S.73-79

SIMON FRASER UNIVERSITY

MEMORANDUM

To: SENATE

From: SENATE COMMITTEE ON UNDERGRADUATE STUDIES

Subject: FACULTY OF SCIENCE NEW COURSE PROPOSALS - MATHEMATICS 104-3, 306-3, 308-3, 316-3, 343-3, 401-3, 402-3, 403-3 ~~AND 416-3~~

Date: JUNE 26, 1973

MOTION 1: "That Senate approve, as set forth in S.73-79, the new course proposals in Mathematics,

Mathematics 104-3 - Elementary Computational Methods
Mathematics 306-3 - Introduction to Automata Theory
Mathematics 308-3 - Linear Programming
Mathematics 316-3 - Numerical Analysis I
Mathematics 343-3 - Combinatorial Aspects of Computing
Mathematics 401-3 - Switching Theory and Logical Design
Mathematics 402-3 - Automata and Formal Languages
Mathematics 403-3 - Algebraic Theory of Automata
Mathematics 416-3 - Numerical Analysis II."

MOTION 2: "That Mathematics 104-3; Mathematics 306-3; Mathematics 401-3; Mathematics 402-3; and Mathematics 403-3 as now approved, now be included as part of the Computing Science Program as earlier recommended."

MOTION 3: "That Mathematics 316-3, as now approved, be included as part of the Computing Science Program as a substitute for Mathematics 406-3, earlier recommended for inclusion in the Program."

MOTION 4: "That Mathematics 405-4 be discontinued on the commencement of Mathematics 306-3; and Mathematics 406-3 be discontinued on the commencement of Mathematics 316-3."

MOTION 5: "That the two semester time lag requirement be waived in order that Mathematics 104-3 may be first offered in the Fall 73-3 semester; and that Mathematics 306-3, 308-3, 316-3, 401-3, 402-3, 403-3 and 416-3 may be first offered in or after Spring 74-1 semester."

S.73-79

SIMON FRASER UNIVERSITY

MEMORANDUM

To: SENATE

From: SENATE COMMITTEE ON UNDERGRADUATE STUDIES

Subject: FACULTY OF SCIENCE NEW COURSE PROPOSALS - MATHEMATICS 104-3; 306-3; 308-3; 316-3; 343-3; 401-3; 402-3; ~~AND 416-3.~~

Date: JUNE 26, 1973

The Senate Committee on Undergraduate Studies, on recommendation of the Faculty of Science, has approved new course proposals in Mathematics, as set forth in SCUS 73-20:

Mathematics 104-3 - Elementary Computational Methods
Mathematics 306-3 - Introduction to Automata Theory
Mathematics 308-3 - Linear Programming
Mathematics 316-3 - Numerical Analysis I
Mathematics 343-3 - Combinatorial Aspects of Computing
Mathematics 401-3 - Switching Theory and Logical Design
Mathematics 402-3 - Automata and Formal Languages
Mathematics 403-3 - Algebraic Theory of Automata
Mathematics 416-3 - Numerical Analysis II.

The Committee further recommends that:

1. Mathematics 104-3; Mathematics 306-3; Mathematics 401-3; Mathematics 402-3; and Mathematics 403-3 as now approved, now be included as part of the Computing Science Program as earlier recommended.

2. Mathematics 316-3, as now approved, be included as part of the Computing Science Program as a substitute for Mathematics 406-3, earlier recommended for inclusion in the Program.

3. Mathematics 405-4 be discontinued on the commencement of Mathematics 306-3; and Mathematics 406-3 be discontinued on the commencement of Mathematics 316-3.

4. The two semester time lag requirement be waived in order that Mathematics 104-3 may be first offered in the Fall 73-3 semester; and that Mathematics 306-3; 308-3; 316-3; 401-3; 402-3; 403-3 and 416-3 may be first offered in or after Spring 74-1 semester.

It should be noted that six of the courses now recommended for approval - Mathematics 104; 306; 316; 401; 402; and 403 - will form part of the Computing Science Program requirements and will also fulfil requirements in the Mathematics degree programs.

In making its submission, through the Faculty of Science, to the Senate Committee on Undergraduate Studies, the Mathematics Department requested that the two semester time lag rule be waived for a number of courses proposed at this time. The request to the Committee noted that this was particularly urgent in the cases of Mathematics 104; Mathematics 306; and Mathematics 316. A copy of the memorandum from the Chairman of the Mathematics Department is attached.

In making its recommendation to Senate, SCUS has restricted its request for permission to offer courses in the Fall semester, 1973 to Mathematics 104 and suggested that the remaining courses, including Mathematics 306 and 316, be offered first in the Spring semester, 1974 or subsequently. Its reasons for making this recommendation are as follows:

1. The Committee felt that a special case could be made for the offering of Mathematics 104 in the Fall semester. It is an integral part of the developing Computing Science Program and failure to offer it in the Fall semester would seriously hinder that program and the progress of students intending to enroll in it. Further, this course had been submitted earlier, as Computing Science 124, and would have been in time for normal inclusion in the Fall semester course guide had not a Motion of Senate removed it from that program.

2. The Committee felt that a special case could not be made for the offering of Mathematics 306 and 316 during the Fall semester. These are courses which are being offered as substitutes for courses currently offered by the Mathematics Department, Mathematics 405 and 406 respectively. These latter courses have already been included in the Mathematics course projections for the Fall semester and, as is indicated in the memorandum from the Department Chairman, will be covering substantially the same material as will be included in Mathematics 306 and 316. The Committee therefore felt that, while it was prepared to make a special recommendation in the case of Mathematics 104 and the Registrar's Office has indicated its willingness to make arrangements for a late inclusion of Mathematics 104 in the Fall course guide, the confusion and inconvenience which would result from the late inclusion of further courses which are already being substantially offered would be too great to justify a further recommendation in this case.

