear Alg I					220				1
Discrete			101	122	141				3
Statistics				260					1
Comp Science	111	111	120	110	100	113	141	152	✔
Comp Science		121	125	115	101	100	143		6
2nd Yr									
Calculus III	200	200	251	200	200	211	223	211	✔
Diff Equations	215	225		201	230			255	5
Linear Alg	221	221	232	233A	226	212	250	221	✔
Intro Analysis	220	220	242		201	220	220	265	7
Abstract Alg				233C	224				2
Op Research					221				1
Math Modeling			202					235	2
Discrete		251	201		142		240	225	5
Statistics		230	270	261		200		270	5
Comp Science	211					123			2
Course Totals									
Mathematics	6	7	8	7	11	5	6	7	
Statistics	0	1	1	2	0	1	0	1	
Comp Science	2	2	2	2	2	2	1	1	
Total	**8**	**10**	**11**	**11**	**13**	**8**	**7**	**9**	

Receiving Institutions (with abbreviations) Included in this Follow-up

Simon Fraser University (SFU)
The University of British Columbia (UBC)
The University of BC (Okanagan) (UBC(OK))
Thompson Rivers University (TRU)
Trinity Western University (TWU)
University College of the Fraser Valley (UCFV)
University of Northern BC (UNBC)
University of Victoria (UVic)

Request for Follow-up Information from Receiving Institutions

Dear Colleague

RE: Request for Feed-back (Mathematics Major Program)

Thank you very much for your earlier response to the request of the Mathematics Flexible Pre-Major Analysis project sub-committee. In beginning its study of the data gathered, the committee has asked me to obtain some follow-up information.

To help in framing Mathematics Pre-Major program recommendations for sending institutions, the committee kindly requests your attention and responses to the following questions:

1. Math Major Program Course List. Listing the course requirements for a Math Major program at institutions as shown in the attachment is helpful in finding common elements. We have not listed all possible first- and second-year Math and Comp Sc courses for your program (rather, those that we consider would be mainstream or more-commonly recognised in the system). Please scrutinise the courses we've listed. Is the list accurate for your program? If not, would you kindly correct it for us.
2. Mathematics "Proofs" Course. I've attached (below) an example of what the committee calls a second-year "Proofs" course. If a sending institution (college) were to include such a course in its mathematics package, could this course satisfy the general learning objectives of and, thus, be used in lieu of an Introductory Analysis course you might have in the second-year of your program?
3. Two Discrete Mathematics Courses. Some institutions require two Discrete Math courses within the first two years of a Math Major program. If your institution has such a requirement, is there an accommodation that will allow a student transferring from a college with all the satisfactory course work of the Math Major program, but having taken only one Discrete Math course, to complete the Math Major program in the two remaining years?

MATHEMATICAL STRUCTURES AND PROOFS (Course Outline)

PREREQUISITE: Calculus II
LECTURES: 3 hours per week
TEXT: Bond and Keane, **An Introduction to Abstract Mathematics**, Brooks/Cole, 1999

COURSE OBJECTIVES:
Math 2XX is commonly called a “transition course” or “bridging course”. The goal is to provide a smooth transition from the computationally-oriented mathematics courses at the first-year level to the more abstract, proof-oriented courses at the third and fourth-year levels. So mathematical proof is the key idea in this course, and students should expect to spend a significant amount of time analyzing sample proofs and constructing their own proofs.

The first two chapters of the Bond and Keane text introduce basic concepts in mathematical logic as well as the language and notation that we will use throughout the course. These two chapters underlie everything we do in this course and you should read them right away.

Ultimately, if we are going to prove theorems, we must prove theorems about **something**. So, the remainder of the course discusses specific mathematical topics. These topics may vary from year to year. This year I have selected the following topics: functions, infinite sets, introduction to group theory, introduction to number theory and complex numbers.

