SIMON FRASER UNIVERSITY

MEMORANDUM

S.82-21

To: SENATE

From: SENATE COMMITTEE ON ACADEMIC PLANNING
SENATE COMMITTEE ON UNDERGRADUATE STUDIES

Subject: PROPOSAL FOR AN ENGINEERING SCIENCE PROGRAM.

Date: January 15, 1982

Action taken by the Senate Committee on Academic Planning at its meeting of January 13, 1982, and by the Senate Committee on Undergraduate Studies at its meeting of January 12, 1982, gives rise to the following motion:-

"That Senate approve and recommend approval to the Board of Governors, as set forth in S82-21 , the proposal for an Engineering Science Program, including:-

a) Academic requirements for the Engineering Science Program
   (1) Admission - page 19.
   (2) Practical experience - page 19, 20.
   (3) Degree requirements - page 20, 21.
      3.1 Basic science core - page 21, 22
      3.2 Engineering science core - page 22, 23
      3.3 Concentration and Project - page 23, 24
      3.4 General studies - page 24, 25
   (4) Details of the concentration areas - page 25, 26
      4.1 Engineering Physics -
         electronics option - page 27, 28
         nuclear option - page 28, 29
      4.2 Industrial Processes - page 30
         manufacturing option - page 31
         process control option - page 31, 32
      4.3 Engineering Chemistry - page 33, 34
      4.4 Electronics and communications - page 35, 36
      4.5 Computer Engineering - page 37, 38
      4.6 Bio-technology - page 39, 40
      4.7 Bio-medical engineering - page 41, 42
      4.8 Engineering mathematics -
         applied mechanics option - page 43, 44
         computing and communications option - page 44, 45
      4.9 Energy engineering
         energy processes option - page 46, 47
         energy systems option - page 47, 48

b) Proposed organization and development of Engineering Science - a Faculty of Engineering Science - page 57.

c) Proposed new courses in Engineering Science - pages 1 - 21

.... 3

c) Proposed new courses in Engineering Science (contd.)

ENSC 445-3	Chemical Process Control - page 17
ENSC 451-3	Seminar in Biomedical Engineering - page 17
ENSC 460-3	Special Topics in Engineering Science - page 17
ENSC 461-3	Special Topics in Engineering Science - page 17
ENSC 462-3	Special Topics in Engineering Science - page 17
ENSC 470-3	Energy Sources - page 17
ENSC 471-3	Energy Distribution and Utilization - page 18
ENSC 475-3	Introduction to Nuclear Engineering - page 18
ENSC 480-3	Production Systems - page 18
ENSC 491	Engineering Science Laboratory (Concentration) - page 19
ENSC 492	Engineering Science Laboratory (Concentration) - page 19
ENSC 493	Engineering Science Laboratory (Concentration) - page 19
ENSC 494	Engineering Science Laboratory (Concentration) - page 19
ENSC 497	Internship I - page 20
ENSC 498	Internship II - page 20
ENSC 499-11	Engineering Science Project - page 20."

<u>For Information:</u> Mathematical Sciences List (page 49) Computing Sciences list (page 50), Electrical Sciences List (page 51) Mechanical Sciences list (page 52), Chemical Processes list (page 53) Life Sciences List (page 54), Engineering Science Course Numbering Guide (page 55), Organization and Development of Engineering Science, and Projected Financial Requirements - Engineering Science Program, relative courses - pages 22-48.

The Senate Committee on Academic Planning action refers to the proposed program proposal and its organization and administration. The Senate Committee on Undergraduate Studies action refers to the program and its details including a number of regulations and requirements and the academic viability of the proposals. The projected financial requirements, while forming part of the proposal, are provided to Senate for information only.

The attention of Senate is drawn to the summary on page 1, the preamble commencing on page 5 and the general description which commences on page 9. Academic requirements commence on page 18, organization and development commences on page 56. Those sections are followed by a section "Engineering Science Course Descriptions" and related courses which commence again with a cover page and page 1.

The present proposal is consistent with the most recent approvals in principle for such a program given by Senate and the Board.

Resource personnel will be available at Senate to speak to the proposal.

SIMON FRASER UNIVERSITY

MEMORANDUM

To: Mr. H. Evans, Secretary
Senate

From: Senate Committee on
Academic Planning

Subject: Engineering Science

Date: 14 January 1982

Action taken by the Senate Committee on Academic Planning at its meeting on 13 January 1982 gave rise to the following motion:

> "That the proposal for an Engineering Science Program as contained in SCAP 82-1 attached be approved and forwarded to Senate for its consideration."

The SCAP action refers to the proposed proposal and its organization and administration. The projected financial requirements, while forming part of the proposal, are provided to Senate for information only.

JSC:ld
Att.

PROPOSAL FOR AN ENGINEERING SCIENCE PROGRAM AT SIMON FRASER UNIVERSITY

14 January, 1982

Contents

ENGINEERING SCIENCE PROGRAM

SUMMARY

SUMMARY

In recognition of the need to increase educational opportunities for engineering, the Universities Council of British Columbia has recommended that the existing program at the University of British Columbia be expanded, that a cooperative engineering program be established at the University of Victoria, and that Simon Fraser University develop a program in engineering science. These recommendations have been accepted in principle by the Ministry of Universities, Science and Communications and special grants were made to the universities for planning and early development. This proposal sets forth the Engineering Science program plan developed at Simon Fraser.

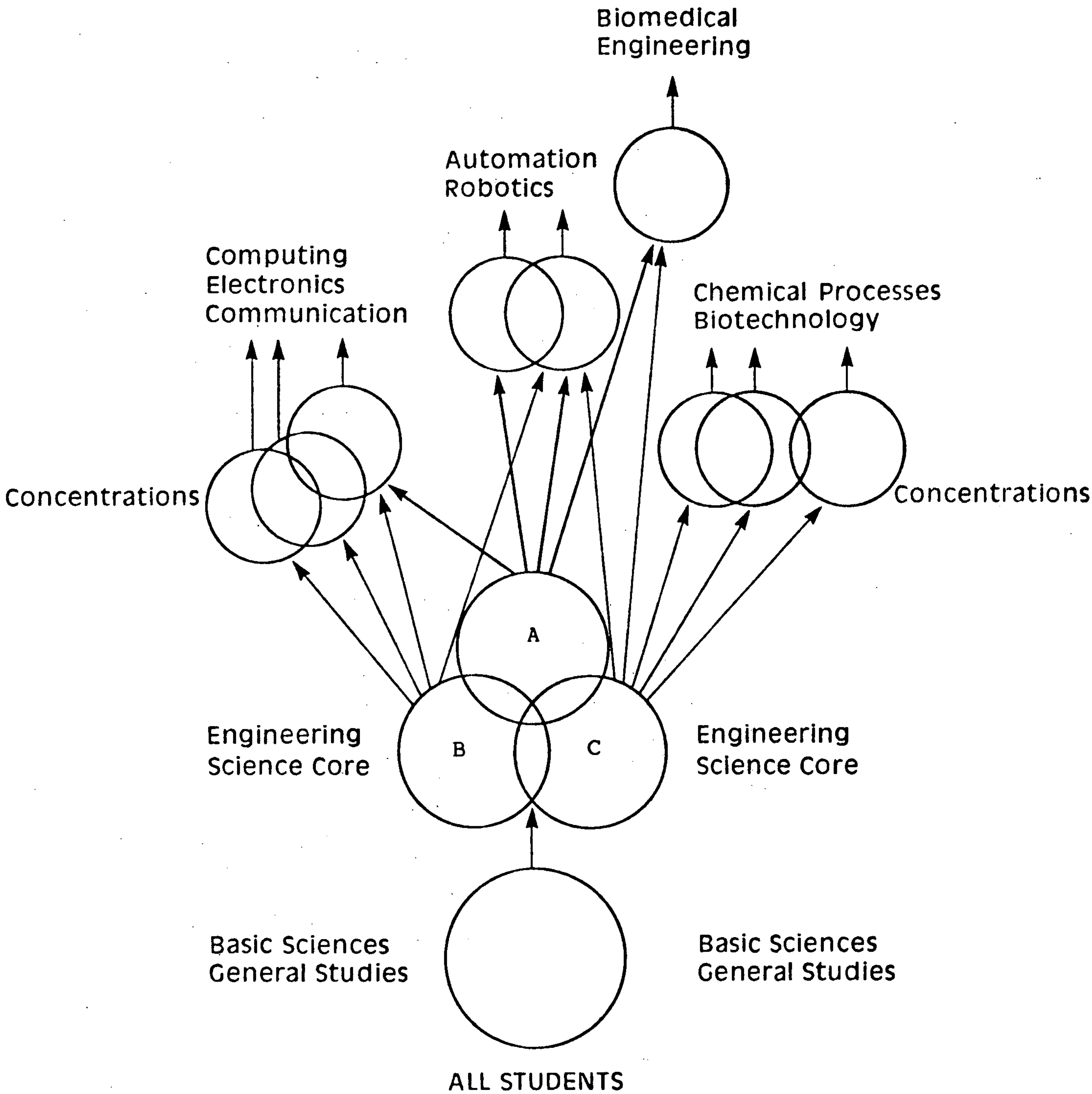
Engineering Science will be a small, selective program oriented towards traditional and new areas of applied science and the microelectronic-based systems for information and materials processing that have been identified by many as the basis for a new "industrial revolution". The goal is the attainment of two objectives simultaneously: education in both natural sciences and system design at a high intellectual level. This duality calls for an innovative blending of courses in science and engineering into a unique educational program in the applied sciences, illustrated conceptually in figure 1.

Following this figure, both the basic sciences core and general studies cores are common to all the engineering science options, while there are three basic options within the engineering science core itself. Core B is typical of other Engineering Science programs with its emphasis on the mechanical, electrical and natural sciences. In contrast, core A is oriented more towards the electrical and computing sciences and core C stresses the chemical and biological sciences. No matter which option is chosen, however, there is a fundamental requirement for breadth of study in engineering science.

The opportunity to concentrate in a particular specialization is found in the upper years of the program. This provides the necessary depth of study in each student's program and, by drawing on the varied resources of Simon Fraser in the pure and applied sciences, a large number of elective opportunities can be offered.

Because the program aims to offer meaningful elective choices to the student, its format is complex. It should be noted, however, that this proposal describes a mature program which will evolve over a period of years. When fully developed, in a decade or so, the details may differ considerably from those described. Some options will develop essentially as shown, others will probably not go ahead and others, not described here, may be established.

Special features of this program also discussed in the proposal are the internship which involves the student in relevant research and development work, the academic requirements leading to the Bachelor of Applied Science (B.A.Sc.) degree, and the admission requirements for Engineering Science and pre-engineering. Transfer into the program with advanced standing and the need for transfer out to the University of British Columbia and other universities with regular engineering programs are also important elements of Engineering Science at Simon Fraser.


Biomedical
Engineering
Automation
Robotics
Computing
Electronics
Communication
Chemical Processes
Biotechnology
Concentrations
Concentrations
A
B
C
Engineering
Science Core
Engineering
Science Core
Basic Sciences
General Studies
Basic Sciences
General Studies
ALL STUDENTS

ENGINEERING SCIENCE PROGRAM

PREAMBLE

PREAMBLE

This proposal for an Engineering Science program at Simon Fraser University is the result of over two years of work. Even though the 1981 proposal for a conventional and co-op based engineering program was not approved, the University was both encouraged and funded to propose a plan for an Engineering Science program such as that at the University of Toronto. As a preamble to the proposal itself, the circumstances and history of the planning process will be briefly reviewed. More detail on the previous proposal may be found in "Proposal for a Faculty of Engineering at Simon Fraser University", November 1980.

Previous discussions of engineering manpower requirements will not be reiterated here, except to note that the aggregate of the planned developments at the University of British Columbia, the University of Victoria and Simon Fraser University bring the British Columbia participation in engineering education to the present average level of the Canadian provinces. Furthermore, those developments will require over a decade to come to maturity and even then will be far, far below current Japanese levels. An additional point is the impact of computerized, automated systems in all phases of productive work from the factory to the office.* If Canada, and British Columbia, is to have even a modest role in the application of the new technologies, then men and women with the background provided by the proposed new program in Engineering Science will be in even higher demand than the more usual engineering graduates.

This University's excellent location in terms of popoulation growth and industrial research and development has been identified already, as have the

*For example, see the report of the federal Task Force on Labour Market Development.

internal academic and scientific strengths relevant to an engineering program. The Engineer Science curriculum detailed in this proposal demonstrates emphatically how SFU's existing capabilities can be extended and redeployed to effect a very special and important form of applied science education.

Formal planning for engineering at Simon Fraser began in December 1979 when Senate gave approval in principle to the development of undergraduate and graduate programs at Simon Fraser. An Engineering Commitee was later established under the chairmanship of Dr. T.W. Calvert as Director of Engineering. External assistance was provided by three former Deans of Engineering acting as consultants, and by an external Planning Advisory Committee chaired by the Chancellor, Mr. Paul Cote, P.Eng. The resulting proposal for a Faculty of Engineering was approved by Senate on 12 January, 1981 and submitted to the Universities Council of British Columbia. Subsequent to the recommendations of Council of 25 March, 1981, a proposal for an Engineering transfer program was approved by Senate on 13 July, 1981. This proposal, having been overtaken by events in the planning of Engineering Science, is not expected to be acted upon.

