Department of Physics and Physical Oceanography

Self-Study Report

February 21, 2003

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Introduction

> *"Memorial will continue to provide strong academic support to undergraduate students and to support extensive involvement of regular faculty in undergraduate classrooms and laboratories, but in response to the needs of a changing economy it will also expand research and graduate teaching as high priorities. The demands of a knowledge-based economy and society for higher education make scholarly research more important than ever, so that Memorial will address a growing demand for graduates with advanced degrees, making graduate studies expand in relative importance.*
>
> *Combining these imperatives, Memorial will enrich undergraduate education by helping students to experience the excitement of intellectual discovery, introducing undergraduates more effectively to the wider academic enterprise."*
>
> **A Strategic Framework for Memorial University**[1]

As the sole degree granting institution in the Province of Newfoundland and Labrador, Memorial University has an obligation to provide a balanced range of programs that are competitive with degree programs offered at other universities across Canada, and yet which are sensitive to the unique character of the region and its communities. Our Department offers quality undergraduate and graduate degree programs in physics that not only train research scientists, but which also prepare all graduates for a wide variety of career options. In addition the Department provides service courses to students pursuing other degree programs in the physical and life sciences and in engineering.

The Department also has a responsibility to participate in and contribute towards the wider scientific endeavour through research excellence. The intellectual vigour of the Department is a prerequisite to quality graduate and undergraduate programs and critical to Memorial's status as an academic institution. Research programs also provide the intellectual and technological basis for the economic and social developments that are vital to the future of this province and the country.

The defining objectives of this department are therefore to

- Provide quality undergraduate programs in physics
- Offer competitive graduate programs in both physics and physical oceanography
- Establish and maintain research excellence in key areas of physics and physical oceanography.
- Contribute to local, regional, national and international organizations and projects that serve to strengthen science, science education and the scientific community.

[1] http://www.mun.ca/ciap/planning/framework.htm

The responsibility for providing quality academic programs and research excellence requires that we maintain a broad range of teaching competency at the undergraduate level, while focusing our research specializations in a few areas to create research clusters both within the Department and through collaborations across departmental and faculty boundaries. The Department has chosen to focus primarily in Condensed Matter Physics and Physical Oceanography while maintaining expertise in Atomic and Molecular Physics. The decision to concentrate our resources in developing two primary research areas has governed the hiring policies and program development within the Department since the early 1980's.

This concentration of the Department's academic focus has served the Department well and anticipated several exciting, emerging areas of research in the physical sciences that are of considerable national and regional strategic importance and has contributed significantly to Memorial's enviable position in the Marine Sciences. This has resulted in a Department with a range of interdisciplinary research interests and collaborations that is more outward looking and applied than more traditional physics departments.

Background

The Department of Physics and Physical Oceanography currently consists of 16 faculty and offers a number of graduate and undergraduate degrees in Physics and Physical Oceanography. The Department has approximately 70 physics majors and graduates around 15 physics majors annually. We currently have 21 students in our graduate programs and we typically award 3~5 graduate degrees annually. In addition, two students in the interdisciplinary programs are presently being supervised by members of this Department.

The Department handles approximately 2,300 registrations annually. The introductory physics courses, with approximately 1,700 registrations, are required for a wide range of degree programs in science and engineering. These figures do not include laboratory registrations. All of our first year courses, as well as our core second year courses, have an associated laboratory requirement.

Of the 16 faculty, 14 currently hold NSERC research grants and another submitted his first application in October 2002. In fiscal year 2001-2002 the department received $2,619,844 in external research funding. The Department maintains a small machine shop and a cryogenics facility that provides liquid He and N_2 to researchers throughout the University, and maintains a comprehensive suite of oceanographic instruments, capable of regional coastal surveys. The Department also houses the Memorial University Advanced Computational and Visualisation Centre (CVC). In addition the Department provides a modest level of system and other technical support to researchers within the Department. Additional electronic and machining support is available from the University Technical Services Department.

The Department's annual budget in the current fiscal year 2002-2003 was $2,338,016. Approximately 93% of this expenditure is for salaries. The Department has a full time staff of 16, consisting of 5 administrative personnel, 5 undergraduate laboratory personnel and 6 technical and system support personnel.

Self Study

There have been two previous self-studies by the Department. The first, in 1981, was submitted to the Senate Review Committee. The second was a five-year plan that the Department prepared in 1995, at the request of the Dean of Science. Departmental policy in the intervening years has been guided by many of the recommendations contained in the five-year plan.

For the present self-study the Head of Department created an ad-hoc Academic Program Review Committee consisting of five Department Members (de Bruyn, de Young, Lagowski, Morrow and Zedel). The APR Committee was chaired by the Head of the Department. As part of the self-study process the Department held a retreat on May 26th 2002. Faculty and one graduate student attended; one undergraduate was invited but did not attend. Prior to the retreat, faculty were divided into three groups and asked to consider the following questions

- What are the strengths of the Department?
- What are the weaknesses of the Department?
- What are problems facing the Department?
- What opportunities are available to the Department?
- What new initiatives should the Department undertake?

At the retreat the Dean of Graduate studies discussed graduate programs at Memorial after which several members of the APR Committee presented reviews of various aspects of the Department's academic programs. In the afternoon, one spokesperson from of each of the three groups presented a summary of their group's discussion. The format and timing of the retreat provided an excellent opportunity for faculty to review and discuss the current state of the Department and its potential for the future. Following the retreat, the APR Committee worked over the summer and prepared preliminary drafts for many of the key sections in the self-study report. This allowed for input by faculty at a very early stage of the preparation of the self–study document.

The APR Committee also arranged with the Centre for Institutional Analysis and Planning (CIAP) to conduct a survey of our current and former graduate and undergraduate students. The results of this survey, presented in Appendix 1, provided the Department with a quantitative assessment of various aspects of its undergraduate and graduate programs.

The initial intention was to prepare a preliminary version of the self-study report for discussion by faculty, staff and students in the fall, with the final version to be ready by the end of November. However the fall semester proved to be a very challenging one for the Department. The retirement of three of our faculty and the sudden illness of another just prior to the beginning of the semester, combined with an increase in our course enrolments, meant a significant increase in the teaching load for the remaining faculty. As a consequence little progress was made on the self-study during the Fall semester.

A preliminary draft prepared by the Head of the Department with input from members of Department. This was circulated to faculty, staff and students for discussion on February 12th 2003, This draft was discussed at a Departmental meeting on February 17th 2003. Based on the discussion at the Department meeting and comments received, revisions were made to this draft and final version submitted to CIAP on February 21st 2003.

Student Information

Undergraduate Student Numbers

The total number of undergraduate registrations is currently around 2,300. This is made up of two distinct components: our introductory courses, which have maintained a constant level of about 1500 ~ 1700 students for the past 7 years, and our senior level courses. Our senior level physics registrations have seen a steady increase from a low of 387 in 1999/2000 to 619 in 2002/2003. These enrolment figures are shown in Figures 1 and 2

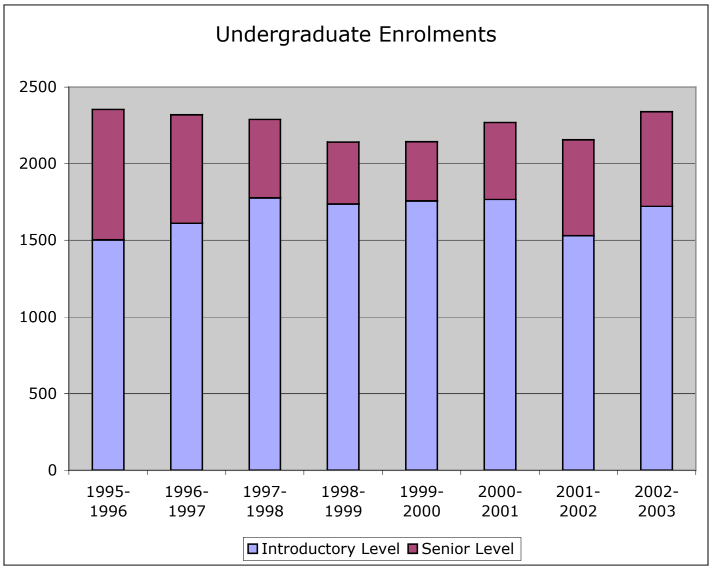

Figure 1: Undergraduate student registration for period 1995-2003

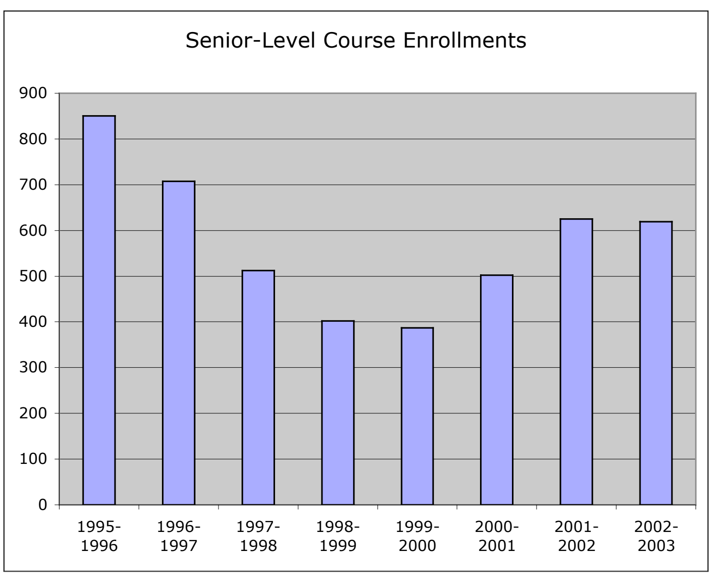

Figure 2: Enrolment in senior level courses from 1995 to 2003

The number of physics majors at the time this report was prepared is 70 and 11 degrees in physics were awarded in academic year 2001/2002, 4 with honours. Figure 3 shows the number of physics majors over the period 1995 to 2003. These data were obtained from the Memorial's BANNER student registration system[2].

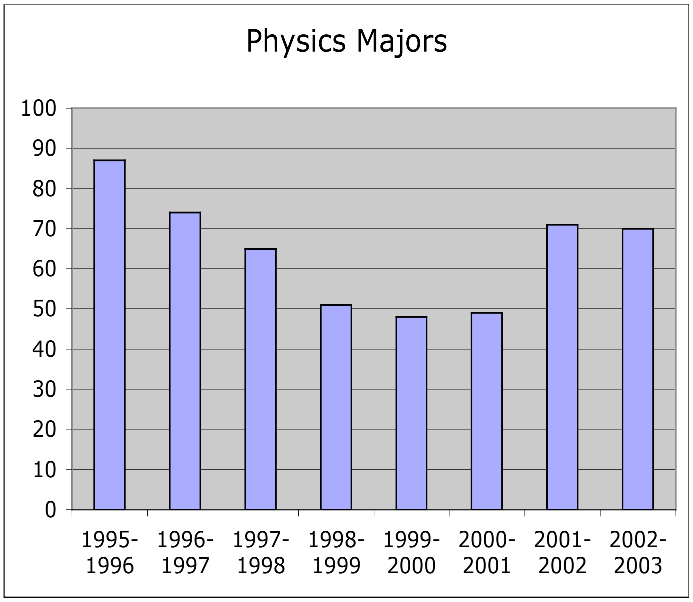

Figure 3: Number of physics majors from 1995 to 2003

The number of physics degrees awarded annually is shown in Figure 4 for the period 1995 to 2002. These data are obtained from the University Student Records system (BANNER). The average number of physics degrees awarded annually by Memorial, for that period is 16. This compares with the average number of physics degrees awarded annually for all physics departments in Canada, which is about 12, and for physics departments at universities with student populations in the range 10,00 ~ 12,000 students, which is around 16[3].

[2] These data include both single and double majors and therefore differ from the data presented in the Academic Unit Profile published by CIAP

[3] Data are obtained from a survey carried out by Dr. E. McFarland (University of Guelph) and presented at the CAP Head's meeting June 2nd 2002 and is based on replies from 41 out of 48 Canadian Universities.

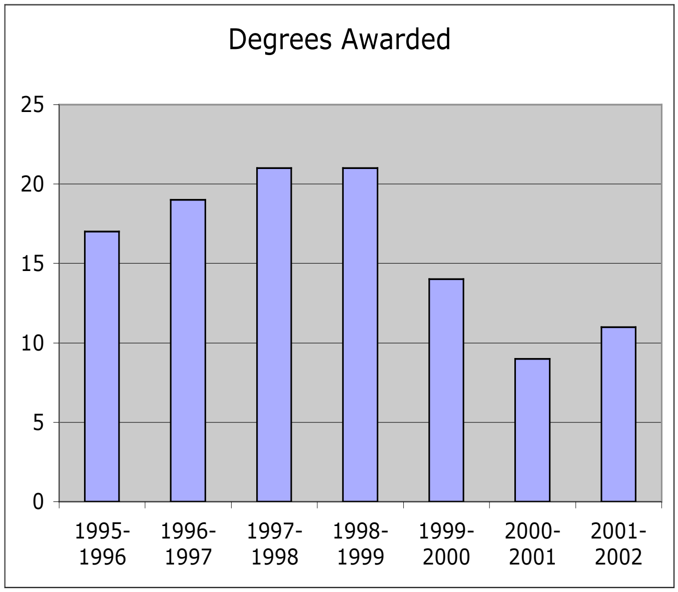

Figure 4: Number of physics degrees awarded annually

The number of physics minors for the period 1995 to 2002 is shown in figure 5. The number of minors has stabilized at around 20 from a high of around 50 in 1995/1996. The physics minor is an important component of our undergraduate programs. Not only does it help maintain healthy enrolments in our senior level courses but it provides an incentive for students in degree programs other than physics to study physics in greater depth than they otherwise might choose to do.

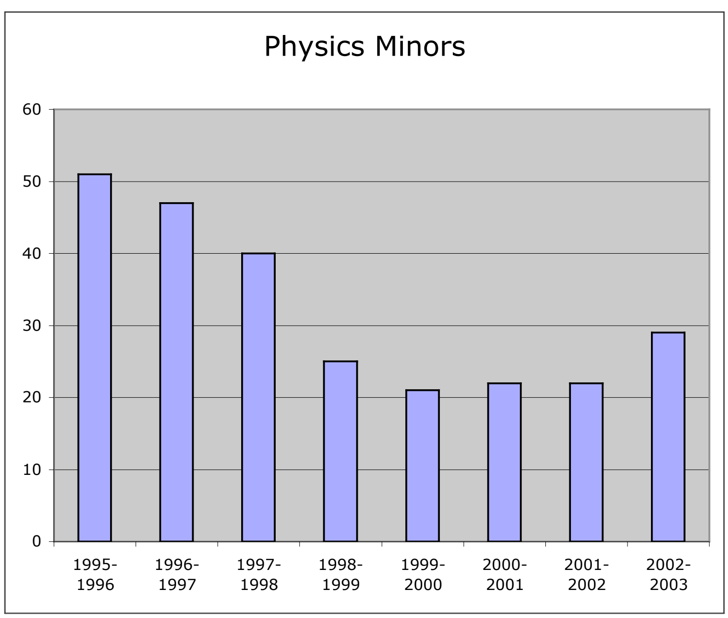

Figure 5: Number of physics minors 1995 - 2003

Graduate Student Numbers

The total number of graduate students supervised by faculty in the Department for the period 1995/1996 to 2002/2003 is shown in Figure 6. Our graduate student enrolment has been roughly constant in recent years, averaging just over 20 students per year. Currently approximately 55% are in Condensed Matter or Atomic and Molecular Physics, 30% are enrolled in Physical Oceanography and 15% are enrolled in interdisciplinary programs. The number of students in each of these areas is shown in Figure 6.