SCUS 73-20a

SIMON FRASER UNIVERSITY

MEMORANDUM

SENATE COMMITTEE ON UNDERGRADUATE STUDIES	From: Dr. R. W. Lardner Chairman Department of Mathematics
Subject: SCHEDULING OF NEW MATHEMATICS COURSES	Date: June 13, 1973

With the advent of the new Computer Science program a number of new courses have been proposed by the Mathematics Department related to this program. These are Mathematics 104-3, 306-3, 308-3, 316-3, 401-3, 402-3, 403-3 and 416-3. All of these courses except one were described within the Computer Science program accepted by Senate and it states there that these courses would later be proposed by the Mathematics Department through the Faculty of Science. These courses form part of the Computer Science program as well as part of the Mathematics program.

It is essential that three of these courses be offered in the coming Fall semester (these are 104-3, 306-3 and 316-3). The Department of Mathematics has requested that Senate give special permission to waive its rules regarding the two-semester period before a course may be offered and to permit these courses to be offered in the Fall. Because the July Senate meeting falls after the deadline for inclusion of courses in the Fall Course Guide it is necessary that Senate give a special dispensation for the courses to be offered in the Fall. I am writing to request such special permission.

We also wish to mount most of the remainder of courses listed in the first paragraph in the Spring semester. I should like to request Senate permission to do this.

The reasons why it is essential to mount the courses in the Fall are as follows:

1. Math 104-3: This is an elementary course in Numerical Methods designed primarily for students with weak Mathematical backgrounds. Its primary purpose is to allow students with weak backgrounds to take the new courses in Computer Science. As such it is essential to offer it early in the program. It is also much to be preferred to offer this course in the Fall semester in order to permit the relevant students to take it as soon as they come to the University. Finally, the faculty member who will teach the course already has a full load of courses in the Spring semester next year and therefore great difficulty would be caused if the course has to be postponed from the Fall to the Spring.

2. Math 306-3: This course is essentially the same as an existing course, Math 405-4, and will replace that course. It will become prerequisite for the courses 401-3, 402-3 and 403-3, one of which will be offered in the Spring semester next year. It will therefore disrupt this sequence of courses if we were not able to offer 306-3 in the Fall.

4. Math 316-3: This course is essentially the same as an existing course, 406-3, which it will replace. It will become prerequisite for the new course 416-3 which will be offered in the Spring next year. Again this sequence will be disrupted if we are not able to offer 316-3 in the Fall.

I understand from Mr. Evans that he is willing to take special measures to ensure that the first of these courses (104-3) is included in the Fall Course Guide should it receive approval to be offered at the July Senate meeting.

As far as the other two courses are concerned the Course Guide will state that the original courses (405-4 and 406-3) will be offered in the Fall. These will be replaced by the two new courses if they receive Senate approval. As far as the transition from 406-3 to 316-3 is concerned this will cause no problem since the credits for the two courses are the same and there is relatively little change in syllabus. For the transition from 405-4 to 306-3 there is a potential problem in that it would involve a reduction in the number of credits for the course. In this case what we propose to do is that after pre-registration is completed the Departmental Assistant approach personally every student who has registered in 405-4 and the course will be changed to 306-3 if these students agree unanimously to do so.

Robin Lardner

R. W. Lardner

RWL:ag

SIMON FRASER UNIVERSITY

MEMORANDUM

To: Senate Committee on Undergraduate Studies

From: J.S. Barlow
Associate Dean of Science

Subject: MATHEMATICS COURSE PROPOSALS

Date: June 5, 1973

Attached for the approval of SCUS are the Mathematics course proposals as approved by the Faculty of Science at its meeting of May 29, 1973. It should be noted that six of these courses (Math 104, 306, 316, 401, 402, and 403) will form part of the Computing Science program requirements, as well as fulfill requirements in the Mathematics degree programs.

lw

J Barlow

NOTES ON THE AUTOMATA THEORY COURSES

These courses, placed as they are between mathematical logic, computing and electrical engineering should have motivational and applied aspects as well as theoretical mathematical interest. Care must be taken to ensure that persons from computer science are not swamped immediately with abstract pure mathematics and that students from mathematics are not over-powered by persons who, having done lots of computing work, may find the application sides of the course 'familiar' in concept even though probably 'new' in detail.

The present mathematics course (Math 405), now being given for the third time, is based on the premise that it is the only automata course being regularly offered at this stage. For this reason it has been taken to have a wide base. The directed studies follow-up course, given twice at student request, has been thought of as an extension of Math 405 to fill in certain details and to bring into focus an additional area, namely that lying between regular sets and recursively enumerable sets, an indication of a motivation for the extension being given in terms of a consideration of methods of sequence generation and an analysis of sentence structure (c.f. Post, Chomsky). Consideration of the concept of calculation has entered into the course but not very deeply.

The course pattern now suggested first replaces Math 405 by a 300 level course with approximately the same material. Differences between Math 405 and the new course would be that in the new course there is

- i) a slight increase in the theory of finite automata - at the moment Math 405 fails to deal with minimization work except at a very superficial level
- ii) a decrease in basic Turing Machine theory - the students will have met Turing Machines in CS 100
- iii) an increase at the end of the course to include 'program machines' which conceptually lie between Turing Machines and ordinary computers.

The course will act as a better basis than Math 405 for later courses on switching theory and algebraic automata theory. Further, in modifying the syllabus, account has been taken of the fact that the students should, in view of the content of CS 100, enter the course better acquainted with relevant background material than has previously been the case.

In the new proposal, Math 306-3 is intended to act as a foundation for three follow-up courses, one on switching theory, one on formal languages and automata, and one on algebraic automata theory.