In July 1981, work began on developing the Engineering Science program with Dr. D.A. George, one of the previous consultants, as Director of Engineering. As a result of the Council recommendations, and discussions between the University and the Ministry and Council, it was established that Engineering Science should be similar to the University of Toronto program, oriented towards areas of high technology of present and future importance to British Columbia, and based on existing strengths in basic and applied science at Simon Fraser.

Following individual meetings with members of the Planning Advisory Committee and others prominent in B.C. research and engineering, visits to universities in Canada, the United States and Japan, and meetings with SFU departmental groups and the members* of the reconstituted Engineering Committee, a basic approach was developed from which this proposal has evolved. At the same time, a projection of the financial needs of the program was developed (of necessity prior to the detailed curricular design) and tabled with the Engineering Expansion Committee**, which had been established to assemble critical numerical data related to the expansion of engineering education in the Province.

The academic proposal for Engineering Science at Simon Fraser University was approved by the Engineering Committee in December, 1981, and forwarded to the Senate Committee on Academic Planning.

*J. D'Auria, L. Boland, B. Frindt, J. Wilson, T. Kameda, E. Pechlaner (alternate, C. Graham), L. Kemp (alternate, K. Nair), J. Morrison, T. Calvert, and D. George (chairman).

**D. Goard (Ministry of Universities, Science and Communications), L. Haazen (Treasury Board), A. Fisher (U.Vic.), A. Meisen (UBC), D. George (SFU).

A GENERAL DESCRIPTION

OF THE

ENGINEERING SCIENCE PROGRAM

THE ENGINEERING SCIENCE PROGRAM

Engineering science and systems is the special emphasis of the engineering program at Simon Fraser University. This orientation towards a strong and broad basis in the pure and applied sciences, coupled with an exposure to the best engineering practice, aims to have graduates who "have a creative sense of practical technology with a firm grasp of the basic sciences." This theme, so well expressed in the educational philosophy of the founder of the Faculty of Engineering Science of Osaka University in Japan, is the basis of the study of engineering at SFU.

Our mandate for Engineering Science at Simon Fraser also includes a strong emphasis on high technology, that is, on those areas of engineering and science where the frontiers are expanding rapidly and which have particular potential for industrial growth. It was also recommended, that we build on and from existing strengths at the University. Based on these imperatives, we have selected three general areas of specialization within a basic program. Thus, a limited range of programs is planned, all oriented towards high-technology.

It is inevitable that those working "at the frontiers" require more than average powers of conceptualization, knowledge of science and capabilities in mathematics. Also essential are entrepreneurial tendencies, at least in their technical work if not also in their business activities. As a consequence, entry into this program will be on a selective basis and a modest level of enrollment is planned.

Engineering Science, as it is generally defined by programs elsewhere, is based on a common core of at least two years duration followed by two years of much more specialized study. At the University of Toronto there are eight specialized options. This approach contrasts with typical "departmentalized" engineering programs where specialization begins at the second year, if not before, and where the final year often consists largely of elective courses within the particular engineering specialization. Also implied by the Engineering Science concept is a greater emphasis on the basic pure, applied and engineering sciences, and a high level of student attainment.

The particular areas for specialization in engineering science and high technology engineering being proposed for development have been chosen to be complimentary to existing strengths in pure and applied science at Simon Fraser University. They are also grouped so as to have a substantial common core. In this way class sizes will not be too small, and the total program cost will be reasonable, even though the total planned enrollment is not large.

The three general areas of specialization being proposed are: computing, microelectronics and communications; industrial automation, control and robotics, and computer-aided design and manufacturing; and chemical and bio-chemical processing and biotechnology. The first grouping is the most developed area of high technology and advanced engineering concepts. While the second area is not so well established, it is taking on a growing importance as North America fights to maintain a competitive manufacturing capability. The last area is an embryonic area of future high-technology as the full potentials of bio-chemical and biological systems are realized. These areas are over-lapped and entwined and they have a common base of mathematics, science and engineering subjects.

Analysis shows that the three areas, with their substantial curricular overlaps particularly in the context of basic science and the role of computers, can make substantial use of existing courses in computing science, physics, kinesiology, chemistry, biology and mathematics. However, it has become evident that the typical engineering science core (based as it is on the mechanical, electrical and physical sciences) is not sufficient for the broad range of fundamentals which the modern engineering sciences should encompass. In terms of the conventional core, the new SFU core calls for considerable extension into computing science at one extreme and into the biological sciences at the other. Obtaining this breadth in sufficient depth in a common curriculum leaves far too little time for specialized study.

The inescapable conclusion is that flexibility is needed, that the traditional core with few course options is not sufficient. Consequently the SFU Engineering Science core has three major orientations, all of which overlap extensively. The traditional Engineering Science program is designated as core B and is based on the mechanical, the electrical and the natural sciences. In contrast, core A is more oriented towards the electrical and computing sciences while still allowing time for study in the natural and mechanical sciences. Core C is based on the chemical, biological and mechanical sciences.

Once the student has progressed well into his or her chosen engineering science core, more specialized study becomes possible. Some of these specializations are natural outgrowths of the engineering science core subjects, while others are based more on existing SFU programs. Those presented here are computer engineering, electronics and communications, engineering physics (with an electronics and nuclear option), biomedical engineering, industrial processes (with a manufacturing and a process control option), engineering mathematics (with an applied mechanics and a computing and communications option), biotechnology, energy systems (with an energy processes and an energy systems option), and engineering chemistry. A very special feature of these areas of concentrated study is a proposed internship which would involve an academic semester spent primarily in an appropriate industrial or research environment.

It is critical that such programs truly be "at the frontier" and not just academically demanding. For that reason, each basic core program will have an external advisory committee drawn from industry, commerce and research to identify current and future areas of program emphasis.

Non-technical subjects form an important part of an engineering curriculum. The economic and social impacts of engineering and advanced technology are of great importance and engineering students must at the least be made aware of these concerns. As well, realistic aspects of engineering work such as financing, management, design methods and entrepreneurship should complement scientific studies. Special efforts are planned to ensure that SFU Engineering Science graduates have good communication skills.

Enrollment will be constrained so as not to grow beyond a first year intake of 150 students, but there could be appreciable intake at the second year level and perhaps even at the third. However, it must be understood that even with selective entry, not all students would attain an academic level sufficient to remain in the program. Others, while qualified academically, would develop interests in engineering which fell outside the scope of the SFU program. It would be expected, then, that at least one-half of the students would transfer to engineering at the University of British Columbia, the University of Victoria or elsewhere. The maximum total graduating class from Engineering Science at SFU would not be expected to exceed 75.

Flexibility is a keynote in the planned program. This has a number of dimensions:

- Opportunities for elective choice in the program are maximized, as is the use of tutorials and directed study.

- The curriculum prescribes general requirements in various areas of engineering, science and mathematics rather than emphasizing the requirements entirely in terms of specific courses.
- There will be opportunities for both full and part-time study, particularly in the early years of the program.
- The SFU semester system will be utilized to give students the widest possible access to courses and programs.
- Special efforts will be made to facilitate entry to the engineering program by students who have technological qualifications from the British Columbia Institute of Technology or the B.C. regional colleges.
- Laboratories will be open for 12 hours daily allowing specific scheduling for individuals and small groups, thereby easing conflicts between laboratory sessions and lecture schedules.

The versatility and flexibility of the program will be based on the limited enrollment and on a carefully crafted core program which will give students ample opportunity to draw on the existing and varied resources of Simon Fraser University.

Of special note in the above list is the potential for students with qualifications in technology to obtain qualifications in engineering. In high technology engineering, individuals who have dual strengths in technological practicalities and the engineering conceptualizations and analyses have a particularly good future. Additionally, engineering science at SFU should reflect the university's overall orientation towards mature students with diverse backgrounds of education and experience. In the light of these considerations, planning is underway to incorporate a conversion program by means of which students with a background in technology may be efficiently prepared for the study of engineering.

As befits a program emphasizing high-technology, educational technology would be expected to play a role in bringing more specialized courses in engineering science to the campus than would otherwise be possible given the relatively small number of faculty. Hopefully, the Knowledge Network* will allow access to courses at UBC and U. Vic. We would expect also to utilize video tapes available from the Massachusettes Institute of Technology and other outstanding universities. This would expand the scope of courses available and at the same time expose the students to instructors with the highest international standing.The expanding technology of computer graphics is rapidly finding its way into the practice of engineering and will receive major emphasis as a tool for learning, conceptualization, design and analysis. It is expected that this emphasis on educational technology will relieve faculty and teaching assistants from certain routine classroom and laboratory duties so that they can work with students individually and in small groups, following the concept of the SFU tutorial system.

Since by definition Engineering Science is concerned with rapidly developing and emergent technologies, an important and on-going feature of this program will be courses taught by eminent engineers and scientists brought to Simon Fraser as visiting faculty. We also plan to utilize the engineering expertise now resident in Vancouver through part-time sessional appointments and through joint-appointments with organizations involved with research, development and advanced engineering.

An internship is planned as an important feature of every student's program. This would involve the student in a period of combined work and study in an appropriate industrial or institutional setting. He or she would

* The Knowledge Network, in addition to its public education broadcasting system in British Columbia, will provide broad-band communication channels between the three provincial universities.

be required to take an intensive program of study (which we call a concentration) aimed at coming to an in-depth understanding of a specific area of advanced technology. A project would be undertaken under the direction of an engineer or scientist working in the organization in which the internship was being spent. This would involve considerable cooperation between Engineering Science at SFU and the participating organization, and would require specific budget provision. University equipment might well be used in undertaking the project and the student might be located either at the University, or at the outside organization or divide his time between the two. An undergraduate thesis, based on the project undertaken during this internship, would be required. The internship is seen as an important component of the bridge that must be built between the SFU Engineering Science program and the Discovery Parks and other high-technology industries and institutions.

It is expected that most or all of the programs will be available either on a regular or co-op basis. Both approaches would feature the internship. The following diagram shows how the students schedule of work (W), study (1 to 8) and internship (I) semesters could be scheduled.

Year		1			2			3			4			5	
Semester	F	S	S	F	S	S	F	S	S	F	S	S	F	S	S
Regular	1	2	W	3	4	W	5	6	I(W)	7	I(8)				
Co-op	1	W	2	W	3	W	4	W	5	W	6	I(W)		7	I(8)

Note that the first internship semester is a work period and that the second is an academic semester as well as an internship semester. The students in the two streams will be together for the last two of their regular academic sessions and that only one upper division semester occurs in the summer. Those two points are very important from the point of view of operational efficiency.

While the document does not address graduate studies, the very concept of Engineering Science implies the existence of a substantial level of graduate work. This would begin coincident with undergraduate studies. Consideration is also being given to combined programs resulting in the joint award of a bachelor's and a master's degree, after five years of study. Regular graduate degrees would be highly research based, more in the British tradition than the North American. Engineering Science programs typically lead more to graduate work than do the usual Engineering programs, and this is reflected in our planning.

A special feature of the Faculty of Engineering Science is to be research and development centres which would span the engineering and science disciplines of the full program. Drawing faculty and students from a range of disciplines, these centers would focus on areas such as micro-electronics, information processing, robotics, bio-medical engineering, and energy. Each faculty member would be required to be a member of at least one centre.

The faculty members would be expected, even in the initial years of program development, enrolment growth and curricular "fine-tuning", to be active in applied research, development or advanced engineering. Contract research, high-technology consulting and the like would have strong priority over the more conventional "curiosity directed" research of university faculty.

The general approach just described serves to define the major elements of the program. In the remainder of this document, the curricular details will be provided. A basic thesis of the program structure is that the courses to be specifically required should be kept to a minimum, that constrained electives be generally prescribed, and that a substantial number of options be available. This gives both the student and the University maximum operational scope.

ACADEMIC REQUIREMENTS

FOR THE

ENGINEERING SCIENCE PROGRAM

1. ADMISSION

Students wishing to study engineering at Simon Fraser University may do so either in the Engineering Science program or in pre-engineering. Admission to Engineering Science is restricted and a high level of academic attainment must be reached to continue in the program. However, students with general admission to the University may enter the pre-engineering program which may lead to admission to Engineering Science at SFU, to transfer to other programs at the University, or to transfer to engineering programs at other universities.

All students wishing to study engineering must obtain admission to the University. Entry to the Engineering Science program will then be judged on the basis of whether the student should be able to attain the necessary standing, and will require Grade 12 mathematics, physics and chemistry (or equivalent). Normally, students continuing in Engineering Science will be expected to maintain a Cummulative Grade Point Average of 3.0 ('B' standing). All other students will be classified to be in pre-engineering.

Only the Engineering Science program leads to a degree in engineering at Simon Fraser University. Pre-engineering students can obtain a degree only by transferring to a degree program at SFU or elsewhere.

2. PRACTICAL EXPERIENCE

No student may graduate in Engineering Science without satisfying the requirement for a minimum of relevant practical experience. Completion of the internship is the normal way to obtain this experience. The student may also elect a Co-operative Education (or sandwich) program of alternate work and study sessions or a Co-operative Education program in which the work sessions occur in the summer only. Alternatively, the student may decide not to enter either co-op program, preferring to plan his own sequence of study and non-study semesters. In all cases, the internship is required.