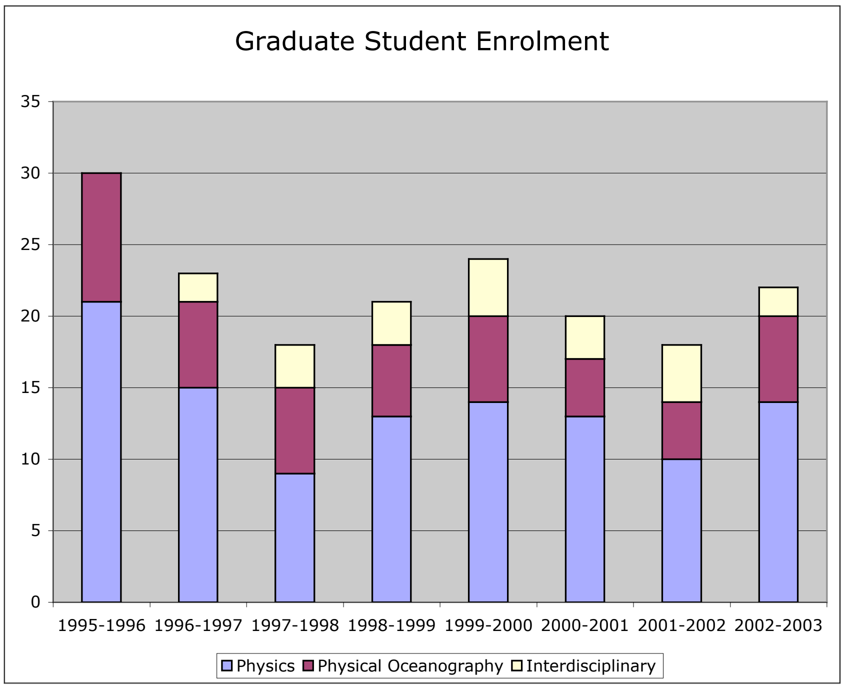

Figure 6: Graduate student enrolment 1995 – 2003

Over the last seven years the Department has awarded 19 MSc degrees (4 in Physical Oceanography and 15 in Physics) and 16 PhDs (3 in Physical Oceanography and 13 in Condensed Matter and Atomic and Molecular Physics). In addition 2 students have completed a degree in Environmental Science and 2 have completed a degree in Computational Science under the supervision of our faculty.

Undergraduate Student Profile

Our undergraduates cover a broad spectrum of ability and choose to major in physics for a wide range of motives. Many finance their education by working part-time, which limits the number of courses they are able to take in each semester. While some have decided on a career in physics, many have not yet committed to a particular career path.

Reason for Majoring in Physics

In order to better understand students' motivations for majoring in physics former physics undergraduates were asked as part of the survey carried out by CIAP to state their reasons for majoring in physics. The results reveal that roughly half of our undergraduates (50.0%) major in physics because of their general level of interest in the subject, while only 6.5% choose to major in physics primarily as a preparation for a specific job or career.

Academic Quality

One measure of the "academic quality" of declared physics undergraduates is provided by the 2001 Academic Performance Profile prepared by CIAP, who quote an average grade of 69.1% for physics majors. This level is comparable to the average of 70.6% for the science faculty as a whole. Another measure of the "academic quality" of our majors is provided by the fact that of 100 students who graduated with majors or joint majors in physics, over the period 1996 to 2002, 48 held at least one award. Of these award holders, the average number of awards held was 5.2, and the maximum held by a single student was 26. Over this same time period an additional 40 students holding awards graduated with minors in physics: the average number of awards held by these students was 4.7. A total of 56 different types of awards were held by these students.

Time to Completion

While many students complete either an honours or a majors degree within four years, others work part-time or are enrolled in joint programs that can take longer than four years to complete. To obtain some estimate of the expected time to graduation for our physics majors we examined the graduation dates for students in three cohorts who enrolled at MUN between 1992 and 1994. This analysis is based on 36 of these students who graduated in the years 1996 to 2000. For these students, the mean time to graduation is 5.2 years. Looking at each cohort individually, the times to graduation for the 1992, 1993, and 1994 cohorts are 5.4, 5.2, and 4.8 years respectively. The slightly reduced time for the 1994 cohort may be due to neglecting students who graduated in 2001 for which data was not available and therefore were not included in the analysis.

Graduate Student Profile

Of the students enrolled in graduate physics programs, approximately 70% are Canadian citizens or Permanent Residents. The numbers of Canadian and Foreign students are shown in Figure 7 for the period 1995/1996 to 2000/2001.

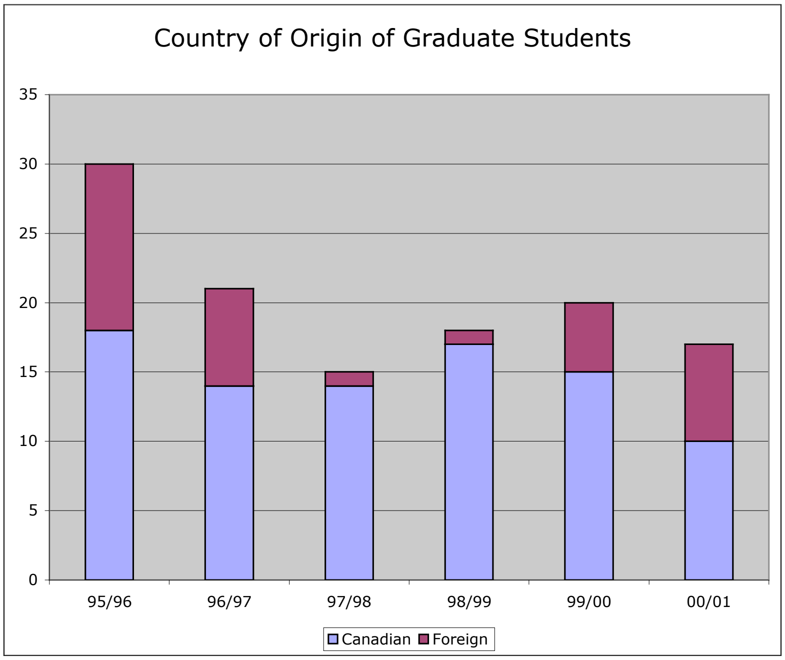

Figure 7: Country of origin of graduate students 1995 – 2001. This data does not include students in the interdisciplinary programs.

For the 25 MSc graduates who have graduated since 1995, the mean time to completion is 36.0 months, while the median time to completion is 32.5 months. In the case of the PhD students the mean time to completion for the 16 PhD students who graduated since 1995 is 63.4 months with a median time to completion of 62.5 months.

Graduate Student Funding

The Department has tried to maintain competitive funding packages for graduate students. Currently we guarantee minimum funding levels of $14,000 per annum for MSc students and $15,500 for PhD students. As Figure 8 below shows funding for our graduate students has increased somewhat over the last ten years, however the Department is concerned that the current levels of funding are no longer competitive and this is affecting our ability to both retain and recruit good students. The Department has agreed to increase the minimum support levels for graduate students by $1,500. While this will go some way to improving our competitive position regarding funding it is realized that this is below what is required to help grow our graduate program and we are exploring ways to expand the funding levels that we can provide.

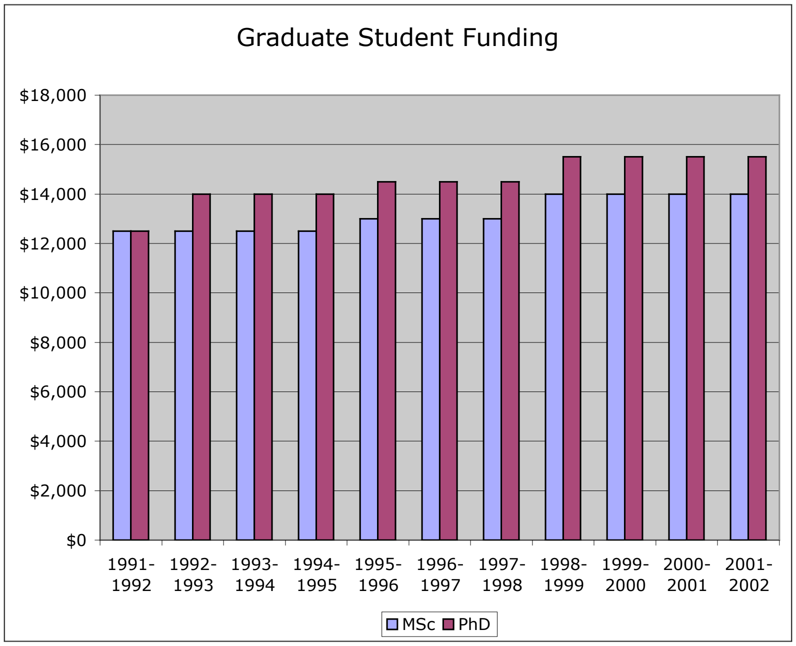

Figure 8: Graduate Student Support 1991 - 2002

Our current graduate student support is made up of three components, a scholarship from the School of Graduate Studies for suitably qualified students, the supervisors research grant and a teaching assistantship. The amount of each component is given in the Table 1 below for both MSc and PhD students.

	Scholarship	Supervisor	Teaching Assistant
MSc	$6750	$5750	$1500
PhD	$8250	$5750	$1500

Table 1: Composition of graduate student support

The scholarship is paid from a fund provided by the School of Graduate Studies (SGS). Currently the SGS provides a baseline funding of $89.1K to the Department. While the SGS has been very receptive to increasing the Department's baseline funding to allow it to make an offer to a particularly well-qualified student, any substantive increase in the scholarship component would mean fewer scholarships for our students. Also the SGS limits the time for which an award can be held; 2 years for an MSc, 3 years for a PhD with an MSc and 4 years for a PhD without an MSc.

The teaching assistantship is paid at the rate of $13.63 per hour. This translates into a $750 unit, which requires 55 hours of teaching. Presently the students are guaranteed 2 units of teaching, however some supervisors "buy out" a student's teaching component to allow them to devote more time to their research. The amount the Department makes available through teaching assistantships is limited by budget, the hourly rate and the amount of teaching we can reasonably expect a graduate student to undertake without extending the time taken to complete his or her graduate program.

Involvement in Governance

A graduate student representative sits on the Departmental Graduate Studies Committee. Undergraduate students, while they do not play a formal role in governance of the department, are consulted from time to time either through the physics students' society or through formal meetings. For example, when new faculty are being interviewed both undergraduate and graduate students are given the opportunity to meet with candidates and provide comment to the search committee. Undergraduate students are also surveyed to determine the potential demand for more specialized courses when course offerings are being planned for a given semester.

Undergraduate Post-graduation activities

The survey carried out by CIAP indicated that 72% of our former undergraduates had found employment after graduation. Of these 86%, were employed full time, while 53.3% indicated that a physics degree was a requirement for their job. In addition 46.7% indicated that the program specific skills they acquired during their study were closely related to their current job, while 53.4% indicated that the general skills acquired during their program were closely related to their current job. Encouragingly 86.7% of the students surveyed felt that the physics program prepared them either "very well" (30%) or "somewhat" (56.7%) for employment.

While the survey revealed our graduates pursued a wide range of occupations following graduation, they were most frequently employed in the academics/education sector (15/30), information technology (5/30) and government (3/30).

In addition to the survey carried out by CIAP the Department compiled a list of 27 Honours graduates from the period 1995 to 2003 that gives the status of the students following graduation and their current status where known. The list of Honours graduates students and their post graduation status is presented in Appendix 2. Of the 27 Honours students all but one went on to pursue graduate studies. The one exception is currently a High School teacher. At least 11 of the 27 are pursuing or have completed doctoral studies.

Graduate Post-graduation activities

The CIAP survey also examined the post-graduation activities of our former graduate students. The survey identified 24 graduates of a M.Sc. or Ph.D. program between 1995 and 2002. Unfortunately, the results of the survey are of limited value as only 4 surveys were successfully completed and the survey omitted to include any of the former graduates from our Physical Oceanography programs. Of the four students who completed the survey, two were employed in academia. To provide some information regarding the post graduation status of our former graduate students, the Department complied a list of post-graduation status of the 36 students who graduated from our graduate programs during the period 1995-2002. The list is given in Appendix 3.

Of the 16 PhD graduates, 4 have tenure or tenure-track positions at a University, 5 are research scientists at government or industrial research laboratories, 3 have professional positions in either industry or academia and two are post-doctoral fellows. The status of 2 are unknown.

Of 20 MSc graduates listed in Appendix 3, 1 has a tenure-track position at a University, 6 are professional scientists, 7 are pursuing doctoral studies and 2 are IT professionals. The status of 4 are unknown.

Undergraduate Teaching Activity

The department offers a range of courses designed to give students a physics education having both depth and breadth. Our first year courses provide a solid grounding in the fundamentals of physics that prepares students for programs in engineering, the life sciences, and physical science. The second year program explores key areas of physics more deeply. Many of our senior level courses maintain a focus on the core areas of physics – electromagnetism, thermal physics, quantum and classical mechanics, experimental and mathematical physics – while others explore branches of physics such as fluid mechanics, oceanography, astrophysics, photonics and solid state physics. Our Honours program includes a two-semester thesis course that introduces our students to the challenge of original research and allows them to apply their knowledge and skills to problems of current scientific interest.

Undergraduate Programs Offered

The department offers a general and honours degree in Physics as well as three joint major programs, five joint honours programs, and a minor in physics. In many cases the joint programs were developed in response to student demand, and we have made it clear to interested students that we are willing to tailor a program to match their interests. A complete list of all of the courses that we offer together with degree programs available is given in Appendix 4.

Our current undergraduate curriculum reflects a major review that was carried out in the early 1990s, and since then has been continually fine-tuned to meet the needs and demands of students. We recently relaxed many of the prerequisites required for our senior courses to give students more flexibility in scheduling their program, and to make it possible to complete an honours degree in four years. Such flexibility also allows the Department some choice in the courses that must be offered each year. We believe these changes have contributed to increased enrolments in our senior courses and an increase in the number of majors.

At first year we offer an algebra-based stream (1020/1021), for which somewhat less physics background is required, and a calculus-based stream (1050/1054). Physics 1054, a hands-on computer-based course developed by this Department just a few years ago, is common to both streams, so 1020/1021/1054 is considered equivalent to 1050/1054.

A physics minor requires first year, our four primary second year courses (2053/ 2054/2055/2056) plus two additional physics electives. This program has been reasonably successful in attracting students, stabilising at around 20 students (Fig. 5).

The majors program requires 13 physics courses beyond first year, some of which are prescribed and some of which are chosen from a list of electives, plus 4 courses in mathematics. The physics major is intended to provide a general education in physics and its applications, along with the ability to tackle complex problems, to think creatively, and to communicate effectively.

The honours program is more demanding, and somewhat less flexible. It requires four courses in mathematics plus 19 physics courses beyond first year, including at least four 4000-level courses plus the honours thesis. The honours program is designed to prepare students for graduate programs in physics, and indeed, as the data presented in Appendix 2 show, of the 27 Honours students who have graduated since 1995, all but one has gone on to post graduate study.

In addition to the existing physics honours and majors degree programs the Department recently submitted a proposal for an honours and majors degree program in Environmental Physics. This program builds on the Department's existing strengths in Oceanography and Environmental Science and related courses offered by the Departments of Geography, Earth Science and Biology. Details of this proposed program is presented in Appendix 5. If approved this program will be available to students in September 2003.

Student Demand and Enrolment in Undergraduate Physics Courses

In examining the factors that determine the demand for and the enrolment in our undergraduate physics courses it is useful to consider the introductory courses and senior physics courses separately. In the case of the introductory courses the bulk of the enrolment is service teaching and includes not only students who plan to major in the physical sciences and engineering but also a large number of students in the life sciences. Maintaining a healthy enrolment in these courses requires that the department pay attention to timetabling issues, provide adequate "seats", ensure that the level of the courses is appropriate and that the quality of instruction is of a high standard.

As the data in Figure 1 shows enrolment in our introductory physics courses has risen from around 1,500 in 1995 to around 1,750 for the period 1997 – 2003, with the exception of 2001/2002 where enrolments dropped to just above 1,500. Figure 9 shows a comparison between enrolments in 1000 level courses for both physics and science normalized to 1995/1996 enrolments for the period 1995 to 2000. The data shows that enrolment in our introductory (1000 level) courses has increased in this period while the overall enrolment in the Faculty of Science has decreased. We have been unable to obtain comparison data beyond 2000/2001.