SYLLABUS:

	Topic	**Text Reference**
1.	Basic Concepts of Mathematical Reasoning - axioms, theorems and proofs - elements of mathematical logic: statements, quantifiers, connectives, logical implication, counterexamples, contrapositive, converse, necessary and sufficient conditions, proof by contradiction	Chapter 1
2.	Set Theory - sets and subsets, union, intersection and complement - sets of numbers: natural numbers, integers, rational, irrational, real, complex	Chapter 2
3.	Functions - definition and examples - domain, codomain, image - injective, surjective, bijective - composition - inverse functions	Chapter 3
4.	Binary Operations and Relations - definition of binary operation; examples - associativity, commutativity, identity and inverse - definition of group; examples - some elementary group theory - equivalence relations	Chapter 4
5.	Elementary Number Theory - mathematical induction - division algorithm - Euclidean algorithm - primes and unique factorization - congruences - the group of integers mod n	Chapter 5
6.	Infinite Sets - countable and uncountable sets - countability of the rationals, uncountability of the reals	Chapter 6
7.	Complex Numbers - definition and basic properties, arithmetic of complex numbers - polar form - deMoivre's Theorem - solution of polynomial equations	Chapter 7

Responses from Receiving Institutions to Follow-up Questions

Institution	Current Program Information?	View of the Sample "Proofs" Course	Necessity - Second Discrete Math Course
UBC	The list you gave is accurate, except that MATH 210 and CPSC 211 are both regularly taken to satisfy the second-year Comp Science requirement. In the case of the other requirements, you have listed the course taken by most of the students.	The example "proofs" course has many of the ingredients of our MATH 220, but not all. It is quite possible we would accept a course such as this in place of MATH 220 for a college-transfer student.	Two Discrete Mathematics Courses: We have no such requirement.
UBC (OK)	The course list is accurate. My only comment is that student may complete COSC 221, Introduction to Discrete Structures, instead of MATH 251. These two courses are equivalent.	The course description you provided is identical to the course outline for MATH 220. This course would therefore satisfy our program requirements.	There is no requirement to complete two Discrete Math courses in the first two years of our program.
SFU	Note that we have just introduced a new Calculus I course, MATH 150, which is an alternate to MATH 151. Comp Science requirements have changed. We require either CMPT 126 or both CMPT 120 and CMPT 125.	There is a substantial overlap between this course and our MACM 101, Discrete Math I = more or less the first 5 topics/chapters. I don't know the textbook you suggest, and so cannot comment on how similar the content would be; however, it is likely that we would find it transferable for this. This course could not possibly replace our MATH 242 requirement.	Students who will be coming without our second Discrete Math course will need to take it as soon as possible after transferring to SFU, since it is a prerequisite to many pure math courses. It is worth noting, though, that not all math major/honors programs require discrete math.
UVic	We made a curriculum change for 05-06 so that our Math 122 (Logic and Foundations - essentially 1st year Discrete Math) is now required in our programs (major and honours).	We don't have an intro analysis course in our program. Instead we use Math 122 and Math 233C, Intro to Abstract Algebra, for this purpose. We might be able to accept a proofs course (such as the one described) for access to our upper level courses in lieu of courses equivalent to 122 and 233C.	This doesn't apply to us as we require only one Discrete Math course.
UNBC	CPSC 142 and CPSC 101 are not required courses for our Math majors (as listed in the attachment you sent), but are recommended courses.	I would hazard to guess that our MATH 224 (Foundations of Modern Mathematics) would be the course closest to the "Mathematical Structures and Proofs" course. However, I will have to check to be sure, esp with Lee Keener who has been teaching MATH 224 at UNBC.	We have one Discrete Math course (CPSC 141) required of our Math majors. The second Discrete course (CPSC 142) is recommended, so they don't have to take it.
TRU	In 2nd year, students are not required to take MATH 224 (Diff. Equations). Rather they must take a statistics course, STAT 200.	The particular course outline that you sent as an example of a "Proofs" course gives the student no analysis. It would probably serve better as a replacement for a course in discrete mathematics rather than an introductory analysis course. I must admit that the material listed in the course outline overlaps with about the first half of our MATH 220.	At present we offer only one discrete math course for our math majors, and this course is not required.
TWU	The list of 1st and 2nd year courses required for our math majors is accurate.	The "proofs" course would not be acceptable in lieu of our introductory analysis courses because it does not cover the same material. Much of the material in the proposed course is covered in our discrete math I course, which also introduces the student to proof.	Our Discrete Math II course is at the 300 level. Our sequence of 2 discrete math courses is offered every second year and students taking them are usually in 2nd or 3rd (sometimes 4th) year.
UCFV	The Computer Science requirement will soon be COMP 152, rather than COMP 150. Intro analysis is now Math 265 rather than Math 214. The discrete math requirement depends on whether the student is a math major in the BA or BSc program: a math major in the BSc program is required to take either discrete math (Math 225) or Math 255 (ODEs).	The generic outline looks fine in terms of proof content but it appears that it does not include anything on sequential convergence. A UCFV math major coming into third year would be required to take Math 340. It would be assumed that (s)he would have knowledge and experience of properties of the real line, cardinality, completeness, infimum, supremum, epsilon-delta arguments and sequential convergence. These topics are part of our Math 265 which is a pre-req for Math 340.	This doesn't really apply to us because we require only the one second-year discrete math course. I expect that the dept would be fairly flexible about transfers in this area.