The switching theory course is thought as presenting a theoretical background to some of the techniques involved in the design of logical circuits. The book chosen as a "possible text" is written by professors of Electrical Engineering and this was a deliberate choice in the sense that it is hoped that the course will help bridge the gap between the more theoretical aspects of circuit design and some of the problems involved in practical hardware construction. The fact that some work was done on McCulloch-Pitts nets in Math 306-3 should prove useful to students taking Math 401-3.

The formal languages and automata theory course (Math 402-3) is similar to a course offered twice before under directed studies/honours essay numbers in the Mathematics Department. It develops the theory of context-sensitive and context-free languages, relating them to regular and recursively enumerable languages. It also provides a theoretical background for a study of some of the work which has been done or is being attempted in the field of sentence recognition in natural and formal languages. Considering, as it also does, modified and restricted forms of Turing machines, the course acts as a suitable point for introduction of aspects of calculation complexity (time and tape forms).

The final course, Math 403-3, on algebraic theory of automata is intended to deal at an abstract level with the close connections between automata theory and certain aspects of semigroup theory (and group theory). A serious algebra prerequisite is desirable (from knowledge and maturity considerations). The course is envisioned as one which will be taken by persons specializing in Pure Mathematics and Computer Science but not necessarily by those concerned more with the central areas of Computer Science and almost certainly not by those concerned mainly with Applied Computer Science. Although mathematically the most specialized of the courses suggested, its importance within Computer Science should probably not be underestimated, for concepts introduced within modern advanced automata theory are frequently expressed in an abstract algebraic format.

In summary, the four (4) courses are considered to be undergraduate ones, starting with a widely based foundational one with intuitive, practical and mathematical content and then extending to include a substantial amount of basic work in each of three different but related fields.

FACULTY OF SCIENCE

NEW COURSE PROPOSAL

I CALENDAR INFORMATION

Department: *Mathematics** Course Number: *104-3** Title: **Elementary Computational Methods*

Sub-title or Description:

An introductory course in numerical methods and various applications.

Credit Hours: *3* Vector Description: *2-0-2*

Pre-requisite(s): *Mathematics 11 (B.C. High Schools) and knowledge of a programming language (e.g., Mathematics 106-3 or* Computing *Science 102-2).*

II ENROLMENT AND SCHEDULING

Estimated Enrolment: *30 per offering*

Semester Offered (e.g. Yearly, every Spring; twice yearly, Fall and Spring):

Yearly, every Fall or Spring

When course will first be offered: *Fall 73 or Spring 74*

III JUSTIFICATION

A. What is the detailed description of the course including differentiation from lower level courses, from similar courses in the same department and from courses in other departments in the University?

Many fields, for example - Biology, Chemistry, Physics, Psychology, Economics, deal with problems which are not amenable to analytic solution. This course provides background for some of the necessary numerical methods for solving problems of this nature. No similar course is offered by this or any other department in the University.

B. What is the range of topics that may be dealt with in the course?

See attached syllabus - page four.

C. How does this course fit the goals of the department?

This course will have an important position in the Computing *Science program. It will also provide a useful service to students in other disciplines who wish to learn elementary computational techniques.*

D. How does this course affect degree requirements?

This course has no direct effect on degree requirements, except that majors in computing science will be required to have a mathematics background at least equivalent to this course.

E. What are the calendar changes necessary to reflect the addition of this course?

New entries in the Mathematics and Computing *Science sections of the calendar.*

F. What course, if any, is being dropped from the calendar if this course is approved?

Mathematics 205-3 has already been dropped from the calendar.

G. What is the nature of student demand for this course?

As previously stated, many fields require some knowledge of elementary numerical techniques. Since this will be a new course and no similar course has been offered, it is difficult to draw comparisons.

H. Other reasons for introducing the course.

IV BUDGETARY AND SPACE FACTORS

A. Which faculty will be available to teach this course?

G.A.C. Graham, E. Pechlaner, R. Russell

B. What are the special space and/or equipment requirements for this course?

Computer time.

C. Any other budgetary implications of mounting this course:

None.

ELEMENTARY COMPUTATIONAL METHODS

CONCEPT OF A NUMERICAL METHOD: *what it means to and how to numerically guess the solution to a problem.*

ITERATIVE METHODS: *heuristic explanation with examples, (including a brief introduction to derivatives).*

APPROXIMATION METHODS: *including their relation to iteration.*

LINEAR EQUATIONS: *what they are and when they arise.*

LINEAR PROGRAMMING PROBLEMS: *mainly aspects related to computation.*

MONTE-CARLO METHODS

Suggested textbooks: (Topics from) ELEMENTARY COMPUTER APPLICATIONS by Barrodale, Roberts and Ehle. (John Wiley and Sons)

(Topics from) COMPUTER-ORIENTED MATHEMATICS by L.D. Kovach (Holden Day 1964)

(Topics from) NUMERICAL ANALYSIS by I.A. Dodes and S.L. Gratzer (Hayden)

FACULTY OF SCIENCE

NEW COURSE PROPOSAL

I CALENDAR INFORMATION

Department: *Mathematics** Course Number: *306-3** Title: **Introduction to Automata Theory*

Sub-title or Description:
Finite-state machines, McCulloch-Pitts nets and the equivalence of these concepts; recognition of sequences by finite state machines and by nets; regular expressions Kleene's theorem. Turing machines; a universal Turing machine; unsolvability of the halting problem and of some related problems; Turing computability and recursivity; program machines.