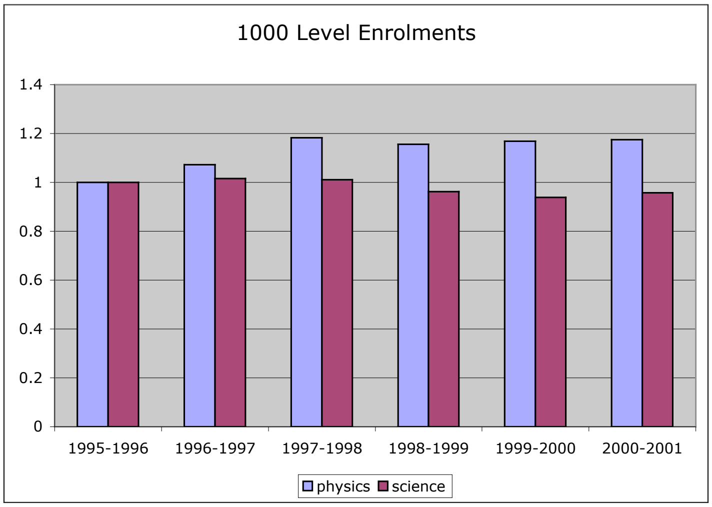

Figure 9: Comparison between enrolment in introductory physics courses and aggregate enrolments for all introductory (1000 level) science courses 1995 – 2001. Enrolments are normalized to 1995 – 1996 levels.

The enrolment data for physics presented in Figures 2 and 3 show a steady increase in our senior level course enrolments, rising from a low of 387 in 1999/2000 to 619 in 2002/2003, and in the number of physics majors, rising from a low of 48 in 1999/2000 to 70 in 2002/2003. The decline in our senior course enrolments and physics major prior to 1999 reflected a general trend within Canada and the United States, which has seen a steady decline in the number of physics majors and physics degrees awarded over the last decade.

The Department recognized this decline in our student numbers and implemented a number of steps to correct it. These measures, discussed in detail elsewhere in this report, include:

- Curriculum changes
- Improved student advising and mentoring
- Integrating undergraduates more fully into research programs
- Faculty renewal
- Introduction of a physics minor
- Introduction of new degree programs, such as Environmental Physics.

While it is overly simplistic to attribute improvements in our senior course enrolments and the number physics majors entirely to effectiveness of the measures listed above, we are nevertheless encouraged and believe that our efforts have played critical role in reversing the downward trend in our undergraduate programs.

While the upturn in our undergraduate enrolments is encouraging there are, nevertheless limits to what we can reasonably expect in terms of majors and graduation rates, based on comparable figures at other universities in Canada and the US and our previous experience. From these considerations, we can identify targets for enrolment and graduation rates in our undergraduate programs:

- As stated earlier the annual graduation rate of physics students in Canada is approximately 12, rising to 16 at larger Universities. In the US there are only a dozen or so Universities who graduate more than 20 physics students annually. Therefore while the department seeks to increase the numbers of physics degrees awarded annually, it is perhaps unrealistic to expect an annual graduation rate in excess of 20 students.
- Assuming a graduation rate of 20 students annually and that the time to completion remains at approximately 5 years we could expect the number of majors in the program to vary between 75 to 100 students throughout the course of the academic year.
- While our senior level courses are designed primarily for students majoring in physics, there nevertheless exists considerable scope to increase enrolment in these courses by providing for non-physics majors. It is not unreasonable to aim for an increase in the total enrolment in our senior level courses from its current level of approximately 620 to its 1995 level of 850.

Obviously to maintain the current growth of enrolment in our senior level courses and our graduation rates requires resources, most importantly, research active faculty and an adequate budget. It is also critical that the department continue to foster a culture in which excellent teaching is valued and that the expectations for faculty, staff and teaching assistants, reflect this.

Undergraduate Program Delivery

In order that the Department provides quality undergraduate programs while maintaining the research productivity of faculty, it is essential that we deliver our programs in an efficient and cost effective manner. This has been a particular challenge as faculty numbers have declined and departmental budgets have been cut.

Introductory Physics

The class size in our introductory physics courses, 1020, 1021 and 1050, has increased in recent years and typically ranges from 100 to 270. Despite this increase in class size, failure and attrition rates in these courses have remained low. Indeed, the grade distribution, failure rates and attrition in the large enrolment sections were indistinguishable from concurrent low enrolment sections while the Course Evaluation Questionnaire results were in fact better for the large enrolment sections.

While our experience indicates that it is possible to maintain the quality of these critical courses with large enrolment lecture sections it requires a careful deployment of resources. The courses must be taught by experienced and motivated instructors, and require the effective and creative use of our teaching support staff, student teaching assistants and computer based technology and resources where appropriate.

Senior Level Courses

At the senior level our first priority in program delivery is to ensure that we provide our students with courses that cover the core areas of physics at an appropriate level and in such a way that they can graduate in a timely manner. We also regard it as important that we allow our students some flexibility in their course selection so that their degree program can reflect their interests and abilities. To accomplish this goal, within our current faculty complement, we have identified several of our senior courses that can be offered in alternate years or as demand and resources permit. This has required that we relax our prerequisite structure and make some of our senior courses more self–contained. We also have arrangements in place with the Department of Mathematics and Statistics and the Faculty of Engineering to "cross-list" courses and share in the teaching of them. While these changes have not been without problems, and require careful planning, it has meant that the enrolments in our senior level courses are maintained at a more acceptable level, without compromising the viability and integrity of our Honours program.

Innovations and Enrichments in the Undergraduate Program

Over the last decade the Department has sought to improve the quality and scope of its undergraduate programs through innovation and enrichment. Prominent among the innovations has been the department's efforts to introduce the scientific applications of computing within its undergraduate program. The Department has sought and obtained funding for several such initiatives in our undergraduate programs and we provided UNIX-based X-windows and PC-systems to our undergraduate students long before such services were common at Memorial. The department also hired a full time programmer/consultant to support academic computing within the Department. This allowed the department to provide all our majors with computer accounts and access to necessary resources such as printers, specialized software integral to modern physics research (e.g. Matlab, Mathematica and Maple), email access and to expand the use of computers in the senior undergraduate laboratories. There are now two full-time personnel who support academic, administrative and research computing within the Department.

In 1997, the department extended the use of computers to our introductory programs with the introduction of Physics 1054. This course makes use of computers to combine the traditional lecture, laboratory and tutorial format into a single integrated unit. This approach had been pioneered in a number of departments in the US with considerable success. The course incorporated a number of, what at that time were innovative techniques: computer based data acquisition as well as the use of the web and power point delivery of the underlying theory associated with each activity[4].

Our experience with the studio format used in Physics 1054 has demonstrated that computer-interfaced experiments and tutorials can be used to create an effective and engaging learning environment for the students. The Department has recently renovated and re-equipped its existing first year laboratories and is currently in the process of replacing the traditional weekly tutorial and laboratory experiment with a more diverse learning experience that combines tutorials and demonstrations to complement the large lecture sections. These changes will allow us to make more effective and creative use of existing support staff and student teaching assistants.

The department has also recently introduced the CAPA system of online assignments, which is widely used in physics departments throughout North America. This system provides each student with a unique set of questions and allows multiple attempts to answer them. Our experience with it thus far has been very positive. Not only does it offer a more convenient format to the student than the traditional assignment, but, more importantly it provides the student with instant feedback, reinforcing concepts as they are covered in the course. In addition the CAPA system also has the advantage of relieving the instructor of many of the logistical problems associated with distributing assignments and collecting, marking, recording and returning solutions.

The Department also operates the Physics help centre. This is a conveniently located room staffed by faculty, laboratory staff and undergraduate students. Faculty have noted a healthy synergy between the CAPA assignment system and the use of the Help Centre. Several microcomputers are located in the Help Centre so that students can access their CAPA assignments online. The Help Centre is open from 9:00 am until 5:00 pm throughout the semester and is extremely popular with the students.

Outside of our introductory programs, the primary enrichment to our students has been through summer employment in the research laboratories. While some students are supported by NSERC Undergraduate Student Research Awards (USRA), and come from universities across the country, we do also employ students from other federal employment programs and directly from research grants. All honours students are given the opportunity to spend a summer active in research.   While some students do come from other countries (e.g. France) most of the students have been from Memorial or other Canadian universities.

We have worked to make the department an open environment for all our students and to encourage them to take advantage of the facilities and people here. We have been working over this past year to expand our seminar program. We have encouraged

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[4] A detailed description of the design and implementation of this course is described in *Expanding the role of computers in physics education: a computer-based First-year course on computational physics and data analysis* John R. de Bruyn *et al* Can. J. of Phys. **80**, 855 (2002)

students to attend regional and national student conferences and have had them practice their talks on a local, friendly audience. Honours students also give talks on their projects to the department and talks by students are a standard component of many senior courses. The Department has also recognized the importance of developing students' writing skills. Several courses, from introductory level (Physics 1054) to senior level (Physics 3900), incorporate written reports as part of the evaluation scheme.

The Department makes use of research resources to enrich the undergraduate programs in other ways. Students in the Introductory and the Advanced Oceanography classes each spend half a day on the 115ft university ship, the Lauzier, learning about oceanographic instrumentation and data collection. A cruise is run from the harbour that involves students getting hands on experience with ships and with the water sampling instrumentation used in oceanography research programs. In the future we hope to make use of the recently opened Bonne Bay Oceanographic Observatory. We have also worked to provide students access to high-performance computational facilities within the department (at the CVC and in physical oceanography). Students are also encouraged to attend Departmental research seminars, over and above those sponsored by the Canadian Association of Physicists and the Atlantic Provinces Council on the Sciences, which are specifically designed for undergraduates.

The Department has worked diligently over the past decade to enhance the physical resources available to students. We have renovated, on our own initiative and in one case with our own funds, two classrooms (C2045 and C3067), one designed for our first and second year students (C2045) and the other for our senior level courses (C3067). These rooms have enabled us to better offer our courses and to take better advantage of new educational media.

As discussed previously, the Department has introduced a number of new programs, for example the physical oceanography and earth sciences joint honours program and the program in Environmental Physics. The Department has considered further extending its degree programs with the introduction of a program in Computational Physics that would complement our research strength in this area.

The Department also provides the physics majors with a study space in the physics reading room (C3002), a small office for the physics society (C3063) and a study room for our Honours students (C3030). In addition to providing our students with space to study and socialize these resources give the students an important focal point within the Department and encourages an important sense of community amongst our undergraduates.

The Department has also worked to accommodate students with disabilities in laboratories, lectures and exams. In 1994 the Department was awarded the 1994 Glenn Roy Blundon award in recognition of their work in disability accommodations.

Cooperation with other Academic Units

Because of the nature of our undergraduate programs and courses the Department is obliged to cooperate widely with other Departments and Faculties at Memorial. In working with other departments we also try to adjust the scheduling of courses to optimize the fit to the students' varied schedules.

We also work collegially with other departments to develop Joint programs, both general and honours, in response to the demands and needs of students. We also assist interested students in preparing for the Diploma program in meteorology at Dalhousie University.

Undergraduate Service Teaching

Introductory physics is required for most degrees in Science and for Engineering, so much of our first-year teaching can be considered as service teaching. Our "calculus" based introductory courses, Physics 1050 and Physics 1054 are required for students in Biochemistry, Chemistry, and Applied Mathematics. There are roughly 150 students in this stream. Physics 1050 is offered in the fall semester, while Physics 1054 is offered in both the fall and winter semesters. The algebra-based courses Physics 1020 and 1021 are required for students in Biology and Engineering. These courses typically have total annual enrolments in the range 800 ~ 900. Due to the high demand for these courses, Physics 1020 is offered in both the fall and winter and Physics 1021 in all three semesters.

One peculiarity of our first year service courses is that engineering requires only the algebra-based courses and not the calculus-based courses. We have discussed this matter in the past with Engineering and we recently presented a proposal to them, which would see the entrance requirements for engineering changed to include calculus-based introductory physics.

Beyond first year, Physics 2054 (electromagnetism, light and optics) is required for students in Chemistry, while 2054 and Physics 2055 are prerequisites for some of the senior-level Geophysics courses offered by the Department of Earth Sciences.

We currently teach two senior-level courses that are part of the Engineering program. We have taught Engineering 3821 (Circuit Analysis) jointly with Physics 3550 (Electric Circuits) for the last three years, and Physics 4300 (Advanced Physical Oceanography) is a required course in the Naval Architecture Program. This arrangement has worked out well and is of considerable benefit to the students. This summer, for the first time, we are offering Physics 3551 (Digital Electronics) jointly with Engineering 4854. We believe that there are a number of other courses that, with some flexibility, could be taught jointly with other units, particularly in Engineering.

A course in Fluid Dynamics (4205) was jointly developed with Mathematics and we now alternate teaching that course. Many courses at the 3000 level are taken by students from other disciplines, in particular such courses as Astrophysics (3150, 3151), Physical Oceanography (3300, 4300) and Photonics (3600).

Program Requirements External to the Department

All of our programs require students to take courses offered by other Departments. These courses include introductory Chemistry 1050 and 1051, and several mathematics courses, Mathematics 1000 and 1001 (differential and integral calculus), Mathematics 2000 (multivariable calculus and sequences and series), Mathematics 2050 (linear algebra), Mathematics 3260 (ordinary differential equations) and Mathematics 3202 (vector calculus). The specific content of the mathematics courses is particularly important, as they are prerequisites to many of our senior level physics courses.

As the size of our faculty complement has shrunk over the last decade our Department increasingly looks to courses offered by other Departments or courses that could be offered jointly with other Departments as a way of expanding the options available to students while minimizing the number of courses the Department must offer in a given academic year. This requires considerable care and cooperation with the other Departments involved. An excellent example of what can be accomplished by this type of cooperation is given by our arrangement with Engineering whereby we teach Physics 3550, combined with Engineering 3821, and the Engineers teach Engineering 4854, combined with Physics 3551 (Digital Electronics). This has the advantage of providing our students with an additional senior level course (Physics 3551) that the Department has been unable to offer in recent years. Another examples is the degree program in Environmental Physics, which the Department plans to offer in the next academic year. This program builds on strengths within the Department and our existing courses, but also draw extensively on courses offered by Biology, Geography and Earth Sciences. This has allowed the Department to create exciting new degree programs with a minimal increase in the number of courses it has to provide.

Joint Programs

Many of our majors are enrolled in joint programs, both joint majors and joint honours. The Department has collaborated with other departments in the Faculty of Science to develop a number of these programs, often to meet the needs of an individual student. To be successful these joint programs, require a considerable degree of cooperation between departments. The course content has to be reasonable and scheduling conflicts resolved to create a program that is viable and appealing to students. Typically these programs are taken by the more capable students and represent an excellent preparation for students who wish to pursue post-graduate research. The Department encourages these students to pursue joint programs and, through the Deputy Head (Undergraduate Studies), the Department works closely with the students to resolve difficulties, particularly scheduling problems that may arise.

Student services and communication

We make an effort to contact students through different routes. At first year, we have developed an approach to help students with scheduling problems register in appropriate courses. One faculty member is available for consultation and there is a mechanism for students to request slot changes that minimizes confusion and optimizes course availability. We have an information night each semester for any students interested in physics. This is an informal event that provides the students the opportunity to talk with faculty who attend (typically 6-7). In the fall we focus more on the programs while in the winter we focus more on research activities of the department and summer opportunities for students. Several faculty take on advising duties, but students may consult any advisor with whom they feel comfortable. The Deputy Head (Undergraduate) takes the lead in providing student advice and ensuring that students are fairly treated in the department. The position has evolved to include aspects of departmental student ombudsman, responding to any concerns raised by students regarding their courses or program. The Department has also developed a student guide that is available on the web or as a 19–page booklet. In addition the Department also provides information on departmental activities (e.g. new courses, future course offerings, teaching assignments, etc.) on our departmental web page.

Indicators of Teaching and Program Quality

In the Fall 2001 the University introduced mandatory course evaluations. The results of the Course Evaluation Questionnaires (CEQ) are provided to the instructor and the Head of Department. In addition a summary report with aggregate results for courses taught by the Department and another with the aggregate results for all courses taught at the University are made available to members of the Department[5]. This allows faculty to compare the results for their courses with the aggregate results for the Department and the University.