Part B - Data - Sending Institutions

Appendix Part B contains the following Mathematics Major program and Receiving Institution Questionnaire response information:

- The Questionnaire provided to Sending institutions.
- A list of the Sending institutions responding to the questionnaire.
- The responses from Sending institutions about present Mathematics, Statistics and Computer Science course offerings.
- The indication of courses in these disciplines that could be offered given incentive.

Questionnaire to Sending Institutions

1. Name of Sending Institution _____
2. Do students from your Institution presently transfer to Math or Math-related* programs? _____
3. Would your Institution, under appropriate conditions, consider preparing students for such programs?
4. Please indicate the present state of course offerings at your Institution in the table below.

Course Name	Like	We Now Offer	We Could Offer	Not Feasible	Comments
Calculus I	UBC - MATH 100				
Calculus II	UBC - MATH 101				
Calculus III	UBC - MATH 200				
Diff Equations	UBC - MATH 215				
Linear Algebra I	UNBC - MATH 220				
Linear Algebra II	SFU - MATH 232				
Intro Real Analysis	SFU - MATH 242				
Abstract Algebra	UVic - MATH 233C				
Discrete Math I	SFU - MACM 101				
Discrete Math II	SFU - MACM 201				
Statistics I	UVic - STAT 260				
Statistics II	UVic - STAT 261				
Operations Research	UNBC - MATH 221				
Math Modeling	SFU - MACM 202				
Comp Science I	SFU - CMPT 101				
Comp Science II	UVic - CSC 115				

5. Do you presently offer an ASc (Mathematics) program? _____
   If so, please provide a description of this program.

Sending Institutions (with abbreviations) Included in this Survey

BC Institute of Technology (BCIT)
Camosun College (Cam)
Capilano College (Cap)
College of New Caledonia (CNC)
College of the Rockies (CotR)
Columbia College (Col)
Coquitlam College (Coq)
Douglas College (Doug)
IIG - All Nations Institute (IIG)
Kwantlen University College (KUC)
Langara College (Lang)
Malaspina Unversity-College (MU-C)
North Island College (NIC)
Northern Lights College (NLC)
Northwest Community College (NWCC)
Okanagan College (Okan)
Selkirk College (Selk)
Vancouver Community College (VCC)
Yukon College (Yukon)

Sending Institutions - Survey Results

Items 2, 3 and 5 refer to Questions 2, 3 and 5 of the Sending Institution's Questionnaire (page 21). "1" indicates a "Yes" response.

[Under Courses - 1 indicates that the course is **presently offered**.]