Credit Hours: *3* Vector Description: *3-1-0*

Pre-requisite(s): Computing *Science 100-3, and fifth level standing or permission the instructor. Students who have obtained credit for Mathematics 405-4 cannot obtain credit for Mathematics 306-3*

II ENROLMENT AND SCHEDULING

Estimated Enrolment: *25 per offering.*

Semester Offered (e.g. Yearly, every Spring; twice yearly, Fall and Spring):

Yearly, every Fall

When course will first be offered: *Fall 73*

III JUSTIFICATION

A. What is the detailed description of the course including differentiation from lower level courses, from similar courses in the same department and from courses in other departments in the University?

This course is a widely based foundational one which replaces the present Mathematics 405-4 (Theory of Computability). No similar course is offered by this or any other Department in the University.

B. What is the range of topics that may be dealt with in the course?

See attached syllabus - page four.

C. How does this course fit the goals of the department?

This course has an important position in the proposed Computing *Science program, being the basic course for the automata theory section of that program. The present automata theory course, Mathematics 405-4 was the only automata theory course being offered. The new course follows essentially the same syllabus but takes into account the increase in prior preparation of students for such work, since they will now be required to have Computing Science 100-3.*

D. How does this course affect degree requirements?

For majors or honours students in Computing *Science, this course may be used in partial satisfaction of degree requirements. For Mathematics students, it will increase the selection of upper level courses which can be used to satisfy their degree requirements.*

E. What are the calendar changes necessary to reflect the addition of this course?

New entries in the Mathematics and Computing *Science sections of the calendar.*

F. What course, if any, is being dropped from the calendar if this course is approved?

Mathematics 405-4.

G. What is the nature of student demand for this course?

Even without a program in Computing *Science, Mathematics 405-4 has had a regular enrolment of about 10 students per year. There should now be an increased demand.*

H. Other reasons for introducing the course.

The course will also be used for students whose main area of interest is mathematical logic and who wish to study applications of that subject in a computing context.

IV BUDGETARY AND SPACE FACTORS

A. Which faculty will be available to teach this course?

A. Freedman, R. Harrop, A. Lachlan

B. What are the special space and/or equipment requirements for this course?

Computing time.

C. Any other budgetary implications of mounting this course:

None - replacement course.

INTRODUCTION TO AUTOMATA THEORY

FINITE-STATE MACHINES: Equivalent histories and states; state-transition diagrams; limitations of calculation possibilities with finite-state machines. Minimization of number of states.

NEURAL NETS: McCulloch-Pitts nets; equivalence of neural nets with finite-state machines.

REGULAR EXPRESSIONS: Recognition of sequences by finite automata and nets; regular expressions; Kleene's theorem.

TURING MACHINES: Review of definition of Turing machines; examples of computations by Turing machines; universal machines; unsolvability of the halting problem and some related problems; primitive recursive functions; (total and) partial recursive functions and equivalence to Turing computability.

PROGRAM MACHINES: Concept of program machine; equivalence of recursive functions and program machine computable functions.

Suggested Textbook: COMPUTATION: FINITE AND INFINITE MACHINES by Minsky (Prentice-Hall)

FACULTY OF SCIENCE

NEW COURSE PROPOSAL

I CALENDAR INFORMATION

Department: *Mathematics* Course Number: *308-3* Title: *Linear Programming*

Sub-title or Description:

Theory and applications of linear programming. Geometric and computational considerations.

Credit Hours: *3* Vector Description: *3-1-0*

Pre-requisite(s): *Mathematics 232-3 and preferably, knowledge of a programming language (e.g., Mathematics 106-3 or* Computing *Science 102-2).*

II ENROLMENT AND SCHEDULING

Estimated Enrolment: *30 per offering.*

Semester Offered (e.g. Yearly, every Spring; twice yearly, Fall and Spring):

Yearly, every Fall or Spring

When course will first be offered: *Fall 73 or Spring 74*

III JUSTIFICATION

A. What is the detailed description of the course including differentiation from lower level courses, from similar courses in the same department and from courses in other departments in the University?

The course will explore in detail the relationship between the mathematical foundations of linear programming and applications. No similar course is offered by this Department or any other in the University.

B. What is the range of topics that may be dealt with in the course?

See attached syllabus - page four

C. How does this course fit the goals of the department?

In addition to those courses primarily concerned with mathematical theory, the Department wishes to offer courses which will enable students to learn skills which could be applied to concrete problems they might encounter either in other disciplines or in industry.

D. How does this course affect degree requirements?

This course has no direct effect on degree requirements. However, for mathematics majors and honours students, it will increase the selection of upper level courses they may take to complete their requirements. It also will provide a useful option for those students who wish to take a minor in mathematics.

E. What are the calendar changes necessary to reflect the addition of this course?

New entry.

F. What course, if any, is being dropped from the calendar if this course is approved?

None.

G. What is the nature of student demand for this course?

The Department has offered 'linear programming' as directed studies courses in previous semesters, with enrollments of 10 - 20 per offering.

H. Other reasons for introducing the course.

The course will be useful for mathematics students who are interested in statistics and computing and their relationship to other fields.

IV BUDGETARY AND SPACE FACTORS

A. Which faculty will be available to teach this course?

B. Alspach, D. Mallory, R. Lardner, R. Russell

B. What are the special space and/or equipment requirements for this course?

Computer time.

C. Any other budgetary implications of mounting this course:

The teaching of Mathematics 106-3 (Fortran) is being phased out with the introduction of the new Computing *Science program. Consequently, those resources so freed will be used in the teaching of mathematics courses related to* computing *science.*

LINEAR PROGRAMMING

1. *Convex sets in n-dimensional spaces.*
2. *Logics, models and applications of linear programming.*
3. *Simplex method - geometric and economic interpretation.*
4. *Simplex method as a computational procedure.*
5. *Shadow prices, imputed values, duality theorem.*
6. *Sensitivity algorithm.*
7. *Parametric programming.*
8. *Decomposition algorithm.*
9. *Variants of simplex method.*

Suggested textbook: INTRODUCTION TO LINEAR PROGRAMMING by C. Kim (Holt, Rinehart and Winston, 1971)

FACULTY OF SCIENCE

NEW COURSE PROPOSAL

I CALENDAR INFORMATION

Department: *Mathematics** Course Number: *316-3** Title: **Numerical Analysis I*

Sub-title or Description:

A presentation of the problems commonly arising in numerical analysis and the basic methods for their solution.