The aggregate CEQ results for the Department and the University for the Fall 2001 and the Winter 2002 semesters are presented in Appendix 6. The results show that while the aggregate scores for questions 1 – 8 are slightly less for the Department than those of the University as a whole, the difference is in most cases statistically insignificant. While the interpretation of these results is controversial they nevertheless indicate a degree of student satisfaction with our courses.

The student survey carried out by CIAP also asked graduates about their level of satisfaction with our undergraduate programs. The results indicate a fairly high level of satisfaction with the curriculum and the quality of the instruction provided. Indeed 80% of the students surveyed agreed with the statement that they would recommend a Physics program at Memorial to others.

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[5] Courses with less than 10 students are CEQ exempt and are therefore not included in the aggregates.

Another indicator of the quality of our Honours program is provided by the data included in Appendix 2 that shows that all but one of our Honours students, who have graduated in the last 7 years have gone on to post-graduate study.

Graduate Teaching Activity

The Department offers MSc and PhD programs in both Physics (Condensed Matter Physics and Atomic and Molecular Physics) and Physical Oceanography. There is essentially no overlap in the course requirements for degrees in these two areas, so the department must offer two distinct streams of graduate courses. The Department also participates in interdisciplinary Master's programs in Computational Science and Environmental Science.

Graduate Programs Offered

The Department offers M.Sc. programs in Physics and a separate M.Sc. program in Physical Oceanography. It also offers Ph.D. programs in Condensed Matter Physics, Atomic and Molecular Physics and Physical Oceanography.

The principal component of all our graduate programs is the thesis which has as its basis original research and review of the current literature in an area of physics. The MSc thesis is examined by two internal examiners appointed by the School of Graduate Studies on the recommendation of the Department Head, although in practice it is the Deputy Head (GS) who makes the recommendation. The examiners submit their reports to the School of Graduate Studies. While there is no formal thesis defence, it is required that the student present a seminar describing their research prior to submission of the thesis.

The expectations for PhD theses are far more demanding and require that the student make a significant contribution to an area of current research in Physics or Physical Oceanography. Almost without exception students have published parts of their graduate research in peer reviewed Journals and there is the expectation that on completion of a PhD a student will not only have carried out original research but have demonstrated sufficient knowledge and expertise to initiate research projects.

The PhD thesis is examined by three internal and one external examiner, who are appointed by the School of Graduate Studies on the recommendation of the Department Head, normally on the advice of the Deputy Head (GS). The thesis examination also includes an oral defence of the thesis. This consists of a public presentation of the content and principle results of the thesis, followed by an oral examination, from which the public is excluded. Current practice requires that the external examiner attend the thesis defence.

Both the Physics and the Physical Oceanography MSc require students to take four graduate courses. The PhD programs in Atomic and Molecular Physics, Condensed Matter Physics and Physical Oceanography, require three additional courses, in the case of a student with an MSc. For a student without an MSc degree the course requirements are determined on the basis of the student's academic background. The PhD also requires that the students pass a comprehensive exam. This is generally taken in the second or third year of a student's PhD program once they have completed their coursework and their proposed research program is well defined.

In addition to the graduate programs offered by the Department, faculty also participate in and supervise graduate students in the Environmental Science and Computation Science MSc programs[6].

Student Demand and Enrolment in Graduate Courses.

As Figure 6 shows our graduate student enrolment declined from around 30 in 1995/1996 to its current value of roughly 20. This decline in enrolment after 1995/96 can be attributed to a combination of factors: the decrease in the number of applications, the departure of a few very active faculty members, the untimely death of another, increased competition for limited NSERC resources and concomitant uncertainty about future funding. Many of these problems are now behind us: the Department has recently hired a number of active new faculty, and is currently in the process of hiring more, and research funding is at least stable. There are also signs that the overall number of students entering graduate school in physics is now starting to rise, and we are confident that our graduate enrolment will increase again over the next few years. The goal for our Department is to increase our graduate enrolment by 50% over the next three years.

Enrolment in graduate courses is naturally lower than in undergraduate courses. The impact of this on our teaching requirement is compounded by the need to offer two distinct sets of courses to support our two areas of graduate study. Typically our core graduate courses are offered every other year so that the enrolment consists of two cohorts of students rather than one. While the number of courses varies considerably from one year to the next, as a consequence of fluctuations in graduate student numbers and the availability of faculty, we have offered an average of 5.5 graduate courses per year over the last 7 years. The number of graduate courses offered in each academic year, over the period 1991 to 2002, is shown in Figure 10.

[6] Details of these programs are available from the program websites www.esd.mun.ca/environment.html and www.mun.ca/sgs/prospectus/framecomputational.html.

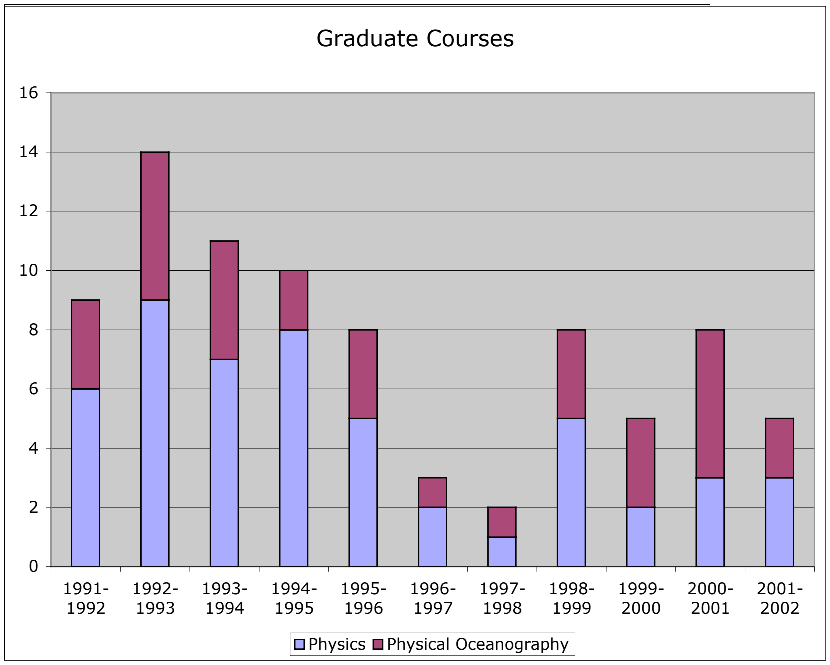

Figure 10: Graduate course offered annually in period 1991 – 2002

Courses with only one or two students – typically specialized advanced courses – are normally offered as reading courses. Graduate lecture courses in Physics typically have enrolments of five to ten, although smaller sections are sometimes unavoidable. Graduate Physical Oceanography courses have enrolments that range from two to five, the larger numbers coming in courses that are also taken by students from other departments.

While the Department must offer the core courses needed by the students to complete their programs in Physics or Physical Oceanography, we also try to offer a range of more specialized courses to meet the needs of more advanced students and to provide training in particular areas. Given the demands associated with the undergraduate program, we do not have a lot of flexibility in the assignment of graduate teaching, but we do try to respond to requests from students for courses on important topics.

Innovations and Enrichments in Graduate Programs.

The Department is continually developing new courses in response to student needs, emerging areas and the availability of expertise in the Department. Recent example include:

- Physics 6363: Laboratory Experiments in Geophysical Fluid Dynamics
  This course consists of a combination of lectures and laboratory experiments in Geophysical Fluid Dynamics, in which students are introduced to a variety of

techniques to visualize and analyse complex fluid flows and how to scale real phenomena to the laboratory.

- Physics 6001, Theory of Solids II
  This course is generally tailored to meet the needs of the students taking it in a given year. In its most recent offering, it included material on chain-like molecules, both polymers and lipids, and their condensed phases. A more extensive version of this material was a core component of an earlier special topics course, Functional Integral Techniques in Condensed Matter Physics.
- Physics 6324: Models in Ocean Ecology
  This course is about models of ecological processes that control marine animal populations with planktonic stages. The approach requires the integration of modelling and theory to study marine, physical and biological processes with application to marine ecological problems at the forefront of the current research literature.
- Physics 6800 Group Theory
  This is a course on group theory especially for physics students. Basic formalism is introduced and applied to point groups, space groups and Lie groups, with applications in quantum mechanics and condensed matter physics.
- Physics 6060: A Survey of Physics for Students of Philosophy[7]
  This course covered the development of physical concepts from late prehistory to modern times, in their institutional settings, with emphasis on the ideas of Aristotle, the Greek astronomers, the mediaeval scholastics, Copernicus and Galileo, Newton, and Mach, and the work of Faraday, Henry, and Clerk-Maxwell on electromagnetism, Einstein on special and general relativity, and with an introduction to the concepts and methods of modern quantum mechanics.

In addition to the courses offered by the Department, our Graduate Students also take courses from other departments (Mathematics, Chemistry, Engineering, Earth Science), where appropriate.

The Department is active in the interdisciplinary M.Sc. programs. Members of this Department were instrumental in establishing this M.Sc. program in Computational Science and two of our faculty (de Young and Zedel) have taught courses in the Environmental Sciences M.Sc. program. Several faculty have supervised students in these programs.

The School of Graduate Studies (SGS) also offers a mandatory Graduate Research Integrity Program designed to make explicit the implicit code of ethical conduct by which responsible research is designed, conducted, and reported. Several graduate students in our Department have also taken advantage of a non-credit programme in teaching for graduate students offered by the SGS.

[7] This course was offered at the request of several students in the M.Phil program.

The Department provides some financial assistance to graduate supervisors to assist their students to attend conferences and workshops. All PhD students and many of the MSc students will have been provided with the opportunity to present their work at a national or international conference before they graduate. In addition the Department offers a series of regular research seminars, in which graduate students are encouraged to participate. Unfortunately, budget cutbacks have limited the range and number of external speakers that the department has been able to bring in recent years.

Collaboration with other departments, schools, faculties, universities and colleges.

There are several ways in which the Department collaborates with other bodies in the delivery of its graduate programs. Many of our students take graduate courses in other departments (e.g., Chemistry, Math, Engineering, etc.), and conversely students from other departments have taken our graduate courses, particularly in Physical Oceanography. The interdisciplinary programs in Computational Science and Environmental Science necessarily involve our graduate students in interactions with students and faculty from other fields. Many of our Ph.D. students have a member of their supervisory committee from another department appropriate to the topic of their thesis research, and we make a point of inviting faculty from other departments to serve on Ph.D. comprehensive examination committees or to act as thesis examiners for our students. Colleagues from Earth Sciences, Chemistry, Biochemistry and the Ocean Sciences Centre, have interacted with our students in this way.

In addition, most members of the department have active research collaborations with faculty from other departments and other universities, and our graduate students are quite often part of these collaborative research efforts. They are thus exposed to people and research from other areas including Chemistry, Math, Biology, Biochemistry and Earth Sciences. Our students have spent time at other universities (Manitoba, Norway, Poland) as part of collaborative research programs. In addition our oceanography students have benefited from faculty collaborations with the Department of Fisheries and Oceans, and participation in GLOBEC.

Indicators of teaching and program quality.

The CIAP survey presented in Appendix 1 asked our current and former graduate level students a number of questions related to the quality our graduate programs. While the number of responses to both surveys was low (4 out of 24 previous graduate students and 9 out of 20 current graduate students) the results suggest that both our current and former graduate students are pleased with the program and the support they received.

Another indicator of the quality of our graduate program is reflected in the success of our students following completion of their graduate program as shown in data presented in Appendix 3, which shows the post-graduation status of the 37 students who graduated over the period 1995-2002.

Research and Creative Activity

Research in the Department of Physics, as it was originally called, began in the areas of geophysics, and atomic and molecular physics. In the early 1980's, we initiated new graduate programs and research in physical oceanography and condensed matter physics. Around this time, the geophysics group merged with the Department of Geology to form a Department of Earth Sciences. Since then we have concentrated on developing clusters of expertise in condensed matter physics and physical oceanography, hence the renaming of the Department to Physics and Physical Oceanography. These areas, along with existing strengths in atomic and molecular physics, optics, and numerical modelling, provide the foundation from which we are building our capacity to train highly qualified personnel that will be required to meet provincial and national targets in areas of emerging scientific and technological importance.

Research in the Department is highly collaborative with much interaction between individuals and groups. We have worked to enhance the complementary elements of the different research subdisciplines by encouraging the common threads of interest between the identified research groups. For example, computational simulation and modelling has grown substantially as an active area in oceanography and condensed matter physics and has led to the development of a new MSc program in Computational Science. Laboratory fluid mechanics is also actively pursued in both oceanography and condensed matter with research underway in low Reynolds number flow and rotating fluids. Materials science encompasses Departmental activities in condensed matter, molecular physics and fluids research and also reaches across to the Faculty of Engineering. Studies of large, complex systems, as diverse as lipid bilayers, magnetic thin films, correlated electron materials and ocean ecosystems are increasingly identified as an area of common interest. Understanding of complex systems, on scales ranging from the microscopic to the geophysical, is inherently interdisciplinary and collaboration with colleagues outside of the Department, the discipline, and the University is growing.

Our particular blend of research has enabled the Department to contribute in several areas of emerging importance. Activity in Physical Oceanography is directly relevant to issues of climate change and ocean ecology. The importance of condensed matter physics to Canada and Canada’s internationally competitive position in this discipline has been demonstrated by the success of this discipline in the two most recent NSERC Reallocation competitions and activity in this Department was specifically noted in the CAP-NSERC Review of Physics that preceded the 1998 Reallocation Competition. Work in these areas has enhanced the international profile of this province and continues to contribute toward the fulfilling of institutional, provincial and national strategic goals. In assembling research expertise, we have built from selected and largely complementary areas of strength. This has been an effective and efficient way to provide the university and the province with significant training and research presence in selected areas of scientific and technological importance and to maintain our capacity to participate in and appreciate emerging areas in a timely and significant way. This is particularly important given that satisfying the need for highly qualified personnel envisioned in Canada's Innovation Strategy will demand both regional and disciplinary balance.

Research Groups and Centres

While recognizing the thematic and technical links and overlap described above, it is possible to organize Departmental research activity into a small number of broad categories.

Physical Oceanography: (Afanassiev, de Young, Zedel). While fluctuating in size, the oceanography group has been able to generate a strong national and international reputation. Physical oceanographers within the Department are focused on interdisciplinary coastal, acoustical and numerical oceanography. This research has been very well funded and integrated with other units within the university and outside, e.g. the Department of Fisheries and Oceans, Dalhousie University, the University of Bergen, Memorial's Ocean Sciences Centre, and Memorial's Fisheries Conservation Chair. There is enormous potential to contribute to the development of a much broader initiative in marine studies within the university. The geographic focus of the research, primarily in the Northwest Atlantic, provides an opportunity for unique and socio-economically relevant studies that provide Memorial with a national and international identity. Significant efforts in Laboratory studies of fluid dynamics, both in Physical Oceanography and Condensed Matter Physics, help to bridge these areas and contribute toward the special character of the Department.

Condensed Matter Physics: (Andrews, Clouter, Curnoe, de Bruyn, Lagowski, Morrow, Quirion, Reddy (retired), Rich, Whitehead, Whitmore) The condensed matter physics group focuses on the physical properties of soft materials and materials in which the behaviour of components are strongly correlated. Strong correlations in materials can lead to such phenomena as superconductivity, magnetic ordering, reduced dimensionality, and structural phase transitions. "Soft matter" includes high molecular weight molecules such as polymers and lipids, complex fluids, and soft crystalline materials. The Department has developed a reputation in this area through a long history of experimental and theoretical studies of the fundamental structural, electronic, and dynamical properties of these systems, and of exotic physical phenomena that occur in them. Research in this area is often interdisciplinary, and members of this group collaborate with researchers in our Chemistry and Biochemistry departments, as well as with people from other universities. Significantly, the condensed matter group is active in over half of the 10 areas identified as strategic themes by the US National Research Council report on Condensed Matter and Material Physics. [These include nonequilibrium processes and the relationship between molecular and mesoscopic properties, soft condensed matter and the physics of large molecules including biological structures and the understanding of magnetism and superconductivity.]