The decision whether or not to enter co-op program A with alternating study and work semesters, or program B with summer work sessions only, need not be taken until the deadline for application for ENSC 195-0, Job Practicum I. This will be at or before registration in the preceeding academic semesters, following the sequences:

YEAR	1	2	3	4	5
SEMESTER	F S S	F S S	F S S	F S S	F S S
Co-op A	A W A	W A W	A W A	W A W	A A
Co-op B	A A W	A A W	A A W	A A	

where A denotes an academic semester and W a work semester. Upon completion of the Engineering Science program on a co-op basis, either "co-op student, six work sessions" or "co-op student, three work sessions" is noted on the student's transcript. While the co-op program is not obligatory, once the program is begun, the student may not depart from the A or B schedule as first chosen, without permission. Otherwise, no further registration in the co-op program is allowed and the co-op designation on the transcript is withheld.

Whether studying in the co-op program or not, every student must complete ENSC 497, Internship I, before registration in the final year of the program and ENSC 498, Internship II, before graduation. Registration in ENSC 497 coincides with a work session and registration in ENSC 498 coincides with the final academic session. During ENSC 498, the student engages in supervised study and practical work in research, development or advanced engineering. A thesis based on the undergraduate project is based on this activity.

3. DEGREE REQUIREMENTS

The Bachelor of Applied Science (B.A.Sc.) degree in Engineering Science is offered permitting specialization, within a basic core program, in the electrical and computer, or mechanical and industrial, or chemical and biochemical areas. A number of options (called concentrations) are available in each of these fundamental areas of applied science.

Degree requirements are:

Basic Science Core	32 semester-hours
Engineering Science Core	54
Concentration and Project	47
General Studies	27
Total	160 semester-hours

which must be completed subject to the detailed specifications which follow, and with a graduation Grade Point Average of 3.0 calculated on the required 160 semester-hours or on 80 required semester-hours credit in the upper division of the program. On graduation the transcript will identify the engineering science core and the concentration.

Normal registration is 20 semester-hours and permission of the Dean is required for reduced loads below 15 semester-hours and overloads above 22 semester-hours.

The next several sections detail the specific courses in the major elements of the program.

3.1 Basic Science Core (28 hours of courses and 4 hours of laboratory.)

These subjects are common to all options within Engineering Science.*

MATH 151-3	Calculus I	3-1-0	
MATH 152-3	Calculus II	3-1-0	MATH 151
MATH 232-3	Elementary Linear Algebra	3-1-0	MATH 151
MATH 272-3	Introduction to Probability and Statistics	3-1-0	MATH 152
CHEM 104-3	General Chemistry I	3-1-0	(MATH 151,CHEM 115)

*These listings include course number; name; vector (hours per week of lecture, tutorial or workshop, and a laboratory respectively); and prerequiste and, in brackets (), corequisite requirements.

CHEM 105-3	General Chemistry II	3-1-0	CHEM 104, PHYS 120
CHEM 115-2	General Chemistry Laboratory	0-0-4	(CHEM 104)
PHYS 120-3	Physics I	3-1-0	(MATH 151)
PHYS 121-3	Physics II	3-1-0	PHYS 120 (MATH 152)
PHYS 131-2	General Physics Laboratory	0-0-3	(PHYS 121)
CMPT 101-4	Introduction to Programming Languages	1-4-0	

3.2 Engineering Science Core (48 hours of courses and 6 hours of laboratory)

Several options are available in the engineering science core of the program, with an overriding objective to provide a combination of both breadth and depth. These alternatives are described below in very general terms, but the prerequisite requirements of the desired concentration area and normal courses prerequisites must be carefully studied in the selection of particular courses. Overall the requirements are: at least*

(a) nine semester-hours in the mathematical sciences (see page 49);

(b) six semester-hours of laboratory;

(c) 18 semester-hours in one of computing (see page 50), electrical (see page 51), mechanical (see page 52); or chemical sciences (see page 53);

(d) nine semester-hours in one of computing, electrical, mechanical, chemical or life sciences (see page 54), other than that chosen in (c), but contiguous to it;

(e) nine-semester hours in engineering science outside the areas chosen in (c) and (d); and

* Courses in the various engineering science core subject areas are identified on the attached lists. It should be noted that these lists give only the core subjects. More advanced and specialized courses are listed in the descriptions of the various concentration areas.

(f) three semester-hours in any of the engineering science core subject areas.

In addition to these general distribution rules, the students program must satisfy one of the following core requirements:

Core A - 27 semester-hours from the electrical and computing sciences;

Core B - 18 semester-hours from the mechanical sciences, and nine semster-hours in the electrical and/or chemical sciences;

Core C - 18 semester-hours from the chemical sciences, and nine semester hours in the mechanical and/or life sciences.

The extent to which these courses are elective depends on the intended concentration area, each of which has a list of prerequisites to be taken as part of the engineering science core.

3.3 <u>Concentration and Project</u> (30 hours of courses and 17 hours of laboratory and thesis.)

Concentration studies require a minimum of 48 semester-hours and incorporate the internship, with the requirements distributed as follows:

Courses		21 semester-hours
Laboratories		6
Internship		20
courses or directed study	9	
project	11	
Total		47 semester-hours

Each concentration area also has a list of required courses which must be taken as part of the concentration unless taken in the Engineering Science core.

The concentration areas are:

1 engineering physics: (a) electronics (for details, page 27)
(b) nuclear (page 28)

2 industrial processes: (a) manufacturing (page 31)
(b) process control (page 31)

3 engineering chemistry (page 33)

4 electronics and communications (page 35)

5 computer engineering (page 37)

6 biotechnology (page 39)

7 biomedical engineering (page 41)

8 engineering mathematics: (a) applied mechanics (page 43)
(b) computing & communications (page 44)

9 energy engineering: (a) energy processes (page 46)
(b) energy systems (page 47)

Some of these areas of specialized study can be based on any of the three core options, given that the prerequisite options are met. Other of the concentrations require earlier selection of the appropriate core option. The table following identifies the specific relationships between the core options and the specializations.

	Core Options		
Concentration	A	B	C
1 a	X		
b		X	
2 a	X	X	X
b	X	X	X
3			X
4	X		
5	X		
6			X
7	X	X	X
8 a		X	
b	X		
9 a			X
b	X		

3.4 General Studies

This section of the engineering program deals with the so-called non-technical part of the program. The primary objective is to develop an awareness of general social, economic and managerial factors which affect engineering and scientific work. In the case of the communications course, however, the aim is that each graduate will master the modes of communication necessary for his professional work. Particular course requirements are:

	Semester-Hours
ENSC 100-6 Engineering Communications	6
ENSC 300-3 Engineering Design and Management	3
ENSC 301-3 Engineering Economics	3
ECON 200-3 Principles of Economics (I) Microeconomic Principles	3
A course dealing with the interaction between society and technology	3
Course sequence in humanities, social sciences or administrative studies	9
	27

4. DETAILS OF THE CONCENTRATION AREAS

The concentration portion of the program requires 30 semester hours of courses, six semester-hours of laboratory and project work of 11 semester-hours, for a total of 47 semester-hours. Also included is the internship which aims to place the student in an industrial, development or research environment for project work and related specialized study. This internship may take place within the University but even then the project supervisor is likely to be associated with an external organization.

Three of the nine courses are associated with the internship and may be selected from the lists of required and elective courses. Alternatively other appropriate courses may be substituted or the student may register in as many as nine-semester-hours of directed study. This work is usually under the guidance of a faculty member or the external supervisor.

Each concentration area has a list of prerequisite courses which are normally taken as part of the Engineering Science core. If not, they must be taken as electives or as requirements beyond the 160 semester-hour minimum.

The areas of specialization, or concentration, are computer engineering, electronics and communications, engineering physics (with an electronics and a nuclear option), biomedical engineering, industrial processes (with a manufacturing and a process control option), engineering mathematics (with an applied mechanics, and a computing and communications option), biotechnology, energy systems (with an energy processes and an energy systems option), and engineering chemistry. The details of these specializations are described in the pages following.

4.1 ENGINEERING PHYSICS

The engineering physics program prepares students for work in engineering and applied sciences which is strongly dependent on a sound, basic knowledge of physics in addition to a fundamental field of engineering. Both an electrical (electronics) or mechanical (nuclear) orientation are available.

ELECTRONICS OPTION

Prerequisites: Engineering Science core A including

MATH 251-3	Calculus III
MATH 252-3	Vector Calculus I
PHYS 211-3	Intermediate Mechanics
PHYS 221-3	Intermediate Electricity and Magnetism
PHYS 344-3	Thermal Physics
PHYS 355-3	Optics
CMPT 105-3	Fundamental Concepts of Computing
CMPT 291-4	Introduction to Digital Circuit Design
CMPT 391-4	Microcomputer Hardware Workshop
ENSC 225-3	Basic Electrical Engineering
ENSC 280-3	System Dynamics
ENSC 322-3	Electronic Design I

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

An approved project (11 semester-hours).

A suitable program of laboratory work (7 semester hours)

In physics and chemistry ,

PHYS 385-3	Quantum Physics	3-1-0	PHYS 211, 221, MATH 252, ENSC 280
(or CHEM 361	Physical Chemistry II	3-1-0	CHEM 105, MATH 310 PHYS 211 (MATH 232)

and at least three of:

PHYS 365-3	Semiconductor Physics	3-1-0	PHYS 385
PHYS 384-3	Methods of Theoretical Physics I	3-1-0	PHYS 211, 221, MATH 252, 310, ENSC 280
PHYS 415-3	Quantum Mechanics	3-1-0	PHYS 211, 221, MATH 252, ENSC 280
PHYS 425-3	Electromagnetic Theory	3-1-0	PHYS 325 & either PHYS 384 or MATH 314
PHYS 465-3	Solid State Physics	3-1-0	PHYS 385
CHEM 465-3	Electrochemistry	3-0-0	CHEM 261

In electronic and electrical systems, at least six of:

ENSC 324-3	Solid State Electronics	3-0-0	ENSC 225, CMPT 391
ENSC 382-3	Control System Design	3-0-0	ENSC 280
ENSC 421-3	Electronic Design II	3-0-0	ENSC 322
ENSC 425-3	Electronic System Design	3-0-0	ENSC 322
ENSC 426-3	High Frequency Electronics	3-0-0	PHYS 221
ENSC 427-3	Communication Systems	3-0-0	ENSC 280, MATH 272
ENSC 429-3	Digital Control Systems	3-0-0	ENSC 382

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

NUCLEAR OPTION

Prerequisites: Engineering Science core B including:

MATH 316-3	Numerical Analysis I
MATH 361-3	Mechanics of Deformable Media
PHYS 344-3	Thermal Physics
PHYS 385-3	Quantum Physics
(or CHEM 361-3	Physical Chemistry II)
MECH 262-3	Engineering Mechanics I
MECH 263-4	Engineering Mechanics II
MECH 265-4	Strength of Materials
MECH 362-3	Fluid Mechanics I
ENSC 225-3	Basic Electrical Engineering
ENSC 230-3	Engineering Materials

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

An approved project (11 semester-hours).

A suitable program of laboratory work (7 semester hours) to include NUSC 346-2, Radiochemistry Laboratory.

In nuclear science, four of:

NUSC 341-3	Introduction to Radiochemistry	3-1-0	60 hrs in science
NUSC 342-3	Introduction to Nuclear Science	3-1-0	NUSC 341 (MATH 251)
NUSC 442-3	Properties of Nuclear Matter	3-1-0	(NUSC 342) CHEM 361 OR PHYS 385
NUSC 485-3	Particle Physics	3-1-0	PHYS 385 OR CHEM 361 (PHYS 415)
PHYS 415-3	Quantum Mechanics	3-1-0	PHYS 385 or CHEM 361 & either PHYS 384 or MATH 314 & 419

In engineering science, all of:

ENSC 311-3	Engineering Thermodynamics I	3-1-0	PHYS 344 or CHEM 261
ENSC 385-3	Measurement, Instrumentation and Transducers	3-1-0	PHYS 121, CHEM 105 ENSC 280
ENSC 410-3	Vibrations and Acoustics	3-0-0	MATH 310,314
ENSC 411-3	Engineering Thermodynamics II	3-0-0	ENSC 311
ENSC 415-3	Advanced Strength of Materials	3-1-0	MATH 361
ENSC 475-3	Introduction to Nuclear Engineering	3-0-0	NUSC 342

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

4.2 INDUSTRIAL PROCESSES

The design and operation of industrial and manufacturing processes is a major engineering activity. Increasingly this involves the processing of both material and information as computer-based systems come into increased use. The engineer must be knowledgable about both the process itself and the methods of computer control. Any of the three engineering science cores can form the basis for study in this area of concentration.

Prerequisites: Engineering Science cores A, B, or C including:

PHYS 344-3 Thermal Physics
(or CHEM 261-3 Physical Chemistry)
CMPT 105-3 Fundamental Concepts of Computing
CMPT 291-4 Introduction to Digital Circuit Design
CMPT 391-3 Microcomputer Hardware Workshop
MECH 362-3 Fluid Mechanics
(or ENSC 212-3 Introductory Fluid Mechanics)
ENSC 225-3 Basic Electrical Engineering
ENSC 230-3 Engineering Materials
ENSC 280-3 Systems Dynamics

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

An approved project (11 semester-hours).