	Cam	*Cap*	*Col*	*Coq*	*CNC*	*Doug*	*Lang*	*Okan*	*KUC*	*MU-C*	**Tot**
Item 2	1	1	1	1	1	1	1	1	1	1	10
Item 3		1	1	1		1	1		1		6
Item 5	1	1							1		3
Courses											
Cal I	1	1	1	1	1	1	1	1	1	1	10
Cal II	1	1	1	1	1	1	1	1	1	1	10
Lin Alg I	1	1	1			1	1		1	1	7
Discrete I	1	1	1	1	1	1	1	1	1	1	10
Stats I	1	1	1	1	1	1	1	1	1		9
Com Sc I	1	1	1	1	1	1	1	1	1	1	10
Com Sc II	1		1	1	1	1	1	1	1	1	9
											65
Cal III	1	1	1	1	1	1	1	1	1	1	10
DE	1	1	1	1	1	1	1	1	1	1	10
Lin Alg II	1	1		1	1	1	1	1	1	1	9
Intro Anal		1	1		1		1		1		5
Abs Alg	1									1	2
Discrete II	1	1	1	1	1	1					6
Stats II	1		1	1				1			4
Op Res											0
Math Mod											0
											46
	13	11	12	11	11	11	11	10	11	10	

Sending Institutions - Survey Results (Continued)

Items 2, 3 and 5 refer to Questions 2, 3 and 5 of the Sending Institution's Questionnaire (page 21). "1" indicates a "Yes" response.

[Under Courses - 1 indicates that the course is **presently offered**.]

	BCIT	**Tot**	*CotR*	*IIG*	*NIC*	*NLC*	*NWCC*	*Selk*	*VCC*	*Yukon*	**Tot**
Item 2		0	1	1	1	1	1	1	1	1	8
Item 3	1	1		1	1			1	1	1	5
Item 5		0									0
Courses											
Cal I	1	1	1	1	1	1	1	1	1	1	8
Cal II	1	1	1	1	1	1	1	1	1	1	8
Lin Alg I		0	1			1		1			3
Discrete I	1	1								1	1
Stats I		0	1	1		1		1			4
Com Sc I	1	1			1	1	1	1		1	5
Com Sc II	1	1			1	1	1			1	4
		5									**33**
Cal III		0	1		1			1			3
DE		0	1					1			2
Lin Alg II		0			1		1				2
Intro Anal		0									0
Abs Alg		0									0
Discrete II	1	1									0
Stats II		0								1	1
Op Res	1	1									0
Math Mod		0									0
		2									**8**
	7		6	3	6	6	5	7	2	6	

Course Names and Abbreviations Used

Although post-secondary institutions employ their own nomenclature in identifying courses, this Project has used course names that are generally familiar and understood within the mathematics community. The comments below amplify on course similarity as used in the Project.

Diff Equations - Introductory Differential Equations or Ordinary Differential Equations
Discrete Math I - Is also called Logic and Foundations or may be a course in Computer Science
Linear Algebra I - Matrix Algebra, Linear Systems or Linear Algebra and DEs
Linear Algebra II - Linear Algebra or Advanced Linear Algebra
Statistics I, II - A first course (I) in Statistics requiring Calculus with (II), a follow-on course
Computer Science I, II - Usually, (I) involves programming and (II) contains data structures

Sending Institutions - Survey Results

[A "1" indicates that the course **could**, under appropriate conditions, **be offered** at the Sending Institutions listed in the table.]

	Cap	*Doug*	*Lang*	*KUC*	*MU-C*	*IIG*	*NLC*	*VCC*	*Yukon*	**Tot**
Courses										
Cal I										0
Cal II										0
Lin Alg I								1		1
Discrete I							1			1
Stats I					1					1
Com Sc I						1				1
Com Sc II						1				1
Cal III						1				1
DE										0
Lin Alg II										0
Intro Anal		1			1					2
Abs Alg		1	1	1						3
Discrete II			1	1	1				1	4
Stats II	1	1			1	1				4
Op Res									1	1
Math Mod		1	1		1					3
	1	4	3	2	5	4	1	1	2	**23**

Part C - Mathematics Associate of Science Degree Programs

Three formal Associate of Science Degree programs with a Mathematics emphasis were identified during this Project. **Appendix Part C** contains an outline of the program at Camosun College, at Capilano College and at Kwantlen University College. In May 2005, Dr. Neil Coburn included a template for a possible ASc (Mathematics) program in his report to the BCcupms. This Proposal appears at the end of this section.