Atomic, Molecular and Optical Physics: (Andrews, Clouter, Gien, Lewis, Reddy (retired), Rich) The Department has a long history of research in atomic and molecular physics, and spectroscopy. We have recently identified the rapidly emerging field of photonics as an area of research that would build on this historical strength and our continuing focus on condensed matter physics. We have recently hired one new faculty member in Optical Physics (Andrews). Given the range of application in this field and the significance of photonics in nearly all aspects of modern data communication and processing, this area of research provides potential for collaboration with engineering and computer science.

Numerical Simulations and Modelling: (Afanassiev, Curnoe, de Young, Gien, Lagowski, Lewis, Whitehead, Whitmore) Computation is a theme underpinning the research of many faculty in this Department. Members of the Department have been instrumental in establishing Memorial as a national and regional presence in high performance computing. We played a critical role in the creation of the recently established Memorial University Advanced Computation and Visualisation Centre (CVC), which is a node on the national computing infrastructure. Taken in combination, the CVC, Memorial's national visibility in this area, our MSc in computational science, our co-operative work across Faculties, and our research expertise in the area, provide a unique combination of current strength and opportunity.

Awards and Other Recognition

While the primary indicator of recognition for this Department's research has been its collective success in competition for research funding, some specific awards are noteworthy. Two of our members (Clouter and Gien) are University Research Professors. Two others (de Bruyn and de Young) have won the president's award for outstanding research while both Dr. Reddy and Dr. Morrow have been awarded the Dean of Science Distinguished Scholar Medal. Two (Curnoe and Lagowski) were selected as NSERC UFA's, and one (de Bruyn) as an NSERC URF. Dr. Zedel was awarded the Petro-Canada Young Innovator Award in 2001. A recent paper by Drs. Whitmore and Whitehead was recognized as the best condensed matter physics paper published in the Canadian Journal of Physics in 1998.

The *Observatoire des sciences et des technologies* (OST) analyzes outputs arising from investments in university research. In the 2000 edition of their report entitled *Canadian Universities' Performance in Research*, the *Relative Weighted Impact Factor* for Physics at Memorial is found to be 0.99 which is effectively at the defined national average of 1.00. Of the 26 Physics Departments rated, Memorial is tied with Waterloo at tenth. Comparable ratings (from 0.96 to 1.02) are reported for Physics at Laval, McMaster, Victoria, Ottawa, Sherbrooke, Dalhousie and Waterloo. In comparison with other science and engineering disciplines at Memorial, Physics' national ranking of tenth is second only to Earth Science, at eighth, and comparable to chemistry (at eleventh). For purposes of the OST comparison, output from the Physical Oceanography group in this Department is likely to have been assessed as part of the Earth and Space Science contribution from Memorial. In terms of *Relative Weighted Impact*, the OST observations indicate that research from this Department is nationally competitive.

Research Revenue

Members of this Department have pursued a broad range of funding opportunities and have been very successful at obtaining the resources to enable the research described above. Total external research funding for this Department for the period 1996 to 2002 is given in Table 2 below, together with the funding per faculty. The corresponding data for the Faculty of Science is also included in Table 2 for comparison.

Year	Total Funding (Physics)	Total Funding (Science)	Funding/Faculty (Physics)	Funding/Faculty (Science)
1996 - 1997	$1.39M	$8.71M	$73.2K	$40.5K
1997 - 1998	$1.39M	$10.06M	$81.8K	$48.3K
1998 - 1999	$1.52M	$12.50M	$95.0K	$60.1K
1999 - 2000	$1.39M	$13.12M	$77.2K	$62.8K
2000 - 2001	$2.79M	$17.73M	$155.0K	$87.3K
2001 - 2002	$2.62M	$18.82M	$154.0K	$94.1K[8]

Table 2: Aggregate research funding and funding per faculty for the Department of Physics and Physical Oceanography and Faculty of Science 1996 – 2002.

The total external research funding for each department in the Faculty of Science for fiscal year 2001/2002 is presented in Figure 11 below.

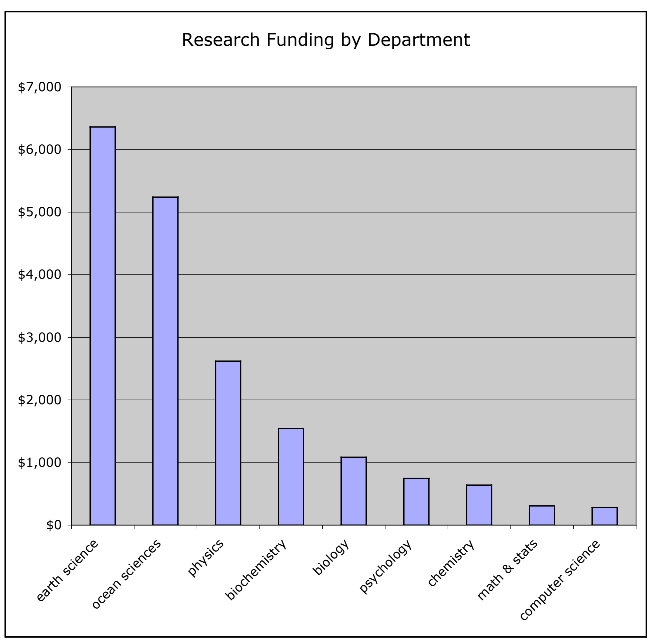

Figure 11: Total research funding by department for fiscal year 2001/2002

[8] This is estimated assuming 200 Regular Full-Time Faculty in the Faculty of Science

As of September 1, 2002, 15 of our 17 faculty members (including one retiree) hold NSERC research grants. Included in this group is every current member of the Department who was hired since 1970. Five grants are at or above the national average for the corresponding GSC. Total NSERC operating grant funding for the current year is $385,000. Other special project grants include a Strategic Grant ($675K in total funding this year), funding from the Canadian Space Agency ($43K), the US Office of Naval Research ($US 56K) and the National Research Council of Canada ($152K). The current grant support for faculty members, through the NSERC Research Grants program is given in Table 3 below.

Name	GSC	Amount	Year
Afanassiev, ID	EES	20,000	3/4
Clouter, MJ	CMP	36,750	4/5
Curnoe, SH	CMP	25,661	2/3
de Bruyn, JR	CMP	44,100	4/6
de Young, BS	EES	37,025	4/5
Gien, TT	GP	22,500	3/4
Lagowski, JB	CMP	28,350	4/4
Lewis, JKC	GP	12,000	1/2
Morrow, MR	CMP	36,750	4/5
Quirion, G	CMP	22,100	3/4
Rich, NH	CMP	10,500	4/4
Reddy, SP	GP	12,000	1/2
Whitehead, JP	CMP	25,000	1/4
Whitmore, MD	CMP	32,000	1/4
Zedel, LJ	EES	20,280	2/4

Table 3: NSERC operating grants currently held by Faculty[9].

Two members of the Department (de Young and Whitmore) have led successful institutional Canada Foundation for Innovation projects. Four others (Afanassiev, Andrews, Quirion, Zedel) have won CFI New Opportunities awards. These are major accomplishments in a province with no fund for matching money. A list of awards made under the CFI program are presented in Table 4 below.

9 CMP = Condensed Matter Physics (Average Grant $33.0K)
GP = General Physics (Average Grant $32.0 K)
EES = Environmental Earth Sciences (Average Grant $28.4 K)

Project	CFI Funding	Program	Date Awarded	Principal Investigator
Computer Visualisation Centre (CVC)	$679.8K	Innovation Fund	22/06/99	Whitmore
Bonne Bay Oceanographic Observatory	$1,797.0K	Innovation Fund	28/01/02	de Young
Low Dimensional Magnetic Systems	$42.9K	New Opportunities	12/10/02	Quirion
Oceanic-Atmospheric Fluid Dynamics	$94.5K	New Opportunities	05/12/02	Myers & Afanassiev
Ocean Accoustics Infrastructure	$50.5K	New Opportunities	06/08/98	Zedel
Brillouin Spectroscopy Analysis	$113.3K	New Opportunities	18/06/02	Andrews

Table 4: CFI grants awarded to Faculty

Drs. de Young and Whitmore have also led national projects. Dr. de Young was the national co-chair of a Research Partnership Program grant funded by both NSERC and the Department of Fisheries and Oceans. He also was one of the leaders of an NCE oceanography program, the Ocean Production Enhancement Network (OPEN), that in some ways was the precursor to GLOBEC. GLOBEC funding was about $6M over four years to more than forty principal investigators across the country at universities and government laboratories. Dr. Whitmore was the principal investigator on a multi-institutional NSERC MFA grant of $1.5 million over three years.

Connection Between Research and Teaching

The strongest links between our research and teaching occur at the graduate level. One of our defining characteristics, and at the same time one of our greatest challenges, is offering full graduate programs in both physical oceanography and condensed matter physics. Our interests in computational physics induced us to play the lead role in founding Canada's first interdisciplinary MSc degree program in computational science, and we also participate in the environmental science program. Offering a strong graduate program related to photonics is an emerging challenge.

Our research interests also have direct impact on our undergraduate courses and programs. We currently offer two undergraduate courses in physical oceanography, and a joint degree in physical oceanography and geophysics. Our advanced physical oceanography course is also taken by students in naval architecture. Our course in ocean acoustics has a direct connection to our research interest in this topic and has attracted interest from other units within the university (e.g. fisheries acoustics and engineering). The Department’s research interest in Physical Oceanography and the courses that are offered in that area provide the foundation for the proposed degree program in environmental physics.

Related to our interest in computational science, we have put substantial effort into the use of computers in undergraduate courses. As discussed previously in Section 4 we introduced an introductory physics course, Physics 1054, that integrates labs and lectures into a single format, and is held in a specially designed laboratory. We have also worked to include computational science into the second year courses (e.g. using Mathematica to solve circuit equations in 2055 and Matlab to solve differential equations in 3821). At the graduate level we teach courses in numerical modelling in oceanography (6318) and an interdisciplinary course in modelling in ocean ecology 6324) that has attracted substantial interest from outside the Department (with 10-12 students) and which is a direct result of our research in numerical modelling and ocean ecology. The Department is considering the possibility of combining these courses together with some courses from other Departments and a new senior level course in computational physics to provide the basis for an interdisciplinary degree program in Computational Physics.

Based on the Department's traditional strength in optics and its more recent focus on photonics the Department offers two senior level courses in Optics and Photonics. These courses combined with undergraduate courses in Solid State Physics, Electromagnetism, Modern Physics and Quantum Mechanics could provide the basis for an interdisciplinary degree program in applied optics and photonics, possibly in conjunction with the Faculty of Engineering.

We strongly encourage our undergraduate students to take part in research projects. All our honours students write theses, which receive two-course credit and often result in publications. We aggressively recruit NSERC summer undergraduate students, and provide generous supplements.

Professional and Community Service

One indicator of this Department's presence in areas of perceived strategic and scientific importance is the recurring participation of Department members on national peer review and reallocation steering committees.

- Drs. **Morrow**, **de Bruyn** and **de Young** have all served on NSERC grant selection committees and on disciplinary NSERC re-allocation steering committees. Drs. **de Young** and **Morrow** have served as GSC chairs.
- Dr. **de Young** has also served on NSF Review Panels, a major review panel for NERC (the UK version of NSERC) and as a founding member of NSERC Ship Time Allocation Committee.
- Dr. **de Bruyn** has served on several panels for NASA and is currently the chair of a NSERC MFA sub-committee for condensed matter as well as serving on a NSERC Major Equipment/Major Installation subcommittee.
- Dr. **Morrow** has also chaired two NSERC Major Facilities Access Grant subcommittees, and served a term on the Canada Council Killam Fellowship committee.
- Dr. **Whitmore** is a member of the Canada Foundation for Innovation Virtual College of Reviewers.

The Department's presence on these committees serves to enhance the Department's profile within the national scientific community as well as providing an opportunity to influence science policy within Canada. Also, many faculty regularly serve as referees for granting agencies and journals.

Our faculty also participate in a number of national and international scientific organisations and on editorial boards of scientific journals.

- Dr. **Whitmore** has served on the executive committee of C3.ca Association Inc. for a number of years, and on the board and executive committee of Genome Atlantic, Inc.
- In 1999, Dr. **de Bruyn** became a member of the Canadian International Union of Physics and Applied Physics (IUPAP) Liaison committee.
- Dr. **de Young** has served on international committees in International Council for the Exploration of the Sea (ICES - Cod and Climate Working Group) and the International Geospheres and Biospheres Program (IGBP – GLOBEC International Numerical Modelling Working Group and the Global Analysis Integration and Modelling (GAIM)).
- Dr **de Bruyn** is an associate editor of the Canadian Journal of Physics while Dr. **Clouter** is on the editorial board;
- Dr**. de Young** is an associate editor of the Canadian Journal of Fisheries and Aquatic Sciences.

Members of this Department have also been active in the organization of conferences and meetings.

- In 1994, Dr. **de Bruyn** organized an international conference on "The Geometry of Forms in Equilibrium and Nonequilibrium Systems". On the national level, he spent three years on the executive of the Canadian Association of Physicists Division of Condensed Matter Physics and organized a one-day symposium on "Patterns and Dynamics in Nonequilibrium systems" at the 1995 CAP Congress. As DCMP chair in 1996-97, he was a member of the CAP Congress Organizing committee.
- Dr. **Lagowski** was a co-organizer of the High Performance Computing in Chemistry Symposium that was part of the 79th Canadian Society for Chemistry Conference held at Memorial (June 23-26) 1996.
- In 1999, Dr. **Gien** organized an "International Symposium on Atomic Physics" in Hanoi, Vietnam. This was the first international conference on Atomic Physics ever held in Vietnam.
- Dr. **Whitehead** was a co–organiser of a special workshop on High Performance Computer Simulation of Cooperative Phenomena at HPCS 2002.
- As secretary of the CAP Division of Medical and Biological Physics and CAP Vice-President elect, Dr. **Morrow** has been involved in organizing sessions for the 2002 and 2003 CAP congress.
- Dr. **de Young** has chaired several national meetings in association with GLOBEC and OPEN and has co-chaired sessions at the American Geophysical Union.
- Drs. **Clouter** and **de Bruyn** were both members of the organizing committee for the 2002 conference on the Physics and Chemistry of Ice and Dr. **de Bruyn** is guest editor for the proceedings of that conference that will appear in the Canadian Journal of Physics.

In addition to various faculty member's involvement in the scientific community, members of the Department contribute to the local community in a variety of ways

- Dr **Zedel** has been a member of Natural History Society of Newfoundland and Labrador executive for last 10 years, serving as both president and vice-president. In this capacity he has been involved in involved in coordinating scientific reviews of the White Rose and Terra Nova oil development environmental assessments and is often contacted by the local media for information on conservation aspects related to offshore oil development.
- Dr. **de Young** has contributed, through voluntary scientific study and as a consultant, to community groups working on the clean-up of St. John's harbour.
- Dr **Zedel** has also participated in Marconi commemorative ceremonies for the last 5 years. This has involved radio interviews and coordinating radio (and other communication links) with Hobart Tasmania.

- Dr. **Morrow** and Dr. **de Bruyn** have both taught an enrichment minicourse for junior high school students. Dr. **Morrow** has also visited Prince of Wales Collegiate to give presentations on careers in science for collegiate career days and Bishops College to give presentations as part of their "Mole Day" celebrations.
- Dr. **Lewis** served as Secretary and then President of Memorial's Pensioners' Association from 1993 to 2002. In that period he participated in the University committees responsible for the management of Memorial's Pension Fund, and directed the writing of three reports to the University's Board of Regents on pension issues.

Departmental Organisation and Human Resources

Administrative Organisation

The administration of the Department is the responsibility of the Head of the Department, Dr. J. P. Whitehead, and the Administrative Officer, Ms. D. Corbett, who reports directly to the Head. The Administrative Officer provides Human Resource Management, Financial Administration and Material Management as well as administrative support to all academic areas dealing with graduate and undergraduate students. Administrative support is provided by the two general office staff, Ms. Simmons and Ms. Crocker and the Stores Clerk, Mr. Power, who report to the Administrative Officer. The Head is assisted by a secretary, Ms. Burke, the Deputy Head (Undergraduate Studies), Dr. Zedel, the Deputy Head (Graduate Studies), Dr. Lagowski, and the First Year Coordinator, Prof Walsh.