Credit Hours: *3* Vector Description: *3-1-0*

Pre-requisite(s): *Mathematics 152-3 and 232-3 and knowledge of a programming language (e.g., Mathematics 106-3 or* Computing *Science 102-2).*

II ENROLMENT AND SCHEDULING

Estimated Enrolment: *15-20 per offering.*

Semester Offered (e.g. Yearly, every Spring; twice yearly, Fall and Spring):

Yearly, every Fall

When course will first be offered: *Fall 74*

III JUSTIFICATION

A. What is the detailed description of the course including differentiation from lower level courses, from similar courses in the same department and from courses in other departments in the University?

The course is concerned with the practical solution of scientific problems on computers, with emphasis on the various available algorithms. Emphasis is placed on the theoretical considerations such as rate of convergence comparisons as well as on practical considerations involving actual implementation of the codes. This course will replace Mathematics 406-3.

B. What is the range of topics that may be dealt with in the course?

See attached syllabus - page four.

C. How does this course fit the goals of the department?

A review of the Department's present numerical analysis course (Mathematics 406-3) led to the conclusion that it was impossible to teach the subject satisfactorily i a one-semester course. The revisions which led to this course proposal (and to th one submitted for Mathematics 416-4) will provide students with a better understanding of numerical analysis. It will also enable those who take the course to see a major application of theoretical tools to numerical applications.

D. How does this course affect degree requirements?

This course has no direct effect on degree requirements. However, for mathematics majors and honours students, it will increase the selection of upper level courses they may take to satisfy their degree requirements. It will also provide an interesting and useful option for those students completing a minor program in mathematics and for students majoring in computing *science.*

E. What are the calendar changes necessary to reflect the addition of this course?

New entries in the Mathematics and Computing *Science sections of the calendar.*

F. What course, if any, is being dropped from the calendar if this course is approved?

Mathematics 406-3.

G. What is the nature of student demand for this course?

The numerical analysis course offered previously (Math 406) had an enrollment of 10-15 students per offering. By replacing certain advanced topics with those which are more easily accessible, it is possible to lower the prerequisites. This should make the course more attractive to students, both in mathematics and in computing *science.*

H. Other reasons for introducing the course.

IV BUDGETARY AND SPACE FACTORS

A. Which faculty will be available to teach this course?

G.A.C. Graham, E. Pechlaner, R. Russell

B. What are the special space and/or equipment requirements for this course?

Computer time.

C. Any other budgetary implications of mounting this course:

None.

NUMERICAL ANALYSIS I

1. *NUMBER SYSTEMS AND ERRORS: representation of numbers; error propagation and error estimation.................1 1/2 weeks.*

2. *SOLUTION OF NONLINEAR EQUATIONS: bisection, modified regula falsi, secant method, Newton's method; fixed point iteration, Aitken's algorithm, Steffensen's iteration; Muller's method...........2 1/2 weeks.*

3. *SYSTEMS OF LINEAR EQUATIONS: elimination method - factorization, pivoting strategy, compact schemes, iterative improvement, inverse calculation; iterative methods; eigenvalue problem....3 weeks.*

4. *INTERPOLATING AND APPROXIMATION: interpolation polynomial - Lagrange, Newton, divided difference forms, error formula; piecewise polynomial interpolation and approximation; data fitting, orthogonal polynomials, least-squares approximation, Chebyshev approximation...4 weeks.*

5. *DIFFERENTIAION AND INTEGRATION: numerical differentiaion; numerical integration - composite rules, Gaussian quadratures, Romberg integration.*

SUGGESTED TEXTBOOK: ELEMENTARY NUMERICAL ANALYSIS by Conte and deBoor (McGraw Hill, 1972)

FACULTY OF SCIENCE

NEW COURSE PROPOSAL

I CALENDAR INFORMATION

Department: *Mathematics*

Course Number: *343-3*

Title: *Combinatorial Aspects of Computing*

Sub-title or Description:

This course is primarily concerned with computational applications of combinatorial theory.

Credit Hours: *3*

Vector Description: *3-1-0*

Pre-requisite(s): *Mathematics 232-3 and either knowledge of a programming language or Mathematics 106-3 or* Computing *Science 102-2.*

II ENROLMENT AND SCHEDULING

Estimated Enrolment: *15 per offering*

Semester Offered (e.g. Yearly, every Spring; twice yearly, Fall and Spring):

Yearly, every Fall or Spring

When course will first be offered: *Fall 74 or Spring 75*

III JUSTIFICATION

A. What is the detailed description of the course including differentiation from lower level courses, from similar courses in the same department and from courses in other departments in the University?

The Mathematics Department offers no similar course and neither does any other Department in the University.

B. What is the range of topics that may be dealt with in the course?

see attached syllabus - page four.

C. **How does this course fit the goals of the department?**

This course will provide students who are interested in pure and applied mathematics with an opportunity to relate theoretical knowledge to practical considerations.

D. **How does this course affect degree requirements?**

This course has no direct effect on degree requirements. However, for mathematics majors and honours students, it will increase the selection of upper level courses they may take to satisfy their degree requirements. It will also provide an interesting option for those students completing a minor program in mathematics.

E. **What are the calendar changes necessary to reflect the addition of this course?**

New entry.

