Strategic Plan
Department of Physics and Physical Oceanography

February 28, 2018

MISSION STATEMENT

We are an active and vibrant department conducting teaching, research, and community engagement. Our Department carries out research in condensed matter physics and physical oceanography. Our research in condensed matter physics focuses on magnetic and electronic properties of materials, soft and biological materials, and photonics. Our research in physical oceanography focuses on laboratory studies, field oceanography, numerical modelling, instrumentation development, and climate studies that include earth systems with ice and glacial dynamics. We provide undergraduate and graduate physics training that prepares students for a diverse range of careers. We engage the community through a dynamic outreach program and advise and contribute to discussions on public policy and governance at the provincial, national, and international levels.

VISION

Students, faculty and staff will achieve their full potential through excellence in research, teaching, and public engagement.

GOALS

1. *Research*

Physics: The challenges in the 21st century are diverse and global, and understanding the fundamentals of matter will play a key role in finding solutions and driving innovation. Physics research will continue to uncover the conceptual underpinnings for new kinds of materials, as it has in previous technological revolutions, and our Department is committed to providing the necessary physics knowledge, tools and approaches to advance fundamental, applied and interdisciplinary materials research at Memorial University.

We will build new strengths in the experimental investigation, fabrication and/or practical development of quantum materials and soft/bio-materials. While applications of such materials are far-ranging (e.g., sensors, tissue scaffolds, quantum computing, electronic and photonic devices), the most novel innovations stem from understanding the basic physics. Experiments are vital to discovering new phenomena, confirming theoretical and computational predictions, and developing technologies. Enhancing our capacity for experimental physics will complement our existing strength in theory and computation.

Physical Oceanography: Understanding the ocean and its resources is a global priority and is also central to Newfoundland and Labrador's prosperity. Ocean physics will thus continue to be a crucially important theme in our Department.

We will strengthen our programs to focus on observational and modelling studies of the North Atlantic, leveraging strong regional, national and international collaborative initiatives. Understanding the North Atlantic is integral to the economic activity of the Province and is vital in the context of adapting to climate change. Combining the predictive power of computational models with accurate and timely data is an effective way of achieving this understanding, and builds on existing observational and modelling capabilities developed within the Department.

To support our research, we will:

- Attract top-quality local, national, and international research students by vigorously showcasing our Department's strengths and accomplishments and by leveraging our own recruiting activities with those carried out by the university. For international and out-of-province graduate students, this includes establishing connections with home institutions of good existing students.
- Encourage and support faculty to engage with other academic, public sector and industry scientists and engineers, both locally and abroad, to address research questions of fundamental and applied importance. This will help develop conduits for improved training, further development and employment for graduates.

2. *Teaching*

Our undergraduate and graduate programs develop multiple skills and abilities: quantitative reasoning and problem solving, computational fluency and expertise in the laboratory. The strength of the physics graduate is the ability to thrive in a technical environment at the forefront of discovery. We offer internationally competitive programs with the highest standards of training. Representing a core discipline within the Faculty of Science, our Department provides an essential foundation in physics training for all students at MUN.

To improve our academic programs to better serve students, MUN, and our province, we will:

- Invigorate experimental and laboratory curriculum components. To become more effective physicists, our students must increase their knowledge and expertise in experimental physics to complement their theoretical understanding of the subject.
    - Physics, like other sciences such as biology, biochemistry, and chemistry, is at its core an experimental endeavour. Students must learn the methods whereby real data are obtained from real physical systems, and not only about the mathematical models used to describe them.