A suitable program of laboratory work (7 semester hours)

In industrial engineering and manufacturing, all of:

ENSC 311-3	Engineering Thermodynamics I	3-1-0	PHYS 344 or CHEM 261
ENSC 380-3	Industrial Engineering	3-1-0	MATH 251,272
ENSC 382-3	Control System Design	3-1-0	ENSC 280
ENSC 439-3	Computer Aided Design and Manufacturing	2-2-0	ENSC 380, 382
KIN. 480-3	Human Factors in Working Environments	3-0-0	KIN. 100,PHYS 101, MATH 151 or 154

MANUFACTURING OPTION

In manufacturing and materials processing, at least five of:

ENSC 315-3	Analysis and Design of Machines	2-2-0	MECH 265
ENSC 410-3	Vibrations and Acoustics	3-0-0	MATH 310, 314
ENSC 411-3	Engineering Thermodynamics II	3-0-0	ENSC 311
ENSC 431-3	Engineering in Extreme Environments	3-0-0	80 Semester-hours in Eng. Sc. Program
ENSC 434-3	Industrial Environmental Control	3-0-0	ENSC 311
ENSC 435-3	Design of Machine Components	2-2-0	MECH 265, ENSC 315
ENSC 436-3	Manufacturing Processes	3-0-0	Upper Div. Standing
ENSC 438-3	Automation and Robotics	3-0-0	ENSC 385, 436, 439,
ENSC 480-3	Production Systems	3-0-0	80 Semester-hours in Eng. Sc. Program
KIN. 467-3	The Components of Skilled Performance	2-1-0	45 Semester-hours in Eng. Sc. Program

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

PROCESS CONTROL OPTION

In process control, at least five of:

ENSC 341-3	Introduction to Extractive Metallurgy	3-0-0	CHEM 261, ENSC 340
ENSC 385-3	Measurement, Instrumentation and Transducers	3-1-0	PHYS 121, CHEM 105, ENSC 280
ENSC 410-3	Vibrations and Acoustics	3-0-0	MATH 310, 314
ENSC 411-3	Engineering Thermodynamics II	3-0-0	ENSC 311
ENSC 429-3	Digital Control Systems	3-1-0	ENSC 382
ENSC 431-3	Engineering in Extreme Environments	3-0-0	80 Semester-hours in Eng. Sc. Program
ENSC 434-3	Industrial Environmental Control	3-0-0	ENSC 311
ENSC 438-3	Automation and Robotics	3-0-0	ENSC 385, 436, 439
ENSC 440-3	Chemical Reaction and Process Design	3-0-0	ENSC 340
ENSC 444-3	Food Processing and Engineering	3-0-0	ENSC 442
ENSC 445-3	Chemical Process Control	3-0-0	ENSC 340, 382

ENSC 480-3	Production Systems	3-0-0	80 Semester-hours in Eng. Sc. Program

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

4.3 ENGINEERING CHEMISTRY

Engineering Chemistry combines the basics of chemical engineering with specialized study in chemistry. The program prepares students for careers in those industries where chemistry is of paramount concern. The orientation is towards areas of chemistry and biochemistry which find application in environmental engineering and in industry.

Prerequisites: Engineering Science core option C including:

MATH 310-3	Introduction to Ordinary Differential Equations
MATH 316-3	Numerical Analysis I
CHEM 118-2	General Chemistry Laboratory II
CHEM 218-3	Introduction to Analytical Chemistry
CHEM 232-3	The Chemistry of Nontransition Elements
CHEM 251-3	Organic Chemistry I
CHEM 252-3	Organic Chemistry II
CHEM 256-2	Organic Chemistry Laboratory I
CHEM 261-3	Physical Chemistry I
ENSC 212-3	Introductory Fluid Mechanics
ENSC 230-3	Engineering Materials
ENSC 240-3	Introduction to Chemical Processes
ENSC 280-3	Systems Dynamics
ENSC 311-3	Engineering Thermodynamics I
ENSC 340-3	Mass Transfer

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

An approved project (11 semester-hours).

A suitable program of laboratory work (7 semester hours), which will inlcude BICH 311-3, Analytical Biochemistry Laboratory.

In chemistry and biochemistry, all of:

NUSC 341-3	Introduction to Radio-Chemistry	3-1-0	60 Semester-hours in Science Program
CHEM 416-3	Modern Methods of Analytical Chemistry	2-0-4	CHEM 218
CHEM 465-3	Electrochemistry	3-0-0	CHEM 261

BICH 301-3	The Structure and Reactivity of Biomolecules	3-1-0	CHEM 252

In chemical process engineering, all of:

ENSC 342-3	Chemical Unit Operations	3-0-0	ENSC 340
ENSC 382-3	Control System Design	3-1-0	ENSC 280
ENSC 440-3	Chemical Reaction and Process Design	3-0-0	CHEM 252, ENSC 340

As electives three of:

BICH 412-3	Enzymology	1-0-4	BICH 301, BICH 311
BISC 311-3	Introduction to Environmental Toxicology	3-1-0	60 Semester-hours in Science Program
BISC 432-3	Chemical Pesticides and the Environment	3-1-0	BICH 301
CHEM 333-3	Inorganic Chemistry of Biological Processes	3-1-0	CHEM 232 and 252
CHEM 357-3	Chemical and Instrumental Methods of Identification of Organic Compounds	2-0-4	CHEM 252,356
CHEM 371-3	Chemistry of the Environment I	3-1-0	CHEM 232
ENSC 341-3	Introduction to Extractive Metallurgy	3-0-0	CHEM 261, ENSC 340
ENSC 385-3	Measurement, Instrumentation and Transducers	3-0-0	PHYS 121, CHEM 105 ENSC 280
ENSC 431-3	Engineering in Extreme Environments	3-0-0	80 Semester-hours in Eng. Sc. Program
ENSC 444-3	Food Processing and Engineering	3-0-0	ENSC 442
ENSC 445-3	Chemical Process Control	3-0-0	ENSC 340, 382
ENSC 470-3	Energy Sources	3-0-0	80 Semester-hours Eng. Sc. Program
CMPT 105-3	Fundamental Concepts of Computing		CMPT 101
CMPT 291-4	Introduction to Digital Circuit Design		PHYS 150, CMPT 105
CMPT 391-3	Microcomputer Hardware Workshop		CMPT 291

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

4.4 ELECTRONICS AND COMMUNICATIONS

Electronics and communications is the area of specialization in electrical engineering which most directly relates to microelectronics and their applications in communications, control and computing. Engineers in this field are primarily concerned with the design and fabrication of systems utilizing microelectronic components and sub-systems.

Prerequisites: Engineering Science core A including:

MATH 243-3	Discrete Mathematics
PHYS 221-3	Intermediate Electricity & Magnetism
CMPT 105-3	Fundamental Concepts of Computing
CMPT 201-3	Data and Program Organizations
CMPT 205-3	Introduction to Formal Topics in Computing
CMPT 291-4	Introduction to Digital Circuit Design
CMPT 391-3	Microcomputer Hardware Workshop
ENSC 225-3	Basic Electrical Engineering
ENSC 280-3	Systems Dynamics
ENSC 322-3	Electronic Design I

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

An approved project (11 semester-hours).

A suitable program of laboratory work (7 semester hours)

In electronics all of:

PHYS 355-3	Optics	3-1-0	PHYS 221,MATH 252
PHYS 425-3	Electromagnetic Theory	3-1-0	PHYS 325 & either PHYS 304 or MATH 314
ENSC 421-3	Electronic Design II	3-0-0	ENSC 322

and two of:

ENSC 324-3	Solid State Electronics	3-0-0	ENSC 225, CMPT 391
ENSC 425-3	Electronic System Design	3-0-0	ENSC 322
ENSC 426-3	High Frequency Electronics	3-0-0	PHYS 221
CMPT 491-4	Analogue and Digital Circuits		CMPT 390, PHYS 221, 326

<u>In electrical systems</u>, at least three of:

ENSC 382-3	Control Systems Design	3-1-0	ENSC 280
ENSC 427-3	Communication Systems	3-0-0	ENSC 280,MATH 272
ENSC 428-3	Data Communications	3-0-0	ENSC 427
ENSC 429-3	Digital Control Systems	3-1-0	ENSC 382
MATH 401-3	Switching Theory & Logical Design	3-1-0	CMPT 101, MATH 306

<u>In computing science</u>, at least two of:

CMPT 301-3	System Development Methodology	3-0-0	CMPT 201
CMPT 393-3	Systems Software for Mini-computers & Microcomputers	3-1-0	CMPT 201, 290
CMPT 400-3	Hardware Architecture	3-0-0	CMPT 201, 205, 290
CMPT 401-3	Software Architecture	3-0-0	CMPT 201, 205
CMPT 405-3	Design and Analysis of Computing Alogorithms	3-0-0	CMPT 201, 205, MATH 152, 232
CMPT 492-3	Microprogramming and Emulation	3-0-2	CMPT 393

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

4.5 COMPUTER ENGINEERING

The dynamic, on-going development and application of computer and digital systems has resulted in a strong demand for computer sytems engineers. These individuals need to have a balanced capability in software and hardware, as well as a solid engineering base.

Prerequisites: Engineering Science Core A including:

MATH 243-3	Discrete Mathematics
PHYS 221-3	Intermediate Electricity and Magnetism
CMPT 105-3	Fundamental Concepts of Computing
CMPT 201-4	Data and Program Organization
CMPT 205-3	Introduction to Formal Topics in Computing Science
CMPT 291-4	Introduction to Digital Circuit Design
CMPT 301-3	System Develoment Methodology
CMPT 354-3	File and Data Base Structures
CMPT 391-3	Microcomputer Hardware Workshop
ENSC 280-3	Systems Dynamics
ENSC 322-3	Electronic Design I

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

An approved project (11 semester-hours).

A suitable program of laboratory work (7 semester hours) which must include CMPT 495-3, Digital Systems Design and Specification Laboratory I and CMPT 496-3, Digital System Implementation Laboratory II.

In computing science, all of:

CMPT 393-4	System Software for Mini-computers and Microcomputers	3-1-0	CMPT 201, 291
CMPT 400-3	Hardware Architecture	3-0-0	CMPT 201, 205, 291
CMPT 404-4	Computer System Measurement and Evaluation	3-1-0	CMPT 305 400
CMPT 405-3	Design and Analysis of Computing Alogorithms	3-0-0	CMPT 201, 205 MATH 152, 232

and at least one of:

CMPT 305-3	Computer Simulation & Modelling	3-1-0	CMPT 201, MATH 272
CMPT 351-3	Introduction to Computer Graphics	2-0-2	CMPT 201, MATH 272

CMPT 492-3	Microprogramming and Emulation	3-0-2	CMPT 393

In electronic and electrical systems, at least five of:

ENSC 382-3	Control System Design	3-0-0	ENSC 280
ENSC 425-3	Electronic System Design	3-0-0	ENSC 322
ENSC 427-3	Communication Systems	3-1-0	ENSC 280, MATH 272
ENSC 428-3	Data Communication	3-0-0	ENSC 427
ENSC 429-3	Digital Control Systems	3-0-0	ENSC 382
CMPT 390-3	Digital Circuits and Systems	3-0-0	CMPT 105, 291
CMPT 392-3	Introduction to Digital Signal Processing	2-0-2	CMPT 291, MATH 251
CMPT 491-4	Analogue and Digital Circuits	3-0-3	CMPT 390, PHYS 221, 326
MATH 401-3	Switching Theory and Logical Design	3-1-0	CMPT 101, MATH 306
PHYS 355-3	Optics	3-1-0	PHYS 221, MATH 252

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

4.6 BIOTECHNOLOGY

Industrial applications of biochemical processes, such as fermentation, are undergoing rapid expansion as genetic manipulation of micro-organisms opens up new approaches to chemical and biochemical processing.

Prerequisites: Engineering Science core C including:

CHEM 118-3	General Chemistry Laboratory
CHEM 218-3	Introduction to Analytical Chemistry
CHEM 251-3	Organic Chemistry I
CHEM 252-3	Organic Chemistry II
CHEM 256-3	Organic Chemistry Laboratory I
CHEM 261-3	Physical Chemistry I
BISC 101-4	Introduction to Biology
BISC 201-3	Cell Biology
BISC 202-3	Genetics
ENSC 212-3	Introductory Fluid Mechanics
ENSC 240-3	Introduction to Chemical Processes
ENSC 280-3	Systems Dynamics
ENSC 311-3	Engineering Thermodynamics I
ENSC 340-3	Mass Transfer
ENSC 342-3	Chemical Unit Operations

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

An approved project (11 semester-hours).

A suitable program of laboratory work (7 semester hours), which will include BICH 311-2, Analytical Biochemistry Laboratory and BICH 312-2, Metabolism Laboratory.

In biological and chemical sciences, five of:

BICH 301-3	The Structure and Reactivity of Biomolecules	3-1-0	CHEM 252
BICH 403-3	Physical Biochemistry	3-1-0	PHYS 121, MATH 310 & BICH 301
BICH 412-3	Enzymology	1-0-4	BICH 301 & BICH 311 (or 312)

BISC 301-3	Biochemistry - Intermediary Metabolism	3-1-0	
BISC 302-3	Genetic Analysis	2-0-4	BISC 202
BISC 303-3	Microbiology	3-0-4	
CHEM 333-3	Inorganic Chemistry of Biological Processes	3-1-0	BICH 301

<u>In chemical and biochemical processes</u>, all of:

ENSC 382-3	Control System Design	3-1-0	ENSC 280
ENSC 440-3	Chemical Reaction and Process Design	3-0-0	ENSC 340, CHEM 252
ENSC 442-3	Introduction to Biochemical Engineering	3-0-0	CHEM 252, ENSC 340
ENSC 444-3	Food Processing and Engineering	3-0-0	ENSC 442
ENSC 445-3	Chemical Process Control	3-0-0	ENSC 340,382

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

4.7 BIOMEDICAL ENGINEERING

Biomedical engineering is concerned with the wide range of engineering problems encountered in medical and surgical treatment, in the interactions of man and machine in a variety of environments, in medical instrumentation, and in the understanding of biomechanics. Engineers with mechanical, chemical and electrical specialization work in this field.

