Department of Physics and Physical Oceanography Memorial University of Newfoundland

Self Study Report, Academic Program Review

November 2015

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Acknowledgments

The preparation of this document was started by Dr. B. deYoung (then Head) in February 2014. As of 1 September 2015, there have been several changes in the administrative positions including a new Head (Dr. J. Lagowski), new Deputy Head Graduate Studies (Dr. S. Curnoe) and new Chair of the Undergraduate Studies Committee (Dr. M. Plumer). Dr. M. Morrow (former chair of Undergraduate Studies Committee) and Dr. T. Andrews (former Deputy Head Graduate Studies) put in a tremendous amount of work in preparing preliminary drafts of many key sections in the report. Ms. D. Corbett prepared the material on Departmental expenditures and on the administration of the Department contained in the report. Ms. J. Simmons provided valuable assistance to the preparation of the graduate studies section. Ms. D. Coombs collected faculty CV's and collated the different components of the final document. I thank Dr. deYoung for coordinating this self study and all those who contributed to it. I would like to express my appreciation to the staff and faculty of the Department of Physics and Physical Oceanography for their cooperation and patience during the preparation of this report.

J. B. Lagowski, Professor and Head

1. Introduction

Memorial plays a unique role in the province of Newfoundland and Labrador as it is the sole degree granting institution in the province. Memorial therefore has a particular obligation to provide a balanced range of programs, from marine biology to archaeology and business to medicine. All those who work here are sensitive to the unique position that we hold in this province and the distinctive character of St. John's and the province. Our department offers high quality undergraduate and graduate programs in physics and physical oceanography not only to train research scientists but to prepare them for their future careers. The Department also provides service source course to students pursuing other degree options in engineering, the life sciences and other physical sciences.

The Department seeks to create an environment conducive to intellectual vigour and learning. This learning environment is necessary for the undergraduate and graduate programs that we offer and our contributions to the wider academic life of the university. Our research programs stimulate intellectual and technological developments that serve as the basis for the economic and social growth needed by both the province and the country.

The defining objects of the department are to

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

The responsibility that we have to provide high quality academic programs and maintain research excellence requires that we maintain a wide range of teaching competency at the undergraduate level built upon and connected to our research program. We have chosen to focus our research primarily in the areas of Condensed Matter Physics and Physical Oceanography with a broad interest in Computational Physics. We are the only Physics department in the country with a strong interest in physical oceanography. While we are focussed around these three research clusters we do also encourage collaborations across the department and outside the department with other units in other faculties. We have maintained our commitment to providing a balanced teaching program built upon a focused research program. Our hiring policies and program development over more than two decades have followed this clustered approach to research.

Our collaborations inside the department and outside the department have grown well in recent years with much collaboration among faculty in the department and with faculty in other units such as Chemistry, Biochemistry, Biology, Geography and Engineering. These collaborations and developments have resulted in a Department with a wide 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 presently consists of 19 tenured and tenure-track faculty members and one visiting assistant professor, and offers a number of undergraduate and graduate degrees in Physics and Physical Oceanography. The Department has approximately 70 physics majors and graduates around 15 majors annually. We currently have nearly 50 graduate students in our own department, and typically award 8-12 graduate degrees annually. In addition, we supervise or co-supervise students in interdisciplinary programs and students in other departments. In total, we supervise, or co-supervise, over 50 graduate students.

The Department handles approximately 2300 registrations annually. The introductory physics courses, with approximately 1700 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 three of our core second year courses, have an associated laboratory component.

Of our 19 academic faculty members, 16 currently hold an NSERC Discovery grant. As an example, in fiscal year 2013-2014 the Department received research support amounting to $1,735,171 in external research funding. The Department continues to support, through a collaborative arrangement with Technical Services, a small machine shop. It also houses several computational clusters supporting HPC activity. The Department provides a modest level of system and technical support for computer systems within the Department. We maintain a comprehensive pool of oceanographic instrumentation for oceanographic field research on the shelf and the neighbouring North Atlantic.

The Department's Annual budget for the fiscal year 2013-14 was just over $3.8 million. Over 90% of this budget is for salaries. The Department has a full time staff of 16 of whom 4 are administrative personnel, 7 are undergraduate laboratory personnel, 1 is an academic program officer and 4 are technical and system support personnel.

Self Study

There have been three 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. The third was in 2003 as part of a departmental review organized by the office of the Vice-President Academic.

The present self study was initiated and compiled by Dr. deYoung (former Head of the Department). This report collects data primarily for the period of 2004 to 2014. Dr. deYoung created an ad hoc Program Review Committee with the former Deputy Head Graduate Studies (Dr. Andrews) and the former Chair of the Undergraduate Studies Committee (Dr. Morrow). Together, they collected and organized data on our undergraduate, graduate and research programs and the structure of the department. As sections of this report were prepared, the Department met to review the material and to consider the following questions:

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

As we reviewed this material we included our considerations and ideas in this document. We met as a Department in October 2015 to review the final document which is presented here.

Results of Previous Self-Study 2004-2006

Recommendation: The Department should develop a format, independent from existing evaluations, in which students can provide feedback on the overall structure of the undergraduate program.

> **Change:** The Head and other faculty meet with students once each semester and we poll students for their course requirements in the winter semester of each year.

Recommendation: The Department should devote sufficient personnel support, probably in the form of senior undergraduate students, to maintain the Help Centre and the computer based laboratories at their current level of accessibility.

> **Change:** The Department upgraded computer facilities in all labs and has assigned staff and graduate students to ensure there is enough support in the Help Centre.

Recommendation: The Department should develop plans for a computational physics stream at the undergraduate level.

> **Change:** The Department developed two new computational Physics courses – 2820 and 3800 – and has added computational activity to other courses but is still working on a formal program.

Recommendation: If the University's plan to increase the number of graduate students is to succeed, there is a clear obligation to inject significant new money into graduate support.

> **Change:** We have more than doubled the number of graduate students from just over 20 students, more than a decade ago, to nearly 60 in 2014-2015.

Recommendation: The Department should consider ways of delivering the required graduate courses in a timely and effective manner, which does not involve teaching common courses to both graduate undergraduate and graduate students.

> **Change:** The Department has limited this practice to senior undergraduate courses (at the 4000 level) and has worked to avoid such co-teaching in the courses where instructors or students raised issues about the overlap.

Recommendation: The Department should arrange regular meetings, perhaps once or twice per academic year, with graduate students to discuss general issues related to all aspects of the graduate program.

> **Change:** The Head and Deputy Head (Graduate Studies) and a few other faculty meet once per semester with graduate students, usually over a pizza lunch.

Recommendation: The University should revise the internal policies that limit career advancement for technical personnel and those that impose restrictions on how faculty members may use their external research funds for employing students and technical assistants.

> **Change:** For some positions, there have been new salary scales added, but on the whole the problem remains.

Recommendation: The Department should, in consultation with the Dean of Science, find sufficient money to bring invited speakers on a regular basis. The Committee feels that $10-15 k should be sufficient.

> **Change:** The Department now regularly spends more than $10k per year to bring in speakers.

Recommendation: The Faculty of Science should carefully review the benefits of existing interdisciplinary graduate programs and take steps to remove any existing disincentives to faculty members' participation in such programs.

> **Change:** While there have been some improvements in the support to such programs and the assignment of teaching to them, the maintenance of these interdisciplinary programs remains a challenge**.**

Recommendation: The Department should work with the Department of Facilities Management to prioritize those renovations that would increase the functionality of research space.

> **Change:** The Department did support the renovation of several new labs although significant renovation required CFI or RDC funding which is dependent upon the Faculty Member. The Department has worked to renovate the undergraduate teaching laboratory space, through application for external support, and graduate student office space.

Recommendation: The current and project teaching workload, the level of research, and comparison with physics departments at comparable Canadian universities all suggest that a faculty complement of 20 is appropriate for the Department.

> **Change:** The present faculty complement is 19, close to the 20 recommended by the External review Panel. We remain convinced that 20 is the appropriate number for this department given our program and research requirements.

Recommendation: The University administration needs to monitor the effectiveness of their financial reporting systems to ensure that these systems are meeting the needs of the academic units as well as the needs of the administrative units. The University should consider instituting regular reviews of all administrative units, equivalent to the Academic Program Review for academic units.

> **Change:** While there have been some changes in administrative practices within the university, there has been no significant improvement in financial accounting or reporting. Concerns raised about the support that we receive from administrative units such as Facilities Management, Human Resources and Research, Grant and Contract Services remain serious concerns.

2. Undergraduate Student Activity

Highlights

- Reasonably stable enrolment and graduation numbers
- Ability and willingness of faculty members to teach across discipline spectrum
- Strong student outcomes
- Strong interactions with other disciplines through joint programs and service course offerings
- Program and instructional innovation
- Good student feedback regarding quality of instruction

Program Statistics 2004-2014

Undergraduate Student Numbers

According to the Centre for Institutional Analysis and Planning (CIAP) 2014 Fact Book, total fall semester undergraduate enrolment at Memorial's St. John's campus has fallen from 13,174 in Fall 2005 to 11,860 in Fall 2014. From 2010 to 2014, Fall semester enrolment in the Faculty of Science has increased from 2,251 to 2,762. Many of these science students take one or more Physics courses.

One way to assess Physics instructional activity in the context of university and faculty demographics is to compare trends in total Physics course and total Science course registrations per semester. Fig. 1 shows total course registrations for Physics and Science at the end of the Winter semester registration period from Winter 2010 to Winter 2015. While there seems to be some phase difference, it does appear that the relative variations in Science and Physics registrations are of similar magnitude.

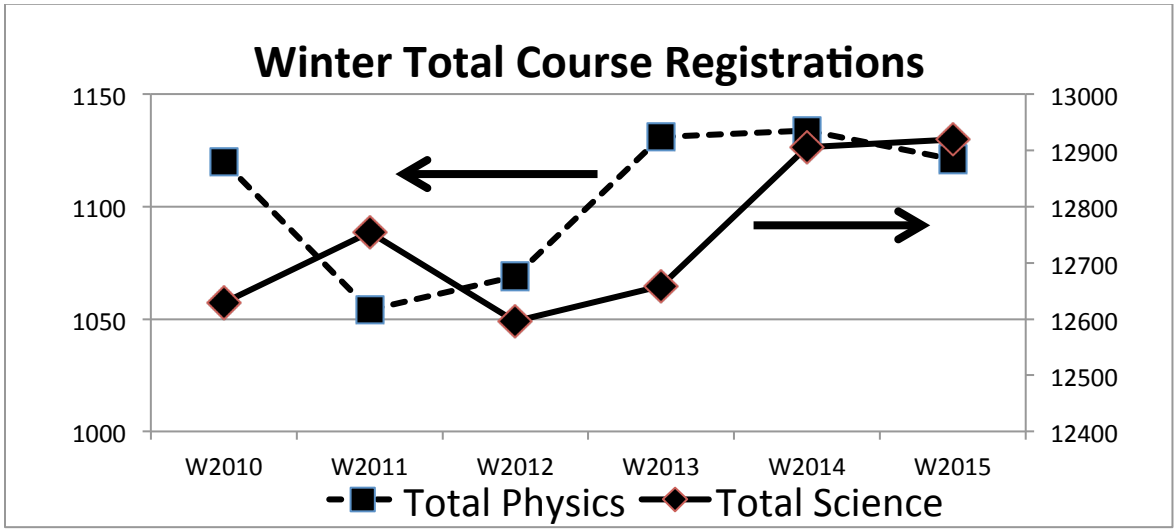


Figure 1: Winter semester undergraduate course registrations in Physics and Science for W2010-W2015

The numbers in the rest of this section have been extracted from the Banner system and provided by Glenn Perfect, Systems Officer in the Registrar's Office. Fig. 2 shows total undergraduate registrations in courses delivered by the Department of Physics and Physical Oceanography between for each academic year between 2004-05 and 2013-14. The total number of undergraduate registrations in 2013-2014 was 2483. This is slightly above the average of ~2450 for annual undergraduate registrations since 2004-05. Over this period, the average enrolment in 1st year courses (P1020, P1021, P1050, and P1051) has been ~1900.

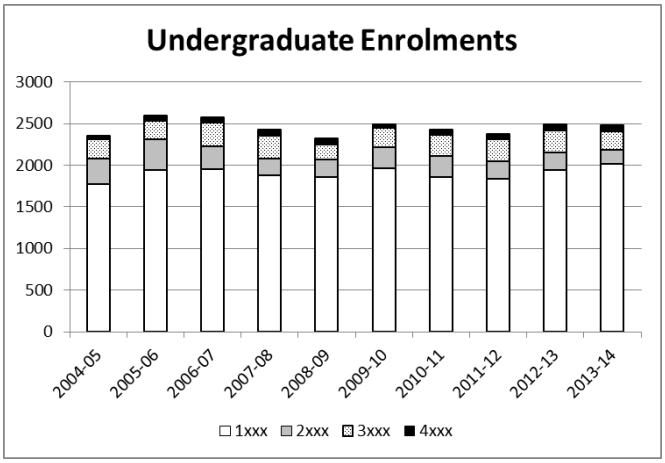


Figure 2: Undergraduate student registrations for 2004-2014

Fig. 3 shows total annual registrations in courses beyond first year from 2004-05 to 2013-14. While there have been significant fluctuations in 2nd year registrations, registrations in senior courses (3rd and 4th year) have been relatively stable since 2010-11.

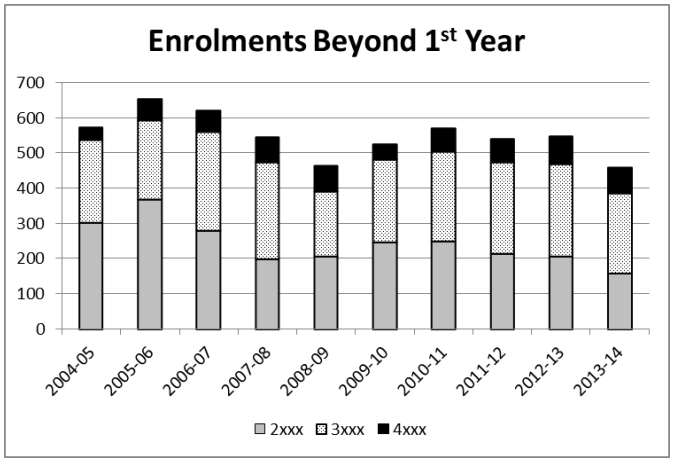


Figure 3: Undergraduate student registrations in courses beyond 1st year for 2004-2014

Fig. 4 shows the number of active undergraduate Physics major students in each academic year since 2004-04. Over the period displayed, there does seem to be a slight overall decline in the number of physics major students but the number of active physics major students has ranged between 55 and 86

over this period. Since 1995-96, the earliest year covered in the department's previous APR Self-Study Report, the minimum number of active Physics majors has been slightly less than 50 (in 1999-2000 and in 2000-01). As will be demonstrated by the breakdown of degrees awarded, a significant fraction of the Physics major students pursue degrees with joint major concentrations in two science disciplines.

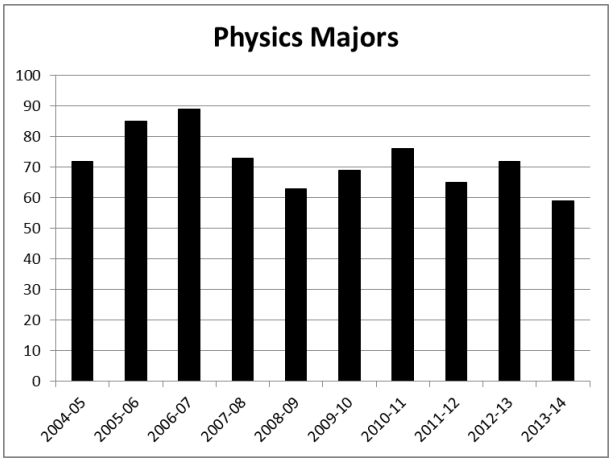


Figure 4: Active physics major students in each academic year since 2004-05.

In addition to its majors' students, the department also provides programs for students pursuing a minor in physics while completing a major undergraduate degree in another discipline. The department values the minor program both because of its capacity to expose students in other disciplines to more advanced concepts in physics and because it enhances the interdisciplinary classroom experience for Physics majors. Fig. 5 shows the annual number of students actively pursuing Physics minor in each academic year since 2004-05.

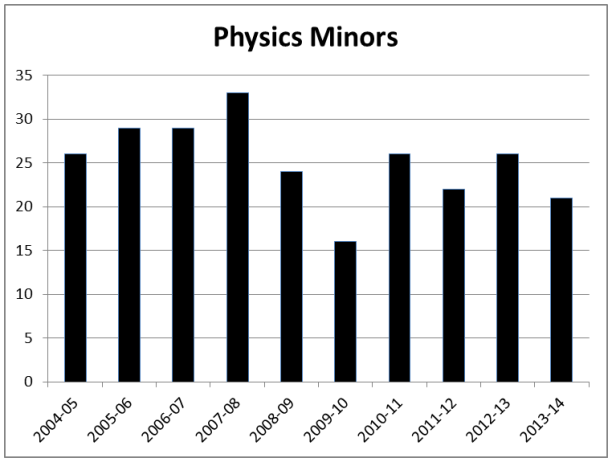


Figure 5: Active physics minor students in each academic year since 2004-05.

Since 2004, the average number of undergraduate Physics major degrees awarded annually (including joint major degrees) has been ~18. This is slightly higher than the 1995-95 to 2002-03 average (~16) reported in the department's last APR Self-Study Report. The average number of Physics minors

awarded over the 2004-2014 period has been ~9. The year-by-year breakdown of these numbers is provided in Fig. 6.

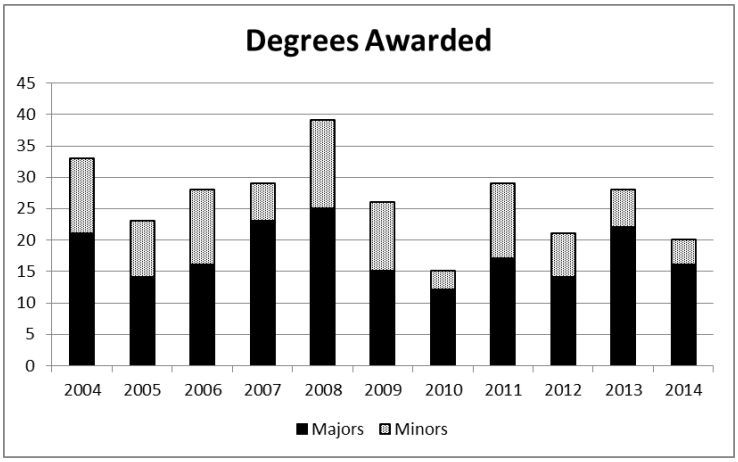


Figure 6: Physics degrees awarded in each academic year since 2004.

The number of Physics major degrees awarded annually is consistent with the numbers reported by Physics departments at other Canadian universities of comparable size. In a 2014 survey of Canadian Physics departments conducted by the Canadian Association of Physicists, the number of major degrees awarded in 2013, averaged across the 14 responding departments with faculty numbers in the range of 15-26 (average ~20), was ~17.5.

One striking characteristic of the group of students choosing to pursue studies in Physics is the breadth of their interests and aptitudes. As noted above, many of these students pursue joint programs with 2 declared majors concentrations. Fig. 7 shows the distribution of programs for all of the students awarded either regular B.Sc. degrees or B.Sc. (Honours) degrees in Physics, alone or jointly with another discipline, since 2004. In the Honours stream, Physics and Physics/Applied Math each accounted for 41% of the degrees with the rest spread over 4 different combinations or Environmental Physics.