    - In the laboratory, concepts become alive, comprehension deepens, and technical skills often unique to physics instrumentation and methodology are learned.
    - The physicist learns to understand real, messy systems by distilling them to their most essential features. Designing appropriate experiments to achieve this distillation is a skill we wish to strengthen in our students.
- Catalyze student engagement with the private sector, government institutions, and non-profits to enhance training and to increase employment prospects.
- Promote career enhancement programs at MUN to our students.
- Build on faculty expertise to offer new physics courses and programs.
- Collaborate with other departments and faculties (e.g. Engineering, Medicine, Grenfell Campus) to offer new cross-disciplinary courses and programs.
- Monitor and adjust our academic programs to ensure that they meet the highest possible standards of course instruction and thesis research supervision.
- Enhance the working environment and opportunities for instructional staff in order to leverage their knowledge and expertise to improve student engagement.
- Expand the scope of student development by fostering collegiality, informal learning, and a sense of community.

3. *Public Engagement*

Outreach activities are very important to us because they promote scientific literacy and build connections between MUN and the general public. We will promote physics engagement by:

- Continuing active outreach with the youth of Newfoundland and Labrador, particularly through schools and educational programs.
- Contribute to public awareness, policy and management of issues relating to physics, our oceans and the environment, by engaging (through public talks, participation in forums, etc.) and working with all levels of government, professional associations and societies, and by directly communicating with the general public.
- Initiating and strengthening long-term relationships with the private sector, governmental organizations and non-profits to improve employment opportunities for graduates.

IMPLEMENTATION: Steps Forward

1. Future faculty

Condensed Matter Physics
The most novel technological innovations stem from observing and understanding the most basic physics of a material. Experiments are thus vital to discovering new phenomena, confirming theoretical and computational predictions, and developing technologies. In our Department, the capacity for experimental physics is relatively

underrepresented with respect to theory and simulation, as noted in the report of the most recent Academic Unit Planning Program Review Panel. (Our last five hires were for theory and computation.) Hiring experimentalists in both hard condensed matter (e.g. quantum materials) and soft condensed matter (e.g. liquids, colloids, polymers, and biophysics) is essential for us to meet the following strategic goals:

- Provide the expertise needed for achieving our strategic teaching goal of laboratory curriculum invigoration. By contrast, shifting capacity towards theory and computation would compromise our ability to deliver the laboratory requirements expected of physics programs.
- Provide a balancing shift towards experiment, i.e. a stronger experimental foundation, in each of our two sub-areas of condensed matter physics.
- Provide more research links with Engineering and Medicine. The majority of current and recent collaborations between our Department and these faculties involve experimentalists within our Department. These links will serve to facilitate academic program development with these faculties.

Physical Oceanography

Currently, the Oceanography side of our Department balances pure, applied and interdisciplinary studies, as well as theoretical, computational, experimental and observational approaches. However, enhancing capacity in physical oceanographic observation and modelling provides MUN a way to solidify its regional leadership in ocean sciences and to quantitatively address economic and environmental concerns for Newfoundland and Labrador.

2. Space

The construction of the Core Science Facility is a major event impacting us during the timeframe of this Strategic Plan, one that will present unique opportunities and challenges as we pursue our goals. Thus, it is incumbent on us to think of physical space as a strategic resource at this time. Appropriately equipped space of sufficient size is required for achieving several outcomes: advancing our research strength in experimental physics and supporting observational oceanography; attracting top candidates for faculty positions and allowing them to develop successful research programs; enhancing laboratory and fieldwork components of student training; promoting collegiality and informal exchanges of ideas among undergraduate students, graduate students, faculty and staff; developing partnerships with industry, other universities, regional and national research organizations, and other community stakeholders; staging outreach events. It is paramount that we have:

- Lab space for new and existing faculty
- Social space for cohesion
- More and better space for students.

3. Staff

The experimental, observational, computational, and administrative activities, which our Department carries out in support of research and teaching programs, are varied both in breadth and degree of specialization. This includes computer support, teaching laboratory instruction, machine shop services, help centre staffing, research accounting support, graduate student administration, and undergraduate student administration. Proper staffing to support all of these activities is required for us to be effective in research, teaching, and outreach. Therefore, we will give these critical support areas high priority when implementing strategic goals.