Prerequisites: Engineering Science core A, B, or C including:

CHEM 251-3	Organic Chemistry I
CHEM 256-2	Organic Chemistry Laboratory I
CHEM 261-3	Physical Chemistry I
(or PHYS 344-3	Thermal Physics)
KIN. 100-3	Introduction to Human Structure and Function
ENSC 230-3	Engineering Materials
ENSC 280-3	Systems Dynamics

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

An approved project (11 semester-hours).

A suitable program of laboratory work (7 semester hours), which will include KIN. 407-3, Human Physiology Laboratory.

In the life sciences and biomedical engineering, all of:

KIN. 305-3	Human Physiology I (Physiology of Motor Activity)	3-1-0	KIN. 100, CHEM 251, 256
KIN. 306-3	Human Physiology II (Principles of Physiological Regulation)		KIN. 305
KIN. 442-3	Biomedical Systems	3-0-0	CMPT 101, MATH 152 KIN 100, PHYS 120
ENSC 382-3	Control System Design	3-1-0	ENSC 280
ENSC 385-3	Measurement, Instrumentation and Transducers	3-1-0	PHYS 121, CHEM 105, ENSC 280
ENSC 451-3	Seminar in Biomedical Engineering		80 Semester-hours in Eng. Sc. Program

For students from core A, at least four of:

CMPT 340-3	Computers in Biomedicine	3-0-0	CMPT 101, KIN. 101, 305
ENSC 322-3	Electronic Design I	3-1-0	MECH 362, ENSC 221
ENSC 421-3	Electronic Design II	3-1-0	ENSC 322
ENSC 425-3	Electronic System Design	3-0-0	ENSC 322
ENSC 427-3	Communication Systems	3-0-0	ENSC 280, MATH 272
ENSC 429-3	Digital Control Systems	3-1-0	ENSC 382

For students from core B, at least four of:

ENSC 315-3	Analysis and Design of Machines	2-2-0	MECH 265
ENSC 410-3	Vibrations and Acoustics	3-0-0	MATH 310, 314
ENSC 431-3	Engineering in Extreme Environments	3-0-0	80 Semester-hours in Eng. Sc. Program
ENSC 434-3	Industrial Environmental Control	3-0-0	ENSC 311
ENSC 435-3	Design of Machine Components	2-2-0	ENSC 315, MECH 265
ENSC 439-3	Computer Aided Design and Manufacturing	2-2-0	ENSC 380, 382

For students from core C, at least four of:

NUSC 341-3	Introduction to Radiochemistry	3-1-0	60 Semester-hours in Science Program
BICH 301-3	The Structure and Reactivity of Biomolecules	3-1-0	CHEM 252
ENSC 212-3	Introductory Fluid Mechanics	3-1-0	PHYS 121
ENSC 340-3	Mass Transfer	3-0-0	ENSC 212, 240
ENSC 434-3	Industrial Environmental Control	3-0-0	ENSC 311

4.8 ENGINEERING MATHEMATICS

The engineering mathematics program contains two options: "applied mechanics" and "computing and communications". The study of applied mechanics prepares the student for the wide diversity of applications in engineering where the capability to undertake advanced mechanical and structural analyses is vital. This is a field which is specialized in its focus but broad in its applications. The computing and communications option has been designed for students with an interest in the general area of applied computing, electrical and systems science, but who wish to develop a more theoretical and mathematical foundation. Graduates would normally undertake post-graduate studies and, later, work in the fields of communications and computing.

APPLIED MECHANICS OPTIONS

Prerequisites: Engineering Science core B including:

MATH 252-3	Vector Calculus I
MATH 310-3	Introduction to Ordinary Differential Equations
MATH 314-3	Boundary Value Problems
MATH 316-3	Numerical Analysis I
MATH 361-3	Mechanics of Deformable Media
MECH 262-4	Engineering Mechanics I
MECH 263-4	Engineering Mechanics II
MECH 265-4	Strength of Materials
PHYS 344-3	Thermal Physics
ENSC 230-3	Engineering Materials

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

An approved project (11 semester-hours).

A suitable program of laboratory work (7 semester hours)

In engineering mechanics, all of:

ENSC 315-3	Analysis and Design of Machines	2-2-0	MECH 265
ENSC 415-3	Advanced Strength of Materials	3-1-0	MATH 361
MECH 362-3	Fluid Mechanics I	3-1-0	MATH 251, 272
MECH 363-3	Engineering Dynamics	3-1-0	MECH 263, MATH 310

<u>and</u>, at least five of:

MATH 462-3	Fluid Mechanics II	3-1-0	MECH 362 (MATH 314)
MATH 466-4	Tensor Calculus	4-1-0	MATH 252,232 (313)
MATH 467-3	Vibrations	3-0-0	MATH 232, 310
MATH 468-4	Continuum Mechanics	4-1-0	MATH 314,361,313
MATH 470-4	Variational Calculus	4-1-0	MATH 310, MECH 262
PHYS 384-3	Methods of Theoretical Physics I	3-1-0	MATH 252, 310 MECH 263
ENSC 385-3	Measurement, Instrumentation and Transducers	3-1-0	PHYS 121, CHEM 105, ENSC 280
ENSC 410-3	Vibrations and Acoustics	3-0-0	MATH 310, 314

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

<u>COMPUTING AND COMMUNICATIONS OPTION</u>

<u>Prerequisites</u>: Engineering Science core A including:

- MATH 243-3 Discrete Mathematics
- MATH 251-3 Calculus III
- MATH 310-3 Introduction to Ordinary Differential Equations (or ENSC 280-3 Systems Dynamics)
- MATH 316-3 Numerical Analysis I
- CMPT 105-3 Fundamental Concepts of Computing
- CMPT 205-3 Introduction to Formal Topics in Computing Science
- CMPT 291-4 Introduction to Digital Circuit Design
- ENSC 382-3 Control System Design

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

<u>An approved project</u> (11 semester-hours).

<u>A suitable program of laboratory work</u> (7 semester hours)

<u>In mathematics</u>, at least five of:

MATH 306-3	Introduction to Automata Theory	3-1-0	CMPT 105
MATH 308-3	Linear Programming	3-1-0	MATH 158 or 232

MATH 343-3	Combinatorial Aspects of Computing	301-9	MATH 243 or CMPT 205
MATH 372-3	Mathematical Statistics I	3-1-0	MATH 251, 272
MATH 375-3	Mathematical Statistics II	3-1-0	MATH 251, 272
MATH 387-3	Introduction to Stochastic Processes	3-1-0	MATH 272
MATH 401-3	Switching Theory and Logical Design	3-1-0	CMPT 103, MATH 306
MATH 402-3	Automata and Formal Languages	3-1-0	MATH 306
MATH 408-3	Discrete Optimization	3-1-0	MATH 308
MATH 416-3	Numerical Analysis II	3-0-0	MATH 310, 316
MATH 418-3	Partial Differential Equations	3-0-0	MATH 314
MATH 419-3	Linear Analysis	3-0-0	MATH 232, 251, 310
MATH 445-3	Introduction to Graph Theory	3-0-0	MATH 243 or CMPT 205
MATH 470-4	Variational Calculus	4-1-0	MATH 310, MECH 262 (MATH 313 or PHYS 384)
MATH 472-3	Linear Models in Statistics	3-1-0	MATH 232, 372
MATH 473-3	Non-Parametric Statistics	3-0-0	MATH 372

<u>In engineering science</u>, at least five of:

ENSC 322-3	Electronic Design I	3-1-0	CMPT 291, ENSC 225
ENSC 380-3	Industrial Engineering	3-1-0	MATH 251, 272
ENSC 425-3	Electronic System Design	3-0-0	ENSC 322
ENSC 427-3	Communication Systems	3-0-0	ENSC 280, MATH 272
ENSC 428-3	Data Communications	3-0-0	ENSC 427
ENSC 429-3	Digital Control Systems	3-1-0	ENSC 382
CMPT 391-3	Microcomputer Hardware Workshop	0-0-4	CMPT 291
CMPT 392-3	Introduction to Digital Signal Processing	2-0-2	CMPT 291, MATH 251
CMPT 405-3	Design and Analysis of Computing Alogorithms	3-0-0	CMPT 201, 205 MATH 152, 243, 232

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

4.9 ENERGY ENGINEERING

The production and distribution of energy in its varied forms is an engineering field of critical importance. This area of concentrated study in Engineering Science has two options: one (energy processes) concerned with the production of energy and the other (energy systems) with its distribution.

ENERGY PROCESSES OPTION

Prerequisites: Engineering Science core C including:

ENSC 212-3 Introductory Fluid Mechanics
(or MECH 362-3 Fluid Mechanics I)
ENSC 225-3 Basic Electrical Engineering
ENSC 230-3 Engineering Materials
ENSC 240-3 Introduction to Chemical Processes
ENSC 280-3 Systems Dynamics
ENSC 340-3 Mass Transfer
CHEM 218-3 Introduction to Analytical Chemistry
CHEM 251-3 Organic Chemistry I
CHEM 252-3 Organic Chemistry II
CHEM 256-2 Organic Chemistry Laboratory I
CHEM 261-3 Physical Chemistry I

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

An approved project (11 semester-hours).

A suitable program of laboratory work (7 semester hours)

In chemistry and biochemistry, all of:

BICH 301-3	The Structure and Reactivity of Biomolecules	3-1-0	CHEM 252
CHEM 465-3	Electrochemistry	3-0-0	CHEM 261

In the engineering sciences, all of:

ENSC 311-3	Engineering Thermodynamics I	3-1-0	PHYS 344 or CHEM 261
ENSC 342-3	Chemical Unit Operations	3-0-0	ENSC 340
ENSC 382-3	Control System Design	3-1-0	ENSC 280
ENSC 411-3	Engineering Thermodynamics II	3-0-0	ENSC 311

ENSC 440-3	Chemical Reaction and Process Design	3-0-0	ENSC 340, CHEM 252

and three of:

ENSC 431-3	Engineering in Extreme Environments	3-0-0	80 Semester-hours Eng. Sc. Program
ENSC 433-3	Fossil Fuel Extraction	3-0-0	80 Semester-hours Eng. Sc. Program
ENSC 442-3	Introduction to Biochemical Engineering	3-0-0	CHEM 252, ENSC 340
ENSC 470-3	Energy Sources	3-0-0	80 Semester-hours Eng. Sc. Program
ENSC 471-3	Energy Distribution and Utilization	3-0-0	80 Semester-hours Eng. Sc. Program
ENSC 475-3	Introduction to Nuclear Engineering	3-0-0	NUSC 342
PHYS 346-3	Renewable Energy Sources and Energy Conversion	3-1-0	PHYS 344

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

ENERGY SYSTEMS OPTION

Prerequisites: Engineering Science core A including:

MATH 316-3 Numerical Analysis I
ENSC 212-3 Introductory Fluid Mechanics
(or MECH 362-3 Fluid Mechanics I)
ENSC 225-3 Basic Electrical Engineering
ENSC 240-3 Introduction to Chemical Processes
ENSC 280-3 Systems Dynamics
PHYS 344-3 Thermal Physics
CHEM 251-3 Organic Chemistry I
CMPT 201-3 Data and Program Organization
CMPT 205-3 Introduction to Formal Topics in Computing

Note that any prerequisite courses not taken in the student's engineering science core are added to the minimum degree requirement of 160 semester-hours. Alternatively, any required concentration courses taken as part of the engineering science core increase correspondingly the number of constrained electives (as listed below) which may be selected.

An approved project (11 semester-hours).

A suitable program of laboratory work (7 semester hours)

In computing science, three of:

CMPT 301-3	System Development Methodology		CMPT 201
CMPT 305-3	Computer Simulation and Modelling	3-0-0	CMPT 201, MATH 272
CMPT 351-3	Introduction to Computer Graphics	3-1-0	CMPT 201, MATH 232
CMPT 400-3	Hardware Architecture	3-0-0	CMPT 201, 205 and 290 or 201
CMPT 404-4	Computer System Measurement and Evaluation		CMPT 400

In the electrical and systems sciences, three of:

ENSC 380-3	Industrial Engineering	3-1-0	MATH 251, 272
ENSC 382-3	Control System Design	3-1-0	ENSC 280
ENSC 427-3	Communication Systems	3-0-0	ENSC 280, MATH 272
ENSC 428-3	Data Communications	3-0-0	ENSC 427
ENSC 429-3	Digital Control Systems	3-1-0	ENSC 382

In energy systems and sciences, three of:

PHYS 346-3	Renewable Energy Sources and Energy Conversion	3-1-0	PHYS 344
ENSC 411-3	Engineering Thermodynamics II	3-0-0	ENSC 311
ENSC 433-3	Fossil Fuel Extraction	3-0-0	80 Semester-hours Eng. Sc. Program
ENSC 470-3	Energy Sources	3-0-0	80 Semester-hours Eng. Sc. Program
ENSC 471-3	Energy Distribution and Utilization	3-0-0	80 Semester-hours Eng. Sc. Program
ENSC 475-3	Introduction to Nuclear Engineering	3-0-0	NUSC 342

and one other course from the above three lists.

With permission, other courses may be substituted for the above, and a maximum of 9 semester-hours of directed study (ENSC 400, 401, 402) is possible.