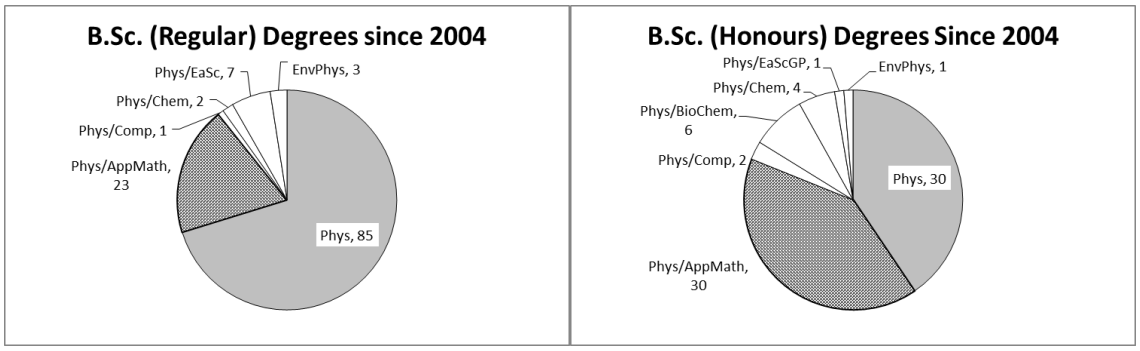


Figure 7: Total numbers of Physics and Physics/XXX Joint Degrees awarded since 2004

Fig. 8 shows the numbers of Regular and Honours Physics or Joint Applied Math/Physics Degrees awarded since 2004. While there are large fluctuations, it does appear that a significant fraction of recent Physics students have opted to pursue the Joint programs in Applied Mathematics.

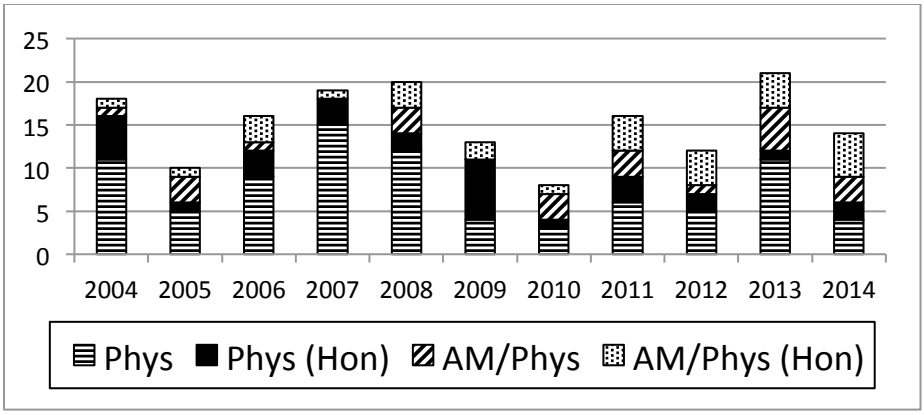


Figure 8: Regular and Honours Physics or Joint Applied Math/Physics Degrees awarded since 2004

Student Information

Undergraduate Student Post-graduation Activities

Practical issues precluded a comprehensive survey of all individuals having completed physics or joint major undergraduate programs over the past decade. It was, however, possible to compile information about post-graduate activities for most of the students, largely from honours programs, who completed undergraduate research projects under the supervision of faculty members in the department. Partial or complete information on post-graduation activities was obtained for 84 individuals who, since 2004, have graduated from physics undergraduate programs or joint majors programs with a physics component.

Of these 84 students, we are aware of 22 who completed or are engaged in PhD programs in physics, physical oceanography, atmospheric physics, or a similarly physics-related discipline. The institutions at which these individuals completed or are pursuing their PhD programs include Oxford, Harvard, Massachusetts Institute of Technology, University of Toronto, Western University, University of British Columbia, University of Victoria, and Memorial. We are also aware of three graduates from the Physics and Applied Mathematics Joint Honours program who went on to pursue PhDs in Mathematics (one at Oxford and two at the University of Alberta). We are aware of six who went on to pursue PhDs in other disciplines including Engineering, Biomedical Engineering, Life Sciences, and Philosophy.

We are aware of an additional 25 students who went on to purse M.Sc. degrees in Physics or related disciplines. There wear also four additional students who pursed M.Sc. programs in Mathematics and six who sent on to M.Sc. programs in other disciplines such as Biochemistry or Business.

In total, then, we are aware of 68 individuals who, having completed an undergraduate program in physics or a joint program with a physics component, went on to graduate studies. Information on subsequent employment activities of these individuals is less complete. Many are still enrolled in the graduate programs identified above or, for the M.Sc. students, in subsequent PhD programs. Some of

the individuals known to have entered PhD programs have now completed them and are now engaged as post-doctoral fellows.

There were a few other post-graduation areas of activity that were significantly represented among the individuals for whom we were able to find information (Some of these are also counted in the M.Sc. and PhD totals). Six individuals have completed or are currently enrolled in medical school. Three more individuals are working as or pursuing training as medical physicists. Six obtained further training in education and are working as teachers at the secondary or college level. Three went on to complete B.Eng. programs and are working as engineers and three are working in positions identified as research assistants or engineering assistant.

From the sample of 84 individuals, there are also 15 that are currently known to be working in the private sector. The areas identified for these individuals include business analysis in the insurance sector, project management, information technology, mining, optical technology, energy, and manufacturing.

In summary, it is apparent that the wide range of physics undergraduate programs offered are providing graduates with a diverse set of skills that are translating into opportunities in a diverse set of sectors including research, education, health, information, and engineering. It is also apparent that the students who pursue Physics programs at Memorial constitute an ambitious and highly capable segment of the student body.

Undergraduate Teaching Activity

The selection of courses offered by the department is intended to provide students with a strong understanding of core physical concepts while also giving them opportunities to explore and appreciate the breadth of current fundamental and applied physics. As an example, we include representative course outlines, and assignments and final exams for recent offerings (primarily 2014/2015 and 2015/2016 academic years) of most of our undergraduate courses (see Appendix D). The first year courses, which are organized into two streams, provide students with the problem solving skills and fundamental physics concepts needed to pursue a broad range of programs in engineering, life science, and physical science. The second year courses provide a deeper exploration of specific areas of physics aimed at students pursuing major or minor programs in physical science. Within our complement of senior level courses, there are a number that focus on key areas of physics such as electromagnetism, thermal physics, classical and quantum mechanics, mathematical physics, and experimental techniques. Another group of senior level courses explore more specialized areas of physics such as fluid mechanics, photonics, condensed matter physics, computational physics, oceanography, and astrophysics. Within the Honours program, students also complete a two-semester thesis course that enables them to apply their knowledge and skills to the planning, execution, and communication activities associated with addressing a problem of current scientific interest in an active research environment.

Complete lists of courses offered and available degree programs are provided in Appendices A and B respectively. Appendix C indicates the semesters in which each course has been offered since Fall 2004.

Undergraduate Programs Offered

The department offers programs to accommodate a broad range of student interests and requirements. In additions to its Physics general and honours degree programs, there are a minor program, a general degree program and an Honours degree program in Environmental Physics, three joint major programs, and six joint honours programs. In some cases, the joint programs were developed in response to student demand and we have made it clear to interested students that we are prepared to tailor specific programs to match their specific interests.

The department's undergraduate curriculum was extensively revised in the early 1990s. The current complement of available courses and programs has evolved from that starting point in response to student demand, the requirements of cooperating academic units, and the emergence of new priorities and areas of activity in the discipline. The changes, since the last undergraduate curriculum revision, have now grown to the point that a new curriculum review (and revision) is required to assess and ensure the consistency and coherence of our program offerings. The department began this curriculum review in Fall 2015. For example we have obtained input from senior undergraduate students regarding our curriculum (see Appendix E). We continue to re-evaluate and, where appropriate, relax or consolidate prerequisites for our senior courses in order to provide students with the flexibility needed to schedule programs, particularly with joint concentrations, and to ensure that our honours programs can be scheduled and completed in four years. This flexibility also allows the department to adjust course offerings slightly each year in response to specific student interests and demand. We believe that flexibility and the capacity to respond to student interests is essential for maintenance and growth of enrolment in our majors programs.

In what follows we describe the current curriculum and program requirements. At the first year level, the department offers a calculus-based stream (P1050/P1051), intended to provide abroad introduction for students intending to pursue physical sciences or engineering, and an algebra-based stream (P1020/P1021) intended to be accessible to students with less preparation in mathematics and physics. In both streams, the emphasis in the 1st course is on kinematics, dynamics, energy and momentum. The second stream deals with waves, electricity, magnetism, and, in P1021, some fluid properties. In order to accommodate students with backgrounds that might have been limited by resources at the high school level, the two streams have been designed so that it is possible for students who do well in P1020 to enrol P1051.

At the first and second year level, the Honours Physics, general Physics, and Physics minor programs all require P1050 (or P1020), P1051 and four prescribed second year level courses. The four prescribed second year courses, P2053 (Thermal Physics), P2055 (Electricity and Magnetism), P2750 (Modern Physics), and P2820 (Computational Mechanics), provide a strong background in core areas of the undergraduate physics curriculum.

The Physics minor program requires two additional physics electives. These are normally drawn from the third year level. For students whose major is Chemistry or Biochemistry, P2053 (Thermal Physics) cannot be used to satisfy the minor program requirements. For Electrical Engineering students, the

prescribed courses beyond first year level are P2750, P3000 (Physics of Device Materials), P3550 (Electric Circuits), and three additional courses from a list P2820 and a selection of third and fourth year level courses dealing with Optics and Photonics (P3600 and P4600), Quantum Physics (P3750 and P3751), Computational Physics (P3800), Solid State Physics (P4000), or General Relativity (P4220)

The Physics major program is intended to provide a broad general education in physics and its applications along with well-developed problem solving skills, critical thinking, and the capacity to communicate effectively. The Physics major program has the same physics requirements as the minor program at the first and second year level. The physics requirement for the major program also includes five prescribed courses at the third year level, two third year level courses drawn from a prescribed list and two additional courses at the third or fourth year level. The Physics major program also requires four mathematics courses beyond the first year level. A number of the required courses also include writing and presentation components.

The Honours Physics program is intended to prepare students for graduate programs in physics or closely related disciplines. The honours program is more demanding than the major program and the requirements are more tightly prescribed. Like the Physics major program, the Honours program requires the prescribed core of physics courses at the first and second year level and four mathematics courses beyond the first year level. There are eight prescribed courses at the third year level, four prescribed courses at the fourth year level, plus the thesis course which counts as two additional prescribed courses at the fourth year level. Finally, the honours program also requires two elective physics courses at the fourth year level and two additional physics elective courses drawn from either the third or fourth year level.

In addition to a number of joint major and joint honours programs, three novel programs have been developed since the last Academic Program Review to take advantage of the department's unique blending of strengths in physics and physical oceanography. These are the Geophysics and Physical Oceanography joint honours program and the major and honours programs in Environmental Physics. The Environmental Physics programs are highly interdisciplinary with required courses beyond the first year level taken from physics, earth science, geography, biology, and mathematics. The department has also introduced P2300, *Introduction to Physical Oceanography*, for inclusion in an interdisciplinary Ocean Sciences minor program.

Student Demand and Enrolment in Undergraduate Physics Courses

The introductory courses that the department offers must serve students intending to pursue degrees in engineering and the life sciences as well as those who will pursue physics or physical sciences. In its delivery of these courses, the department must be responsive to the requirements of the units in which most of these students will ultimately pursue their degree programs. The department must also cooperate with other units to resolve timetabling and prerequisite issues. While the delivery of these courses requires the mobilization of considerable resources on the part of the department, this is justified by the large enrolment in these courses and by the potential impact of these courses on students pursuing degrees in other disciplines and on the programs in those other disciplines.

The number of enrolments in first year level physics courses since 2004 is consistently in the 1800-2000 range with an average of ~1900. The consistency of this level of enrolment over a period when programs in other units have been revised or reconfigured reflects the department's efforts to maintain the quality of its first year level offerings while responding to changes that affect the scheduling of course components, particularly the laboratory and problem workshop sessions, the program requirements of students, and the levels of mathematical and physics preparation of potential students pursuing different degree streams. Specific aspects of this effort are discussed in more detail under *Undergraduate Program Delivery.*

There is a perception among students that physics is a challenging degree program and the maintenance of strong numbers within the physics major programs and strong enrolments in courses beyond second year is a challenge for most North American physics departments. As noted elsewhere, numbers taken from the 2014 survey of Canadian physics departments conducted by the Canadian Association of Physicists suggest that, within the Canadian context, the number of major degrees awarded by this department is commensurate with its size.

Figures 2, 3 and 5 show, respectively, the enrolment in courses beyond first year, the number of active majors, and the number of Physics major degrees awarded each year since 2004. The obvious fluctuation in the number of degrees awarded reflects, to some extent, the statistics of small sample sizes. Following a significant dip in 2010, the number has been trending slightly upward since. The total numbers of active majors and enrolments in courses beyond first year are smoothed because of the contribution to those numbers from multiple cohorts. The enrolments also reflect the presence of students from other disciplines, particularly engineering, in specific third and fourth year courses. This aspect of the data is discussed below.

The department is continually sensitive to student numbers in senior courses and, over the years, has implemented a number of measures aimed at encouraging enrolment in courses beyond first year. These include:

- curriculum renewal and the development of new resources for course and program delivery;
- student advising and mentoring at both the high school and university levels;
- the development of scholarships and awards, along with recognition events, for physics undergraduate students;
- the promotion of opportunities for undergraduates to gain meaningful experience in active research environments;
- faculty renewal (two new faculty members have been hired and another search is underway);
- the development of new degree programs;
- cooperation with other Canadian physics departments through the annual departmental leaders meetings at the Canadian Association of Physicists and through initiatives emerging from such meetings; and
- the development of senior courses to address requirements in programs operated by other units.

Specific examples of such measures are discussed in more detail elsewhere in the report.

While a comparison with similarly-sized departments in Canada suggests that senior course enrolments here are not unusual, the department is continues to explore options to achieve appropriate growth in both program participation and individual course enrolments beyond first year. A number of initiatives aimed at advancing these objectives are currently under consideration. These include:

- further curriculum review and development particularly at the second year level (full curriculum review has been initiated in September 2015);
- increased flexibility in program requirements to accommodate students with a wider range of career objectives;
- development of new programs such as a computational physics degree program;
- further cooperation with other Canadian physics departments and the Canadian Association of Physicists to develop better information resources on career opportunities for physics graduates; and
- further cooperation with other units, such as the new Department of Ocean Sciences, to develop courses to address specific program requirements.

Continued development and renewal of physics programs, and growth of enrolment in senior physics courses, is dependent on many factors including the maintenance of a dedicated, research active faculty complement and the availability of an adequate and sufficiently flexible departmental budget. It is also critical that the department continue to foster a culture in which teaching excellence is valued and that this continues to be reflected in the expectations for faculty, staff, and teaching assistants.

Undergraduate Program Delivery

The department is committed to providing high quality undergraduate education and programs while also supporting competitive graduate programs in a productive research environment. Achieving these goals requires that our undergraduate programs be delivered efficiently, creatively, and effectively. These continue to be important considerations as the program evolves. One important characteristic of program delivery in this department is the ability, and willingness, of most faculty members to teach across a broad spectrum of theoretical and/or experimental courses.

Introductory Physics

First year class sizes have been stable for the last 8-10 years. In a typical fall semester, the department offers 2 lecture classes of P1020 (~250 each), 2 lecture classes of P1050 (~170 each), 1 lecture section of P1021 (~70) and one lecture section of P1051 (~80). In a typical winter semester, there will be 2 lecture classes of P1021 (~185 each), 2 lecture classes of P1051 (~140 each), 1 lecture section of P1020 (~120) and one lecture section of P1050 (~40). In the spring semester, 1 section of P1051 (~65) is normally offered to accommodate students seeking to enter term three of the engineering program in the fall.

Each large lecture class is divided into 3-4 smaller sections (55-75 depending of laboratory capacity) for laboratory and problem workshop delivery. The failure/attrition rates for the large classes are not significantly different from those for the smaller "off-semester" classes and feedback provided by students through the Course Evaluation Questionnaire (CEQ) system also seems to indicate that class size is not a significant determinant of student satisfaction. Our experience indicates that it is possible to maintain the effectiveness and quality of student experience in these critical courses using a large lecture format as long as particular attention is focussed on the deployment of resources. These courses require leadership from experienced and motivated instructors along with the creative and effective utilization of a dedicated complement of teaching support staff, student teaching assistants, classroom demonstrations, and computer-based technology and resources where appropriate. More detail on how the delivery of these courses has evolved is provided under *Innovations and Undergraduate Initiatives*.

Courses at the first year level have been taught by regular faculty members and by contractual staff with a particular interest and expertise in undergraduate teaching such as the academic program officer and term appointees. Recently, demand for teaching resources at the graduate and senior undergraduate levels coupled with fluctuations in faculty availability due to sabbatical leave or remission for other duties has resulted in the need to assign some first year sections to per course instructors.

In light of planned growth of undergraduate Engineering programs demand for first year Physics courses, and thus the need to commit significant departmental resources at this level, will likely remain high. Students who have either already been admitted to the Engineering program via direct entry (about 300 per year), or who are hoping to gain admission to the Engineering program after completing first year Science courses, already comprise a significant fraction of the Introductory Physics enrolment, particularly in the P1050/P1051 stream. Currently, the number of students who are successful in entering term 3 Engineering in the fall semester after having completed first year Physics courses during the previous academic year is about 350. The demand for Introductory Physics from admitted and prospective Engineering students is expected to increase in response to the planned expansion of the undergraduate Engineering program between now and 2020. In particular, Engineering will be adding approximately 50 new faculty positions and the number of individuals graduating from undergraduate Engineering programs is planned to increase from a current number of about 170 to about 250 (i.e. by ~47%) by 2020.

Courses Beyond First Year

For courses beyond first year, the priority in program delivery is to provide students with courses that cover core areas of physics at an appropriate level and in way that facilitates timely completion of their programs. It is also important that students be allowed sufficient flexibility, in terms of course availability and program requirements, for their degree program to be tailored to their interests and aptitudes. As illustrated by the table of course offerings in Appendix C, we strive to offer core courses at least once every year while some more specialized courses are offered when resources permit and demand justifies. To accomplish this, and ensure that students are able to take advantage of required courses as they are offered, we have periodically re-assessed prerequisite structures and relaxed them by making courses more self-contained where warranted. We have also modified the sequence of

courses in some specific areas, such as thermal physics, mathematical physics, and the senior laboratory courses, by moving some materials from the third to fourth year level and adjusting the distribution of courses between semesters. In order to optimize the offering of senior level courses, students are asked to fill out a survey each winter semester indicating which courses they require to complete their programs and which physics electives they would be interested in pursuing. The information gathered in this way is considered for course offerings for the following academic year. In order to maximize the range of senior courses available to students, the department also maintains arrangements with the Department of Mathematics and Statistics and the Faculty of Engineering to "cross-list" selected courses and share in their teaching. Our experience indicates that the careful planning and attention to student feedback and requirements reflected by this approach to program delivery is critical to the effective delivery of our program and the maintenance of acceptable senior course enrolments and thus to the viability and integrity of our honours programs.

Innovations and Undergraduate Program Initiatives

The department places a high priority on continuing to improve the quality and scope of its undergraduate programs and on enriching the education experience of its students. To this end, a number of initiatives have been pursued over the past decade or are currently being explored.

Scientific applications of computing – The department has always placed a high priority on integrating scientific applications of computing into all aspects of its undergraduate program. The department provided undergraduate students with access to UNIX-based X-windows networks and Windows based systems long before such services were common at Memorial and has continued to support and enhance the resources available to Physics majors. The department employs a full-time programmer/consultant to support academic computing and provides all major students with access to printers and specialized software such as Matlab and Mathematica. The use of computers for data acquisition and analysis and for image analysis is now integral to all of the senior undergraduate laboratory courses. There are now three dedicated personnel supporting academic, administrative, and research computing within the department.