Camosun College - Associate of Science Degree – Mathematics

ADSCI Requirements	ADSCI - Mathematics
First Year English	Engl 150
First Year English	Engl 160 or 164
Math 100 or 108	Math 100
Math	Math 101
Lab Science	Phys 104 or 114
Science	Comp 132
Science	Math 110
Science	Math 111
Science	1 of Math 126, Comp 139 or Sci elective
Science	Sci. elective
Second Yr Science	Math 103 or 230
Second Yr Science	Math 218
Second Yr Science	Math 220
Second Yr Science	Math 225/235
Second Yr Science	Second Yr Science
Second Yr Science Different Subject	2nd Yr Science other than Math
Arts course other than English	Phil 210 recommended
Arts course other than English	Phil 212 recommended
Elective	1 or Math 219 or Comp 227 or any UT elective
Elective	UT elective

Recommend transfer after year one for UBC, SFU, UNBC.

***UBC Notes:**

- Students transferring to UBC must take Chem 110 and Phys 104, Phys 11 prerequisite if no Phys 12. (Be sure to check the prerequisites for these courses.)
- All students require 2 courses from Chem or Phys beyond the Grade 12 level. i.e., Chem 120 and 121 OR Phys 114 and 115.
- Students are also required to have Biology 11 (Biology 060) or 12, (Biology 080). Biology 100 and 102 do not transfer to UBC. Students with Biology 11 and 12 are required to take one of Biology 124, 126, OR Geos 100 or Geog 204 AND 206.
- UBC's CPSC 111/211 or CPSC 111/Math 210 equivalents are not offered at Camosun, but must be completed in the first two years.

Associate of Science Degree in Mathematics (Capilano College)

Associate of Science - Mathematics Specialization

English requirement		Course Credits	Required Credits
			6.00
Required Courses:		6.00	
ENGL	English 100 level	6.00	

Mathematics requirements - 1st year		Course Credits	Required Credits
			9.00
Required Courses:		9.00	
MATH 116	Calculus I	3.00	
MATH 124	Discrete Mathematics I	3.00	
MATH 126	Calculus II	3.00	

Science requirements - 1st year		Course Credits	Required Credits
			15.00
Choose 4.00 Credits from the following list:			4.00
PHYS 108	Basic Physics	5.50	
PHYS 110	General Physics I	4.00	
PHYS 114	Fundamental Physics I	4.00	
Choose 4.00 Credits from the following list:			4.00
PHYS 111	General Physics II	4.00	
PHYS 115	Fundamental Physics II	4.00	
Choose 7.00 Credits from the following list:			7.00
SCEL	100-level Computer Science, Biology, Chemistry, Geology	7.00	

Mathematics requirements - 2nd year		Course Credits	Required Credits
			15.00
Required Courses:			9.00
MATH 200	Linear Algebra	3.00	
MATH 230	Calculus III	3.00	
MATH 235	Introduction to Differential Equations	3.00	
Choose 3.00 Credits from the following list:			3.00
MATH 204	Probability and Statistics for Applications	3.00	
MATH 205	Introduction to Probability and Statistics	3.00	
Choose 3.00 Credits from the following list:			3.00
MATH 215	Introduction to Analysis	3.00	
MATH 224	Discrete Mathematics II	3.00	

Science requirement - 2nd year		Course Credits	Required Credits
			3.00
Choose 3.00 Credits from the following list:		3.00	
SCEL	200 level or higher	3.00	

Arts elective - 100 level or higher (excluding subjects that have transfer in both arts & science)	Course Credits	Required Credits
		6.00
Elective		6.00