List of Appendices

This strategic plan provides a general framework to help our department prioritize and plan for the future. More detailed information is provided in appendices:

- Appendix A identifies hiring opportunities beyond our most immediate strategic goals.
- Appendix B describes our Department's fit within the University and Faculty strategic plans.
- Appendix C outlines how this strategic planning document was developed.

APPENDIX A
LOOKING AHEAD: Opportunities to Grow

Here we outline opportunities that would enhance, complement or grow out of our core strengths. These opportunities are based on new and/or external financial sources. Should hires successfully arise out of these opportunities that do not fulfill the strategic goals described above, they should be viewed as necessitating an increase in the faculty complement. The positions envisioned align with priorities of MUN and the Province.

1. Canada Research Chairs

The most recent Academic Unit Planning Program Review Panel encouraged us to pursue Canada Research Chairs, noting two recently expired positions within our Department. While recognizing the need for flexibility in pursuing such opportunities, our primary goal is to strengthen research intensity in our core areas and to help realize our strategic goals. Chair positions in experimental hard condensed matter (e.g. quantum materials) or experimental soft condensed matter (e.g. liquids, colloids, polymers, and biomaterials) would support economic diversification by supporting the high-tech sector, possibly directly and certainly by training local highly qualified personnel. A Chair in observational oceanography would align squarely with the importance of ocean sciences to economic prosperity. Realizing such positions through the Canada Research Chairs program would both attract well qualified job applicants and provide a means for reducing the financial hurdles inherent in starting up an experimental or observational research program.

2. Industrially-Sponsored Research Chair

One benefit of having an industry partner fund a Research Chair in Physics would be a clear illustration to students, both graduate and undergraduate, of the usefulness of physics beyond academia. Such a chair would demonstrate the benefits of fundamental physics to the Province and the greater community as well. A Research Chair in the area of applied physics pertaining to devices, materials, photonics and ocean physics would fit well with our core strengths.

3. Engineering Physics

The hiring of an engineering physicist would complement the expansion of the Faculty of Engineering and Applied Sciences. We would look for hiring candidates with expertise that is rooted in our core strengths but that would also provide Engineering with expertise that they do not have. In a sense, this would expand on the kinds of research collaborations we currently share, and include areas such as quantum, nano- and micro-device engineering, photonics, materials (including those related to oil and gas), and ocean monitoring. Beyond this, nuclear/isotope physics may be beneficial for the Province's medical physics needs. An engineering physicist would also fit with our plan to continue increasing our academic program ties with Engineering.

4. Medical Physics

There has been interest expressed by members of the Faculty of Medicine to build a medical physics program in order to address an increasing difficulty in attracting medical physicists to the province. A few (around five) of our graduates are currently working in the area of medical physics in Canada, so there is interest, and a medical physics program could help attract a new stream of physics students. With sustained interest from Medicine, such a program could arise within Eastern Health, and a potential hire in our Department would be coupled to that program. A medical physicist would find a fit within our Department through several existing research areas: instrumentation, soft matter and biophysics (in particular, magnetic resonance methods), image processing, and materials physics.

APPENDIX B

Our fit within the Strategic Plans of Memorial University and of the Faculty of Science

The 2014-2017 Strategic Plan of Memorial University identifies four pillars:

1. Teaching and Learning (Teaching and Learning Framework 2014-2017, Enrolment Plan 2014-2020, Strategic Internationalization Plan 2015-2020): The Enrolment Plan describes Memorial's obligation as the only university in the province "to remain a comprehensive university by continuing to offer an almost full spectrum of academic programs ..."

2. Research, Scholarship and Creative Activity (Research Strategy 2011, Strategic Research Intensity Plan 2014-2020, Faculty of Science Strategic Plan): The Strategic Research Intensity Plan aims to strengthen all aspects of research at Memorial University of Newfoundland. The Faculty of Science Strategic Plan has a vision to create "a research-intensive Faculty that is renowned both for the caliber of our research and the quality of our graduates" and is "dedicated to international excellence in research and teaching to the benefit of people locally, nationally, and internationally".