F. **What course, if any, is being dropped from the calendar if this course is approved?**

None, specifically - see comment on page three.

G. **What is the nature of student demand for this course?**

Since this is a new course in a new area of mathematics it is impossible to make an accurate assessment of student demand at this time. However, rapidly-growing interest in the subject, particularly in industry, would seem to forecast a reasonable demand.

H. **Other reasons for introducing the course.**

Although the course proposed is a mathematics course, it is hoped that students in Computing Science would find it useful as well as interesting.

IV BUDGETARY AND SPACE FACTORS

A. **Which faculty will be available to teach this course?**

B.R. Alspach, T.C. Brown

B. What are the special space and/or equipment requirements for this course?

Computer time.

C. Any other budgetary implications of mounting this course:

The teaching of Mathematics 106-3 (Fortran) is being phased out with the introduction of the new Computing *Science program. Consequently, those resources so freed will be used to teach mathematics courses related to* computing *science.*

COMBINATORIAL ASPECTS OF COMPUTING

1. Representations of integers.
2. Representations of sets.
3. Enumeration and counting techniques: back track methods, inclusion-exclusion, and Polya's method.
4. Searching in linearly ordered sets.
5. Trees and their uses in searching and traversal problems.
6. Algorithms for graph theory: path problems, flow problems, and matching problems.

SUGGESTED TEXTBOOK: ELEMENTS OF COMBINATORIAL COMPUTING by M.B. Wells (Pergamon)

FACULTY OF SCIENCE

NEW COURSE PROPOSAL

I CALENDAR INFORMATION

Department: *Mathematics** Course Number: *401-3** Title: **Switching Theory and Logical Design*

Sub-title or Description:

Mathematical foundations, switching devices, minimization of Boolean functions, tabular minimization and multiple-output circuits. Sequential circuits, pulse-mode and fundamental mode sequential circuits. Introduction to threshold logic.

Credit Hours: *3* Vector Description: *3-1-0*

Pre-requisite(s): Computing *Science 102-2 (or Mathematics 106-3) and Mathematics 306-3 (or Mathematics 405-4).*

II ENROLMENT AND SCHEDULING

Estimated Enrolment: *15 per offering.*

Semester Offered (e.g. Yearly, every Spring; twice yearly, Fall and Spring):

Initially, Spring every three years.

When course will first be offered: *Spring 75*

III JUSTIFICATION

A. What is the detailed description of the course including differentiation from lower level courses, from similar courses in the same department and from courses in other departments in the University?

This course will present a theoretical background at a mathematical/automata theory level to some of the techniques involved in the design of logical circuits. No similar course is offered by this Department or any other in the University.

B. What is the range of topics that may be dealt with in the course?

See attached syllabus - page four.

C. How does this course fit the goals of the department?

This course forms an integral part of the development of the Computing *Science program at this University, and in particular, of the automata theory section of that program.*

D. How does this course affect degree requirements?

This course has no effect on degree requirements. However, for majors or honours students in Computing *Science, it may be used to partially satisfy degree requirements. For Mathematics students, it will increase the selection of upper level courses which can be used to satisfy their degree requirements.*

E. What are the calendar changes necessary to reflect the addition of this course?

New entries, in the Mathematics and Computing *Science sections of the calendar.*

F. What course, if any, is being dropped from the calendar if this course is approved?

None

G. What is the nature of student demand for this course?

Since this is a new course, it is difficult to assess what the actual student demand will be, but it is expected that the demand will be a natural outgrowth of the Computing *Science program.*

H. Other reasons for introducing the course.

IV BUDGETARY AND SPACE FACTORS

A. Which faculty will be available to teach this course?

R. Harrop

B. What are the special space and/or equipment requirements for this course?

Computer Time

C. Any other budgetary implications of mounting this course:

None.

SWITCHING THEORY AND LOGICAL DESIGN

MATHEMATICAL FOUNDATIONS: *Truth functions and review of Boolean algebra.*

SWITCHING DEVICES: *Switches and relays; diode transistor logic, resistor transistor logic; NAND and NOR circuits; flip-flops.*

TABULAR MINIMIZATION AND MULTIPLE-OUTPUT CIRCUITS: *The Quine-MCKluskey method for determining prime implicants; minimization and prime implicants for multiple-output circuits.*

SEQUENTIAL CIRCUITS: *Counters; timing in clocked circuits; transition tables and state diagrams; simplification of circuits; state assignment and excitation equations; incompletely specified sequential circuits.*

PULSE-MODE AND FUNDAMENTAL MODE SEQUENTIAL CIRCUITS: *Flow tables and transition tables; analysis and synthesis of circuits; cycles and races.*

INTRODUCTION TO THRESHOLD LOGIC: *Linear separability and the use of threshold logic devices.*

Suggested textbook: *INTRODUCTION TO SWITCHING THEORY AND LOGICAL DESIGN by F.H. Hill and G.R. Peterson, (Wiley)*

FACULTY OF SCIENCE

NEW COURSE PROPOSAL

I CALENDAR INFORMATION

Department: *Mathematics** Course Number: *402-3** **Title:** *Automata and Formal Languages*

Sub-title or Description:

Languages and grammars. Finite automata and regular grammars; context-free grammars and pushdown automata; Turing machines and recursively enumerable (type 0) languages; context-sensitive grammars and linear bounded automata. Operations on languages. Complexity of calculation. Deterministic pushdown automata.

Credit Hours: *3* Vector Description: *3-1-0*

Pre-requisite(s): *Mathematics 306-3 (or Mathematics 405-4), or permission of the Mathematics Department.*

II ENROLMENT AND SCHEDULING

Estimated Enrolment: *15 per offering*

Semester Offered (e.g. Yearly, every Spring; twice yearly, Fall and Spring):

Initially, Spring, every three years.