The Deputy Heads are typically appointed for a two-year term. The First Year Coordinator position was created last semester to assist the Head in dealing with the situation created by the recent retirement of five faculty who taught primarily at the first year level. The First Year Coordinator is appointed on a semester-by-semester basis and at present there is no plan to extend this position beyond the current academic year. Each position carries a modest stipend.

The Deputy Head (Undergraduate Studies) and the Deputy Head (Graduate Studies) chair the Departmental Undergraduate and Graduate Studies committees and have responsibility for many of the routine tasks related to administering our academic programs. In addition to these duties the Deputy Heads have in the past played a proactive role in formulating and implementing changes to Departmental policy as well as representing the interests of the Department within the Faculty and the wider University community.

The Department has been fortunate in having had some of our leading faculty serve as Deputy Heads. Not only does this provide much needed administrative assistance to the Head, but it also diffuses the decision making process among the faculty and helps ensure that the views of both faculty and students influence both the administration of the Department and the formulation of policy. The Deputy Head positions have also proved useful in providing continuity during changes in Headship.

The current administrative structure within the Department has changed little in the last twenty years. However, dramatic changes within the University environment, over that period have impacted substantially on the nature of the administrative functions within the Department. The duties of the administrative support staff at one time consisted of typing manuscripts, assignments and exams as well as maintaining student records manually. Most faculty now prepare their own manuscripts and instructional materials using personal computers. The implementation of the University's Banner Student and Banner Finance and the recently introduced computerized purchasing system have largely relieved the Department of the need to manually maintain extensive student and financial records.

These changes have substantially altered the tasks carried out by the administrative support personnel and resulted in the need for a far higher degree of computer literacy than was previously the case. As a consequence the administrative support positions have become more complex, requiring staff to adapt to more varied tasks as needs arise. With an increasing emphasis on providing a quality of service to faculty and students, the support staff must be well organized, demonstrate good interpersonal skills and be able to complete tasks with a minimum of supervision.

The introduction of the Collective Agreement, the increased complexity of Departmental finances and the downloading of many administrative functions to departments has meant that the duties and the responsibilities of the Department Head have also changed with time. In light of this and the changes that have taken place in the administrative function of the Department, consideration should be given to the efficiencies that could be achieved if the General Office, the Head’s Office and the Administrative Officer were more fully integrated both physically and operationally.

Reporting Structures

In addition to the administrative positions the Department also maintains a permanent staff of five plus two contractual positions to manage the undergraduate laboratories. A technical support staff of six, provide system support for the undergraduate, administrative and research computers, operate and maintain the cryogenics facility and machine shop and support the operation of the physical oceanography group. The reporting structure for departmental staff is presented in Figure 12.

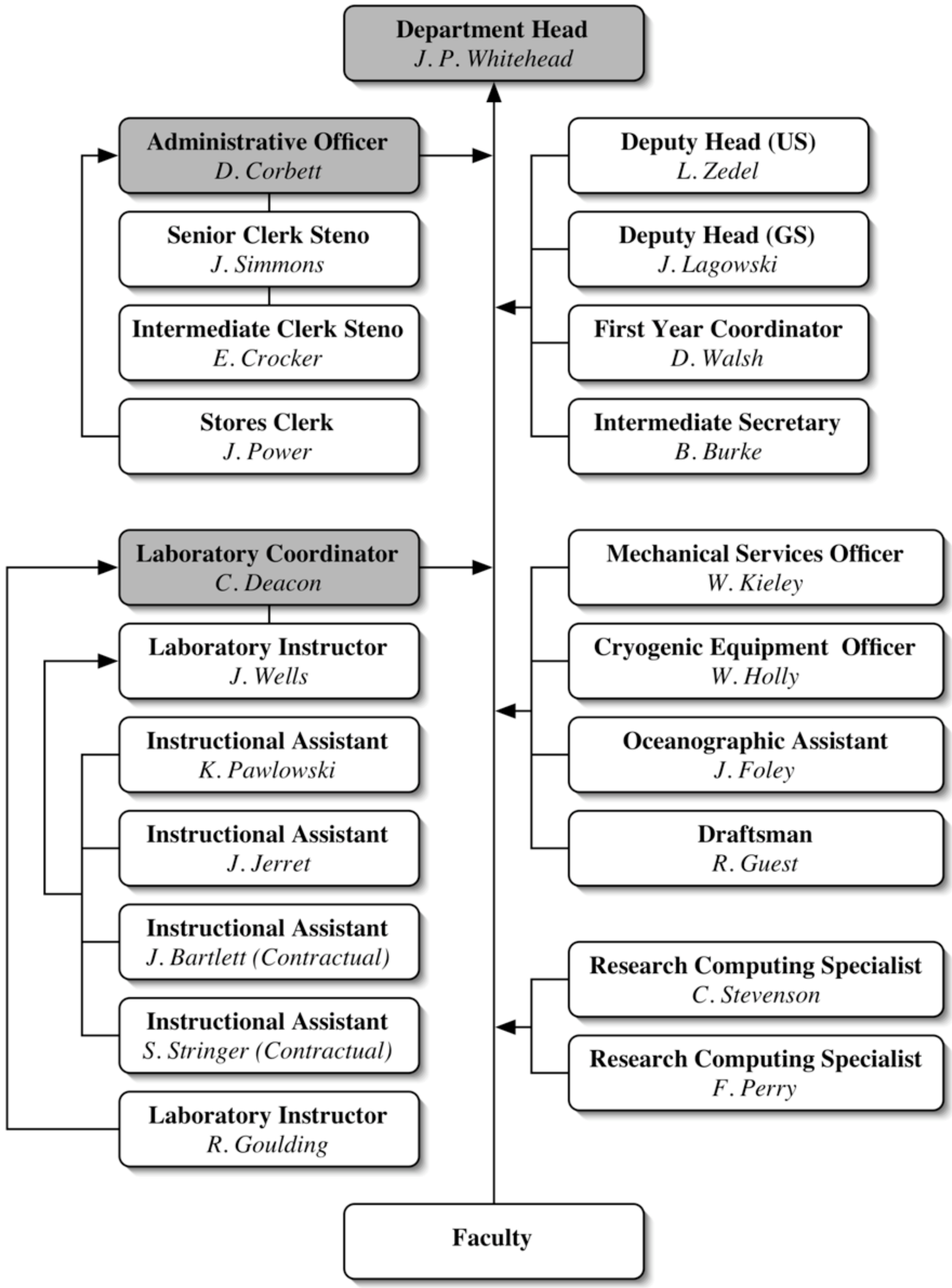

Figure 12: Reporting structure for Departmental staff

Faculty Information

The Department currently consists of 16 full-time tenured or tenure-track faculty. In addition we currently have two full-time teaching term appointments and two Emeritus Professors. A list of current faculty members and their qualifications is presented below.

Head

Whitehead, J. P., B.Sc. St. Andrew's, Ph.D. Alberta; Professor

Professor Emeriti

Cho, C. W., B.Sc. Seoul, M.A., Ph.D. Toronto

Reddy, S. P., M.Sc., D. Sc. Andhra, F. Inst. P. London, F.A.P.S.

Rochester, M.G., M.A. Toronto, Ph.D. Utah, FRSC; University Research Professor, Awarded 1986

Professors

Clouter, M. J., M.Sc. Memorial, Ph.D. Toronto; University Research Professor, Awarded 2000

de Bruyn, J. R., M.Sc. Queen's, Ph.D. British Columbia; Winner of the President's Award for Outstanding Research, 1996-97

de Young, B., B.Sc., M.Sc. Memorial, Ph.D. British Columbia; Winner of the President's Award for Outstanding Research, 1997-98

Gien T. T., Lic es Sc. Saigon, M.Sc., Ph.D. Ohio; University Research Professor, Awarded 2001

Morrow, M. R., B.Sc. McMaster, M.Sc., Ph.D. British Columbia

Rich, N. H., B.Sc., M.S. Maine, Ph.D. S. California

Whitmore, M. D., B.Sc., M. Sc., Ph.D. McMaster

Associate Professors

Lagowski, J.B., B.Sc. Manitoba, M.Sc., Ph.D. Toronto

Lewis, J. C., B.Sc., M.Sc. Carleton, Ph.D. Toronto

Walsh, D. J., B.Sc. Memorial

Zedel, L., B.Sc., M.Sc. Victoria, Ph.D. British Columbia; Petro-Canada Young Innovators Award, Awarded 2001

Assistant Professors

Afanassiev, I., Ph.D. P.P. Shirshov Institute of Oceanology, Russian Acad., M.Sc. Moscow Physical-Technical University

Andrews, G.T., B.Sc. (Hons.), M.Sc., Ph.D. Memorial

Curnoe, S.H., B.Sc. Toronto, Ph.D. British Columbia (NSERC UFA)

Quirion, G., B.Sc., M.Sc., Ph.D. Sherbrooke

A brief outline of the research interests of each faculty is given in Appendix 7.

Faculty Complement

Figure 13 shows the number of full-time tenured or tenure track faculty in the Department over the last 10 years. Figure 13 also indicates the number of faculty who were awarded a research grant by an external funding agency in that year.

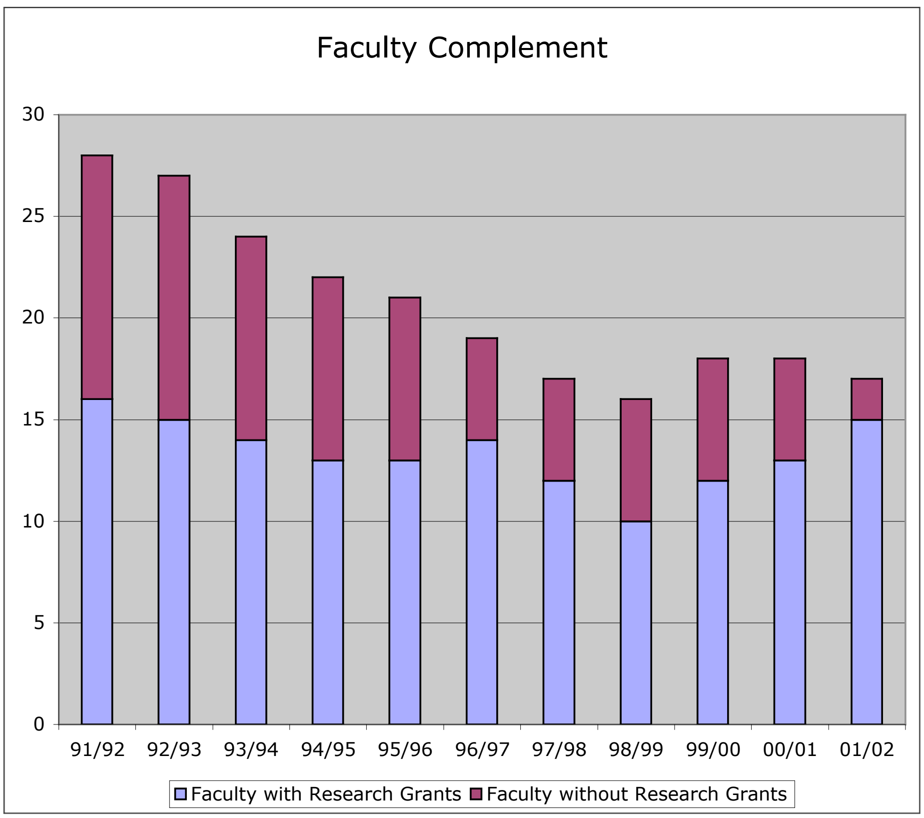

Figure 13: Faculty complement in the period 1991 - 2002

Two trends are obvious from Figure 13. The most obvious is the decline in the overall number of faculty from a high of 28 in 1991/1992 to a low of 16 in 1998/1999. The other obvious trend is that the number of faculty with grants, while showing some variability, has remained roughly constant over the ten year period, with almost the same number of grant holders now as 10 years ago. In interpreting this data it is important to bear in mind two facts

- That all the variability in the number of grant–holders has been due to retirements and resignations. No faculty member in that 10-year period has had his or her NSERC Research Grant nilled.
- All faculty hired since 1982, have been continuously funded through NSERC Research Grants.

Comparing the declining faculty numbers shown in Figure 13 with the increasing student registrations shown in Figure 1 implies an increase in the "teaching productivity" of our faculty as measured by the number of registrations per faculty. This ratio is given in Figure 14 for the period 1991/1992 to 2001/2002, and show that the registrations per faculty has increased by approximately 50% over the last 10 years. The data do not include the registration in laboratory sections.

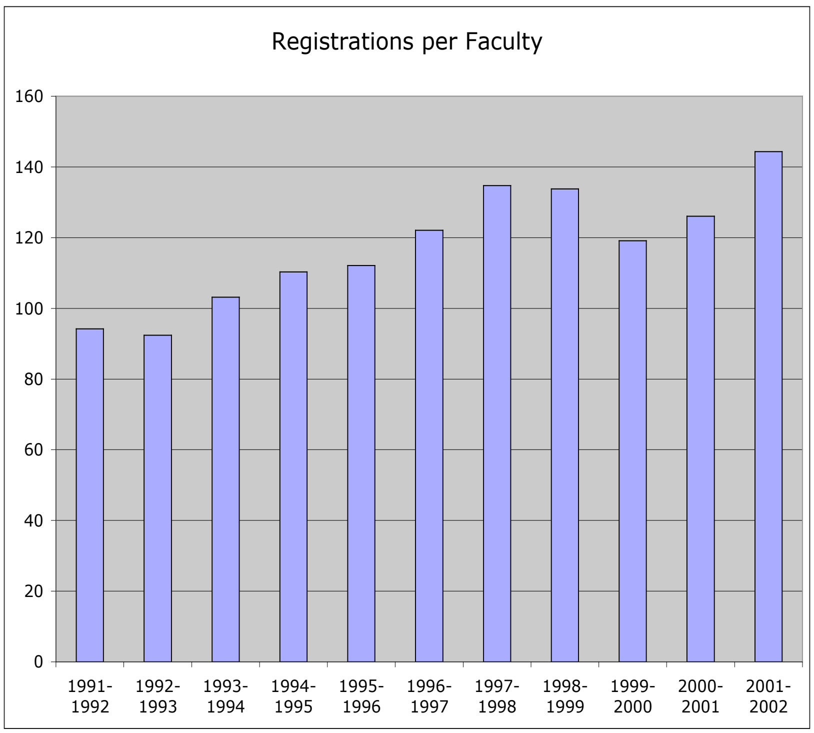

Figure 14: Registrations per faculty in the period 1991 - 2002

When considering the decline in faculty complement and the increase in registration per faculty it is important to keep in mind that many of the faculty who have retired in recent years were some of our most experienced instructors and in many instances carried a higher teaching load than the norm for the Department.

Faculty Workloads

Faculty workloads are determined by the current Collective Agreement between Memorial University and the Faculty Association. The Collective Agreement (Article 3.8) states that the duties and responsibilities of Faculty Members fall into three categories

1. *In the absence of specific alterations ….the following two categories shall constitute approximately equal portions of a Faculty member's work*
    a. *Undergraduate and graduate teaching*
    b. *Research, scholarship and creative activities which may enhance the Faculty Member's professional competence or standing, or which may advance the discipline*
2. *Some academic service is expected of each faculty member. The contribution of a faculty member in the academic service category shall be sufficient to ensure that collegial responsibilities can be carried out.*

The normal amount of teaching assigned for each faculty member is referred to as the "teaching norm", and is specified in the Collective Agreement for each Academic Unit. For physics the "teaching norm" is defined as 4 3-hour lecture course equivalents per academic year. How this specification translates into the workload of a typical faculty member in physics whose teaching load may involve a combination of lecture and laboratory based courses together with the supervision of both graduate and undergraduate research is specified in the "Course Equivalency Plan" which establishes the equivalency between various teaching responsibilities of a faculty member in this Department and a 3-hour lecture course. This document is included in Appendix 8.

The current Collective Agreement contains provisions that allow for variations in the proportion of a Faculty Member's devoted to teaching under various circumstances. These include

The work devoted to teaching by a faculty member can be increased:

- By voluntary agreement between the Head and the Faculty Member with a reduced expectation in research, scholarly, creative and professional activities or
- Where a Faculty Members record of research, scholarly, creative and professional activities is significantly below expectations.