In 1997, the department introduced computers into the first year program through Physics 1054, a studio-format course with integrated lecture and laboratory components in which students could obtain data from interfaced experiments and then use computational resources for analysis and/or modeling. This initiative involved a significant renovation of an existing laboratory space. By 2004, Physics 1054 had evolved into Physics 2820 (Computational Mechanics), which extended the studio-physics approach to slightly more advanced material, and the first year laboratory program, in which the use of computers for data acquisition and analysis was extended to the full suite of first year courses. This expansion, and the ongoing renewal of this facility, was funded by a number of faculty and university educational initiatives to which the department successfully applied. In particular, extending the utilization of computers to the full suite of first-year laboratories involved a significant renovation of space including the consolidation of three smaller laboratory spaces into a single space in which all of the computers could be managed together.

The department has also leveraged its research expertise in scientific computing to develop new course and program opportunities for Physics major students. Honours students are now required to take Computer Science 1510 (Introduction to Programming for Scientific Computing) and all major students take Physic 2820 (Computational Mechanics). This provides them with the background needed to make effective use of computer resources in other senior courses including laboratory courses. The department has also introduced Physics 3800 (Computational Physics) that is a project-based course in which students develop applicable skills in computational methods by writing and compiling code (C or Fortran in a UNIX environment) to solve problems drawn from various areas of physics. The department is now developing proposals for a second computational physics course and for a distinct Computational Physics Program. Such a program would prepare graduates for many career or advanced education opportunities including Memorial's interdisciplinary M.Sc. program in Scientific Computing, one of the first such programs in North America and still the only such program in Atlantic Canada.

Classroom and problem-solving workshop innovations at the first year level – In addition to the ongoing integration of computers into the laboratory components of our first year courses, the department has continued to seek ways to innovate and enhance the effectiveness of instruction at the first year level. Traditional tutorials have been replaced by problem-solving workshops in which students work on selected problems in small, peer-instructional groups. In some first year courses, the format has been a problems session/mini-quiz combination in which students work for an hour and then write a mini-quiz. In this format, feedback is provided through *Self Correction* or *Peer Correction* with papers coded and anonymized. The emphasis is on mastery of a few specific concepts in each session and students are encouraged to continue working on problems until they have identified conceptual gaps that might have been limiting their success. These sessions typically alternate with biweekly laboratory sessions. These sessions are sometimes also used to show demonstrations that are better experienced interactively or at closer range than can be practical in a large lecture theatre. Our experience has been that branding these sessions as workshop components of the course, rather than tutorials, has significantly improved attendance and effectiveness.

In some first year courses, the issues of student engagement and classroom participation have been addressed by using a range of quick evaluation tools including pre-class quizzes, in-class question sheets, and questions, for submission at the next lecture, to encourage immediate review of the material covered in a particular lecture. This level of student feedback and interaction is enabled by the use of QR code technology to scan submitted work. Other ways in which technology contributes to the delivery of large-enrolment courses is the use of social media (Twitter) to provide an additional channel for communication of course events to students and the provision of specific worked problem examples through online-videos (including instructor audio).

In order to ease the transition to university-level expectations, first year students have been provided with practice mid-term and final examinations. One perennial challenge with large enrolment courses is logistics associated with final examinations. Over the past few years, the department has refined an approach for organizing examination seating and paper tracking for examinations administered in a large gym environment. The use of assigned seating and individual examination numbering has reduced

both the student stress associated with entering/leaving the exam venue and the administrative overhead associated with ensuring examination security.

Online homework and assignment systems – The department first began using the CAPA (Computer-Assisted Personalized Assignments) system more than a decade ago. This kind of system provides each student with a unique set of questions and allows multiple attempts at solving them. The department now uses LON-CAPA for first-year courses, second-year courses, and at least one third-year course, Physics 3000, for which a full set of online-compatible questions had to be developed. For many of these courses, the online work is supplemented by the submission of selected written problems but our experience is that the instant feedback provided by the online systems is very valuable for reinforcing concepts covered in class. Because of its efficient usage of personnel resources, the online system also allows students to practice over a more comprehensive range of course concepts.

Physics Help Centre – The Physics Help Centre has evolved into an integral part of the department's first-year physics delivery strategy. The centre is housed in a comfortable and newly renovated room that is conveniently located close to first-year laboratories and adjacent to a high traffic route between classroom buildings and the University Centre. To facilitate student access to the online assignment systems, the Help Centre is equipped with printers and computers running on the same network as the first-year laboratory computers. The Help Centre operates from 9:00-5:00, Monday to Friday. Teaching support staff members staff the Centre and every faculty member is assigned at least one hour of Help Centre duty per week during the Fall and Winter semesters. Some students schedule their use of the Centre so that they can interact with a particular staff or faculty member with whom they have developed some rapport. Some students visit the Centre to get help with specific issues but some students just use the Centre as a study venue where help is available if a question arises. The Help Centre has proven to be very popular with students and the department has noted a healthy synergy between the online assignment system and utilization of the Centre.

Classroom demonstrations – In physics classes, concrete demonstrations are important not only for illustrating and reinforcing important physical concepts, but also for periodically re-engaging the class and challenging preconceptions. Large lecture theatres, such as are used for most of our first-year lecture classes, are particularly challenging venues in which to present many of the most effective demonstrations in mechanics, waves, fluids, and electromagnetism. In past years, the department has applied for and received funding from Memorial's Classroom Teaching Infrastructure Development Fund (CTIDF) for a variety of projects including the acquisition of equipment for use in the development of new classroom demonstrations suitable for use in a range of venues including large lecture theatres. One of our challenges is that the theatres in which our large first-year lecture classes are taught are in other buildings that must be accessed via tunnels or overhead walkways during the winter. Despite the challenges, instructors who are determined to enrich the lecture experience with meaningful demonstrations have found ways to transport and assemble sometimes complex demonstrations during the few minutes available between lectures in the heavily utilized theatres and the demonstrations are often cited very positively in Course Evaluation Questionnaires (CEQs) submitted by students. In 2014, the department was awarded $19,000 for mobile demonstration systems. These will be self-contained mobile platforms on which demonstrations can be assembled in the department and then wheeled into

the classroom for direct use without reassembly in the classroom. The department is now in the process of assembling the platforms and mobile demonstrations that will make up these systems.

Other funded teaching initiatives **–** The department and various faculty members regularly seek and obtain funds from CTDIF, and the earlier Instructional Development Grant program, for a variety of instructional initiatives. Some of the uses to which such funding has been put include renewal of senior undergraduate laboratory infrastructure, the development of online tutorial or problem-solving videos for use in specific courses, and a pilot study into the effectiveness of providing students in a senior class with specific mobile device platforms from which to access compatible course material.

Unstructured study space **–** The department provides Physics major students with study space in the physics reading room (C3007). While working on their theses, undergraduate students can also obtain a carrel in the honours student study room (C3030). In addition to providing students with space to study and socialize, these resources provide a focus for student collaboration within the department and encourage an important sense of community within our undergraduate student body.

Undergraduate research access to research infrastructure **–** Experience in a research environment is one of the best ways for a student to appreciate the context from which material in his or her program is drawn and it can have an enormous impact on future career choices. The department is committed to the enrichment of student experience through summer employment in departmental research environments. In particular, the department strives to ensure that all honours students are given an opportunity to spend at least one summer in an active research program. Students are supported through NSERC Undergraduate Student Research Awards (USRA) or directly from faculty members' research grants. Recently, qualified students have also been supported through the Faculty of Science Summer Undergraduate Research Award Program (SURA). Some support has also been obtained from federal programs (i.e. the Canada Summer Jobs program) and, during teaching semesters, the Memorial Undergraduate Career Experience Program (MUCEP).

Students are encouraged to take advantage of opportunities to attend departmental seminars and, when they are arranged, accessible public presentations from distinguished visitors (for example, Clifford Will in 2005, David Mermin in 2007, Andrew Weaver in 2010, Sajeev John and Tom Pedersen in 2011 and David Shoesmith in 2013). Undergraduate students are also encouraged to attend the annual visiting lecture sponsored by the Canadian Association of Physicists Foundation and the lectures of other sponsored periodic visiting lecturers hosted by other organizations (i.e. the Harlow Shapley Lecture sponsored by the American Astronomical Society, the CMOS lecture sponsored by the Canadian Meteorological and Oceanographic Society and the annual lecture sponsored by CNC-SCOR).

Students are also encouraged to develop their own communication and presentation skills. With support from the Faculty of Science, the department, and supervisors, students are encouraged to attend regional and national undergraduate physics conferences (the Atlantic Undergraduate Physics Conference and the Canadian Undergraduate Physics Conference respectively). In preparation for their presentations, students are often given opportunities to practice their talks before a local, friendly audience. Honours students present their projects to the department and talks by students are

standard components of many senior courses. The development of writing skills is also recognized as an important element of a student's development and a number of courses incorporate written reports into the evaluation scheme.

There have been some instances where students in an undergraduate course have benefitted from access to infrastructure that was primarily a research resource. One example is the opportunities that students in Physical Oceanography courses have had, in the past, to spend a few hours on a university ship learning about oceanographic instrumentation and data collection. Until 2005, the 115 ft university ship, the *MV Louis Lauzier* was utilized for this purpose. Since then, the university's new ship, the *MV Anne Pierce* has been utilized once but getting access for teaching purposes seems to have been more challenging but this is an initiative that the department is still interested in pursuing. Another area in which undergraduate education can benefit from existing research infrastructure is through the utilization of high performance computing infrastructure by students in the course of specific projects.

Novel undergraduate programs – As described elsewhere, the department has been very active in the development of novel programs, such as Environmental Physics, and joint initiatives such as the Geophysics/Physical Oceanography joint honours program and the interdisciplinary Ocean Sciences minor. The department is currently exploring the ramifications of establishing a Computational Physics program to complement and utilize its research strength in that area.

Cooperation with Other Units

Because of the nature of its undergraduate programs and the relevance of its courses to programs offered by other units, the department cooperates widely and extensively with several other science departments and with the Faculty of Engineering at Memorial. Examples of such interactions include the scheduling of courses to optimize accessibility to specific student cohorts, the adjustment of prerequisite requirements to facilitate the utilization of physics courses in programs offered by other units, the development of joint programs and interdisciplinary programs, the development and optimization of course offerings to accommodate program requirements in other units, and the co-teaching of courses for which the department assumes shared responsibility. Our efforts to work collegially with other departments on these initiatives have been facilitated by the creation of a dedicated departmental Academic Program Officer position through which communications with other units can be channelled.

Undergraduate Service Teaching

Introductory physics is required for Engineering and for most degrees in Science so much of our first-year teaching can be considered as service teaching. The calculus-based introductory courses, Physics 1050 and 1051, are required for programs in Chemistry, Biochemistry, Applied Mathematics, and Engineering. Students in Biology require the algebra-based courses, Physics 1020 and 1021. To accommodate students who enter university without the opportunity to obtain sufficient secondary-school level preparation in mathematics and physics, there is provision for movement from the Physics 1020 stream to Physics 1051 on attainment of a specified minimum mark in Physics 1020. As noted

above, all four courses are available in each of the Fall and Winter semesters. Lecture classes in the algebra-based courses are typically larger in each semester. Physics 1051 is offered in the Spring semester to accommodate students seeking to enter the third semester of the Engineering program in the following Fall semester. Scheduling of laboratory sections for Physics 1051 is typically done in consultation with Engineering to ensure that sufficient non-conflicting sections are available to accommodate Engineering students.

Beyond first year, a number of physics courses are requirements of programs in other units. Physics 2820 (Computational Mechanics) provides a good introduction to computational methods and is required for the honours programs in Computational Chemistry, Applied Mathematics, and for some versions of the honours program in Earth Science. Physics 3220 is also required for the honours program in Applied Mathematics and Physics 2055 is also required for some versions of the honours program in Earth Science. The department has recently developed a new course, Physics 2300 (Introduction to Physical Oceanography), which will be required for the interdisciplinary minor program in Ocean Sciences that is currently under development.

There are a number of important links between the Physics and Engineering programs. Physics 3550 (Electric Circuits) is cross-listed with a course, Engineering 3821 (Circuit Analysis) that is required for Electrical Engineering. This course has been taught within the Engineering faculty in recent years. Physics 3000 (Physics of Device Materials) is also required for the Electrical Engineering Program. This course, with recent enrolments of ~50, is taught by a physics faculty member but scheduled specifically to accommodate the schedule of engineering students. Until recently, Physics 4300 (Advanced Physical Oceanography) was a required course in the Naval Architecture Program and typically had enrolments of ~25. In 2014-2015, the Naval Architecture requirement changed to Physics 3300. As a result, the enrolment in this Physics 3300, which had typically been 15-20, increased to 60 students for Winter 2015. The department remains open to other opportunities to collaborate with other units in the delivery of courses tailored to specific program requirements.

Students pursuing programs in other disciplines regularly take a number of other physics courses. A fluid dynamics course (Physics 4205/Mathematics 4180) was jointly developed with Mathematics and the two departments alternate responsibility for its delivery. Senior physics courses in a number of areas including optics and photonics (Physics 3600, Physics 4600), Physical Oceanography (Physics 3300, Physics 4300), and Astrophysics (Physics 3150) are also taken as electives by students majoring in other disciplines.

Program Requirements External to the Department

All of the Physics major programs require students to take courses offered by other departments. These courses include English 1080 plus one other first year English, Chemistry 1050 and 1051 (General Chemistry) and several mathematics courses including Mathematics 1000, 1001, and 2000 (differential, integral, and multivariate calculus), Mathematics 2050 (linear algebra), Mathematics 2260 (ordinary differential equations), Mathematics 3202 (vector calculus), and Computer Science 1510 (introduction

to programming for scientific computing). The specific content of the mathematics courses is particularly important, as some of them are prerequisite to some senior level physics courses.

The recently developed honours and major programs in Environmental Physics builds on strengths within the department, particularly in physical oceanography, but also includes required courses drawn from Biology, Geography, and Earth Sciences. This has allowed the department to create a novel and interesting degree program with a minimal increase in the number of courses that it needs to provide.

Joint and Interdisciplinary Programs

Many Physics major students enrol in joint major or joint honours programs. The department has collaborated with a number of other departments in the Faculty of Science to develop these programs, sometimes in response to interest expressed by an individual student. To be effective, the development and administration of these joint programs require a considerable degree of cooperation and consultation between departments. When some joint honours programs were introduced in the 1990s, the course requirements imposed by the cooperating departments sometimes precluded any possibility of the programs being completed in four years. Through cooperation and consultation, all of these programs have now been reconfigured to enable completion in four years. For these joint programs to be viable the course content must be reasonable and scheduling conflicts must be resolved to create a program that is viable and appealing to students. These programs are often taken by the most capable students and provide excellent preparation for students intending to pursue post-graduate research particularly in emerging and rapidly developing areas. The department encourages these students to pursue joint programs and, through the Academic Program Officer, works closely with students to resolve difficulties, particularly scheduling problems that might arise. Considerable coordination, consultation, and flexibility may be required in some cases.

The recently developed Geophysics and Physical Oceanography joint Honours program provides students with an opportunity to pursue a program built from an unusual combination of specific strengths at Memorial. The Ocean Sciences interdisciplinary minor program, courses provided by Chemistry, Earth Science, Ocean Sciences, Biology, and Physics, has required considerable coordination to develop but also provides a novel interdisciplinary opportunity for students.

Student Services and Communication

Physics programs can be challenging and the extent to which the department is able to attract students and successfully guide them through their programs depends on its capacity to communicate with and advise students as they are considering their program choices and as they progress through those programs. Communications begin at the high school level where a number of department members participate in the annual high-school advising visits organized by the Academic Advising Centre. Within the department, students can consult with the Academic Program Officer regarding all aspects of course selection, scheduling, and program requirements. Centralizing student advising in a specific, highly accessible individual has ensured the consistency and effectiveness of advice provided. The Academic

Advising Officer can also serve as a liaison between students and other units or offices within the university.

For students who do not need the specific services of the Academic Program Officer, the departmental web site is an important resource for information about program selection and course availability. As noted elsewhere, another important channel for communication between students and the department is the annual course demand survey that is circulated to all second and third year students in the Winter semester. The information gathered from the survey provides important input into the process of selecting courses to be offered each year.

There are also many informal channels for mentoring and communication with students. All faculty members in the department are accessible to students for assistance with course issues but are often approached for academic or career advice as well. The Physics Help Centre is primarily intended to assist students with problem solving issues arising in the introductory courses but it can also provide a venue for communications between students and faculty members, each of whom serves in the Help Centre for one hour every week during the Fall and Winter semesters.

Another venue for interactions between students and the department are annual information/awards lunches at which students can hear about department initiatives and new programs and talk with faculty and more senior students about program opportunities.

Indicators of Teaching and Program Quality

Students can find physics courses challenging and the Department of Physics and Physical Oceanography recognizes that student outcomes in such a challenging milieu are highly dependent on the ability of instructors to engage students and to present material clearly and effectively. The extent to which the department has been successful in doing this is reflected by the steady enrolment figures in its course offerings and by the high achievements of its graduates. One more direct measure is provided by the Course Evaluation Questionnaire (CEQ). While the recent move to online administration of this questionnaire has negatively affected participation rates, scores on the questionnaire, averaged across the department, have consistently fallen within a few percent of the scores averaged over the Faculty of Science. For example, Fig. 9 compares departmental and faculty averaged responses to the CEQ question “Overall, the quality of instruction was:”.

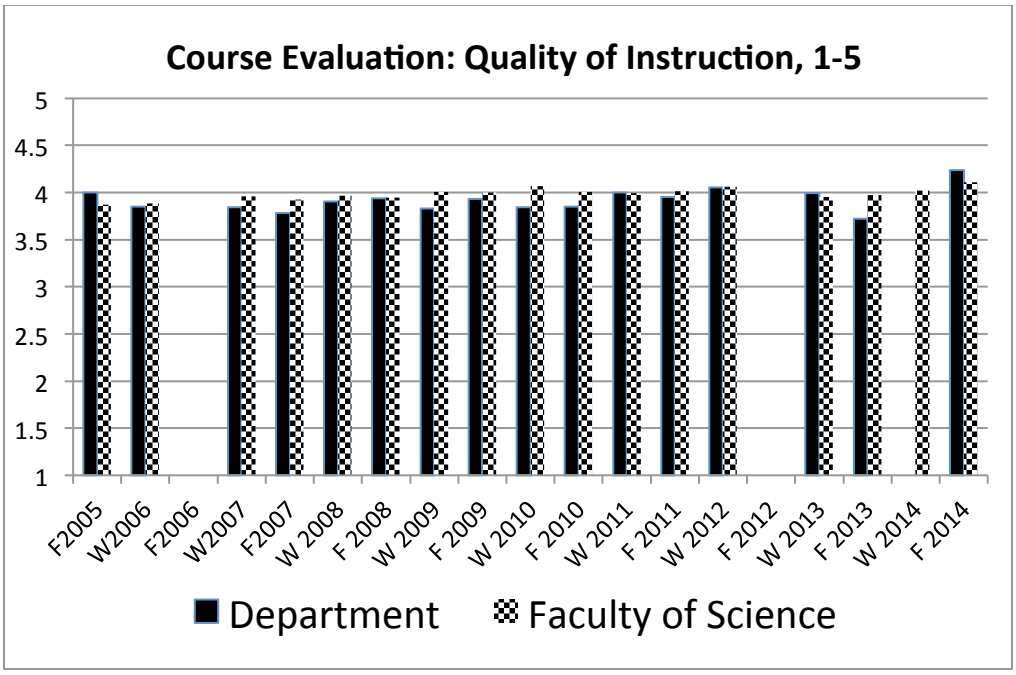


Figure 9: Departmental and Faculty average responses, on a 1-5 scale, to "Overall, the quality of instruction was:" on the Course Evaluation Questionnaire

Future Undergraduate Programs Plans

As stated above the department has begun a curriculum review of our undergraduate courses. This will be followed by a review of our undergraduate programs. The department is also intending to develop a proposal for a new (undergraduate) Computational Physics Program. Other program proposals that might be explored by the department are minors in Engineering Physics and Medical Physics.