When course will first be offered:

Spring 74

III JUSTIFICATION

A. What is the detailed description of the course including differentiation from lower level courses, from similar courses in the same department and from courses in other departments in the University?

The course develops the theory of context-sensitive and context-free languages, relati[ng] them to regular and recursively enumerable languages. It also provides a theoretical background for a study of some of the work which has been done or is being done in the field of sentence recognition in natural and formal languages. Considering as it also does, modified and restricted forms of Turing machines, the course acts as a suitable point for the introduction of aspects of calculation complexity. No similar course is now offere[d].

B. What is the range of topics that may be dealt with in the course?

See attached syllabus - page four.

C. How does this course fit the goals of the department?

This course forms an integral part of the development of the Computing *Science program at this University, and in particular, of the automata theory section of that program. The course should also enhance the Mathematics Department's service function with respect to students interested in the linguistics field at an advanced level.*

D. How does this course affect degree requirements?

This course has no direct effect on degree requirements. However, for majors or honours students in Computing *Science, it may be used to partially satisfy degree requirements. For Mathematics students, it will increase the selection of upper level courses which can be used to satisfy their degree requirments.*

E. What are the calendar changes necessary to reflect the addition of this course?

New entries, in the Mathematics and Computing *Science sections of the calendar.*

F. What course, if any, is being dropped from the calendar if this course is approved?

None.

G. What is the nature of student demand for this course?

A course of this nature has already been given, at student request, under selected topics/honors essay numbers during two of the three years in which Math 405-4 (Theory of Computability) has been offered. It was again requested for the Spring semester 73, but could not be offered.

H. Other reasons for introducing the course.

IV <u>BUDGETARY AND SPACE FACTORS</u>

A. Which faculty will be available to teach this course?

R. Harrop

B. What are the special space and/or equipment requirements for this course?

Computer time.

C. Any other budgetary implications of mounting this course:

Although this is not a replacement course, the Mathematics Department will be able to mount it during the next academic year, since there will be no selected topics courses offering during that time. (For the 72-73 academic year, 8 hours of selected topics courses were mounted.)

AUTOMATA AND FORMAL LANGUAGES

LANGUAGES AND GRAMMARS: Concepts of language and grammar including reference to natural and formal languages and to regular, context-free, context-sensitive and recursively enumerable (type 0) grammars and their related languages.

FINITE AUTOMATA AND REGULAR GRAMMARS: Deterministic and non-deterministic finite automata; relation to regular grammars; closure and decidability properties. Two-way finite automata.

CONTEXT-FREE GRAMMARS AND PUSHDOWN AUTOMATA: Derivation trees; Chomsky and Greibach normal forms. The 'uvwxy' theorem; self-embedding property; pushdown automata in empty store and accepting state form; equivalence of the concepts of context-free language and language accepted by (non-deterministic) pushdown automaton. Examples of 'closure' and 'decidability' results.

TURING MACHINES AND RECURSIVELY ENUMERABLE (Type 0) LANGUAGES: Review of the definition and elementary properties of Turing machines; modified forms of the definition including, for example, the use of storage tapes, multi-track tapes, and read only inputs; Turing machines and type 0 grammars.

CONTEXT-SENSITIVE GRAMMARS AND LINEAR BOUNDED AUTOMATA: Languages determined by linear bounded automata; equivalence to context-sensitive languages; the context-sensitive languages as a proper subclass of the class of recursive languages.

OPERATIONS ON LANGUAGES: Consideration of closure of properties of regular, context-free, context-sensitive and recursively enumerable languages under operations such as union, intersection, complementation, concatenation, reversal, and *-closure.

COMPLEXITY OF CALCULATION: Consideration of time and tape bounded Turing machines and of time and tape complexity classes.

DETERMINISTIC PUSHDOWN AUTOMATA: Definition of deterministic pushdown automata and an example of a context-free language which is not definable using a deterministic pushdown automaton.

Suggested Textbook: FORMAL LANGUAGES AND THEIR RELATION TO AUTOMATA by J.E. Hopcroft and J.D. Ulman (Addison Wesley)

FACULTY OF SCIENCE

NEW COURSE PROPOSAL

I CALENDAR INFORMATION

Department: *Mathematics** Course Number: *403-3** Title: *Algebraic Theory of Automata**

Sub-title or Description:

This course gives a development within an abstract algebraic context of several concepts introduced in Mathematics 306-3. Algebraic preliminaries. Semiautomata, recognizers, regular expressions, coverings of automata.

Credit Hours: *3* Vector Description: *3-1-0*

Pre-requisite(s): *Mathematics 306-3 (or Mathematics 405-4), and Mathematics 432-4; or permission of the Mathematics Department.*

II ENROLMENT AND SCHEDULING

Estimated Enrolment: *15 per offering.*

Semester Offered (e.g. Yearly, every Spring; twice yearly, Fall and Spring):
Initially, Spring, every three years.

When course will first be offered:

Spring 76.

III JUSTIFICATION

A. What is the detailed description of the course including differentiation from lower level courses, from similar courses in the same department and from courses in other departments in the University?

This course is intended to deal at an abstract level with the close connections between automata theory and certain aspects of semigroup theory (and group theory). No similar course is offered by this or any other Department in the University.

B. What is the range of topics that may be dealt with in the course?

See attached syllabus - page four.