Mathematical Sciences List

Course Number	Course Name	Vectors	Prerequisites (Co-requisites)
MATH 216-3	Introduction to Computorial Methods	3-1-0	MATH 151,CMPT 101
MATH 243-3	Discrete Mathematics	3-1-0	MATH 151
MATH 251-3	Calculus III	3-1-0	MATH 152
MATH 252-3	Vector Calculus I	3-1-0	MATH 251,
MATH 306-3	Introduction to Automata Theory	3-1-0	CMPT 105
MATH 308-3	Linear Programming	3-1-0	MATH 232
MATH 310-3	Introduction to Ordinary Differential Equations	3-1-0	MATH 152
MATH 313-3	Vector Calculus II	3-1-0	MATH 232, 252
MATH 314-3	Boundary Value Problems	3-1-0	MATH 252, 310
MATH 316-3	Numerical Analysis I	3-1-0	MATH 152, 232 CMPT 105
MATH 322-3	Complex Variables	3-1-0	MATH 251
MATH 343-3	Combinatorial Aspects of Computing	3-1-0	CMPT 105
MATH 372-3	Mathematical Statistics I	3-1-0	MATH 251
MATH 375-3	Mathematical Statistics II	3-1-0	MATH 272
ENSC 280-3	Systems Dynamics	3-0-0	MATH 152, 232

Computing Science List

Course Number	Course Name	Vectors	Prerequisites (Co-requisites)
CMPT 105-3	Fundamental Concepts of Computing	3-1-0	CMPT 101
CMPT 201-4	Data and Program Organization	3-1-0	CMPT 101, 105, 118
CMPT 205-3	Introduction to Formal Topics in Computing Science	3-1-0	CMPT 105, MATH 151
CMPT 301-3	Systems Development Methodology	3-0-0	CMPT 201
CMPT 354-3	File and Database Structures	3-0-0	CMPT 201

Electrical Sciences List

Course Number	Course Name	Vectors	Prerequisites (Co-requisites)
PHYS 221-3	Intermediate Electricity and Magnetism	3-1-0	PHYS 121 (MATH 251,252)
PHYS 355-3	Optics	3-1-0	PHYS 221, MATH 252
CMPT 291-4	Introduction to Digital Circuit Design		PHYS 150, CMPT 105, MATH 151
CMPT 391-4	Microcomputer Hardware Workshop	0-0-4	CMPT 291
ENSC 225-3	Basic Electrical Engineering	3-0-0	PHYS 121,131 (MATH 251)
ENSC 322-3	Electronic Design I	3-0-0	ENSC 225, CMPT 291
ENSC 382-3	Control Systems Design	3-0-0	ENSC 280

Mechanical Sciences List

Course Number	Course Name	Vectors	Prerequisites (Co-requisites)
MATH 361-3	Mechanics of Deformable Media	3-1-0	MATH 252, 262
PHYS 211-3	Intermediate Mechanics	3-1-0	PHYS 121 (MATH 251)
PHYS 344-3	Thermal Physics	3-1-0	PHYS 121, MATH 251
MECH 262-4	Engineering Mechanics I	3-2-0	MATH 152, PHYS 120 (155)
MECH 263-4	Engineering Mechanics II	3-2-0	MECH 262,(MATH 251)
MECH 265-4	Strength of Materials	3-1-0	MATH 152,MECH 262
MECH 362-3	Fluid Mechanics I	3-1-0	MECH 262 (MATH 314)
ENSC 212-3	Introductory Fluid Mechanics	3-1-0	PHYS 121
ENSC 230-3	Engineering Materials	3-0-0	CHEM 105, PHYS 121
ENSC 311-3	Engineering Thermodynamics I	3-1-0	PHYS 344 or CHEM 261

Chemical Processes List

Course Number	Course Name	Vectors	Prerequisites (Co-requisites)
CHEM 118-3	General Chemistry Lab II	0-0-4	CHEM 104, 115 (105)
CHEM 218-3	Introduction to Analytical Chemistry	2-0-4	CHEM 105
CHEM 232-3	Chemistry of Non-transitive Elements	3-1-0	CHEM 105
CHEM 251-3	Organic Chemistry I	3-1-0	CHEM 105 (256)
CHEM 252-3	Organic Chemistry II	3-1-0	CHEM 251
CHEM 256-2	Organic Chemistry Laboratory	0-0-4	CHEM 115
CHEM 261-3	Physical Chemistry I	3-1-0	CHEM 105, MATH 152, PHYS 121
CHEM 361-3	Physical Chemistry II	3-1-0	CHEM 105, MATH 310 PHYS 211
	(or PHYS 385 Quantum Physics)		
ENSC 240-3	Introduction to Chemical Processes	3-1-0	CHEM 261
ENSC 340-3	Mass Transfer	3-0-0	ENSC 212, ENSC 240
ENSC 342-3	Chemical Unit Operations	3-1-0	ENSC 340

Life Sciences List

Course Number	Course Name	Vectors	Prerequisites (Co-requisites)
BISC 101-4	Introduction to Biology	2-1-4	
BISC 201-3	Cell Biology	3-1-0	BISC 101, 102
BISC 202-4	Genetics	3-1-0	BISC 101,102
KIN. 100-3	Introduction to Human Structure and Function	2-1-0	

and other courses with permission of the Faculty. Note that courses from the chemical processes list may be substituted for courses in biological sciences in the Engineering Science core _if_ an equivalent number of biochemistry (BICH) courses are included in the student's overall program.

Engineering Science
Course Numbering Guide

X = 1, 2, 3 or 4
Y = 0 through 9

ENSC X0Y	General
ENSC X1Y	Mechanical Sciences
ENSC X2Y	Electronics and Communications
ENSC X3Y	Manufacturing and Materials Processing
ENSC X4Y	Chemical and Bio-chemical Processes
ENSC X5Y	Biomedical Engineering
ENSC X6Y	Special Topics in Engineering Science
ENSC X7Y	Energy Engineering
ENSC X8Y	Industrial and Systems Engineering
ENSC X9Y	Engineering Science Laboratory, Project, Internship, and Co-op Practicum

ORGANIZATION AND DEVELOPMENT OF ENGINEERING SCIENCE

ORGANIZATION AND DEVELOPMENT

This final section deals with the position of Engineering Science within the organizational structure of Simon Fraser University, and with the development of the program from its present state as an engineering transfer program to the steady-state program described in the foregoing. A range of development scenarios is described in order to illustrate the flexibility of the proposal in responding to various financial and academic circumstances.

ORGANIZATION

It is proposed that this professional program be the responsiblity of the Faculty of Engineering Science at Simon Fraser established on a non-departmentalized basis. As this new Faculty will be small in size, the regular organization of a Faculty would be inappropriate. Table 1 itemizes a structure which provides the essential committees even in the very early years of development.

SCHEDULE OF DEVELOPMENT OF ENGINEERING SCIENCE

Presently, Engineering Science at SFU is staffed at the level of a director, an assistant to the director and a secretary. The major activity is planning but some effort is being put into improving the organization of the existing transfer program. A $200,000 grant has been provided for these activities.

The detailed development schedule will depend on a number of factors, many of which are not known at this time. Our planning is for a staged evolution of the program, and the particular schedule laid out in the following is but one of a number of possible scenarios. Actual development could be somewhat faster and certainly considerably slower. Work is presently underway to identify the possibilities more clearly.

Table 1

Faculty of Engineering Science

Appointments

Dean: Appointed under policy for Faculty Deans

Chairman: Undergraduate Curriculum Committee

Chairman: Graduate Program Committee

3 Area Co-ordinators will be appointed, in time, but initially their responsibilities will be fulfilled by the Dean and Chairmen.

Committees

1. Council of the Faculty of Engineering Science

To advise the Dean on all aspects of the operation of the Faculty until such time as there are sufficient faculty appointed to carry out this function.

Composition

- Dean of Engineering Science, Chair
- Dean of Science or designate
- Dean of Interdisciplinary Studies or designate
- Dean of Arts or designate
- All Engineering Science Faculty (full and joint appointees)
- Where the Deans or their designates or the faculty joint appointees do not provide representation from the departments listed below, additional members will be appointed.
  - Physics
  - Chemistry
  - Biosciences
  - Mathematics
  - Computing Science
  - Kinesiology
  - Economics

2. Tenure and Promotion Committees

Composition determined by University Policies. Chairman elected by faculty in Faculty.

Table 1 Continued

3. Undergraduate Curriculum Committee

4. Graduate Program Committee

5. Appointments Committee

   Initially Subcommittees of the Council will serve the function of (3), (4) and (5).

It is unlikely, in fact, that the program in ten years time will follow exactly the format defined in the proposal. Some of the options will develop as defined. Others may well not become operational. Certainly, over time, new or radically changed concentrations will be designed. For now, we can only assume that all aspects of the proposed program will come into being and project its growth on that basis.

For 1982-83, it is proposed to move into an early development stage which would involve detailed planning, initial development work on courses and laboratories, and the recruitment of faculty. Special efforts would be directed towards informing prospective students of Engineering Science at SFU and beginning the coordination of the internship program. Prospective faculty would be engaged on a consultative basis to aid this work and initial faculty appointments could begin in this period.

The first offering of Year 2 of Enginering Science would begin in 1983-84 and course and laboratory development for Years 3 and 4 would continue, with special emphasis on educational technology and computer graphics. Recruitment of faculty would continue.

In 1983-84, a restricted enrollment class would begin in the electrical/computer area of the program. Starting with this single program area will allow for a more orderly development, and will keep the program restricted in size in the period before permanent space becomes available. Inevitably, extensive "fine-tuning" will be needed particularly in the innovative parts of the program, and this will allow the other two program areas to develope with the experience gained in the electrical/computer area. Starting with this particular emphasis is recommended because many of the computer engineering courses will be common to the whole program and because SFU has more existing strengths here than elsewhere in Engineering Science. As a matter of policy to allow for sound development efforts before regular operational requirements become dominant, each program area will hold year 3 level enrollment to 10 students for the first year and 15 for the second year.

In 1984-85 the other two program areas will begin at the Year 3 level, and the whole program will then evolve to its steady-state level.

Graduate studies and research must be a significant part of the work in Engineering Science from the beginning. Development of the undergraduate program cannot be at the price of the loss of the Faculty members research momentum. Faculty research would begin with their arrival on campus and the first graduate students would be expected in the Fall of 1984.

Following this development schedule, the enrollment projection is given in Table 2, the growth of staff in Table 3 and the financial requirements in Table 4. In addition to these costs, a portion of the capital equipment costs would be required prior to the equipping of the new building so as to permit the development of labs as required by the proposed schedule.

Table 2 Projected Enrollments

Academic Year/ Calendar Year	1	2	3	4	Conversion Program	Total U/G	Graduate students
81-82	40	--	--	--	--	40	--
82-83	60	--	--	--	--	60	--
83-84	80	48	--	--	--	128	--
84-85	100	64	10	--	5	174	5
85-86	120	80	35	9	10	254	10
86-87	140	96	49	31	15	331	17
87-88	150	112	68	44	20	394	26
Steady-state	150	120	85	75	20	450	40

Table 3 Staff Requirements

	81-82	82-83	83-84	84-85	85-86	86-87	87-88	Ongoing
Dean/director	1	1	1	1	1	1	1	1
Faculty	0	2[a]	6	9	14	18	21	21
Coordinators[b]	1	1	2	4	5	5	5	5
Secretaries	1	1	2	3	4	5	5	5
Lab Instructors	0	0	2	4	5	6	6	6
Technical	0	0	2	4	8	9	9	9

Notes [a] FTE of 3 appointments

[b] includes graphics supervisors

Table 4

Estimated Budgets, SFU Engineering Science Program

(Thousands of 1981-82 Dollars)

RECURRING	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	Later	Steady-State
Faculty (a)		192	428	591	913	1156	1312		1312
Teaching Assistants (b)		0	129	257	355	452	452		452
Support Staff (c)		66	75	95	115	135	135		135
Technical Staff		0	93	221	372	401	401		401
Computer Charges (d)		0	13	18	26	39	42	45	45
Supplies and Services		33	98	140	210	266	305		305
Sub total		291	836	1322	1991	2449	2647		2650
Indirect Costs at 50%		146	418	661	995	1225	1323		1325
Total		437	1254	1983	2986	3674	3970		3975

NON-RECURRING	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	Later	Project Total
Start-up Equipment (e)		25	175	300	300	1200	500	400	2900
Library		0	30	30	30	30	30		150
Recruitment and Moving (f)		25	52	39	54	43	27		240
Other (g)			35	35	35				105
Space (h),(i)		433	2167	3900	2166	0	0	1028	9694
Total	200	483	2459	4304	2585	1273	557		13089
GRAND TOTAL	200	920	3713	6287	5571	4947	4527		

Notes:

(a) Includes part-time instructors and visitors, and is based on an average salary of $48,500 plus 13.5% benefits.

(b) Includes laboratory instructors.

(c) Includes secretaries and administrative assistant.

(d) At $100 per student.

(e) At 30% of building cost, plus $400,000 for graphics.

(f) At $2300 per position in year prior to appointment for recruiting and $9000 per position in year of appointment for relocation.

(g) For rental/purchase of temporary space.

(h) 36,000 NASF is included in the SFU building Applied Science, Phase I, and is scheduled as shown; another 4,270 will be needed in a later phase of this building.

(i) There is no provision for scientific equipment in these space figures.