3. Graduate Student Activity

Highlights

- Tripling of number of graduate students supervised by our faculty members since 2001/2002.
- Post-graduation successes of our graduate students indicate high program quality.
- High degree completion yields for all graduate programs involving our faculty members.
- New research-active faculty and incentives have increased number and proportion of PhD students.

Program Statistics 2001-2014

Graduate Student Numbers

Fig. 10 shows the total number of graduate students supervised by faculty in the Department for the period 2001/2002 to 2013/2014. As is evident, the number of graduate students supervised by our faculty approximately tripled between 2001/2002 and 2008/2009 and has remained roughly constant since then at about 50 students per year. Currently, approximately 53% of students supervised by our faculty are in Condensed Matter Physics, 30% are enrolled in Physical Oceanography, 11% are enrolled in interdisciplinary programs, and 6% are in other units within the university.

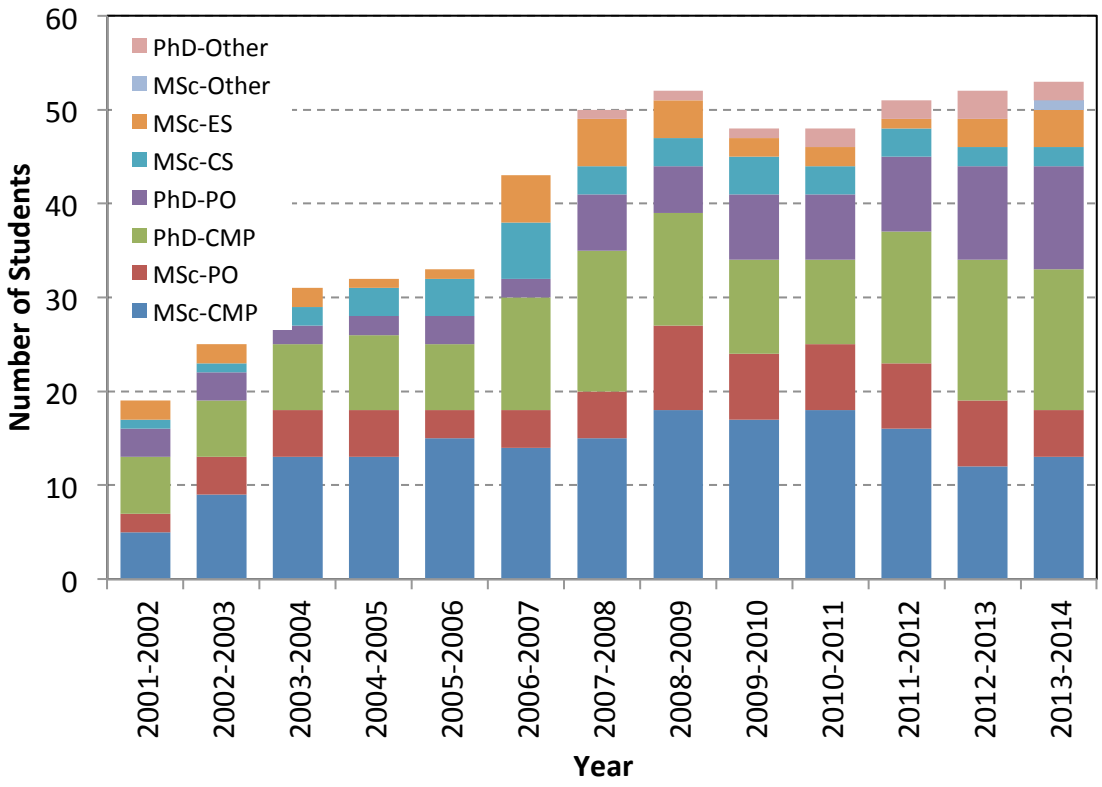


Figure 10: Number of graduate students supervised by Physics and Physical Oceanography faculty from 2001-2002 to 2013-2014. Note: ES = Environmental Science, CS = Computational Science, PO = Physical Oceanography, CMP = Condensed Matter Physics.

The ratio of the number of PhD students to MSc students enrolled in our home programs has also increased over the past few years (see Fig. 11). This increase and the overall increase in the number of students supervised by our faculty, is due to an increase in the number of research-active faculty and Memorial's increased focus on PhD recruitment and the associated financial incentives for highly-qualified students. For example, in 2014/2015 academic year, we had 26 students in Physics and Physical Oceanography PhD programs (59% of our graduate student population) and 18 students in Physics and Physical Oceanography MSc programs (41% of our graduate student population).

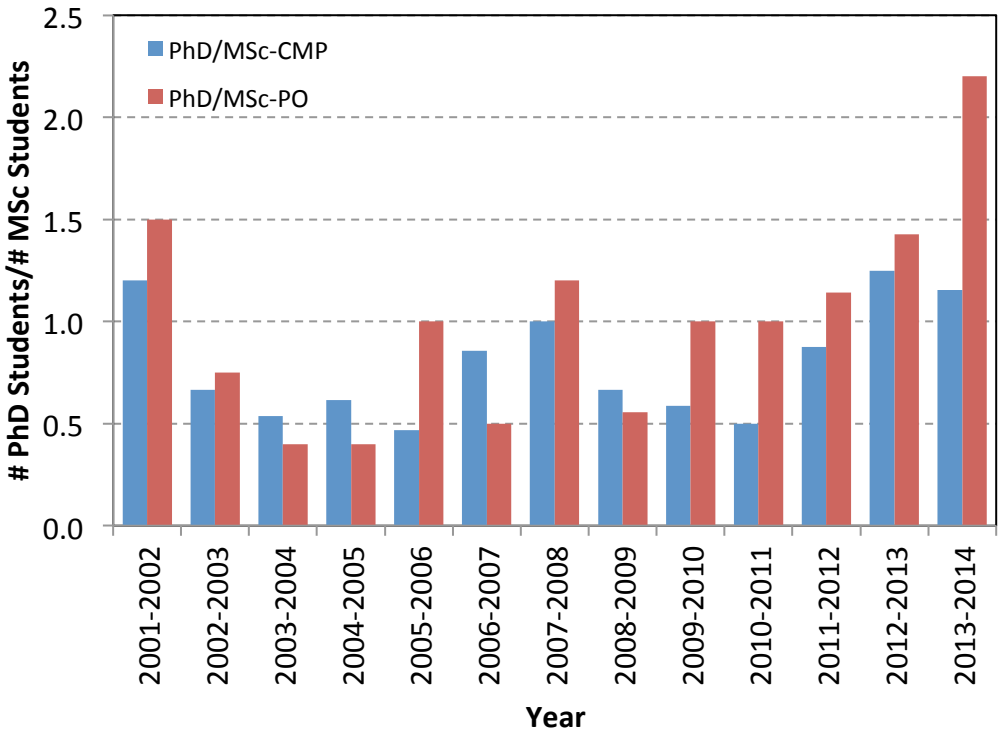


Figure 11: Number of PhD Students-to-Number of MSc students ratio from 2001-2002 to 2013-2014. Note: CMP = Condensed Matter Physics, PO = Physical Oceanography.

Number of Degrees Awarded and Completion Times

Since May 2001, 82 students have completed MSc degrees (61 in Physics and 21 in Physical Oceanography) and 29 PhD degrees (21 in Condensed Matter and Atomic and Molecular Physics and 8 in Physical Oceanography) in our Department. The mean time to completion for these students is 27 months and 60 months, respectively (see Fig. 12). In addition, 9 students supervised by our faculty have completed MSc degrees in Environmental Science and 10 have completed MSc degrees in Computational Science (now called Scientific Computing).

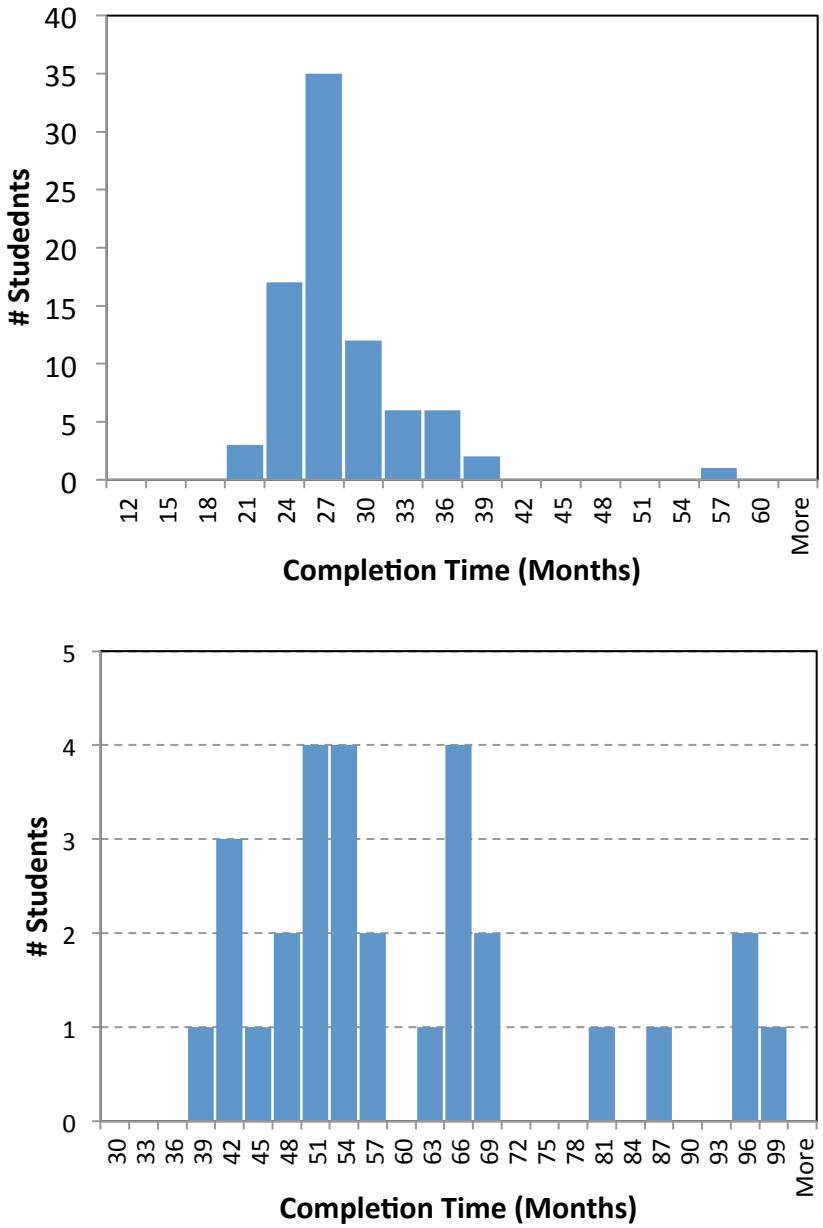


Figure 12: Degree completion times for MSc (upper histogram) and PhD (lower histogram) students since May 2001.

Graduate Student Profile

Fig. 13 shows the number of Canadian and foreign students enrolled in graduate physics programs. Our Canadian student population was relatively stable from 2001-2002 to 2007-2008 at about 8 students. It spiked to roughly double this number in 2008/09 and has since been declining. At present, 6 of our graduate students are Canadian. Foreign student enrolment increased dramatically over the period 2001-2002 to 2007-2008, and currently stands at 38 students.

The Department is very pleased to note the growth in graduate student numbers with about 3 graduate students per faculty member at present. We would be even more pleased if this growth included a wider diversity of students, in particular if we were able to attract more students from North America and from Canada in particular. While we have made great efforts to maintain the quality of students that we have accepted it remains a challenge to assess the quality of applications from foreign countries where the university programs and standards may be quite different from those that we are used to in North America.

Another challenge posed by this dramatic growth in numbers and global representation of nationalities is the social cohesion of the Department. We have students who speak many different languages, have quite different cultural and religious backgrounds and different expectations of workload and approaches to study and research. We make efforts to integrate students into the Memorial environment, e.g. by requiring that they attend respectful Workplace seminars, but do find that managing such a diverse group of students poses challenges for the supervisors and the Department.

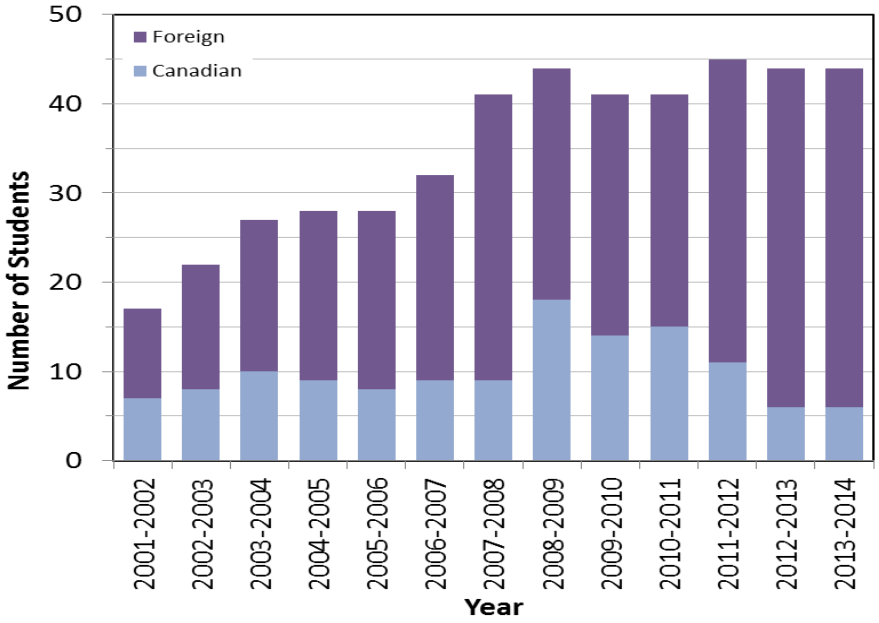


Figure 13: Country of origin of graduate students 2001/2002 to 2013/2014. Data for interdisciplinary programs are not included.

Graduate Student Funding

The Department has tried to maintain competitive funding packages for graduate students and has guaranteed minimum levels to which our students must be funded. In addition, the Department also provides some financial assistance for student conference participation.

Annual Stipends

Currently we guarantee minimum funding levels of $17,000 per annum for MSc students and $18,500 for PhD students. As Fig. 14 shows, these stipends have increased marginally over the last 10 years, but

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.

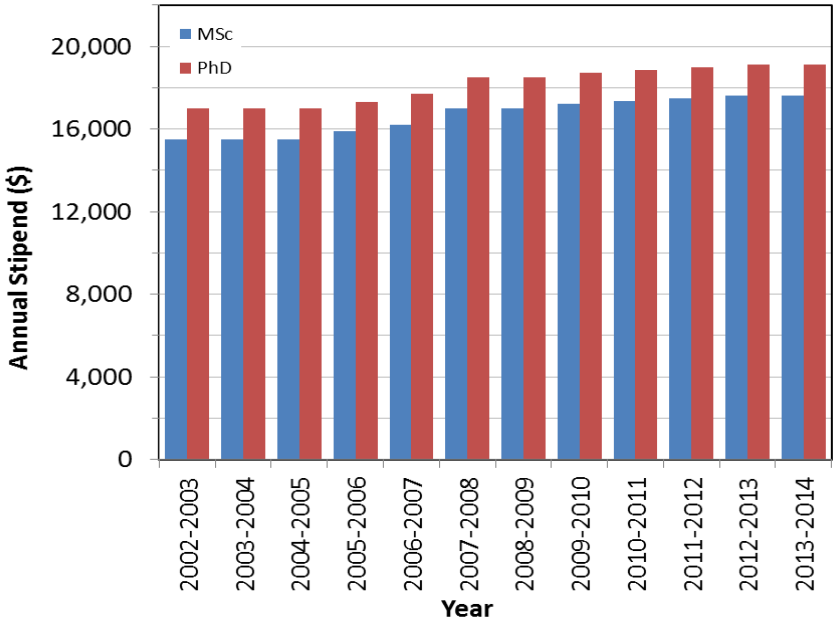


Figure 14: Annual stipends for graduate students 2002/2002 to 2013/2014.

Our current graduate student support consists of three components – a fellowship from the School of Graduate Studies for eligible students, a contribution from the supervisor`s research grant, and a teaching assistantship. The amount of each component is given in Table 1 for both MSc and PhD students.

Table 1: Breakdown of support and minimum annual stipends for MSc and PhD program students.

Program	School of Graduate Studies Fellowship	Supervisor`s Research Grant	Teaching Assistantship	Total Minimum Annual Stipend
MSc	6400	7675	3553	17,628
PhD	8700	6875	3553	19,128

The fellowship is paid from a fund (for example, $232,557 for the 2014-2015, up from $89,100 in 2001-2002) provided by the School of Graduate Studies. In recent years, the School of Graduate Studies has adjusted this baseline funding according to a formula that provides a fixed amount of funding for each MSc student and for each PhD student. The School of Graduate Studies limits the time for which an award may be held to 2 years and 4 years for MSc and PhD students, respectively.

The teaching assistantship is paid at a rate of $21.15 per hour. This translates into $1184.40 per 56-hour unit. Currently, students are guaranteed 3 units of teaching, but some supervisors ``buy out'' a student`s teaching component to allow him or her to devote more time to research. The amount that 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 program.

Conference Aid

The Department provides some funding to support graduate student participation in conferences and workshops. This funding, together with contributions from supervisor's research grants and other university entities (School of Graduate Studies, Faculty of Science, Graduate Students' Union), has enabled many of our graduate students to present their work at national or international conferences. In fact, most of our graduate students have the opportunity to attend such conferences before completion of their programs.

Graduate Student Involvement in Governance

Our graduate students are not currently involved in Departmental governance. The Department recognizes this as an area that requires improvement and, as a first step toward rectifying this, plans to invite a graduate student representative to attend Departmental Faculty meetings.

Graduate Programs

The Department offers MSc and PhD programs in both Physics (Condensed Matter Physics) and Physical Oceanography. There is essentially no overlap in the course requirements for degrees in these two areas, requiring the Department to offer two distinct streams of graduate courses. The Department also participates in interdisciplinary Masters programs in Computational Science (now called Scientific Computing) and Environmental Science. The Department also has a student participating in the new "accelerated MSc" pilot program in which academically-strong undergraduate students can obtain an MSc degree by doing graduate courses in the final year of their undergraduate program and research and thesis writing in the year immediately following.

Thesis

The principal component of all of our graduate programs is the thesis, which has as its basis original research and review of 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 usually the Deputy Head (Graduate Studies) who makes the recommendation. The examiners submit their reports to the School of Graduate Studies. While there is no formal thesis defence, the student is required to present a seminar describing his or her work prior to submission of the final version of his/her thesis.

The expectations for PhD thesis 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 an expectation that on completion of a PhD degree, the student will not only have carried out original research but will also have demonstrated sufficient knowledge and expertise to initiate research projects.

The PhD thesis is examined by two internal examiners and one external examiner appointed by the School of Graduate Studies on the recommendation of the Department Head, normally on the advice of the Deputy Head (Graduate Studies). The thesis examination also includes an oral defence of the thesis. This consists of a public presentation of the content and principal results of the thesis, followed by an oral examination. A few years ago, due to the availability of video-conferencing technology and budgetary constraints, the School of Graduate Studies stopped subsidizing the travel costs associated with having the external examiner physically present at the thesis defence and instead adopted an "e-defence" model in which the external examiner is present via videoconference. The Department and the Faculty of Science as a whole, voiced considerable concern over this change, arguing that the benefits of bringing an external examiner in for a PhD defence far outweighed the associated costs. In particular, the Department noted the value in students meeting an expert in a their field of study, the collaborative opportunities for both student and supervisor, and the fact that many of the external examiners give research seminars of general interest to the Department. Such opportunities are lost if the external examiner attends only via video conference.