Elective - 100 level or higher	Course Credits	Required Credits
		6.00
Total Program Credit		**60.00**
Elective	6.00	

KWANTLEN UNIVERSITY COLLEGE
ASSOCIATE of SCIENCE DEGREE in MATHEMATICS
(ASc - Mathematics)

The Associate Degree was created in 1991 in recognition of full completion of the first two years of a Bachelor degree in either Arts or Science. Initially intended as an exit credential for those deciding not to further their education beyond that point, it has taken on a new role for academic transfer to a recognized degree-granting institution. An Associate Degree will guarantee transfer of 60 receiving institution transfer credits, but still requires the make-up of any missing core courses at the receiving institution in their first two years. All courses counting must have transfer credit to at least one of UBC, SFU, UVic or UNBC.
In effect, students receive transfer credit for every course completed within the Associate Degree even if any particular course does not have course-to-course transfer equivalency at that receiving institution.

English

Two ENGL 1100 or higher level courses

First Year Mathematics

a) MATH 1120 and MATH 1220; or
b) MATH 1130 and MATH 1230

Note: MATH 1120 and MATH 1220 are suggested, and students should ask an instructor before assuming the alternate is acceptable.

First Year Science

Note: plan ahead for second year prerequisites

CPSC 1103 and 1204*
plus
4 other sciences chosen from:
BIOL 1110, 1210
CHEM 1110, 1210
CPSC 1100, 1205
GEOG 1110, 1120
GEOL 1210
MATH 1115 (if not counting MATH 2335)
PHYS 1101, 1120, 1220

Notes:
UBC requires Chem 12 and Phys 12 (or equivalent)
UBC requires two of CHEM 1110, CHEM 1210, PHYS 1120 (or 1101) or PHYS 1220
UBC requires BIOL 1110 if lacking either Biology 11 or 12
* SFU does not require CPSC 1204, nor is a substitute for this omission required
SFU requires PHYS 1120 (or 1101) and 1220

Note: the sum of 2nd year science and math courses must total six

Second Year Science

SFU Mathematics and Applied Mathematics both require CPSC 2302 and CPSC 2405
SFU Applied Mathematics requires PHYS 2330
UNBC requires CPSC 2405

Second Year Mathematics

UBC requires MATH 2232, 2321, 2331, 2421
SFU Mathematics requires MATH 2232, 2315, 2321, 2331
SFU Applied Mathematics requires MATH 2232, 2315, 2321, 2322 and 2331
UVIC requires MATH 2232 2315, 2321, 2322 and 2421
UNBC requires MATH 2232, 2322 plus courses not matched at Kwantlen

Other Courses

Any four courses, at least two chosen from:
ANTH, CRIM, ECON, FINA, FREN, GEOG (not those listed under science), GERM, HIST, JAPN, LING, MAND, MUSI, PHIL, POLI, PSYC, SOCI or SPAN

Notes:
All four must have transfer credit status
SFU Applied Mathematics requires only two "other" courses
UVIC: suggest CPSC 2405 to complete 2nd year credit requirements for ASc
UBC and UNBC: need more 2nd year courses for ASc

Missing make-ups outside the Associate Degree
UBC missing MATH 210; **SFU** Applied Mathematics missing MACM 202; **SFU** Mathematics missing MACM 201 and 201; **UVIC** missing MATH 233C and STAT 261 (which can be deferred to third year); **UNBC** missing MATH 201, 221, 224, 226 and 230.

CHEM 1105, MATH 1112, or PHYS 1100 may be counted within an Associate of Science under very limited conditions - generally it is best to confirm this in advance with the university you plan to attend.

Transfer status may vary from institution to institution. Please be sure to confirm the transfer status at each university or other institution you are considering for degree completion.

An average overall grade of C (cumulative GPA of 2.0 or its equivalent), calculated on all courses passed and counting towards the Associate Degree, must be achieved.

Remember, it is important to verify your academic program with an Educational Advisor.