C. How does this course fit the goals of the department?

This course forms an integral part of the development of the Computing *Science program at this University, and in particular, of the automata theory section of that program. The course will be taken by those specializaing in pure mathematics and computer science, but not necessarily by those concerned with the central areas of* Computing *Science. Mathematica it is the most specialized of the automata theory courses proposed. Concepts introduced within modern advanced automata theory are expressed in an abstract algebraic format.*

D. How does this course affect degree requirements?

This course has no direct effect on degree requirements. However, for majors or honours students in Computing *Science, it may be used to partially satisfy degree requirements. For Mathematics students, it will increase the selection of upper level courses which can be used to satisfy degree requirements.*

E. What are the calendar changes necessary to reflect the addition of this course?

New entries in the Mathematics and Computing *Science sections of the calendar.*

F. What course, if any, is being dropped from the calendar if this course is approved?

None

G. What is the nature of student demand for this course?

Study of aspects of this course have been requested by students in the Mathematics Department's Automata Theory Seminar.

H. Other reasons for introducing the course.

The course forms a useful link with the algebra courses offered by the Mathematics Department and there may be students entering the course with a strong algebra background who consider the course as an applied algebra course rather than an abstract Computing *science course.*

IV BUDGETARY AND SPACE FACTORS

A. Which faculty will be available to teach this course?

R. Harrop

B. What are the special space and/or equipment requirements for this course?

Computer time.

C. Any other budgetary implications of mounting this course:

None

ALGEBRAIC THEORY OF AUTOMATA

ALGEBRAIC PRELIMINARIES: Review of some aspects of the theory of semigroups and the theory of groups including simple groups and direct products of groups.

SEMIAUTOMATA: Subgroup associated with a semiautomaton, subsemiautomata and subsemigroups; homomorphisms of semiautomata; nondeterministic semiautomata.

RECOGNIZERS: Automata as recognizers; regular and nonregular sets; characterization of regular sets; equivalence of non-deterministic and deterministic automata; reduction and homomorphisms of automata.

REGULAR EXPRESSIONS: Kleene's theorem; equality of regular expressions; axioms systems for the algebra of regular expressions; canonical form of a regular expression.

COVERINGS OF AUTOMATA: Moore and Mealy machines; coverings of automata and of semiautomata. Direct product and cascade product of automata; premutation-reset and grouplike semiautomata; covering of reset and grouplike semiautomata; theory of Krone and Rhodes.

Suggested Textbook: ALGEBRAIC THEORY OF AUTOMATA by Ginzburg (Academic Press, 1968)

FACULTY OF SCIENCE

NEW COURSE PROPOSAL

I CALENDAR INFORMATION

Department: *Mathematics* Course Number: *416-3* Title: *Numerical Analysis II*

Sub-title or Description:

The numerical solution of ordinary differential equations and elliptic, hyperbolic and parabolic partial differential equations will be considered.

Credit Hours: *3* Vector Description: *3-1-0*

Pre-requisite(s): *Mathematics 316-3 and Mathematics 352-2.*

II ENROLMENT AND SCHEDULING

Estimated Enrolment: *15 per offering*

Semester Offered (e.g. Yearly, every Spring; twice yearly, Fall and Spring):
Alternate years in the Spring.

When course will first be offered: *Spring 75*

III JUSTIFICATION

A. What is the detailed description of the course including differentiation from lower level courses, from similar courses in the same department and from courses in other departments in the University?
Students with some knowledge of differential equations will be introduced to a number of methods for their numerical solution. The advantages of the various methods for solving ordinary differential equations will be compared. For parti differential equations, each type of problem will be emphasized. No similar cou is now offered by this or any other department in the University.

B. What is the range of topics that may be dealt with in the course?

See attached syllabus - page four.

C. How does this course fit the goals of the department?

This course will allow an in-depth treatment of some of the aspects of numerical analysis which could not be covered in previous courses. It is an advanced course, primarily for mathematics students with strong interest in differential equations or numerical methods.

D. How does this course affect degree requirements?

This course has no direct effect on degree requirements. However, for mathematics majors and honours students, it will increase the selection of upper level courses they may take to satisfy their degree requirements.

E. What are the calendar changes necessary to reflect the addition of this course?

New entry.

F. What course, if any, is being dropped from the calendar if this course is approved?

None.

G. What is the nature of student demand for this course?

In addition to mathematics students, it is hoped that those outside mathematics with backgrounds in scientific applications of computing will be attracted to the course.

H. Other reasons for introducing the course.

IV BUDGETARY AND SPACE FACTORS

A. Which faculty will be available to teach this course?

R. Russell.

B. What are the special space and/or equipment requirements for this course?

Computing time.

C. Any other budgetary implications of mounting this course:

Each year, the Department plans to alternate the offering of this course with the offering of Mathematics 413-4 (Ordinary Differential Equations) so that there will be no increase in the total number of course hours.

NUMERICAL ANALYSIS II

1. SOLUTION OF DIFFERENTIAL EQUATIONS: Taylor series, convergence and error for Euler's method; Runge-Kutta, Multistep, predictor-corrector methods; stability, round-off propogation; systems of differential equations.................4 weeks.

2. BOUNDARY VALUE PROBLEMS IN ORDINARY DIFFERENTIAL EQUATIONS: initial value or shooting methods; finite difference methods; Ritz and collocation methods..................2 weeks.

3. ELLIPTIC PARTIAL DIFFERENTIAL EQUATIONS: Laplace equation on a rectangle-finite differences, matrix formulation; iterative methods for solution - Gauss-Seidel, SOR, ADI.................3 weeks.

4. PAROBOLIC AND HYPERBOLIC PARTIAL DIFFERENTIAL EQUATIONS: Wave equation - differe approximation, convergence, domain of dependence; heat equation - explicit and implicit methods......3 weeks.

5. GENERAL THEORY: consistency, convergence and stability......1 week.

SUGGESTED TEXTBOOKS: ELEMENTARY NUMERICAL ANALYSIS by Conte and deBoor; material from various texts, especially ANALYSIS OF NUMERICAL METHODS by E. Isaacson and H.B. Keller.