Courses and Comprehensive Examination

Both the Physics and the Physical Oceanography MSc require students to take four graduate courses. The PhD programs in Condensed Matter Physics and Physical Oceanography require students to complete three graduate courses and to pass a comprehensive examination. This examination must be completed prior to completion of the student's seventh semester in the PhD program. In order to insure that student fulfill all the program requirements in a timely manner, once a year (typically at the end of the Summer semester) they all have to attend and discuss their progress at a supervisory meeting.

Interdisciplinary Programs

In addition to the graduate programs offered by the Department, our faculty members also participate in, and supervise graduate students in, the Environmental Science and Scientific Computing MSc programs. Details on these programs may be found at the following websites:

http://www.mun.ca/science/graduate/interdisciplinary/envs/msc.php

http://www.mun.ca/science/graduate/interdisciplinary/cmsc/

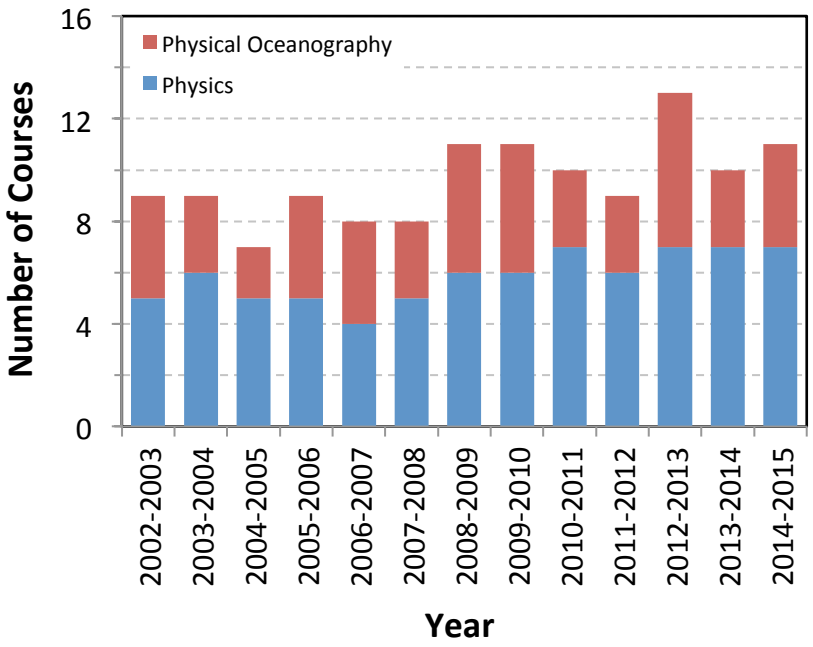


Figure 15: Number of graduate courses offered per year from 2002-2003 to 2014-2015.

Student Demand and Graduate Course Enrolment

Our graduate student enrolment increased dramatically from 2001 to 2008 and has since remained relatively constant at approximately 45 students (see Fig. 10). This increase represents an approximate tripling of our graduate student enrolment since our last Departmental Review in 2002.

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. As can be seen in Fig. 15, we have broadened our graduate course offerings over the past few years, offering approximately 11 courses per year over this period.

Innovations and Enrichments

As mentioned above, the Department has broadened its graduate course offerings over the last few years in response to student needs and the availability of expertise in the Department. Some examples of these courses include:

- Physics 6012: Advanced Photonics;
- Physics 6013: Soft Matter Physics;
- Physics 6900: Techniques in Experimental Condensed Matter Physics;

In addition to our course offerings, our graduate students also take courses offered by other units (e.g., Mathematics and Statistics, Chemistry, Earth Sciences, and Engineering).

The Department is active in interdisciplinary MSc programs. Members of our Department were instrumental in establishing the MSc program in Scientific Computing (formerly Computational Science)

and Dr. M. Plumer of our Department was the Chair of this program till Aug. 2015. Drs. Demirov and Saika-Voivod have contributed to the teaching of Scientific Computing graduate courses. Drs. Demirov, deYoung and Zedel have taught courses in the Environmental Sciences MSc program and several of our faculty members have supervised students in these programs.

Research Seminars

In addition to conference and workshop attendance, the Department also 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 speakers that the Department has been able to bring in in recent years.

Collaboration with Other Units and Institutions

The Department collaborates with other university bodies in many ways in the delivery of its graduate programs. Many of our students take graduate courses in other Departments (e.g., Mathematics and Statistics, Chemistry, Earth Sciences, and Engineering), and, conversely, graduate students from other Departments have taken our graduate courses, particularly in Physical Oceanography. A second example is our Advanced Photonics course which has been taken by many graduate students in Engineering. The interdisciplinary programs in Scientific Computing and Environmental Science naturally provide a means for interaction between our students and students and faculty members from other disciplines. The Supervisory Committees of many of our PhD students have a member from another Department with expertise in an area closely related to their thesis research. Moreover, faculty from other Departments have served as examiners on the PhD Comprehensive Examination Committees of many of our students. We have also hosted visiting graduate students from other universities.

Indicators of Program Quality

The Department regularly solicits student feedback to assess and improve overall program quality. Other measures of program quality include the post-graduation activities of our students and degree completion yields.

Solicitation of Feedback

The Department solicits feedback from graduate students on all aspects of our graduate programs informally during annual “pizza lunches”. During these events, students are encouraged to voice any concerns that they have about their graduate program experience – either in the open forum of the event or privately with their supervisor, the Deputy Head (Graduate Studies), or the Department Head.

Post-Graduation Activities

An important indicator of the quality of our graduate programs is the success of our students following completion of their graduate programs. Figure 16 shows the post-graduation activities of 129 students who graduated over the period 2002-2014. As can be seen, 81% of these PhD students went on to postdoctoral studies or related positions at academic institutions. The remainder accepted positions in Health Care or the private sector. In the case of MSc students, 60% went on to PhD studies, many continuing on at Memorial. 15% of our MSc students accepted positions in the public sector in health,

education, or research. Another 16% joined the private sector, while 6% did further studies in either education or medicine.

Degree Completion Yield

Since May 2002, 95 students began MSc programs in Physics or Physical Oceanography. Of these, 82 completed the program. This corresponds to a yield of 86%. Similarly, since May 2002, 29 of 34 students who began PhD studies in Physics or Physical Oceanography completed the degree program, for a yield of 85%. Over the same period, 100% of the 19 interdisciplinary (MSc in Computational Science and Environmental Science) students supervised by our faculty members completed the degree. It is worth noting that the primary reasons for program termination for students that did not successfully complete their degrees are (i) lack of progress in research and (ii) failure in graduate courses, reflecting insufficient breadth and depth of background preparation.

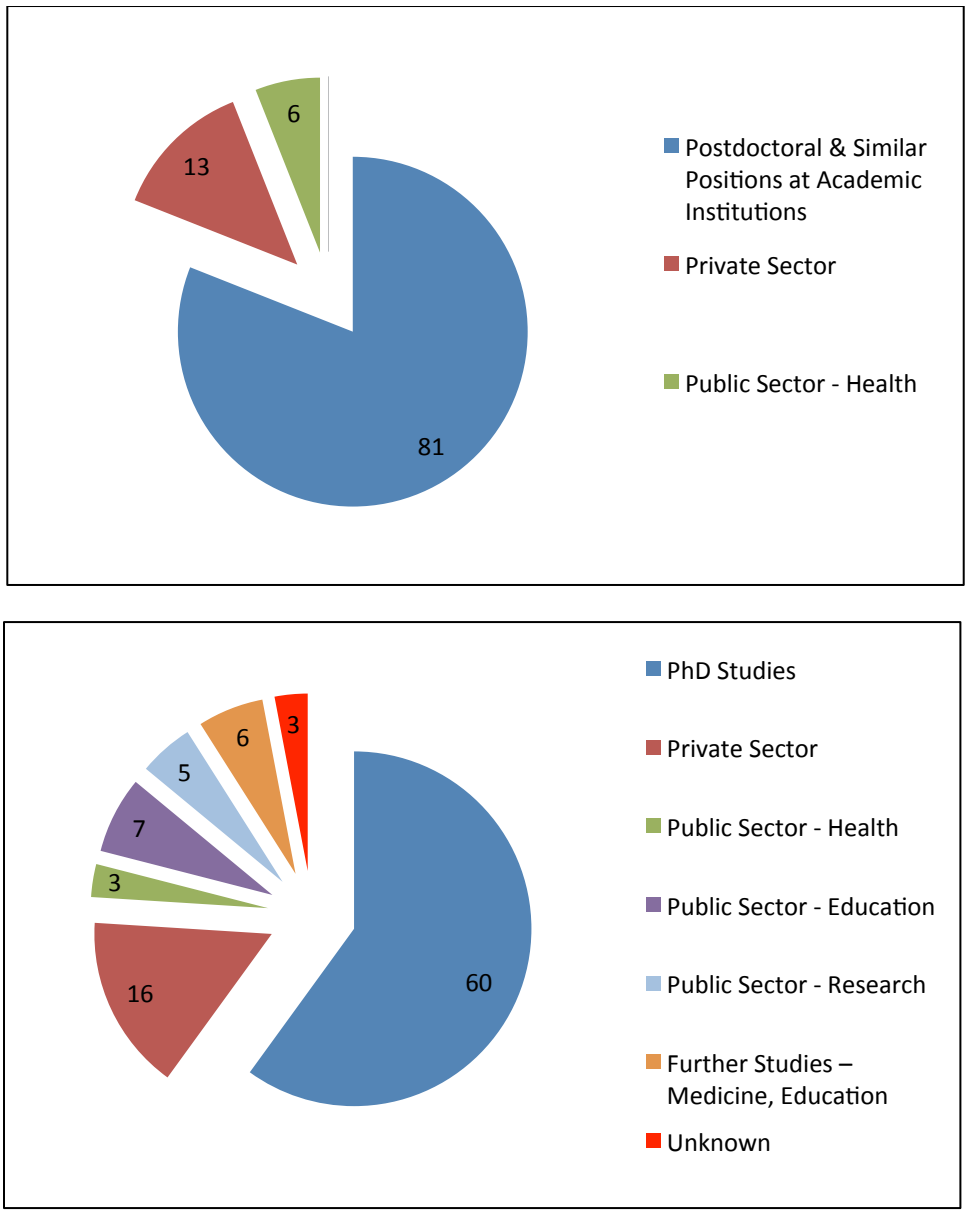


Figure 16: Post-graduation activities of our PhD students (upper pie chart) and MSc students (lower pie chart) over the period 2002-2014.

Postdoctoral Research

At any given time, the Department is home to a number of postdoctoral researchers. Table 2 presents selected postdoctoral research projects that have been carried out over the last few years in our Department.

Table 2: Selected projects carried out by postdoctoral researchers over the past few years in the Department of Physics and Physical Oceanography.

Group	Years	Project
Afanassiev	2014	Experimental investigation of baroclinic instability on the polar beta-plane
Beaulieu	2012-2014	Using cantilever sensors functionalized with modified calixarene molecules for detecting heavy metals in fresh water.
deYoung	2014-2017	Ocean gliders in the Labrador Sea for determining links between air-sea gas exchange and ocean climate
deYoung	2014-2016	Development of an underwater ocean profiler and new approaches to using aerial vehicles for ocean applications
deYoung	2014-2016	Developing new radar systems for measuring ocean waves
Poduska	2011-2015	Nanophosphor materials for colour control in solid-state lighting applications
Poduska	2009-2010	Electronic structure calculations for nanoscale ZnO
Yethiraj	2007-2008	Colloids in electric fields
Yethiraj/Saika-Voivod	2008	Dipolar colloids
Zedel	2012	Modelling acoustic Doppler sonar measurements of bedload transport. Barclay now a CRC II at Dalhousie.
Zedel	2014-2015 (4 months)	Developing a swath Doppler system for measuring sediment transport.

Future Graduate Programs Plans

These will be discussed at the end of section 4 of this report.

4. Research and Creative Activity

Our Department was originally called the Department of Physics and had research in the areas of atomic and molecular physics and geophysics. In the early 1980s, we developed new research and graduate programs in condensed matter physics and physical oceanography. At about the same time the geophysics group within the Department merged with the Department of Geology to form the Department of Earth Sciences. In the mid-1990's we formally recognized the growth of the physical oceanography group within the Department with a renaming to the department of Physics and Physical Oceanography. Since that time the Department has consolidated its interests and focus around two primary research strengths: Condensed Matter Physics (with a strong focus in Materials Physics) and Physical Oceanography, and a collective, significant shared interest in Computational Physics.

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 sub-disciplines by encouraging shared interests between the various research groups. As an example, computational simulation and modeling has grown substantially as an active area of research both in oceanography and in condensed matter physics and led to the development of the interdisciplinary MSc program in Scientific Computing. Laboratory fluid mechanics is now actively pursued in both oceanography and the condensed matter groups with research ongoing in low Reynolds number flow, rotating fluids and internal waves. Materials science encompasses Departmental activities in condensed matter, molecular physics and fluids research. There are strong links with researchers in the Departments of Chemistry and Earth Sciences and the faculty of Engineering. Studies of large, complex systems, as diverse as lipid bilayers, magnetic thin films, correlated electron materials and ocean ecosystems are clear areas of common interest. The understanding of complex systems, on scales ranging from the microscopic to the geophysics, is fundamentally interdisciplinary and requires collaboration with colleagues both inside and outside our Department.

As part of this self study report, our department reviewed earlier documents defining the strategic interests of our Department, including the last report in 2003. In reviewing this material as a group we discussed our future plans and considered how to define the strategic interests of the Department. Over a period of a few months, involving many meetings and much discussion, we formally adopted a Strategic Plan for the Research in our department. This Strategic Plan outlines our goals and interests for research in the coming years. While focused on the research of our Department, clearly there are links to the wider academic purpose of the department and to our plans for the hiring of both faculty and staff.

Strategic Plan for Research in Physics and Physical Oceanography

While the research of the department covers a wide range of interests, from photonics to global climate change, there are also many areas of shared expertise, from mathematical physics to computational modelling, as well as a shared approach that combines observation and experiment with theory, analysis, and numerical simulation.

Most faculty pursue a mix of fundamental and applied research, because, at its core, physics is the study of fundamental natural principles that can be applied to real-world situations. In this spirit, we fully embrace the Faculty of Science's Strategic Plan Goal to "engage with partners within and outside of Memorial to promote and support interdisciplinary research, research networking, and research collaborations." Much of the

research in our department is aligned with the University's Strategic Plan Research Themes, including arctic and northern regions; culture and heritage; environment, energy and natural resources; oceans, fisheries and aquaculture; and wellbeing, health and biomedical discovery.

Looking forward to the next decade, we intend that future faculty hires will be primarily driven by our strategic research focus. Our Department has two primary research strengths: Condensed Matter Physics (with a strong focus in Materials Physics) and Physical Oceanography, and a collective, significant shared interest in Computational Physics. Materials and Marine Science are currently featured as strengths in the Faculty of Science. We intend to build upon these two core areas, and to bridge with emerging topics of University-wide interest.

Condensed Matter, Materials Physics and Theoretical Physics

Condensed matter and materials physics relate the atomic-level structure of substances with their physical behaviors, including optical, magnetic, electronic, biological, chemical, and mechanical properties. The broad themes of this research focus in our department are magnetic and electronic materials, biological and soft materials, and photonics. Our condensed matter faculty members include experimentalists (Andrews, Beaulieu, Chen, Morrow, Poduska, Quirion, and Yethiraj and cross-appointee V. Booth from Biochemistry), and theorists (Curnoe, Evstigneev, Lagowski, Plumer, Saika-Voivod, Wallin). Other active faculty include retirees (Clouter, Lewis, Whitehead). The Faculty of Science oversees a separate interdisciplinary Ph. D. program in Theoretical Physics that is administered by members of the Department of Mathematics and Statistics and our department. Research in that field includes astrophysics (Lewis) as well as particle physics (A. Aleksejevs, cross-appointed with the Grenfell Campus of Memorial), and gravity and cosmology (I. Booth, cross-appointed with Department of Mathematics and Statistics).

We investigate condensed matter with a wide variety of materials properties such as semiconductors, topological insulators, superconductors, conjugated polymers, thin-film metals, magnetic materials, and quantum spin systems. Research in biological and soft materials includes studies of lipids, membranes and proteins, ordering and dynamics in colloidal systems and emulsions, cantilever-based detection of biological material as well as the study of glassy dynamics and nucleation in liquids and the theory of nano-biology. Our photonics research is devoted to the study of ultrafast nano-photonics and has a large overlap with both materials physics research and with spectroscopic sensors used in the investigation of materials. A particular focus of much of this research activity is to relate understanding at the fundamental level to applications that involve a wide range of potential technologies, including micro-cantilever sensors, solid-state lighting, magnetic storage, fiber optics, organic photonics and biophotonics.

We employ a large variety of experimental techniques to study these materials, including spectroscopic measurements with Raman and Brillioun scattering, ultrasound, NMR, magnetometry, X-ray absorption, micro-cantilevers, and confocal microscopy. Two state-of-the-art laboratories have been established for photonics research (ultrafast nanoscale optical and laser applications). We also use theoretical and computational methods to study the materials systems based on group theory, quantum theory of magnetism, equilibrium and non-equilibrium statistical mechanics, density functional theory, and molecular dynamics and Monte Carlo simulations. The department maintains and continually upgrades its Centre for Magnetic and Materials Simulations (CMMS) lab, which includes office space for five graduate students and five advanced workstations. In theoretical physics our research is based on the theory of general relativity, elementary particle theory, and computational astrophysics.

Our research benefits from a broad range of collaborations within our department, with other departments at MUN, and with numerous external researchers. Within the department there are extensive shared research activities in the study of magnetic properties of materials, soft colloidal and bio-systems and sensors. We also have long-standing collaborations with the members of the Departments of Biochemistry, Earth Science, Chemistry and the Faculty of Engineering. A portion of the research activity of each of our faculty members in condensed matter and theoretical physics involves work with external collaborators at universities and government laboratories around the world. Some of the research projects with industrial partners include those involving magnetic recording, solid-state lighting, biological sensors and biopharma.

Physical Oceanography

Physical oceanography is the study of physical interactions that take place in the oceans. Approaches taken include theoretical study, field observations, laboratory experimentation and numerical simulation. Observational studies must deal with the expansive space and time scales of the oceans which necessitate creative and efficient data collection schemes to achieve meaningful outcomes. These challenges drive the individual interests of researchers within the department. It is also important to recognize that the greater discipline of oceanography is inherently interdisciplinary with strong links between the physical, biological and chemical sub-disciplines; this character is evidenced by significant interdisciplinary involvement of the department faculty.

The research done by the physical oceanography group covers a wide range of areas of geophysical fluids dynamics of the atmosphere and ocean, climate and ocean dynamics in the North Atlantic. The main focus of this research is on fundamental problems of the ocean and earth system and applied studies of the regional climate and ocean environment of Canada.

The oceanography group has developed a significant capacity for advanced studies and training including ocean instrumentation and computing facilities for advances ocean observation and modelling, knowledge, experience and collaborations between members of the team. We have a substantial pool of laboratory and field oceanographic equipment including mooring equipment, ocean gliders and acoustic sensors and the ability to independently deploy these instruments in field programs around the globe, although with a primary focus on the North Atlantic. Physical oceanographers within the department cover a wide range of interests including laboratory studies, field oceanography, numerical modelling , instrumentation development, and climate studies including earth systems studies that includes ice and glacial dynamics. The research of each of the faculty in oceanography (Afannassiev, Demirov, deYoung, Munroe, Tarasov, Zedel) covers many of the interests listed above.

The oceanographic research interests of the department has evolved over the years but has typically covered interdisciplinary climate and ecosystem studies, acoustical oceanography, laboratory fluids studies, coastal ocean dynamics and in recent years a growing focus on instrumentation development and application. There are many opportunities within the university for collaboration and program development both inside the Faculty of Science (with Biology, Chemistry, Earth Sciences and Ocean Sciences) and with other units such as Geography, the Faculty of Engineering, and C-CORE. While the geographic focus of most of the field research has been on the Northwest Atlantic and Arctic, there are opportunities for research that reaches well beyond the Atlantic. Researchers in oceanography have been active in many different regional, national and international programs with varying themes over the years, from fisheries to instrumentation development to climate change. This flexible approach to the thematic focus of the physical oceanographic group has served it well over the years.