Proposal for an
Associate of Science Degree in Mathematics
May 3, 2004

By: Neil Coburn, Selkirk College

Year One

Fall	*Winter*
Calculus I	Calculus II
Chemistry I	Introductory Linear Algebra
English Composition	Introduction to Programming II
Introduction to Programming I	100- or 200-level English
Physics I	100-level Science

Year Two

Fall	*Winter*
Calculus III (Multivariable)	Computer Data Structures
Discrete Math I	Differential Equations
Probability and Statistics	Discrete Math II
Linear Algebra	Real or Complex Analysis
Arts elective	Arts elective

Transferability Notes:

1. Simon Fraser University
   Year One – *All* requirements met.
   Year Two – Students require a course in Mathematical Modelling.
2. University of British Columbia
   Year One – Honours versions of Calculus I and II (Math 120 and 121) are required. Will *strong* students be given credit if they have taken a "regular" Calculus?
   Year Two – Honours version of Linear Algebra is required (Math 223). In addition, students require Calculus IV.
3. University of Northern British Columbia
   Year One - A*ll* requirements met.
   Year Two – Students require courses in Foundations of Modern Mathematics and Operations Research
4. University of Victoria
   Year One - A*ll* requirements met.
   Year Two – A*ll* requirements met.

Part D - Project Sub-Committee

The six members of the Mathematics Flexible Pre-Major Analysis Sub-Committee were:

Peter Danenhower teaches Mathematics courses at Langara College.

Bruce Kadonoff chairs the Mathematics Department of Coquitlam College and is a Limited Term Lecturer at Simon Fraser University.

Clint Lee instructs in Mathematics and Statistics at the Vernon Campus of Okanagan College.

David Leeming is a recently retired Professor of Mathematics from the University of Victoria.

Alex Liu teaches Mathematics courses at Kwantlen University College and chaired the Sub-Committee.

Leo Neufeld is a retired Mathematics instructor from Camosun College and Project Contractor.

Peter Danenhower

Bruce Kadonoff

Clint Lee

David Leeming

Alex Liu

Leo Neufeld

Part E - Acknowledgements

Hosts for Sub-Committee Meetings

The Sub-Committee gratefully acknowledges the hospitality of the Department of Mathematics and Kwantlen University College for providing a comfortable meeting site and other, thoughtful provisions to enhance each of its meetings. These accommodations assisted significantly in furthering the productivity and success of Sub-Committee sessions.

Associate of Science (Mathematics) Working Group

The work in 2004 done by Neil Coburn and his team in attempting to identify an ASc (Mathematics) template was directly instrumental in originating the present initiative. These efforts and the resulting documentation were very helpful to the Sub-Committee in structuring its activities, and are acknowledged with thanks.

Respondents - Receiving Institutions

John Byl
Trinity Western University

Bruce Crofoot
Thompson Rivers University

Sylvie Desjardins
UBC (Okanagan)

Rajiv Gupta
The University of British Columbia

Gary MacGillivray
University of Victoria

Tom Archibald and
Malgorzata Dubiel
Simon Fraser University

Gillian Mimmack
University College of the Fraser Valley

Sam Walters
University of Northern British Columbia

Respondents - Sending Institutions

Ian Bailey
Malaspina University-College

Jim Bailey
College of the Rockies

Nicholas Buck
College of New Caledonia

Patricia Corbett-Labatt
North Island College

Hongbin Cui
Northern Lights College

Peter Danenhower
Langara College

Anatoly Demch
Columbia College

John Inglis
Kwantlen University College

Mona Izumi
Northwest Community College

John Josafatow
Selkirk College

Bruce Kadonoff
Coquitlam College

Costa Karavas
Vancouver Community College

Wayne Matthews
Camosun College

Christopher Morgan
Capilano College

David Murray
Okanagan College

Susan Oesterle
Douglas College

Louise Routledge
BC Institute of Technology

Lana Stowe
IIG All Nations Institute

Tim Topper
Yukon College