The work devoted to teaching by a faculty member can be reduced:

- If a faculty member is appointed as a University Research Professor
- In the case of a new faculty member.

- Through the award of a teaching remissions upon application to the Dean of Science.

In practice the workloads specified in the Collective Agreement, together with the "Course Equivalency Plan" established by the Departments, mean that a typical, research active, faculty member will teach a first or second year course, with multiple lab sections, and two lecture courses. In addition he/she would normally supervise the research of 1~2 graduate students and possibly an undergraduate student. Exceptions to this, in the current academic year, include Dr. Clouter and Dr. Gien, who are both University Research Professors, Dr. Curnoe who holds an NSERC University Faculty Award and Dr. de Bruyn and Dr. de Young, who were awarded a one-course teaching remission for the current academic year, Dr. Andrews, who is a new faculty member, and Dr. Whitmore who has recently been appointed Director of the CVC.

While it is difficult to compare the workload of faculty in Physics departments at different Universities, a survey carried out by the previous Head, Dr. Morrow, in which he contacted several the Chairs of several Physics Departments at Universities across Canada indicated that the faculty workload in this Department is comparable with that of similar Departments. The results of Dr. Morrow's survey are contained in Appendix 9.

Given the workload specified by the collective agreement and equivalencies contained in the "Course Equivalency Plan" document it is relatively straightforward to calculate that the number of teaching tasks (1 teaching task is defined as equivalent to the 3 hour lecture course specified in the collective agreement) required to sustain our current undergraduate and graduate programs falls in the range 70 ~ 80. This includes instruction at the introductory, senior undergraduate and graduate level, graduate and undergraduate supervision and help centre duty.

An analysis of the faculty workload has shown that the minimum faculty required to maintain the viability of the Department's current graduate and undergraduate programs and research activity is 17. The arithmetic is relatively straightforward. Taking into account sabbaticals and course remissions, 17 faculty corresponds to 14 full-time equivalents (FTE). With a teaching load specified in the Collective Agreement of 4 teaching tasks per FTE, this gives a teaching capacity of 56 teaching tasks. The difference between this teaching capacity and the 70 ~ 80 teaching tasks required to deliver of academic programs is made up by

- teaching performed by faculty in other academic units
- per-course and teaching term appointments and teaching term appointments
- teaching performed by faculty in the department beyond that specified in the Collective Agreement.

If the number of faculty were to fall below 17 this would mean that much of the core material in our undergraduate programs would no longer be taught by tenured or tenure-track faculty, or increases in faculty workload which would severely impact on the research productivity of the Department.

Faculty Renewal

In the last six months four faculty have retired. The age profile for the 16 remaining faculty is shown in Figure 15 below.

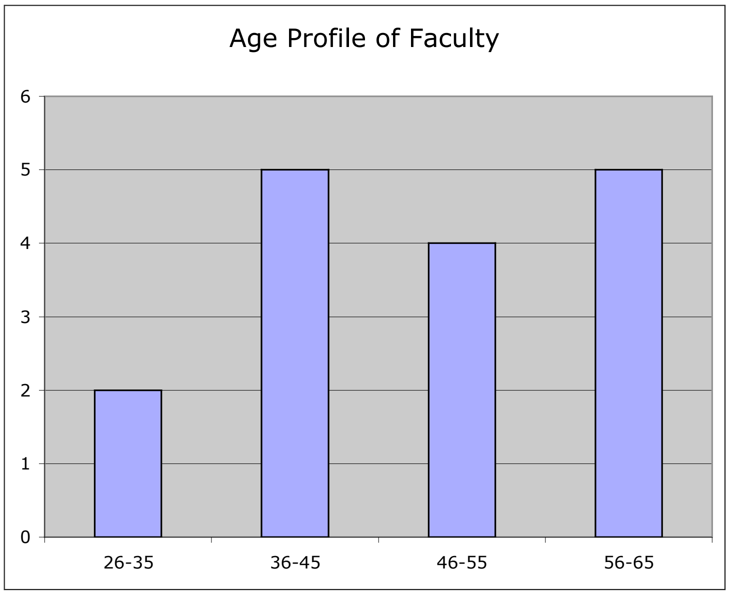

Figure 15: Age profile of current faculty

Of the 5 current faculty in the 56-65 age group another three will retire by September 2003 and a fourth by September 2004. The remaining faculty member in that age group will retire by September 2009. Thus in the two year period from September 2002 to September 2004 eight faculty, slightly less than half the Department, will have retired.

While the retirement of so many experienced colleagues represents a significant loss for the Department, it also provides the opportunity for the Department to strengthen its existing areas of research focus and perhaps expand into new areas through faculty renewal. This assumes that the Department will be allowed to replace at least some of these positions with new hires. The Department is currently seeking to fill three positions, one in the area of experimental condensed matter physics and another two in the area of physical oceanography. The successful applicants for these positions are expected to have a doctoral degree in an appropriate discipline, relevant postdoctoral experience and an established publication record. They will be expected to develop an active research program and to teach at the graduate and undergraduate levels.

If the Department is able to successfully fill the three advertised position then this will maintain the Department's current faculty complement of 16 following the three retirements in September 2003. Once the current search is complete the Department intends to request a further two new positions to be filled by September 2004. This would replace the eight retirements that will have occurred between September 2002 and September 2004 with five new appointments, stabilizing the Department's faculty complement at 17 by September 2004.

Support Staff Information

The current staff complement consists of 5 Administrative, Management and Support positions, 2 Information Technology positions, 7 Laboratory management and Support positions, including 2 contractual positions, and 4 Technical support positions.

Staff Profiles

Administrative Officer – Ms. D. Corbett

Responsible for the direction of administrative functions including purchasing, financial administration, budgeting, and personnel in the department. Supervises general office and purchasing staff. Reports to Department Head

Senior Clerk Steno – Ms. J. Simmons

Work involves responsibility for performing varied and complex clerical tasks and including but not limited to overseeing the General Office activities as well as supervising the Intermediate Clerk Steno position; acts as Secretary to the Graduate Studies Committee and handles graduate student applications process. Reports to Administrative Officer.

Intermediate Clerk Steno - Ms. E. Crocker

Acts as Secretary to the Undergraduate Studies Committee; processes requests for waivers, re-reads, deferred and supplementary exams; processes final grades; maintains absentee reports; answers incoming telephone calls and counter enquiries from students; and provides secretarial duties to departmental members requiring same. Reports to Senior Clerk Steno and Administrative Officer.

Stores Clerk – Mr. J. Power

Processes all departmental and research purchases (except stationery supplies); custodian of departmental procurement card; processes petty cash purchases; arranges shipment of materials, when required; includes newly purchased items on departmental inventory, if necessary. Reports to Administrative Officer.

Intermediate Secretary – Ms. B. Burke

Provides secretarial support to the Department Head; acts as secretary of the Faculty Committee;

Laboratory Coordinator – Dr. C. Deacon

Coordinates the activities for all second year laboratories; provides instruction in several second year laboratory sections; marks and assign grades for students labs; oversees/ supervises the activities for first year laboratory staff. Reports to Department Head.

Laboratory Instructor – Mr. J. Wells

Coordinates the activities for all first year laboratories; instructs several laboratory sections; supervises instructional assistants; hires and supervises student assistants. Reports to Laboratory Coordinator.

Instructional Assistant – Ms. K. Pawlowska

Demonstrates first year Physics laboratories; sets up apparatus for labs; assists students with experiments and provides guidance for preparation of lab booklets; assists students with assignments in the Physics Help Centre. Reports to Laboratory Instructor.

Instructional Assistant/Computer Programmer – Mr. J. Jerrett

Demonstrates first year Physics laboratories; assists students with experiments and provides guidance for preparation of lab booklets; assists students with assignments in the Physics Help Centre; provides computer support to first year labs; programs and maintains servers for first year labs. Reports to Laboratory Instructor.

Laboratory Instructor – Dr. R. Goulding

Instructs second year laboratories; grades laboratory assignments; assigns lab marks; assists students in the Physics Help Centre. Reports to the Laboratory Coordinator.

Mechanical Services Officer – Mr. W. Kieley

Assists faculty and researchers in the technical aspects of design of equipment and scientific apparatus. Fabricates apparatus for undergraduate laboratories. Reports to Department Head.

Cryogenic Equipment Officer – Mr. W. Holly

Responsible for the efficient operation of cryogenics facility; repairs and maintains facility equipment; ensures sufficient quantity of liquid nitrogen and helium are available for customers, i.e. Faculty of Science, Faculty of Medicine, Health Care Corporation. Reports to Department Head.

Oceanographic Assistant – Mr. J. Foley

Provides research support to oceanographers through the deployment of instruments and monitoring results. Assists in Senior Undergraduate Laboratories and with Lauzier research cruises. Reports to Department Head.

Draftsman – Mr. R. Guest

Position title does not reflect the duties and a title change has been requested. Provides assistance to Cryogenics Equipment Officer in the operation of the nitrogen/helium facility; assists Mechanical Services Officer in the Physics Machine Shop. Reports to Department Head.

Research Computing Specialist – Mr. C. Stevenson

Provides research computing support to the Oceanographic Group; maintains mail server for department; maintains all computers and peripherals in senior laboratories. Reports to Department Head.

Research Computing Specialist – Mr. F. Perry

Provides computing support to administrative offices; research groups; maintains all computer (personal computers and Macintosh's); provides advice to Head regarding updating of software and equipment. Reports to Department Head.

Changes in Staff Complement

A number of changes have taken place in the Department over the last seven years. Some of these changes reflect a downsizing of the Departmental staff levels others the changing needs and operational requirements of the Department.

- Clerk Steno – Grace Woodford – obtained a position with the Comptroller's Office in August 1995. This position was converted to a Programmer Consultant and was filled in December 1996 by Fred Perry
- Instrumentation Officer – Hector Clarke – opted for retirement package in May 1996. This position was not filled.
- Photographer – Robert Bradley – position and individual transferred to Biology in March 1997. This position was not filled.
- Research Computing Specialist – Allan Goulding – obtained a position with Computing and Communications in September 2000. This position was reclassified to a Programmer Consultant and Neil Boland was hired in November 2000. Neil Boland left the Department in May 2001. This position was not filled.
- Oceanographic Assistant – Jack Foley transferred to Physics from Ocean Sciences Centre (OSC) in April 1998.
- Instructional Assistant (contractual) – Jason Baggs was hired for the period September 1998 to April 1999.

- Instructional Assistant (contractual) – Angie Randall was hired for the period January 1998 to April 1998.
- Instructional Assistant (contractual) – Sandra Gin was hired for the period September 2001 to June 28, 2002.
- Instructional Assistant (contractual) – John Bartlett was hired in September 2002 on an eight-month contract.
- Instructional Assistant (contractual) – Steven Stringer was hired in September 2002 on an eight-month contract.

Age Profile of Staff

The age profile of the 16 staff positions is shown in Figure 16. There are no mandated retirements until 2009.

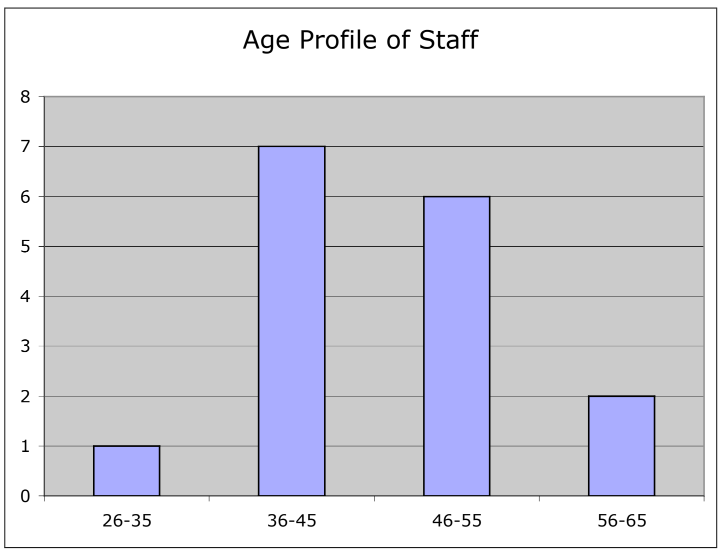

Figure 16: Age profile of departmental staff

Departmental Expenditures

The Department's budget has decreased somewhat over the last decade, from $2,429K in fiscal year 1991/1992 to $2,338K in the current fiscal year 2002/2003. During that time that portion of the budget devoted to staff and faculty salaries has increased in both absolute and relative terms from $2,114K (87.0% of net expenditures) in fiscal year 1991/1992 to $2,165K (92.6% of net expenditures) in fiscal year 2002/2003. During this period, in which our budget has declined, both student enrolments and research funding have increased.

Net Expenditures

The data presented in Figure 17 show the net expenditures for the Department for the period 1991 to 2003. While the Department's net expenditures have decreased by approximately 4% over this period, a closer examination show that expenditures dropped substantially from a high of $2,490K, in fiscal year 1993-1994 to low of $1,797K in fiscal year 1998/1999. Since then expenditures have risen steadily due to increases in faculty and staff salaries.

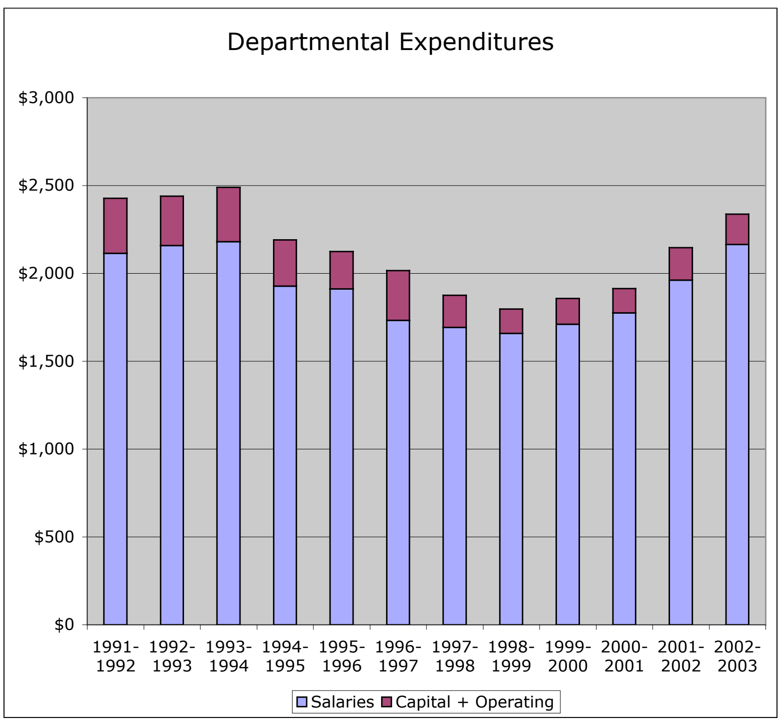

Figure 17: Departmental expenditures for the period 1991 - 2003

To obtain some context for the Departmental expenditures in this period Figure 18 presents the "cost per registration" (Departmental Expenditures/Student Lecture Registrations) for the Department of Physics and Physical Oceanography and the average figures for the Faculty of Science. The data show that while the cost per registration has risen overall in the Faculty of Science it has declined in Department of Physics and Physical Oceanography.

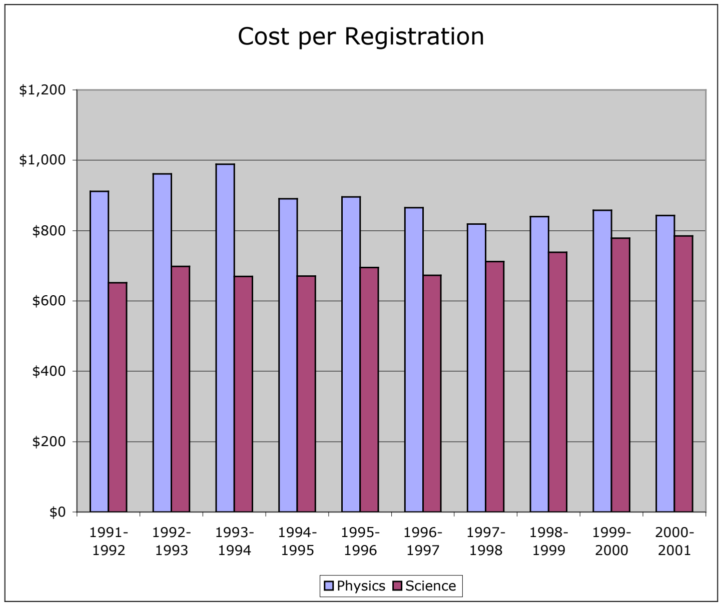

Figure 18: Cost per registration for the Department of Physics and Physical Oceanography and the Faculty of Science for the period 1991 - 2001

A more detailed comparison between cost of delivering our programs and the cost in other academic units within the Faculty of Science is presented in Figures 19, which show the cost per registration for each of the academic units in the Faculty of Science for fiscal year 2000/2001.