Computational Physics

The use of numerical calculations continues to expand as an integral part of condensed matter, materials physics and physical oceanographic research. Computational investigations enable a control and precision often unavailable in the laboratory. They can provide information inaccessible by other means, can guide in the design of new experiments, and can be crucial for the development of technological devices. Computational research has become a key approach for understanding the fundamental and applied aspects of complex materials and fluids.

Theoretical and computational physics have become increasingly intertwined in recent decades, and the research activities of many members of our department reflect this evolution. These activities involve large-scale molecular dynamics, Monte Carlo and Brownian dynamics simulations, parallel tempering and free energy methods, Density Functional Theory methods, etc. Using these techniques, a broad range of topics is investigated by our faculty members, such as superconducting and magnetic systems, crystal nucleation and glass transition, organic semiconductors and electronic properties of polymers to name but a few.

Ocean modelling still includes a strong component of model development, i.e. improving process representation within the models, but is also moving towards development of tools and approaches for applied and operational oceanography. There is a very strong link between data collection and analysis and model development and verification. Strong collaboration with experimental groups, within and outside the department, is recognized as a key component of these computational research activities.

The involvement of our faculty in the remarkable expansion of computational resources available for scientific research together with the development of programs and courses in scientific computation over the last two decades is a sign of our recognition of the increasingly important role of computational physics. We were instrumental in the creation of the only interdisciplinary M.Sc. degree in Computational Science (now called Scientific Computing) in Atlantic Canada, as well as the Atlantic regional computing consortium (ACEnet), now a part of Compute Canada. Both major research groups in the department, Condensed Matter and Physical Oceanography, support and operate computational clusters for their numerical research.

Future Plans

We will maintain the present thematic focus of the department including materials and condensed matter and materials physics, physical oceanography, and computational and theoretical physics. In the coming years, we will work to establish links with other thematically related groups and researchers located elsewhere inside and outside the university. We have identified three particular opportunities for growth that build upon our existing strengths and apply to many within the department.

***Sensor and Instrumentation Development**:* There is a strong interest in sensor development in both condensed matter physics and physical oceanography with projects and collaborators both inside the university (e.g. in Chemistry, Engineering, Geography and Archaeology) and outside the university (from the offshore industry to the lighting industry). As examples, Zedel has been working on the development of acoustics Doppler systems for sampling in nearshore waters, deYoung has been working on autonomous underwater vehicles (AUVs) and profiling mooring systems and Poduska has been working on new lighting systems and Beaulieu is developing micro-cantilever sensors for industrial and medical applications.

Enhanced Collaboration and Multidisciplinary Research- The department will enhance and facilitate collaboration both intra-departmental and extra-departmental. We will work to encourage seminars by potential collaborators from outside the department provides an opportunity to build such linkages. Initiatives such as Magnetic North and Ocean Gliders Canada were led by researchers in the department and are good examples of multi-institutional and interdisciplinary initiatives that we will encourage and support. We will foster research into new areas that build on our discoveries and achievements in materials physics (such as archaeological research) and in oceanography (such as ecosystem studies) and expand into new areas such as theoretical astrophysics and medical physics. Links to other departments and faculties of the university, from Arts to Engineering, can be further developed around the shared strategic interests of our department that align with other groups. These exist in several different thematic areas, from the development of computational techniques to integrating physical oceanographic models with biological observations.

Biophysics and Medical Physics – There are several faculty in the department (Morrow, Poduska, Saika-Voivod, Wallin, Yethiraj) and several outside the department (from Chemistry and Biochemistry for example) with an interest in enhancing the level of activity in biophysics through initiatives such as a multi-disciplinary journal club and networking symposia with external visitors. There is also an opportunity to collaborate with medical physics research interests in the Faculty of Medicine and to develop an undergraduate or graduate program in biophysics or medical physics.

Faculty Research Interests

Currently, Physics Department has 10 Full Professors, 6 Associate Professors, 3 Assistant Professors, and 3 Cross-Appointed Professors

NAME	POSITION	RESEARCH INTERESTS	HIRED
Afanassiev, Iakov	Professor	large scale dynamics of oceans and atmospheres rotating planets, planetary waves, vortices and turbulence, laboratory experiment, numerical modelling	1999
Andrews, Todd	Associate Professor	laser spectroscopy, phononics, photonics nanostructured materials, elasticity, semiconductors, light-hypersound interaction	2002
Beaulieu, Luc	Associate Professor	cantilever sensors, chemical sensors, scanning probe microscopy, thin film deposition and characterization, heavy metal detection in water	2004
Chen, Qiying	Professor	ultrafast photonics, nano-photonics, near-field optics, laser fabrication, fibre optics, opt-micro, fluidics, photovoltaics, optical sensing	2004
Curnoe, Stephanie	Professor & Deputy Head	theory of frustrated magnets, quantum magnetism, unconventional superconductors, structural, magnetic and superconducting phase transitions	2001
Demirov, Entcho	Associate Professor	polar and subpolar oceanography, semi-enclosed seas, ocean climate, sea-ice, water masses, ocean mixing, deep convection, ocean modelling, data assimilation	2004
deYoung, Brad	Professor	coastal ocean dynamics, ocean observation, ocean instrumentation, ocean modelling, climate change, ocean ecology	1988
Evstigneev, Misha	Assistant Professor	non-equilibrium statistical physics, stochastic processes, surface science, atomic friction, friction aging, biophysics, nanophysics, molecular dynamics	2014
Lagowski, Jolanta	Professor & Head	organic conjugated polymers and oligomers, density functional theory, electronic and optical properties, charge transport, organic solar cells and diodes	1992

NAME	POSITION	RESEARCH INTERESTS	HIRED
Morrow, Michael	Professor	soft condensed mater, biophysics, model membranes, protein-lipid interaction, lung surfactant, colloid, and solid state NMR	1986
Munroe, James	Assistant Professor	stratified fluid dynamics, internal waves, ocean mixing, laboratory experiments in fluid dynamics	2010
Plumer, Martin	Professor	statistical mechanics, computer simulations, nanomagnetism, magnetic recording, Monte Carlo, spin dynamics, frustrated antiferromagnets	2005
Poduska, Kris	Professor	materials physics, structure-property relations, semiconductors, natural materials, magnetism, electrodeposition, archaeological science	2003
Quirion, Guy	Professor	multiferroic, magnetoelectric effect, phase diagram, phase transition, ultrasonic velocity, high pressure, high magnetic field, low dimensional systems	1999
Saika-Voivod, Ivan	Associate Professor	computer simulation, phase transitions, crystal nucleation, glass transition, tetrahedral liquids, colloids, lipid membranes and proteins	2006
Tarasov, Lev	Associate Professor	earth systems modelling, model calibration, abrupt climate change, climate dynamics, uncertainty assembly, diffusion, electric fields, hydrodynamics	2007
Wallin, Stefan	Assistant Professor	models and methods for protein simulations, folding and interactions of proteins, biochemical reactions, protein evolution, protein ‘misfolding’	2015
Yethiraj, Anand	Associate Professor	soft matter, colloids, emulsions, confocal microscopy, nuclear magnetic resonance, self-assembly, diffusion, electric fields, hydrodynamics	2005
Zedel, Len	Professor	underwater acoustics, Doppler sonar, fisheries acoustics, sediment transport, instrument development, ocean ambient sound	1996

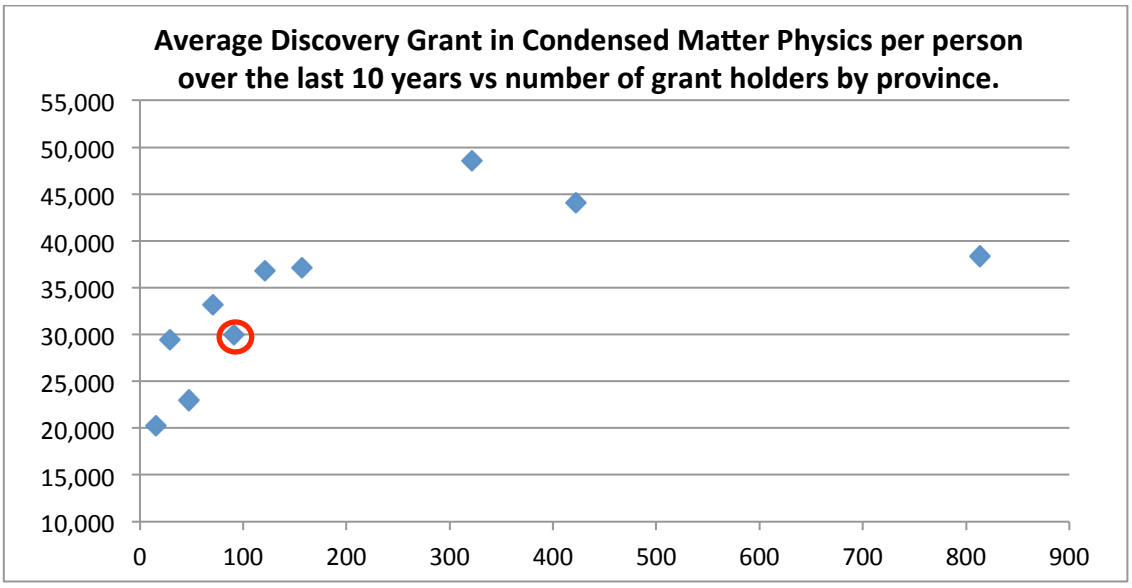
Cross-Appointments	Research Interests	Hired
Booth, Ivan	mathematical relativity, black hole physics, dynamical black holes, fluid-gravity duality, perturbation theory	2008
Booth, Valerie	biophysics, protein structure, nuclear magnetic resonance (NMR), calorimetry, dynamic light scattering, molecular dynamics simulation	2008
Aleksandrs, Aleksejevs	baryon structure and dynamics, high-energy particle collisions, physics beyond the standard model, dark matter searches	2010

Research Revenues

Faculties in this Department have pursued a broad range of funding opportunities and have been very successful at obtaining the resources needed to enable their research programs. The research funding for the Faculty of Science over the past several years averaged over the past five years shows that we have averaged just under $2 M per year, and rank third in the Faculty of Science after the Departments of Earth Sciences and Ocean Sciences.

Physics & Physical Oceanography
Major Project Funding for the period 2009-2013.

Project	Funding	Program	Date Awarded	Principal Investigator
Long Harbour Hydromet	340,000	Vale/RDC	2011	Beaulieu/Georghiou
Ultrafast Nano-Photonics & Laser Applications	100,000	RDC Leverage	2011	Chen
Laser Applications Laboratory	667,926	RDC Leverage/CFI	2011	Chen
MEOPAR Observation Core	460,000	MEOPAR	2013	deYoung/Bachmayer
Ice Ocean Sentinel System (IOSS)	3,993,408	NSERC AIF/ACOA/IBRD/RDC	2012	deYoung/Bachmayer
VITALS	709,000	CCAR	2013	deYoung/Demirov
Internal Waves and Mixing	100,000	RDC Ignite	2011	Munroe
Long Term Thermal Decay in Media	237,500 US	Western Digital	2010	Plumer
Fast and Economical Material Patterning	108,000	RDC Leverage	2010	Poduska
Far-infrared spectromicroscope	260,000	RTI/RDC	2012	Poduska
Nanoscale phosphor development	112,500	NSERC CRDPJ	2012	Poduska
CRC in Glacial Dynamics Modeling	100,000	RDC Leverage	2013	Tarasov
High Performance Scientific Computing	241,477	RDC Leverage	2013	Tarasov
Seismic Modeling & Inversion	1,076,841	RDC Leverage	2011	Whitehead
Rheometer for Study of Structured Soft Mateials	129,475	NSERC RTI	2009	Yethiraj
Advanced Acoustic Technologies	393,960	Dalhousie Univ./AIF Subcontract	2009	Zedel



The plot above displays the average Discovery Grant in Condensed Matter Physics for the period 2005-2014. Memorial University is the fifth point (circled) with 91 successful awards holders and an average grant of $29,942.

Links Between Research and Teaching

We strongly support the links between teaching and research as necessary to stimulate and invigorate the academic life of our department. It is at the graduate level that there are the strongest connections between research and teaching but we also work to include undergraduate students in the research life of the Department.

It remains a challenge for the Department to offer what are, in essence, two graduate programs, one in condensed matter physics and the other in physical oceanography. We have been very successful in attracting students to these programs and have done fairly well in offering the necessary balance of courses.

Since the last self study we have made changes to our first year program, enhancing the calculus-based stream and better differentiating the algebra-based life sciences stream, and have increased the role of computation in the overall undergraduate program. The development of the courses P2820 and P3800 arise form our recognition of their importance for undergraduate students and our own departmental research strengths in computational science. We have also developed a course on Materials Physics (P3000) that primarily serves students from the Faculty of Engineering. The development of this course is a direct result of our growing strength in materials physics.

We encourage our undergraduate students to take part in research projects. All our honours students write theses, and thereby receive credit for two courses. Not infrequently the theses of undergraduates lead to publications by the students. We recruit NSERC summer undergraduate students providing them with generous support supplements.

5. 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 reallocations committees.

- Drs. **Chen** (2009-2012), **deYoung** (2011-2014) (as chair) and **Yethiraj** (2013-2016) have all served on NSERC grant selection committees.

- Dr. **Lagowski** (2009-2010) was a member of the Review Panel for the Ontario Premier's Discovery Awards.

- Dr. **Morrow** (2007-2008, 2012-2015) was a member of the NSERC Steacie Memorial Fellowship Committee and Dr. **deYoung** (2012-2013) was twice a member of the NSERC Polanyi Committee.

- Dr. **Beaulieu** (2003-2005) was a member of the NSERC Committee on Grants and Scholarships.

- Dr. **deYoung** (2010-2015) sat on a CFI review panel, a British Columbia Research Foundation review committee and served on two different European Commission reviews.

The Department's presence on these committees serves to enhance our profile within the national and international scientific community as well as providing an opportunity to influence science policy and practice within Canada. Of course, most faculty members regularly serve as referees to granting agencies and journals.

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

- Departmental members have been active on the Canadian Association of Physics (CAP) Herzberg, Achievement Medal (2009-2013) and Brockhouse Medal (2002-2004) selection committees (Dr. **Morrow**) and on the CAP University Prize Exam Review committee.

- Dr. **Morrow** (since 2007 till present) was an Associate Editor of the Canadian Journal of Physics. Dr. **Morrow** served on the executive (2002-2006) and was president (2004-2005) of the CAP.

- Dr. **Plumer** achieved Senior Member status in the Institute of Electronics and Electrical Engineers (IEEE) in 2006.

- Dr. **Poduska** (since 2015) is an Executive Member and the Science Policy Director of the CAP. Dr. **Poduska** is an Editorial Board Member of the Journal of Materials

Science: Materials in Electronic (2009) and is an Executive Member-at-large of the Canadian Section of the Electrochemical Society (since 2014).

- Dr. **Saika-Voivod** is an Associate Editor for the Canadian Journal of Physics. Dr. **Saika-Voivod** is the Chair of the ACEnet Institute for Materials Modelling and Simulation and ACEnet MUN user group.

- Dr. **Yethiraj** was vice-chair (2012-2013), then Chair (2013-2014) and the past-chair (2014-2015) of the Division of Condensed Matter and Materials Physics of the CAP.

- Dr**. Zedel** is a member of the Canadian National Committee of the Scientific Committee on Oceanic Research.

- Dr. **deYoung** is on the Research Management Committee (RMC) of the NCE MEOPAR program (2012-2017). Dr. **deYoung** also sits on the International Management Committee for the multinational (USA, Canada, UK, Germany, The Netherlands) research program OSNAP.

Faculty have been active in organizing a wide range of meetings and workshops, national and international.

- Dr. **Morrow** led, and all members of the department were active in organizing the 2011 annual CAP Congress that was held here.

- Dr. **deYoung** organized a national workshop on ocean gliders and is a founding member of Ocean Gliders Canada (2014).

- Drs. **Plumer**, **Curnoe** and **Whitehead** were the lead organizers for the Magnetic North meeting (see www.magneticnorth.mun.ca). The Magnetic North Workshops have regularly attracted more than 50 participants.

- Dr. **Yethiraj** was a co-organiser for two CECAM (Centre Européen de Calcul Atomique et Moléculaire) workshops in 2012 and 2014 on emergent structures and dynamics in colloidal systems.

- Dr. **Zedel** has been an organizer and session chair for Acoustics Session at annual Canadian Meteorological and Oceanographic Society conferences.

Faculty have also been very active in contributing to the wider community making contributions beyond the walls of academia.

- The research of Dr. **Afanassiev** was highlighted by the BBC with a focus on the ocean in the laboratory (2010).

- Several faculty have organized public science lectures each of which have attracted several hundred people or more: Clifford Will (2005), David Mermin (2007), Andrew Weaver (2010), Sajeev John (2011), Tom Pedersen (2011), Elisabetta Boretto (2012) and David Shoesmith (2013).

- Dr. **Beaulieu** was one of the co-founders and a member of the Newfoundland Woodworkers Association (2012-2014).

- Dr. **deYoung** has done local, regional, national and international media interviews on different aspects of oceanography from regional climate change to looking for airplanes in the South Pacific (several times a year over the past five years).

- Dr. **deYoung** was invited to speak to the European Union Parliamentary Committee on Fisheries (2012).

- Many faculty members in the Department including Drs. **Goulding**, **Lagowski**, **Morrow**, **Harlick**, **deYoung** and **Zedel** have been judges at the Eastern Newfoundland Regional Science Fair.

- Dr. **Poduska** was guest scientist on the BBC radio Naked Scientists and the CBC Quirks and Quarks (2011).

- Dr. **Zedel** was a witness to the House of Commons Standing Committee on Finance and was a member of the White Rose Advisory Group.

- Dr. **Zedel** has played many different roles in Nature and Newfoundland and NL Wilderness and Ecological Reserves Advisory Council.

Local Community Outreach

The department has been actively involved in public outreach. Both faculty and staff have been active in outreach including, in particular, Drs. Harlick, Morrow, Goulding and Shorlin. We have regularly given evening demonstrations to Spark, Brownies, WISE and other community groups. Since 1997, we have offered a yearly 2-day mini-enrichment course in May for talented junior high school students. The department has participated in the university sponsored Science Rendezvous every spring since 2013. In each of the past three summers we did afternoon physics presentations for Engineering summer camps (Robotics & Junior Engineer, ARCTICEngineer, Girl Quest) and MUN MedQuest. We did 6-8 of these presentations each summer, roughly one per week. This fall we participated in Science Literacy Week which involved an Astronomy night, an afternoon physics demonstration, and a Science at the Mall event. Each summer, since 2007 we have done workshops for the Shad Valley program which brings exceptional students to our campus from all over Canada. Dr. Harlick has been an active participant in the Woman in Science (WISE) program. She has mentored several WISE students. Mr. Stevenson is a president of the Royal Astronomical Society St. John's. We sponsor an award for the Eastern Newfoundland Regional Science fair and our staff and faculty regularly volunteer as judges. Dr. Goulding was Chief Judge at the regional fair for more than 15 years and Chief

Judge of the Canada Wide Fair in 2004. We sponsor the Canadian Association of Physicists High School and University Prize exams and Dr. Goulding is the provincial coordinator for the high school exam. We make sure that our doors are open to high school teachers who want to use our facilities. Overall, our department is actively involved in community outreach but could benefit from more staff and faculty participation.

6. Department Organization and Human Resources

Faculty Information

The Department currently consists of 19 full-time tenured or tenure-track faculty members. In addition we currently have one full-time teaching term appointment, two Honorary Research Professors and four Emeritus Professors. A list of current faculty members and their qualifications is presented below.