ENGINEERING SCIENCE COURSE DESCRIPTIONS

In addition to the Engineering Science (ENSC) courses, this collection of course descriptions includes the MECH courses in applied mechanics presently denoted in the SFU Calendar as MATH, and also those courses listed under ECON, BICH, BISC, CHEM, CMPT, KIN., MATH and PHYS which are included in the Engineering Science program.

All ENSC courses are new and require academic approval. MECH 262-4, 263-4, 265-4 and 362-3 are presently MATH courses; Mathematics have agreed to recommend that MATH be changed to MECH for these four courses on approval of the Engineering Science program. MECH 363-3 and PHYS 365-3 are proposed new courses yet to be approved but listed here for convenience.

4 January, 1982

ENSC 100-6 Engineering Communications

Rationale

The objective of this course is to develop the student's written, verbal and graphical communication skills to an acceptable level. The basic premise is that these skills are best learned and demonstrated in the context of the student's work in engineering. Evaluations of laboratory reports, course essays, and project reports will, as a result, be central to this course. Demonstrated competence is required and unsatisfactory work is returned to the student to be done again. Communication skills must be demonstrated at a satisfactory level before the student will receive course credit.

Calendar Description

This course is spread throughout the duration of the engineering program. It is concerned with written, verbal and graphical communications. Course credit is obtained by demonstration of a proficiency in the skills of engineering communication.

For the most part the need for communications will arise in various courses in the program such as in laboratory reports, course essays and project reports. Other activities will be specified for the particular engineering program in which the student is enrolled. The final report and interim oral report on the thesis project undertaken during the final semester of the program will be components of ENSC 100. This course will also include essays based on the guest lecturer series. Visual literacy, utilization of information resources such as libraries and computer graphics are within the scope of this course.

Particular requirements will be specified as the student progresses with his studies. A resource centre, tutorials, self-instructional materials, audio-visual materials, lectures, mini-courses and other instructional methods are utilized to aid the student in acquiring these skills which are considered important in the practice of the engineering profession. The student will formally register for the course in the semester in which all requirements are completed. Normally this will be the final semester. The course is graded on a credit/no entry basis.

ENSC 195-0 Job Practicum I

This is the first semester of work experience in a Co-operative Education program available to engineering students.

Prerequisite: Students must apply to the Faculty Co-op Co-ordinator at least one semester in advance.

ENSC 196-0 Job Practicum II

This is the second semester of work experience in a Co-operative Education program available to engineering students.

Prerequisite: ENSC 195. Students must apply to the Faculty Co-op Co-ordinator at least one semester in advance.

ENSC 212-3 Introductory Fluid Mechanics 3-1-0

Fluid properties, fluid pressure, hydrostatics. Fundamentals of fluid flow; conservation laws of mass, momentum and mechanical energy; flow of fluid in conduits; flow past immersed bodies. Equations of motion, Bernoulli equation, rotational and irrotational flow, similitude. Introduction to boundary layers, causes of drag, normal shock waves.

Prerequisite: PHYS 121

ENSC 225-3 Basic Electrical Engineering 3-1-0

Nature and properties of electrical circuits; basic circuit elements; voltage and current sources; Kirchoff's laws; linearity and superposition; Thevenin and Norton Theorems. AC signals and phasors. AC steady state circuit analysis: impedance, admittance and transfer properties; frequency response; detailed treatment of first order (RL and RC) circuits; properties of LCR circuits. DC circuits. Basic characteristics of electrical generators, motors, transformers and transmission lines. Electrical power distribution; power factor.

Prerequisites: PHYS 121, 131. Corequisite: MATH 251

ENSC 230-3 Engineering Materials 3-0-0

Introduction to the science of materials relating their mechanical, thermal, electronic and chemical properties to atomic, molecular and crystal structure. Ceramic and metallic crystals, glasses, polymers and composite materials. Multi-phase materials, strengthening processes. The course emphasizes the mechanical properties of materials. Related laboratory assignments include mechanical properties of metals and polymers, micro-structure, heat treatment of steel, corrosion.

Prerequisites: CHEM 105, PHYS 121

ENSC 240-3 Introduction to Chemical Processes 3-1-0

Basic principles of chemical engineering calculations: mass and energy balances in reacting and non-reacting systems; calculatons of equilibrium yields; single and multi-phase systems; chemical engineering thermodynamics.

Prerequisite: CHEM 261

ENSC 280-3 Systems Dynamics **3-1-0**

Rationale

It is critical that an engineer have a deep appreciation of the dynamical nature of engineering structures and processes and societal and biological systems generally. The objective of this course is to provide the depth of understanding which is associated with a capability to analyse such systems. This study of linear system analysis also provides necessary background for subsequent courses in control systems, process analysis and design, and communications.

Calendar Description

Properties of linear systems. Linear dynamic models of engineering systems: differential equations, block diagrams, signal flow graphs and state-space methods. Methods of solution including applications of the Laplace transform. Frequency and time response. Effects of feedback on system behavior; introduction to linear control. System simulation with analogue digital computers.

Prerequisites: MATH 152, 232

ENSC 291 Engineering Science Laboratory (Core)

Laboratory work is defined each semester on an individual student basis depending on the core program and the particular lecture courses in which he or she is enrolled. Both the particular assignments and the academic credit are set as appropriate. In some cases, laboratory work in courses outside Engineering Science may count towards the total requirement of six semester-hours of laboratory work in the Engineering Science core.

ENSC 292 Engineering Science Laboratory (Core)

Laboratory work is defined each semester on an individual student basis depending on the core program and the particular lecture courses in which he or she is enrolled. Both the particular assignments and the academic credit are set as appropriate. In some cases, laboratory work in courses outside Engineering Science may count towards the total requirement of six semester-hours of laboratory work in the Engineering Science core.

ENSC 293 Engineering Science Laboratory (Core)

Laboratory work is defined each semester on an individual student basis depending on the core program and the particular lecture courses in which he or she is enrolled. Both the particular assignments and the academic credit are set as appropriate. In some cases, laboratory work in courses outside Engineering Science may count towards the total requirement of six semester-hours of laboratory work in the Engineering Science core.

ENSC 294 Engineering Science Laboratory (Core)

Laboratory work is defined each semester on an individual student basis depending on the core program and the particular lecture courses in which he or she is enrolled. Both the particular assignments and the academic credit are set as appropriate. In some cases, laboratory work in courses outside Engineering Science may count towards the total requirement of six semester-hours of laboratory work in the Engineering Science core.

ENSC 295-0 Job Practicum III

This is the third semester of work experience in a Co-operative Education program available to engineering students.

Prerequisite: ENSC 196. Students must apply to the Faculty Co-op Co-ordinator at least one semester in advance.

ENSC 296-0 Job Practicum IV

This is the fourth semester of work experience in a Co-operative Education program available to engineering students.

Prerequisite: ENSC 295. Students must apply to the Faculty Co-op Co-ordinator at least one semester in advance.

ENSC 300-3 Engineering Design and Management 2-2-0

Rationale

While an engineering curriculum provides extensively for engineering and science content, the general processes of engineering design, problem solving, management and decision making are usually addressed only implicitly. This course is included to ensure that the student has a basic acquaintence with these processes and with the qualitative side of management and engineering practice.

Calendar Description

This is an introductory and overview course on modern concepts of engineering design, problem solving and management. Material is presented through lectures, seminars, case studies, and historical review. Studies involve the inter-relationship of such factors as problem definition, feasiblity studies, specifications, constraints, modelling, analysis techniques, evaluation and production. The basic elements, tasks, functions and activities of the management process including planning, organizing, staffing, directing and controlling, dilemmas and constraints, and management style will be examined. Guest lecturers will examine topics such as collective bargaining and the psychology of management, etc. An orientation towards the particular problems of engineering practice is provided which includes the legal, ethical and professional factors. Study of the course is in part through independent reading rather than formal lectures.

ENSC 301-3 Engineering Economics 3-1-0

The economics of capital projects and production processes. Financial analysis: annuities, mortages, bonds, loans, direct costs, depreciation, taxes and financial statements. Estimation of sales, capital and operating costs of new processes and products. Cash flows. Evaluation of alternatives. The engineer as a businessman and entrepreneur. Study of the course, is, in part, through independent reading rather than formal lectures.
Prerequisite: ECON 200

ENSC 311-3 Engineering Thermodynamics I 3-1-0

Introduction to heat transfer and thermal energy conversion. Steady-state and transient conduction, surface and gas radiation, convection, boiling and condensation. Introduction to the analysis and design of heat engines, engine and turbine cycles for vapours and gases, combustion.
Prerequisites: PHYS 344 or CHEM 261

ENSC 315-3 Analysis and Design of Machines 2-2-0

Velocities and acceleration in plane mechanisms. Balancing of rotating and reciprocating machinery. Gears and gear trains. Introduction to the selection of components and machine design.
Prerequisite: MECH 265

ENSC 322-3 Electronic Design I 3-1-0

This course builds upon the material of CMPT 291 with an emphasis on the design of analogue electronics. Topics: bipolar and field-effect transistors, characteristics, biasing, temperature effects and compensation; linear amplifiers, single and cascaded stages, differential stage, frequency response, transient response and bandwidth considerations; power amplifier stages and frequency multipliers; linear integrated circuits; feedback and oscillation, oscillator design. The analogue aspects of digital electronics are also emphaiszed: MOS transistor switches, logic gates, flip-flops and trigger circuits, timing, waveform processing circuits, multivibrators, memory circuits, registers and counters. At least two semester-hours credit in laboratory work must be taken in association with this courses.

Prerequisites: CMPT 291, ENSC 225

ENSC 324-3 Solid State Electronics **3-0-0**

Properties of semiconductors as they relate to the characteristics of junction diodes, bipolar junction transistors (BJT) and field effect transistors (JFET and MOSFET) are studied. Examples of the application of these devices, including rectifiers and voltage regulators, TTL and MOSFET logic gates and low-frequency BJT amplifiers, are presented.

Prerequisites: ENSC 225, CMPT 391

ENSC 340-3 Mass Transfer **3-0-0**

Mass transfer by diffusion and convection; applications to both stage-wise and continuous separation processes such as distillation, extraction and absorption; analogies between momentum, energy and mass transport. Design examples.

Prerequisite: ENSC 212, 240

ENSC 341-3 Introduction to Extractive Metallurgy **3-0-0**

The physical and chemical characteristics of ores and intermediates. An introduction to pyrometallurgy, hydrometallurgy and electrometallurgy. A survey of extraction processes. The principles of thermodynamics and kinetics applied to metallurgical processes.

Prerequisites: CHEM 261, ENSC 340

ENSC 342-3 Chemical Unit Operations 3-0-0

Study of chemical engineering unit operations: humidification, distillation, solvent extraction, absorption and ion exchange.

Prerequisite: ENSC 340

ENSC 380-3 Industrial Engineering 3-1-0

Rationale

This course aims to provide the student with an introductory understanding of a number of basic methods of decision making, organization and system optimization. Such techniques are fundamental to the analytic approach to engineering design and management. Both deterministic and statistical methods are considered.

Calendar Description

This course introduces the fundamentals underlying rational decision making in large engineering systems and the concepts and the scope of industrial engineering methods. The following topics will be examined: static optimization; steepest descent and quadratic convergence strategies; linear programming; the simplex methods, computational aspects, duality; network analysis; finite graphs; and critical path scheduling. Application of simple decision trees to probabilistic planning problems. Bayesian estimation. The utility concept. Recursive formulation of multistage decision problems. Introduction to dynamic programming. Introduction to queues and their application to the operation of engineering systems.

Prerequisites: MATH 251, 272

ENSC 382-3 Control System Design 3-1-0

Review of Laplace transform techniques. Effects of feedback: frequency response, pole-zero positions. Compensation design: root locus, Bode plots. State variables: formulation, solution of linear systems. Examples of simple second-order non-linear systems. Discrete time systems, Z-transforms, signal reconstruction, sample-and-hold circuits. Introduction to optimum control solution of linear quadratic problem.

Prerequisite: ENSC 280

ENSC 385-3 Measurement, Instrumentation and Transducers **3-1-0**

General characteristics of measurement procedures, transducers and instrumentation with particular reference to engineering processes; an overview of typical physical, chemical and biological measurement processes; mathematical models and simulations. At least one unit of laboratory work must be taken in association with this course.

Prerequisites: PHYS 121, CHEM 105, ENSC 280

ENSC 395-0 Job Practicum V

This is the fifth semester of work experience in a Co-operative Education program available to engineering students.

Prerequisite: ENSC 296. Students must apply to the Faculty Co-op Co-ordinator at least one semester in advance.

ENSC 400-3 Directed Studies in Engineering Science **3-0-0**

Directed reading in a topic chosen in consultation with a supervisor. Admission requires selection of a faculty supervisor and submission of a study topic to the Faculty at least one month prior to the start of the semester in which the course will be taken.

Prerequisite: With permission.

ENSC 401-3 Directed Studies in Engineering Science **3-0-0**

Directed reading in a topic chosen in consultation with a supervisor. Admission requires selection of a faculty supervisor and submission of a study topic to the Faculty at least one month prior to the start of the semester in which the course will be taken.

Prerequisite: With permission.

ENSC 402-3 Directed Studies in Engineering Science **3-0-0**

Directed reading in a topic chosen in consultation with a supervisor. Admission requires selection of a faculty supervisor and submission of a study topic to the Faculty at least one month prior to the start of the semester in which the course will be taken.

Prerequisite: With permission.