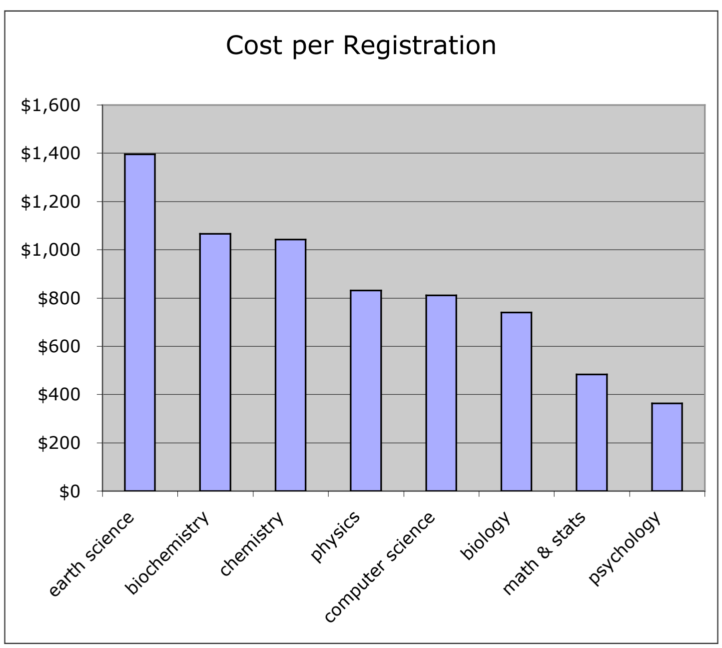

Figure 19: Cost per registration of academic units in the Faculty of Science for Fiscal Year 2000/2001

While the above figures are subject to some variance from year to year and reflect, in part, the nature of each discipline and certain economies of scale in some departments, the figures nevertheless show that the Department of Physics and Physical Oceanography delivers its programs and provides service courses to other programs in a cost effective and efficient manner. Unfortunately we have not been able to obtain data that allows a comparison between Physics Departments at different universities in Canada. Also it should be noted that the above aggregates do not include laboratory sections but do include graduate programs.

Operating Expenditures

While the Department has adapted to the financial constraints imposed on it by the University, delivering its undergraduate programs in a more cost effective manner, the decreased funding levels have nevertheless impacted on many aspects of the teaching and research activity within the Department. This has been compounded by the fact that the Department's operating and capital budgets have fallen both in absolute and relative terms from a combined total of $314K in fiscal year 1991-1992, representing approximately 13% of net departmental expenditures, to $172K in fiscal year 2002-2003, representing less than 7.4% of net departmental expenditures.

These funds are used to pay graduate and undergraduate teaching assistantships, travel costs for external speakers and undergraduate students, laboratory equipment and supplies, as well as the many expenses associated with the normal operation of the Department. While the Department plans carefully to ensure the capital and operating budget it has available is spent wisely, the decline in operating and capital budget has forced the Department to cut back in a number of important areas. For example, the Department can no longer afford to bring in external seminar speakers on a regular basis. Also the amount the department spends on graduate student stipends has remained constant for nearly 5 years. This is unfortunate as the quality of the seminar series and graduate student stipends are an essential component of a research active Department.

Finally it should be noted that the Department has always acted in a fiscally responsible manner. It has never, in the last decade, exceeded its allocated budget and has worked closely with the office of the Dean to provide detailed financial projections of its operations to assist in the strategic planning for the Faculty of Science. The Department realizes the financial constraints that confront the University and the Faculty of Science, and has responded by operating in an increasingly cost efficient manner while working hard to maintain the quality of its academic programs and the level of its research productivity.

Physical Resources

Equipment

The Department operates the Cryogenics Fluids Facility for the University. This consists of a StirLin Nitrogen Liquefier and a Koch Helium Liquefier. In addition to providing researchers in the Department of Physics and Physical Oceanography with liquid Nitrogen and Helium, the Cryogenics Fluids Facility supplies the Departments of Chemistry, Earth Sciences, Biochemistry and Biology as well as the Ocean Science Centre, the School of Medicine and the Faculty of Engineering.

The StirLin-1 nitrogen liquefier was commissioned in August 2001, and was a joint investment by Memorial University and Canada/Newfoundland Comprehensive Economic Development Agreement. The StirLin-1 liquefier represents a new "on-site" technology which extracts, purifies and condenses the Nitrogen without the need for a distillation column. It is capable of continuous production, producing 12 litres/hr and is equipped with an automated start/stop. It is the first PSA cycle Nitrogen liquefier in Canada, third in North America, and is the Canadian model for site preparation.

The Koch Helium liquefier was purchased in 1985 and has been in almost continuous operation since that time. The Department recently purchased a second identical liquefier from Dalhousie University. A decision has yet to be made as to whether the second liquefier will be put into production or will be used as spare parts.

The Department also maintains and operates a small machine shop. This comprises a hydraulic press, band saw, milling machine 2 lathes and a drill press. This facility complements the service provided by Technical Services, and is essential in allowing researchers to prototype and modify experimental apparatus. It also provides an essential part of the training for our experimental graduate students. In addition to supporting the research within the Department the machine shop also supports our undergraduate laboratories, allowing the department to construct and maintain apparatus for undergraduate use.

The Department also maintains over 100 Macintosh computers that are used primarily in our introductory physics laboratories for data acquisition and analysis. In addition the Department supports over 100 Intel based computers as well as in excess of a dozen UNIX servers of various kinds. These computers are used in support our graduate, undergraduate, research and administrative computing.

Space

The Department occupies offices and laboratories in the Chemistry Building.

- Level 1 houses the research laboratories for the condensed matter group, the cryogenic facility and machine shop, the physics stores and several offices used by faculty, staff and students. The oceanography group maintains a research laboratory and equipment room on level 1.
- The teaching laboratories for our introductory physics courses are located on level 2, together with a classroom, C2045, that the Department renovated several years ago and which it uses for classes of 30 ~ 100 students. Level 2 also contains offices for the undergraduate support staff and some graduate students.
- Level 3 contains the Physics General Office, the Head's office and the offices of the Administrative Officer and a Programmer Consult. Many of the faculty have offices on this floor as well as graduate students and post-doctoral fellows. It also contains the second year undergraduate laboratories and the physics help centre. A small classroom, C3067, that the Department had installed two years ago and which seats approximately 20 students is located on this level as well as the seminar room, C3024, which also serves as a meeting room. This level also contains the Physics Honours Room, the Physics Reading Room and the Physics Society Room, which are used by our physics majors.
- Level 4 contains the offices and research labs for the Physical Oceanography group as well their students, postdoctoral fellows and support staff. It also houses the senior undergraduate research laboratory.

While this space has been adequate for the Department's needs over the years, there is increasing pressure for office space, particularly on level 3 with the growth of the research activity within the Department. Some rationalization of the space available on level 3 could provide some additional office space and provide the Department with a more effective focus than currently exists.

Conclusions

The self-study report describes a department in transition. By September 2004, about half the faculty will have joined the Department within the previous six years. In the following 5 years, there is only one mandated retirement. For a successful transition, the Department will need to build on its strengths and accomplishments and develop strategies to overcome the challenges that it faces. This is an exciting time for the Department as the ongoing process of faculty renewal provides opportunities for research and program development.

Strengths and Achievements

Although considerably smaller than it was seven years ago, the Department is more focused and, through careful planning, has sustained its level of research productivity and the quality of its academic programs.

Our undergraduate course enrolments have remained roughly constant over the last decade, while graduation rates and numbers of physics majors are increasing. The process of faculty renewal currently underway and the introduction of new programs such as Environmental Physics should allow us to sustain these positive trends in the foreseeable future.

Our undergraduate programs are generally well regarded by both former and current students and our graduates are successful in finding employment following graduation. The education our Department provides appears to give our graduates the skills and training they need to succeed in the workplace or in academia.

Our research programs are active and well funded. Fourteen of the current faculty of 16 hold NSERC research grants. Faculty have also been successful in taking advantage of many other funding opportunities that are available, with total external funding for the last two fiscal years in excess of $2.5M.

Our faculty participate within the national and international scientific community, enhancing the Memorial's prestige and visibility, while providing the University with valuable input regarding national science policy.

Our Department has been fiscally responsible and generally well administered. We have undertaken a number of new initiatives during a time of financial constraint within the Faculty of Science; yet have remained within our allocated budget. Key measures, such as the cost per registration, demonstrate that the Department has been successful in adjusting to the current fiscal realities, delivering academic programs and conducting research in a cost efficient manner.

Challenges

A successful transition will not be without challenges. Undoubtedly, the most critical challenge for the Department will be to maintain and enhance academic programs that are both stimulating and appealing to our graduate and undergraduate students and competitive with those offered elsewhere, while providing an environment that will allow new faculty to build and sustain their research activity throughout their careers at Memorial. Departmental policy in the years ahead must be directed toward achieving these goals.

Success will require a clear strategy regarding budget and faculty complement. In December 2002, the Department submitted budget projections for the period 2003 – 2006 as part of a strategic planning exercise for the Faculty of Science. These projections represent the culmination of careful long-range planning by the Department. Assuming a stable faculty complement of 17 by September 2004 and a modest increase in the operating budget, Departmental expenditures would fall by 7% over the three year period covered by these projections, due largely to savings that would result from the retirement of senior faculty.

It is essential at this critical juncture in the Department's development that the University Administration provides some assurance that the assumptions that underlie these projections, particularly those regarding faculty complement, represent a realistic blueprint for the Department's future development. Such an assurance would represent a very useful outcome of the present review process.

Although this self-study shows that the Department is working well, some shortcomings have been revealed.

While the post-graduation activities of our graduate students attest to the quality of our graduate programs, the current size of our graduate program does not match the level of research activity within the Department. While enrolment in our graduate programs is showing signs of improvement, the Department needs to make a concerted effort to increase the number of graduate students substantially. A realistic goal would be to increase our graduate enrolment by 50% over the next three years.

Despite our efforts to integrate computing into the undergraduate program (see page 22), it would appear from the survey of our current and former students that our undergraduate programs do not yet fully meet the demands of the students. The proposed Computational Physics program will require the Department to examine the programming and computational skills within our existing programs as well as providing an attractive option for students with an interest and aptitude in computing.

It is also evident that students regard the emphasis on writing and speaking skills as inadequate, despite the requirements for writing and presentation in many of our courses. The Department also clearly needs to be more active in providing our undergraduate students information and advice on careers and the opportunities that a degree in physics provides.

While not trivial, the challenges identified in this self-study are not insurmountable. Their resolution will require the Department be given the necessary resources, specifically an appropriate faculty complement combined with a stable and adequate budget.

Opportunities

The Department is currently seeking to fill three new positions, one in condensed matter physics, and two in physical oceanography. With these new appointments plus the twelve faculty who are not scheduled to retire before September 2004, the Department will consist of five physical oceanographers (Afanassiev, de Young, Zedel plus two new hires), five condensed matter experimentalists (Andrews, de Bruyn, Morrow, Quirion plus one new hire) and five theorists (Curnroe, Lagowski, Lewis, Whitehead, Whitmore). This, we believe, represents an optimal size for these different groups, providing the critical mass needed to ensure that research within the Department remains competitive and to support the range of programs we currently offer and which are planned for the future.

Two further new positions beyond these three will be required to bring the total faculty complement to 17. While there is general agreement on the two areas of thematic focus, and the need to support them, it is also recognised that new hires could add diversity while providing complementary expertise to the Department. This would allow the Department to plan for the future, take advantage of current and future funding opportunities and to strengthen research at Memorial, possibly in collaboration with other academic units. Photonics, complex fluids, biophysics and astrophysics are all areas of possible expansion that have been discussed within the Department. Selecting one such area, the Department could expand its current research interests, while maintaining its critical concentration in existing areas of expertise.

As well as broadening the Department research expertise, these new positions will help the Department address the student's concerns regarding computational skills and the variety of courses we are able to provide as well as supporting the new academic programs the Department plan to introduce. In addition to the Degree program in Environmental Physics described in this report, a proposed major in Computational Physics has been widely discussed within the Department. Like the Environmental Physics program this would draw on existing research strengths and expertise within the Department, while allowing the Department to take advantage of courses currently offered in Computer Science, Mathematics and Engineering, minimizing the number of new courses such a program would require the Department to offer. In this way the Department can provide innovative new degree programs that are both relevant and timely. Both these programs, Environmental Physics and Computational Physics, would be strongly coupled to the existing MSc programs in Environmental Science and Computational Science.

The Department also hopes that the proposal to require Engineering students to take the introductory calculus-based physics is accepted by the Faculty of Engineering. Not only would this allow some rationalization of our introductory courses and benefit students pursuing programs in the physical sciences and engineering but would also stimulate further cooperation between the Department and the Faculty of Engineering on program delivery and development. There are, at present, several examples of shared teaching between our Department and the Faculty of Engineering that serve as excellent examples of how both programs can benefit through cooperation. Given the Department's existing strengths in materials science, physical oceanography and photonics, there are obviously opportunities for further cooperation.

Given the forecast declining number of high-school graduates in Newfoundland and Labrador, it will be important for the Department to reach out to the wider community. The Department has, in the past, maintained strong links with the High Schools throughout the province. Unfortunately, many of the faculty who have been actively involved with this outreach are retiring. It is essential that the Department maintain and strengthen these linkages, particularly in the coming years.

Looking Forward

While this self-study focuses on the current status of the Department and its recent history, it has obliged us to look to the future of our Department, 10 or 20 years from now. Our Department and many others across Canada are undergoing dramatic changes that will permanently restructure the way that Universities function and redefine their role within society. Physics itself is undergoing a renaissance both with respect to fundamental discoveries and in its application to other areas of science and technology such as environmental science, materials science and the life sciences.

Memorial must contribute to these developments, to ensure that our province benefits from the intellectual, educational and economic advantages that will arise for our youth and for our province. The Department of Physics and Physical Oceanography has a critical role to play in these developments.

If the Department can successfully navigate the next few years, it will emerge well placed to meet the coming challenges. With a young, research active faculty and new and innovative programs, the Department will be able to achieve the goals set out in the introduction and allow Memorial to meet its obligation to the people of our province and the wider scientific community.

Acknowledgements

I would like to thank a number of people who helped prepare this document. The members of the APR committee: Dr. de Bruyn, Dr. de Young, Dr. Lagowski, Dr. Morrow, Dr. Whitmore and Dr. Zedel, all put in a tremendous amount of work in preparing preliminary drafts of many key sections in the report. Ms. Corbett prepared the material on Departmental expenditures and on the administration of the Department contained in the report. Ms. Simmons provided valuable assistance throughout; collecting CV's from faculty, generating statistics on our academic programs and collating the different components of the final document, all in a very tight time frame. I would also like to thanks Dr. Morrow and Dr. Zedel for reading and commenting on numerous penultimate drafts and final drafts of the report. Finally I would like to express my appreciation of the staff and faculty of the Department of Physics and Physical Oceanography for their cooperation and patience during the preparation of this report.

Appendices

1. CIAP Student Survey
2. Post graduation status of Honours graduates 1995 – 2003
3. Post graduation status of Graduate Students 1995 – 2003
4. Description of undergraduate courses and degree programs
5. Description of proposed degree programs in Environmental Physics
6. Aggregate results from Course Evaluation Questionnaires
7. Outline of Faculty research interests
8. Teaching equivalency document
9. Survey of Faculty workload in selected Canadian physics departments