Head

Lagowski, J.B., B.Sc. *Manitoba*, M.Sc., Ph.D. *Toronto*; Professor

Professor Emeriti

Cho, C.W., B.Sc. *Seoul*, M.A., Ph.D. *Toronto*
Clouter, M.J., M.Sc. *Memorial*, Ph.D. *Toronto*; University Research Professor, Awarded 2000
Gien, T.T., Lic. És. Sc. *Saigon*, M.Sc., Ph.D. *Ohio*; University Research Professor, Awarded 2001
Rochester, M.G., M.A. *Toronto*, Ph.D. *Utah*, FRSC; University Research Professor, Awarded 1986; Cross appointment from Department of Earth Sciences

Honorary Research Professors

Lewis, J.C., B.Sc., M.Sc. *Carleton*, Ph.D. *Toronto*
Whitehead, J.P., B.Sc. *St. Andrew's*, Ph.D. *Alberta*

Professors

Afanassiev, I., Ph.D. *P.P. Shirshov Institute of Oceanology, Russian Acad.*, M.Sc. *Moscow Physical-Technical University*
Chen, Q., B.Sc. *Shanghai Jiao Tong University China*, M.Sc., Ph.D. *Shanghai Institute of Optics and Fine Mechanics, China*
Curnoe, S.H., B.Sc. *Toronto*, Ph.D. *University of British Columbia* (NSERC UFA); Recipient of the President's Award for Outstanding Research, 2005-2006
deYoung, B., B.Sc., M.Sc. *Memorial*, Ph.D. *University of British Columbia*; Appointed to Robert A. Bartlett Professorship in Oceanography; Recipient of the President's Award for Outstanding Research, 1997-1998
Morrow, M.R., B.Sc. *McMaster*, M.Sc., Ph.D. *University of British Columbia*
Plumer, M., B.Sc. *St. Francis Xavier*, M.Sc. *Dalhousie*, Ph.D *Toronto*
Poduska, K., B.A. *Carleton College,* Ph.D. *Cornell*; Cross appointed with the Department of Chemistry
Quirion, G., B.Sc., M.Sc., Ph.D. *Sherbrooke*
Zedel, L., B.Sc., M.Sc. *Victoria*, Ph.D. *University of British Columbia*; Petro-Canada Young Innovators Award, Awarded 2001

Associate Professors

Andrews, G.T., B.Sc., M.Sc., Ph.D. *Memorial*

Beaulieu, L., B.Sc. *University of Ottawa*, M.Sc., Ph.D. *Dalhousie*; Petro Canada Young Innovators Award, Awarded 2008
Demirov, E., M.Sc., Ph.D. *University of St. Petersburg, Russia*
Saika-Voivod, I., B.Sc., Ph.D. *University of Western Ontario*
Tarasov, L., B.Sc. *Guelph*, M.Sc., Ph.D. *Toronto*; CRC Glacial Dynamics Modelling
Yethiraj, A., B.Sc. *Bombay (St. Xavier's College)*, M.Sc. *Houston*, Ph.D. *Simon Fraser*; Recipient of the President's Award for Outstanding Research 2008-2009

Assistant Professors

Evstigneev, M., B.Sc., Ph.D. *York*
Munroe, J.R., B.Math.(Hons.), M.Math, *Waterloo*, Ph.D. *Alberta*
Wallin, S., M.Sc., Ph.D. *Lund University*

Visiting Assistant Professor

Harlick (Polomska), A., M.Sc. *Adam Mickiewicz*, M.Sc., Ph.D. *Memorial*

Adjunct Professors

Barkanova, S., B.Sc., M.Sc. *University of Latvia*, Ph.D. *University of Manitoba*
Davidson, F., B.Sc. *Ottawa*, M.Sc., Ph.D. *Memorial*
Han, G., B.Sc., M.Sc., Ph.D. *Hohai University*
Pool, P., B.Sc. *St. Francis Xavier University*, M.A., Ph.D. *Boston University*

Cross-Appointments

Aleksejevs, A., B. Phys. (Hons.), M. Phys. *Latvia*, Ph.D. *Manitoba*; Cross appointment from Department of Physics, Grenfell Campus, Memorial University
Booth, I., B.Sc. *Memorial*, M.Sc., Ph.D. *University of Waterloo*; Cross appointment from Department of Mathematics and Statistics
Booth, V., B.Sc. *Victoria*, M.Sc. *Waterloo*, Ph.D. *Toronto*; Cross appointment from Department of Biochemistry

Faculty Complement

Fig. 17 shows the number of full-time tenured or tenure-track faculty in the Department over a 10 year period. Fig. 17 also indicates the number of faculty who were awarded a research grant by an external funding agency in that year. This chart does not include Adjunct or Honorary Research Professors.

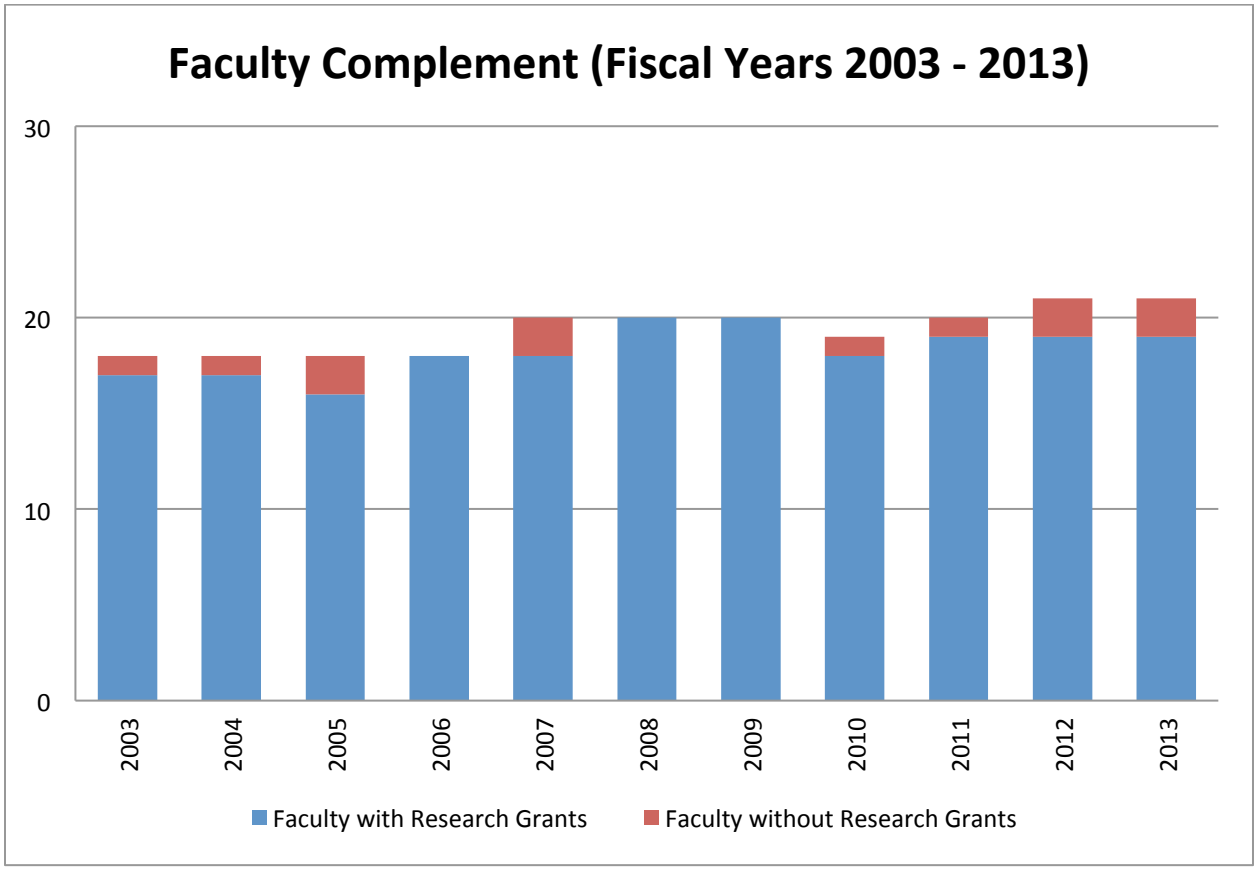


Figure 17: Faculty complement in the period 2003 – 2013

One trend is obvious from Fig. 17, which is that the number of faculty with grants has been fairly steady overtime. One or two faculty members have lost NSERC Discovery Grants but a similar number were also able to get their grants back.

Student Registrations per Instructor

Comparing the faculty and instructor numbers with the student registrations in Fig. 18 implies fluctuation in the number of registrations per instructor. This (representative) ratio is given in Fig. 18 for the period 2004 to 2012, and shows a peak in 2010. The data do not include the registration in laboratory sections.

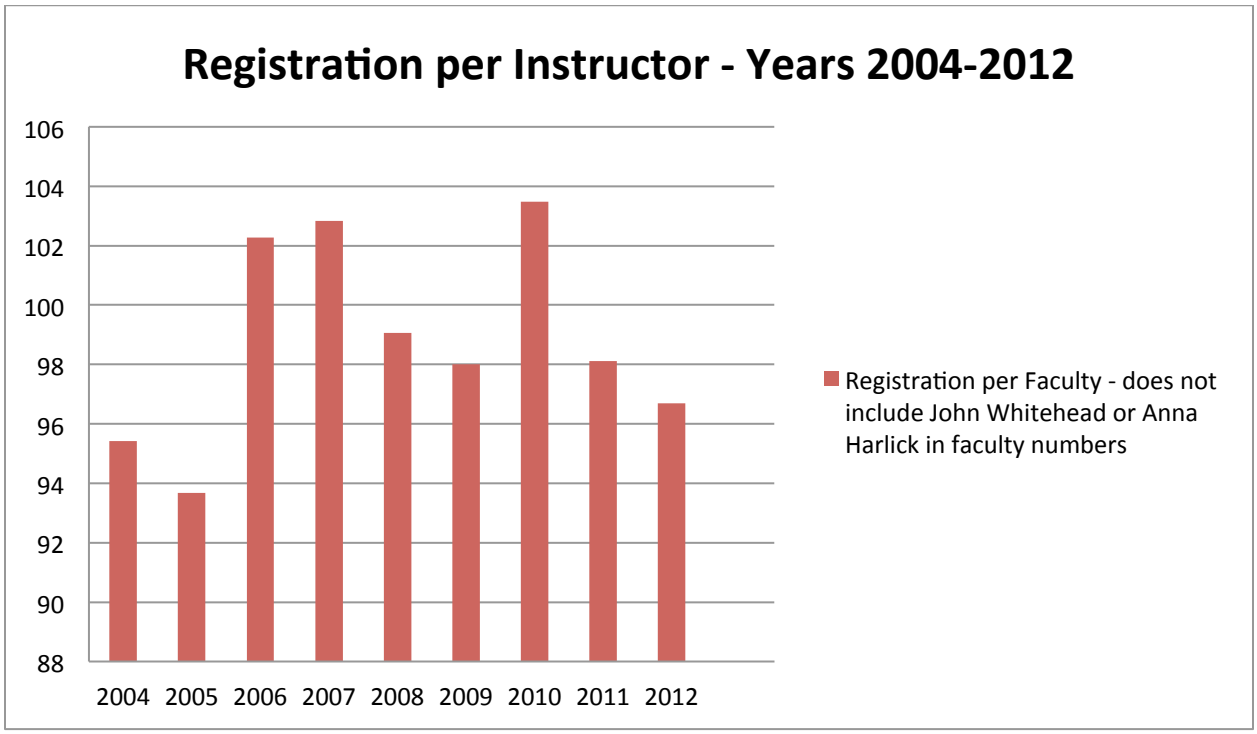


Figure 18: Registrations per instructor in the period 2004 – 2012

Support Staff Information

The current staff complement consists of 4 Administrative, Management and Support positions, 2 Information Technology positions, 8 Laboratory Management and Support positions, plus 2 contractual positions and 1 Technical support position.

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 staff. Reports to Department Head.

Graduate Program Coordinator – Ms. J. Simmons

Handles all aspects of graduate students from initial acceptance to graduation; prepares all graduate payroll forms for all sources of funding; maintains Departmental Fellowship allocation; acts as Secretary to the Graduate Studies Committee. Reports to Administrative Officer.

Intermediate Clerk Steno – Ms. M. Wade

Acts as Secretary to the Undergraduate Studies Committee; processes requests for waivers, re-reads, deferred exams; processes final grades; maintains absentee reports; answers incoming telephone calls and counter enquiries from students. Reports to Graduate Program Coordinator and Administrative Officer.

Intermediate Secretary – Ms. D. Coombs

Provides secretarial support to the Department Head; acts as Secretary of the Faculty Committee; handles all travel claims for faculty, staff and students.

Laboratory Coordinator – Dr. C. Deacon

Coordinates the activities for all second year laboratories; provides instruction in several second year laboratory sections; marks and assigns grades for student's labs. Reports to Department Head.

Academic Program Officer – Dr. R. Goulding

Coordinates first year registration; oversees operations of first year laboratories; provides academic advice to Physics undergraduate students; coordinates Department's outreach activities; oversees administration of the CAP High School Exam; point of contact for Office of the Registrar. Reports to the Department Head.

Laboratory Instructor – Mr. J. Wells

Coordinates the activities for first year laboratories; instructs several laboratory sections; hires and supervises student assistants; assists students with assignments in the Physics Help Center. Reports to Academic Program Officer.

Laboratory Instructor – Dr. K. Shorlin

Coordinates the activities for first year laboratories; instructs several laboratory sections; assists students with assignments in the Physics Help Center. Report to Academic Program Officer.

Instructional Assistant – Dr. M. Bromberek

Demonstrates first year Physics laboratories; assists students with experiments and provides guidance for preparation of lab booklets; assists students with assignments in Physics Help Center. Reports to Academic Program Officer.

Instructional Assistant – 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 Center; provides computer support to first year labs; programs and maintains servers for first year labs. Reports to Academic Program Officer.

Instructional Assistant – Ms. L. Men

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 Center. Report to Academic Program Officer.

Instructional Assistant – Mr. J. Pittman

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 Center. Reports to Academic Program Officer.

Oceanographic Technician – Mr. M. Downey

Provides research support to oceanographers through the deployment of instruments and monitoring results; assists with Lauzier research cruises. Reports to Department Head/Oceanographic Group.

Research Computing Specialist – Mr. C. Stevenson

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

Research Computing Specialist – Mr. F. Perry

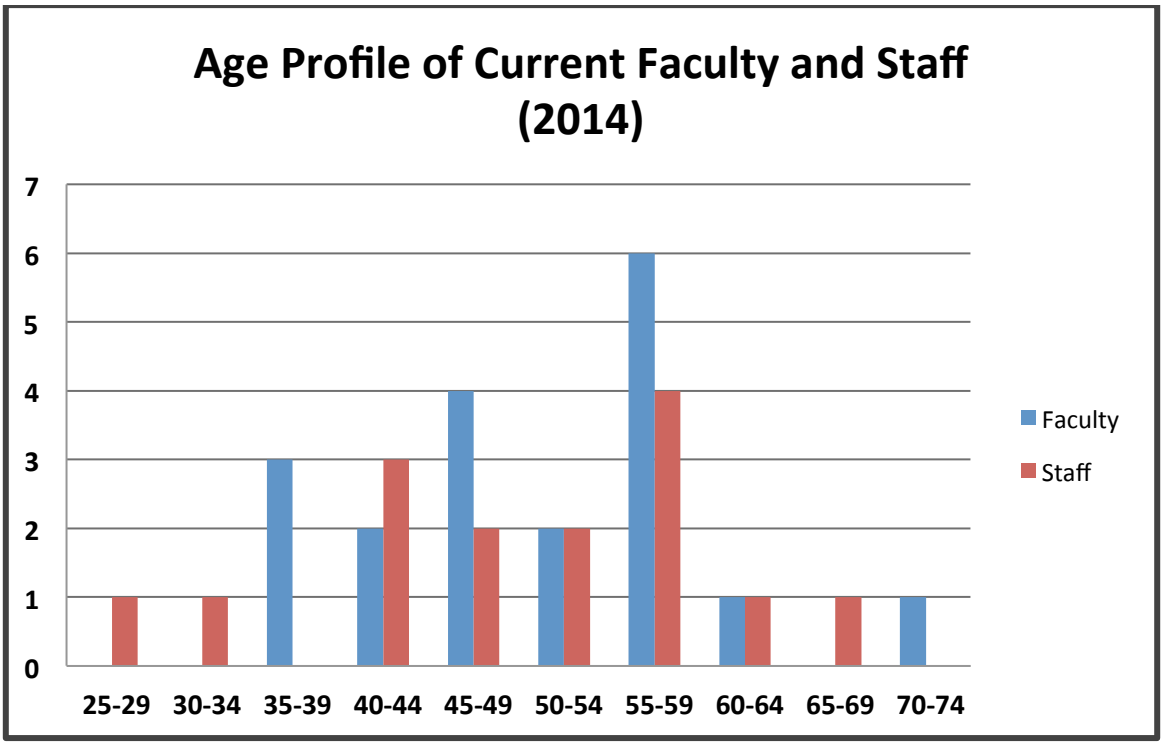
Provides computing support to administrative offices; research groups; maintains all computers (PC and Macs); provides advice to Head regarding updating of software and equipment. Report to Department Head.

Changes in Staff Complement

[redacted]

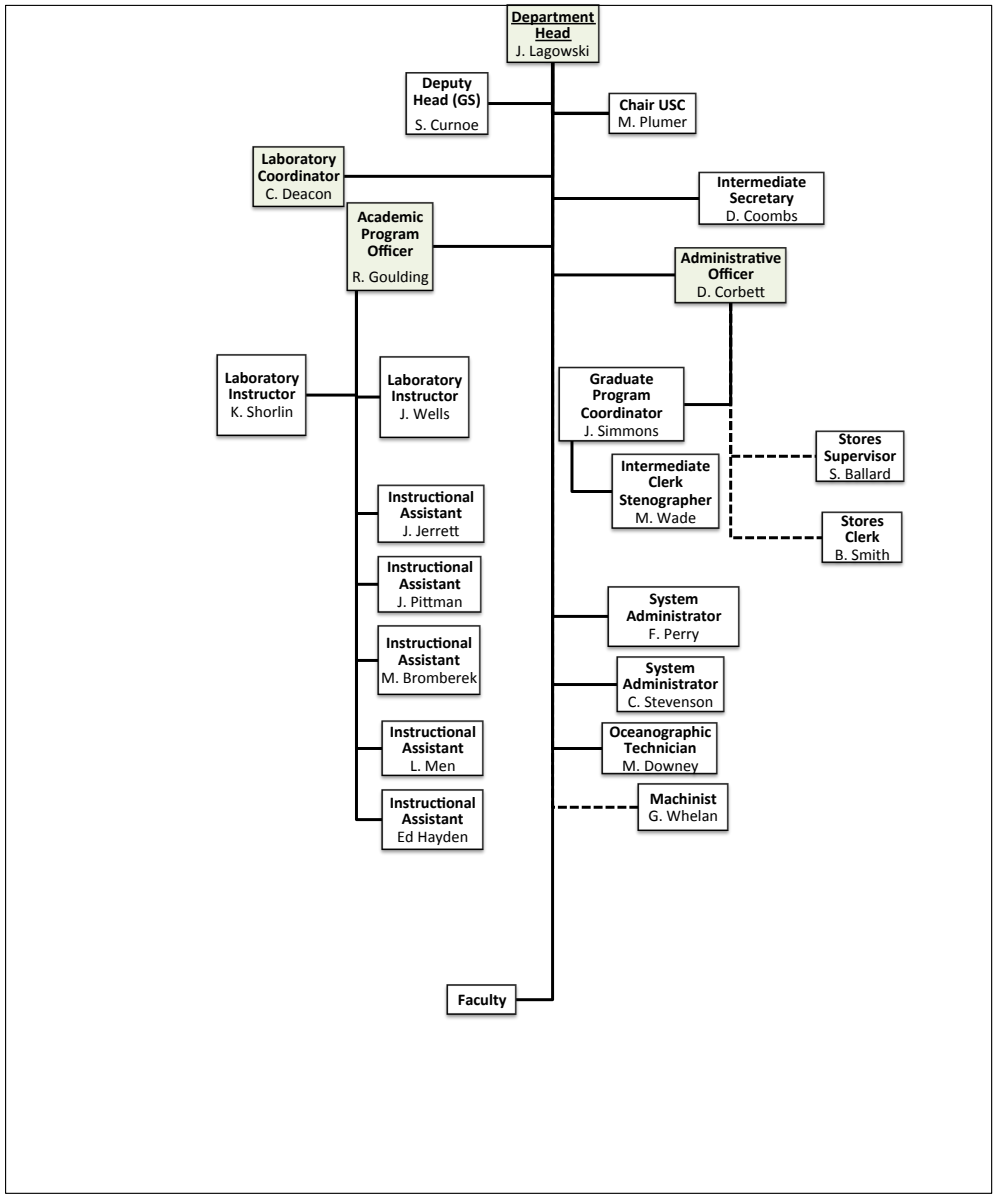
[redacted]

Age Distribution of Faculty and Staff



The age distribution of faculty shows a significant peak of 6 faculty members who are 55-59 but does also show that the department has a good distribution of faculty who are much younger with 5 and 6 faculty members who are 35-44 and 45-54 respectively. The age distribution of staff is quite similar but we do have some staff who are less than 34 years old.