ENSC 410-3 Vibrations and Acoustics **3-0-0**

Free and forced vibration of single degree of freedom systems with and without damping, vibration isolation. Free vibration of two degrees of freedom lumped mass systems; vibration absorption; beam vibrations. Sound waves, sound sources, noise; subjective aspects of noise, noise control.

Prerequisites: MATH 310, 314

ENSC 411-3 Engineering Thermodynamics II **3-0-0**

A continuation of ENSC 311-3, Engineering Thermodynamics I. Mixtures of perfect gases and vapours, psychrometry, combustion processes, differences between real and ideal cycles, gas cycles and vapour cycles for power and refrigeration plant, principles of turbomachines. The engineering of heat transfer apparatus.

Prerequisite: ENSC 311

ENSC 415-3 Advanced Strength of Materials **3-1-0**

Thin walled pressure vessels, cladding, thick cylinders, shrink fits, theory of failures and applications, torsion, stability, fracture mechanics, crack propagation.

Prerequisite: MATH 361

ENSC 421-3 Electronic Design II **3-1-0**

The transistor is described in terms of its major characteristics when employed as a linear active device in signal amplification. Biasing, temperature compensation and bandwidth limitations are treated as well as class A, class B and class C amplifiers. Frequency multipliers, feedback leading to the design of oscillators, and modulation and demodulation completes the linear part of the course. The use of the transistor as a switch in Schmitt Triggers, multi-vibrators, NOR and NAND gates is discussed. Frequency division, shift registers and counters are treated. The application of other devices, such as four-layer diodes, SCR and UJT's is included. Associated laboratory work is completely project-oriented and each student is expected to design and construct four circuits to meet given specifications.

Prerequisite: ENSC 322

ENSC 425-3 Electronic System Design **3-0-0**

Aspects of design using digital and analogue integrated circuits as circuit blocks for the realization of required system functions are treated, with project activities in the laboratory. Topics include differential amplifiers; operational amps - non-ideal aspects; slew rate, gain error, sensitivities. Active filter design. D/A and A/D conversion. MSI and LSI digital circuits, combinational and sequential: decoders, encoders, multiplexers, ROM's, counters, controllers. Communication circuits: AM and FM modulators and demodulators, multiplexers, pulse modulation.

Prerequisite: ENSC 322

ENSC 426-3 High Frequency Electronics 3-0-0

Transmission lines and waveguides, microwave devices, travelling wave devices. An introduction to the theory of radiation, antennae and wave propagation, and microwave scattering theory. The design of complete communication systems incorporating microwave, optical and satellite channels.
Prerequisite: PHYS 221

ENSC 427-3 Communication Systems 3-0-0

Representation of signals; Fourier series and transforms; time and frequency convolution. Amplitude modulation theory, circuits and systems; single sideband; vestigal sideband. Operational mathematics for non-stochastic signals; correlation; energy spectra. Sampling theorem; time division multiplexing; discrete Fourier transforms. Angle modulation; phase and frequency modulation theory, circuits and systems. Television and facsimile waveforms, spectra and modulation methods. Characteristics and uses of classical, transversal and recursive filters. Noise in circuits and systems. Pulse code modulation and delta modulation.
Prerequisites: ENSC 280, MATH 272

ENSC 428-3 Data Communications 3-0-0

Review of probability and random variables. Digital modulation and transmission: modems, signal-to-noise ratios and error rates. Data networks: circuit/message/packet switching. Data codes. Network functions: modulation, multiplexing, concentration, polling. Synchronous and asynchronous transmission. Error detection. Protocols: SNA, HDLC, X.25. Examples of public data networks.
Prerequisite: ENSC 427

ENSC 429-3 Digital Control Systems **3-1-0**

Discrete-time control and signal processing systems, the Z-transform. Analogue-to-digital and digital-to-analogue conversion. Digital system architectures. Applications in control, filtering, electronics, signal processing. Introduction to adaptive systems.

Prerequisite: ENSC 382

ENSC 431-3 Engineering in Extreme Environments **3-0-0**

An overview of the problems and special approaches to designing and operating engineering facilities in extreme environments. Attention is given to heat, cold, winds, tides and currents, inaccessibility, lack of power sources, corrosive environments, dust, moisture, high and low barometric pressures, radiation, and other unusual conditions. Visiting lecturers and a project are components of the course.

Prerequisite: Upper Division Standing

ENSC 433-3 Fossil Fuel Extraction **3-0-0**

Origin, nature and behavior of petroleum reservoir fluids, natural gas and coal; elements of oil and gas well drilling and completion; description of surface and underground methods of coal mining; engineering of fossil fuel production and distribution facilities.

Prerequisite: Upper Division Standing

ENSC 434-3 Industrial Environmental Control **3-0-0**

Concepts and techniques in refrigeration and heating; moisture and temperature control; removal of pollutants; protection of personnel and the natural environment.

Prerequisite: ENSC 311

ENSC 435-3 Design of Machine Components 2-2-0

Analysis and design of machine components, belts, brakes, clutches, gears, cams, springs, governors, Design Project.

Prerequisites: ENSC 315, MECH 265

ENSC 436-3 Manufacturing Processes 3-0-0

The principles of manufacturing unit processes including casting, forming, machining, and joining. Interactions between design, materials (metals, polymers, ceramics) and processes. Advantages and limitations, relative costs and production rates of competitive processes.

Prerequisite: Upper Division Standing

ENSC 438-3 Automation and Robotics 3-0-0

Industrial processes amenable to automation: materials handling, unit processes, assembly, testing. Principles involved in automation: task definition, control, co-ordination with other tasks, geometric modelling of mechanical parts and processes, sensors in programmable automation, problems in assembly. The design of industrial robots: programming articulated elements, languages for control, machine vision, intelligent robots. Case studies of selected automated processes and industrial robots used in the electronics, automobile and chemical industries.

Prerequisites: ENSC 385, 436, 439

ENSC 439-3 Computer Aided Design and Manufacturing 2-2-0

Survey of methods for computer aided design and manufacturing (CAD/CAM) including experience with basic systems in the workshop component of the course. Each student will undertake a course project. CAM will include computer controlled machine tools and robots, and the use of the computer in indirect support of the manufacturing process.

Prerequisites: ENSC 380, 382

ENSC 440-3 Chemical Reaction and Process Design **3-0-0**

Homogeneous reactors: batch, CSTR, tubular flow systems, ideal models, residence time distributions in ideal reactors, temperature effects, steady states, semi-batch systems, non-ideal behavior. Hetrogenious catalysis: mass transfer effects, catalytic rate equations, fixed and fluidized bed reactors. Design considerations.

Prerequisite: ENSC 340

ENSC 442-3 Introduction to Biochemical Engineering **3-0-0**

A review of those aspects of microbiology and biochemistry relevant to biological process industries and environmental pollution. Classification and growth characteristics of microorganisms. Physio-chemical properties of biological compounds. Metabolism and biochemical kinetics. Examples of biochemical processes in industrial application and pollution.

Prerequisites: CHEM 252, ENSC 340

ENSC 444-3 Food Processing and Engineering **3-0-0**

Applications of heat and mass transfer operations to processing natural and texturized foods. Design and analysis of sterilization, low temperature preservation, concentration, separation and purification processes. Effects of formulation, additives and processing on organoleptic and nutritional quality.

Prerequisite: ENSC 442

ENSC 445-3 Chemical Process Control 3-0-0

Modelling of chemical process systems, simulation, linear and nonlinear analysis, process control equipment, sampled data systems, computer control.

Prerequisites: ENSC 340, 382

ENSC 451-3 Seminar in Biomedical Engineering

A seminar course dealing with examples, principles and particular problems of enigneering applications in medicine. Case studies, visiting participants and student projects are utilized.

Prerequisite: Upper Division Standing

ENSC 460-3 Special Topics in Engineering Science 3-0-0

Studies in areas not included within the undergraduate course offerings of the Engineering Science Program.

Prerequisite: With permission.

ENSC 461-3 Special Topics in Engineering Science 3-0-0

Studies in areas not included within the undergraduate course offerings of the Engineering Science Program.

Prerequisite: With permission.

ENSC 462-3 Special Topics in Engineering Science 3-0-0

Studies in areas not included within the undergraduate course offerings of the Engineering Science Program.

Prerequisite: With permission.

ENSC 470-3 Energy Sources 3-0-0

An intensive overview of the sources of energy and their geographic distribution: petroleum, coal, hydro-electric, wind, solar, geothermal, nuclear and chemical. Emphasis will be placed on the processes by which usable fuels are obtained, net energy gains, economic and environmental factors.

Prerequisite: Upper Division Standing

ENSC 471-3 Energy Distribution and Utilization 3-0-0

Study of the means by which energy is distributed and the relative effectiveness of energy transportation. Utilization and conservation of energy; interchangeability of various forms of energy. Energy systems.

Prerequisite: Upper Division Standing

ENSC 475-3 Introduction to Nuclear Engineering 3-0-0

Study of nuclear reactor systems for the generation of energy or radiation products including design, instrumentation and operation. Environmental and social aspects.

Prerequisite: NUSC 342

ENSC 480-3 Production Systems 3-0-0

The meaning of production. The economist's and engineer's approach to production; the systems approach. Production as materials processing and information processing. Characteristics of production operations: their energy, space, material yield, environmental, control and scale implications. Introduction to the basic features of production systems and methods of modelling their operation; the material flow, information and control systems. Forecasting, inventories, service level and its measurement, periodic and continuous review inventory models, ABC analysis, aggregate inventory models. The role of inventories in physical distribution. Inventories in manufacturing: requirements planning vs order point control. Planning production capacity. Production control and scheduling.

Prerequisite: Upper Division Standing

ENSC 491 Engineering Science Laboratory (Concentration)

Laboratory work is defined each semester on an individual student basis depending on the concentration and the particular lecture courses in which he or she is enrolled. Both the particular assignments and the academic credit are set as appropriate. In some cases, laboratory work in courses outside Engineering Science may count towards the total requirement of seven semester-hours of laboratory work in the concentration.

ENSC 492 Engineering Science Laboratory (Concentration)

Laboratory work is defined each semester on an individual student basis depending on the concentration and the particular lecture courses in which he or she is enrolled. Both the particular assignments and the academic credit are set as appropriate. In some cases, laboratory work in courses outside Engineering Science may count towards the total requirement of seven semester-hours of laboratory work in the concentration.

ENSC 493 Engineering Science Laboratory (Concentration)

Laboratory work is defined each semester on an individual student basis depending on the concentration and the particular lecture courses in which he or she is enrolled. Both the particular assignments and the academic credit are set as appropriate. In some cases, laboratory work in courses outside Engineering Science may count towards the total requirement of seven semester-hours of laboratory work in the concentration.

ENSC 494 Engineering Science Laboratory (Concentration)

Laboratory work is defined each semester on an individual student basis depending on the concentration and the particular lecture courses in which he or she is enrolled. Both the particular assignments and the academic credit are set as appropriate. In some cases, laboratory work in courses outside

Engineering Science may count towards the total requirement of seven semester-hours of laboratory work in the concentration.

ENSC 497 Internship I

This is the first session of the internship and comprises a semester of work experience arranged through the Co-operative Education program. The objectives of the sessions are to gain relevant practical experience and to prepare for ENSC 498, Internship II, during which the work undertaken leads to the student's undergraduate thesis. For co-op students this is the final semester of work experience.

ENSC 498 Internship II

This is the second session of the internship and is coincided with the student's last semester of academic work. The student's time in this session is devoted to supervised study (course registration is separate and appropriate to the student's program) and to supervised research, development or advanced engineering work leading to the undergraduate thesis. The locale of this work may be external to the Univerity or within a University laboratory, and supervision may be external, internal or shared. In any event, the work is to be relevant to the activities of the external organization or an on-going University research project.

ENSC 499-11 Engineering Science Project

A thesis is based on the research, development and engineering project undertaken in the student's internship. This period of internship normally occurs during a combined academic and internship semester (corresponding to the eighth and final acadmeic semester of work) and the previous work period. The locale of the internship may be external to the University or in a University research laboratory, or may bridge the two locations.

Supervision may be external, or by a faculty member, or joint, quite independent of the principal location of the activity. Registration for ENSC 499 takes place in the semester in which the thesis will be presented and defended. Formal approval from the Faculty of Engineering Science must preceed any but the most preliminary work on the topic chosen. Grading will be on a Pass/Fail basis, but with recognition of outstanding work.

SIMON FRASER UNIVERSITY

MEMORANDUM

To: T. W. Calvert
Dean
Interdisciplinary Studies

From: E. A. Weinstein, Head
Sciences Division
Library

Subject: Library Support Costs,
Engineering Program

Date: 82/01/18

Our initial estimate of library support costs, dated 80/11/17, was constructed with reference to the Engineering Program proposal of that year. The small change (from $25,000 to $30,000) you have made in my original estimate of non-recurring costs is entirely consistent with our continuing inflation and the shift in program emphasis from the traditional engineering disciplines to a rather more research-oriented high technology program.

Again, it should be stated that library support for the SFU program requires acquisition of basic and current library materials. It is intended that we depend on area resources for depth of support, and this is consistent with our present utilization of U.B.C. resources in particular. You have noted the great discrepancy between our proposed library support costs and those of the University of Victoria. I can only affirm that U.Vic library staff did not participate in the construction of this estimate by the U.Vic consultants. This amount is far in excess of the needs of an undergraduate engineering program.

c.c. T. Dobb

EAW