Reporting Structure for the Departmental Staff Chart



7. Departmental Expenditures

The Departmental budget has been going up, slowly, over the past decade but primarily because of salary increases associated with union collective agreements. Our expenditures on graduate students did go up with the dramatic doubling in the number of graduate students that we have seen but we have not seen any increase in our operating or capital expenditures.

Net Expenditures

The data in Fig. 7-1 shows the net expenditures for the department for the period 2004-2014. While there has been an almost doubling of the net expenditure over this period there has been no real increase in the operating and capital expenditures during this same period. It should be noted that our net staff complement has actually declined over this period in which salary costs have risen so significantly.

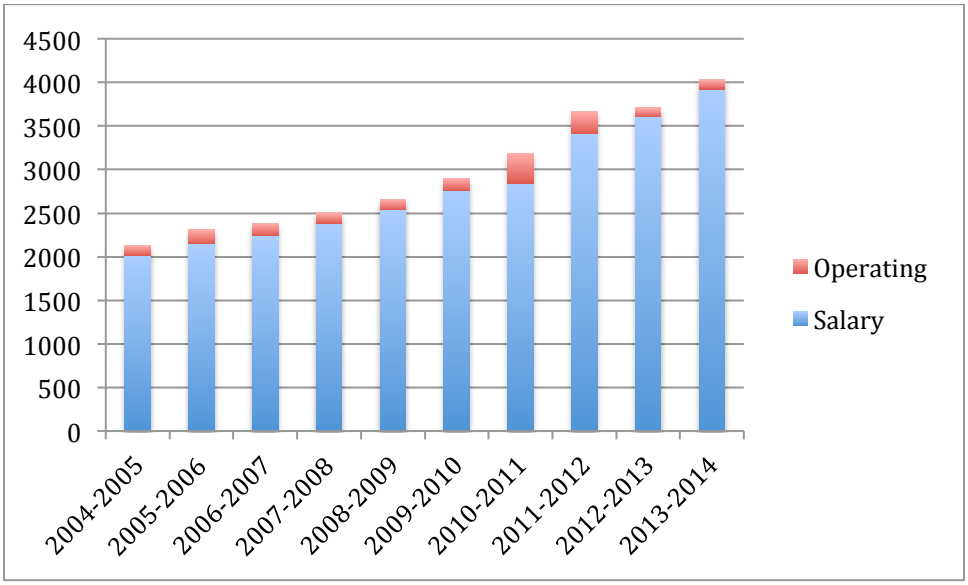


Figure 7-1: Histogram of budget for 2004-2014 showing the total salary costs and operating over the period.

Our expenditures can perhaps best be considered by looking at them in the light of cost per registration (Fig. 7-2). The time series of costs in the Faculty of Science shows that there has been a steady increase in the costs per registration in the overall Faculty and while there has also been an increase in the department of Physics and Physical Oceanography it has been slightly slower.

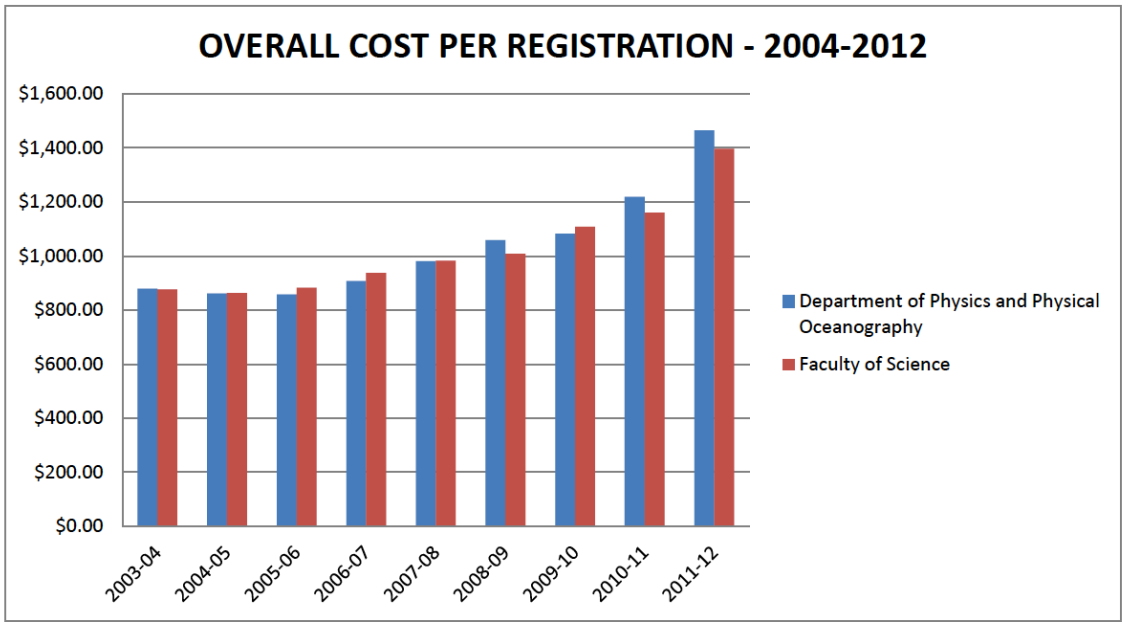


Figure 7-2: Costs per registration

Another way to consider the effectiveness of the Department in course delivery is to compare our costs per registration with other departments in the Faculty of Science (Fig. 7-3). The plot of cost per registration for 2013-2014 shows that Physics is in the middle of the science departments. It demonstrates that the department offers quite cost effective course delivery compared to other departments in the Faculty of Science.

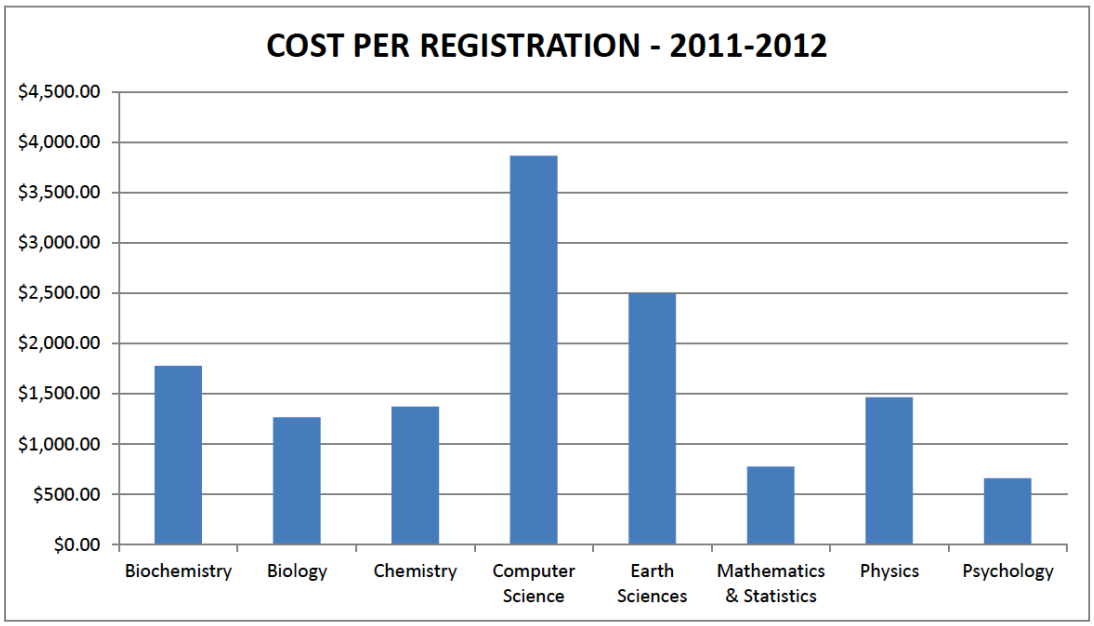


Figure 7-3: The cost per registration for different departments in the faculty of Science in 2011-2012.

Operating Expenditures

The Department budget has been quite healthy in terms of salary support but we have not done as well in terms of operating and capital expenditures. Our operating and capital budget was $314k in 1991-1992 (in 1991 $) but was only 109k $ in 2013/14. We did have two years during this period, from 2010-2012 when we were able to include funds to rejuvenate our undergraduate laboratory equipment. We used that opportunity to make substantial investment (more than $350k) in all of our laboratory equipment, at first and second year and also in the senior laboratory hardware. We have normally been able to get funding for special projects for our first year laboratories, from $30-50k per year, but 2010-2012 was the only time that we were able to significantly invest in our senior laboratories.

The Department has always acted in a fiscally responsible manner. In all but one of the last ten years we have balanced our budget. We have worked with the office of the Dean to provide detailed financial projections to assist in the strategic planning in the faculty of Science. We recognize that while salaries have increased we have had to operate under quite significant operating constraints that have made it difficult to maintain the quality of our academic programs and ensure appropriate support to the infrastructure that supports our research. As an example, we have spent $10-20k of our capital each year to renovate graduate student space to improve the quality of the office space and to ensure that we are making effective use of the graduate student space. We could certainly have used much more money and admit that our space is not as good as it should be but have, within the constraints of our budget, worked to continually improve the space for graduate students. We have also used our limited funds to renovate the study space that we have for undergraduates providing them with dedicated space for our Honours students and an open study space for our majors.

8. Physical Resources

The Department maintains and operates a machine ship. We operate this shop through a shared arrangement with Technical Services whereby a machinist from Technical works in our shop and we cover a portion of his salary. The chop consists of a hydraulic press, band saw, two milling machines, two lathes, a drill press and a propane torch. This facility complements the services provided by technical Services but allows more flexible and supportive arrangements enabling researchers to more easily prototype and modify experimental apparatus. In the past we have used this shop for the training of graduate and undergraduate students but in recent years have not been using the machine shop in this manner.

Space

The Department occupies offices and laboratories on four floors of the Chemistry –Physics Building. At present, there are no plans to move the Department to the new science building that is being constructed. It is expected that the new building will be completed by 2019.

- Level 1 houses the research laboratories for the condensed matter group, the machine shop, and several offices used by faculty and students. The oceanography group operates three research laboratories and two storage rooms on Level 1.
- The teaching laboratories for our introductory physics courses are located on Level 2. Also on Level 2, is the teaching classroom– C2045 –that was renovated by the Department many years ago and which it uses for classes of 30-100 students. Level 2 also contains two small laboratories and offices for faculty, undergraduate support staff and some graduate students.
- Level 3 contains the Physics General Office, the head's office and the offices of the administrative staff of the Department and the departmental seminar room. This wing also contains the Physics Honours Room, the Physics Study Room (formerly the Reading Room) and a small kitchen. Many of the faculty also have offices on this floor as well as graduate students and postdoctoral fellows. The southwest wing of Level 3 houses the second year undergraduate laboratories and the physics hell centre. A small classroom that seats 20 students – C3067 – was renovated by the Department several years ago.
- Level 4 contains the offices for faculty, postdoctoral fellows, students and support staff for the Physical Oceanography group. It also includes a small computer laboratory and the senior undergraduate teaching laboratories.

Space poses challenges for our department. Over the past decade, our available office space has declined, with rooms on Levels 2 taken over by the Dean and two large graduate student spaces on Level 3 taken over by the Department of Chemistry. The Department has renovated many of the graduate student rooms to enhance their functionality but we have reached the limit in improvements that we can make to the rooms. We are also limited in laboratory space as we have no unused laboratory space and have many over-crowded labs and several that are in serious need of renovation. In recent discussions around hires for new faculty we have been uncertain that we would be able to adequately house a new experimentalist given the present space that we have and the configuration of that space.

The University is planning to build a new Core Science Building with an expected completion date of 2019. This new building will greatly enhance the overall facilities for the Faculty but will do little for our Department. At least one other Science department, probably Mathematics and Statistics, will move into the Chemistry-Physics building following the completion of the new science building. There has been some discussion of moving some of the research laboratories, e.g. those using cryogenics and the cryogenic facility itself, to the new building but details of these arrangements are still under discussion. We can tolerate our office facilities, particularly if there was an expansion of space, but our general building facilities and in particular our laboratory facilities, both research and teaching, are inadequate and in desperate need of modernization. The contrast between the newly built labs for Biochemistry, Biology and Chemistry will make the antiquity of our laboratory space even more apparent. We have made requests for commitments and plans for the needed renovation of our laboratory space but have only vague assurances that it will be considered following completion of the Core Science Building.

Equipment

Oceanographic Equipment

The physical oceanography group maintains a wide range of equipment for field and laboratory studies. Field equipment includes several Teledyne Webb Slocum gliders, a Chelsea Nu-Shuttle towed body, Aanderaa and InterOcean S4 current meters, and several RDI Instruments ADCPs and EG&G acoustics releases. The group has several CTDs and temperature probes, a Rockland turbulence shear probe, many Vemco temperature probes, a BioSonics multi-frequency scientific echosounder, water level recorders, weather stations, and much other scientific equipment to support field oceanographic cruises. In the laboratory, the group has calibration facilities for the ocean instrumentation, a rotating tank and computer imaging facility and several large tanks and imaging systems for studying internal waves.

Condensed Matter Physics Equipment

The condensed matter physics group operates and does research with a diverse set of equipment that is used to synthesize, analyze and characterize various (soft and hard) materials. The equipment includes: sputter deposition system, scanning probe microscopes, solid state NMR spectrometers, scanning electron microscope, x-ray diffractometers, various lasers including wavelength-tunable femtosecond lasers, near-field scanning optical microscope, polarized light and fluorescence microscope, potentiostat/galvanostats for electrodeposition, confocal Raman microscope, ultrasonic interferometer, fluorescence laser-scanning confocal microscope, pulsed-gradient (diffusion) NMR spectrometer and many others.

9. Conclusions

This self study describes a mature department that seeks to consolidate and build upon its strengths following a period of change. The period prior to the last self study, about a decade ago, was one of great change in which about half of the faculty of the department were replaced over about six years Our faculty complement has grown slightly from the time of the past review, from 16 faculty to 19. The department very successfully worked through an increase in our faculty numbers, an increase in our research intensity and a doubling of the number of the graduate students. There will be opportunities for new faculty in the coming years as 4-5 faculty members retire in the coming years.

Strengths and Achievements

The Department has maintained its faculty complement for an extended period and has very successfully expanded and enhanced its graduate student program.

While the number of majors in physics has fluctuated over the years, the Department has maintained its undergraduate course enrollments.

Our undergraduate programs are well regarded by both our present and former students and our graduates are generally successful in finding relevant employment following graduation. The education that we offer to our students appears to offer our graduates the skills and training that they need both in the workplace and in academia.

All faculty members in the Department are active researchers and all but three hold NSERC Discovery Grants. Faculty have been successful in applying to many different funding agencies with total funding of more than $1.7 million over the past year.

Our Department continues to be fiscally responsible and generally well administered. We have worked diligently to improve our workspace, through renovations of our office and lab space, and through the development of new equipment and laboratories for our undergraduate program.

Our faculty members are active participants in the national and international scientific community, enhancing the status and visibility of the Department and the University.

Challenges

Attracting students to our undergraduate and graduate programs will be the fundamental challenge for the department in the coming years. In recent years, the number of our undergraduate students has decreased somewhat and, while we have increased the number of our graduate students, we are concerned about maintaining this number and would like to improve the quality of graduate students that enter our programs.

Maintaining the success of the teaching and research programs will be another challenge given changes in research funding priorities, shifting demographics within the province and possible

declines in oil revenues within the province of Newfoundland and Labrador. The Department will need to maintain the clarity of its focus and also continue to work together towards shared common goals with each other, with colleagues in the Faculty of Science and with other units and departments of the University. In addition, as indicated in section 8 of this report, physical space poses a number of challenges for our department and lack of it will have an adverse effect on the research conducted by the present and future faculty members.

The Department has been very successful in growing the size of its graduate student population, from just over 16 more than a decade ago to just about 50 this year. There is little expectation that the graduate student numbers can be grown from the present level but there is a general desire to increase the diversity of the population, with more North American students, and to improve the overall quality and to have more students who hold NSERC scholarships (a marker of ability).

There remain opportunities to improve and modify the undergraduate program offerings to meet the needs and interests of the students. New developments could arise from inside the department but could also be in collaboration with other Departments. Several opportunities are apparent, e.g. a Physics-Engineering program, an Oceanography undergraduate degree and Computational Physics.

Some challenges identified in the last review remain relevant today. Our students recognize the needs for writing and speaking skills and it is clear that do not prepare them well with these skills despite requirements for writing and presentation in many of our courses. We also could do better in providing our undergraduate students with information and advice on jobs, careers and the opportunities that a degree in physics provides.

Opportunities

The Faculty of Science is building a new Core Science Building and while this Department is not scheduled to move into the new building there will be opportunities for change to our existing space. Assuming that Physics and Physical Oceanography remains in its existing building there will be opportunities for renovation to the existing teaching and research facilities. We could greatly benefit from new and modern teaching classrooms and laboratories and better designed and integrated research laboratories. No detailed plans presently exist for such changes and so the Department will need to push to ensure that its future space needs are addressed as the new Core Science Building is opened.

The Department expects to replace one faculty member this year with as many as three to four to be replaced in the coming five years. We have three retired faculty who remain active in the department (Clouter, Lewis, Whitehead) and would like to continue to encourage active involvement by retired faculty. The department includes three groups of researchers: experimentalists (Andrews, Beaulieu, Chen, Morrow, Poduska, Quirion, Yethiraj), theorists (Curnoe, Evstigneev, Lagowski, Plumer, Saika-Voivod, Wallin) and oceanographers (Afanassiev, Demirov, deYoung, Munroe, Tarasov, Zedel). We will seek to maintain the critical mass of each of these groups and the balance between them.

The demographics continue to show that there will be a declining number of high-school graduates in the coming year. It will be important therefore, for the Department to reach out to the wider community to attract interest in Physics and Physical Oceanography. It will be important for the Department to maintain and strengthens its linkages with schools beyond St. John's, particularly in the coming years, to be able to fulfill the University, Faculty and Departmental goals of maintain enrollment numbers over the next decade.

The expansion of the Faculty of Engineering offers an opportunity to further develop programs and courses that serve the wider university community. We have developed a minor in Physics for some Engineering students and could work towards the expansion of this minor to include other aspects of the Engineering program. We would also be interested in working with Engineering to develop a full Engineering-Physics program.

We have had discussions regarding the development of a Bio/Medical Physics program and there is some interest, both in the department and externally, for the development of such a program. The current plan is to explore the potential. As a first step in this development, we plan to propose one course that would contribute to a minor in Bio/Medical Physics.