3. Public Engagement: The Strategic Plan links public engagement activities with teaching and learning and research.

4. Enabling Success (Multi-Year Infrastructure Plan): The Infrastructure Plan outlines planned improvements to infrastructure.

We have strong research and teaching track records that not only align with, but have also helped to inform, the University and the Faculty of Science strategic plans.

Teaching

The Department of Physics and Physical Oceanography embraces the University Teaching and Learning Framework, as supported in the University and Faculty of Science Strategic Plans. Among the key principles of teaching and learning listed in the University's Strategic Plan, our existing strengths are rooted in the following:

- Creation of synergies among the various components of teaching and learning: research, interdisciplinary teaching and learning, classroom setting, informal experiences, and practical applications.
- Commitment to quality of curricula and learning experiences through continuous evaluation of courses, programs and instruction to ensure that they are relevant, creative, innovative and appropriately challenging.

The evolving research interests of Department members are reflected in several of our senior undergraduate and nearly all of our graduate courses, in both practical (i.e. laboratory) and theoretical aspects. Our Department has ongoing program development and expansion into interdisciplinary teaching, including the creation of new subject minors (such as a Physics Minor for Electrical and Computer Engineering students) and the development of interdisciplinary courses (including biophysics and quantum computing) and programs (for example, Ocean Physics degrees, or the Interdisciplinary PhD program in Scientific Computing). Cross-appointed members of our Department contribute to these efforts through the supervision or co-supervision of students in our programs. Extensive details about our effective teaching record can be found in our most recent Academic Program Review documents (2015-2016).

Our teaching strengths and goals are also aligned with the University's Strategic Internationalization Plan 2020. We are attracting global talent through our strong pool of international graduate students, and teaching them the knowledge and skills they need to be successful.

The University's Strategic Enrollment Plan projects a modest increase (4-5%) of graduate enrollment. Graduate student enrollment in our Department is correlated with the number of qualified applicants, the availability of research funding, and the number of faculty members. These factors are interrelated, and ultimately depend upon excellence in research and teaching, as addressed in our strategic plan.

Research

The current faculty complement includes nineteen tenured or tenure-track faculty (currently and temporarily we are at 20, with a retirement scheduled for August, 2018), of whom six have research interests that lie within the *physical oceanography* side of the Department, and the remainder in *physics*.

On the *physics* side, the common sub-discipline that links the research pursuits of all faculty members is *condensed matter physics*, the study of the physical properties of liquids and solids. This common interest has supported vibrant collaboration on diverse

subjects such as biophysics and biological materials, magnetic materials, topological insulators and quantum materials, archeological materials, solar energy cells, colloidal and polymer materials, and sensor technologies. The outcomes from our research efforts fall broadly into three categories (in no particular order): *hard condensed matter*, involving solids with high melting points, ultra-low temperatures, quantum mechanical effects; *soft condensed matter*, involving liquids, colloids and polymers, proteins, lipids, viruses and cells; and *applied physics*, involving sensors and photonics.

The Oceanography side of our Department balances theoretical, computational, experimental and observational approaches to studies of planetary fluid dynamics, glacial ice sheet dynamics, acoustic observation methods, instrument development and deployment, and global climate modeling.

Beyond this, cross-appointed faculty (notably from Mathematics, Biochemistry and the Grenfell Campus) supervise or co-supervise students in our Department, while several of our own faculty members supervise or co-supervise students in other programs, notably Chemistry, Environmental Science, Engineering and Scientific Computing. Roughly half of our faculty have engaged in industry collaboration or industrially-sponsored research in the last five years.

While the University plan supports “excellence in all forms of research”, it does identify certain themes that the Faculty’s Plan refines in the context of current research strengths. Our Department engages in each and every one of these five strategic research areas, at both fundamental and more applied levels. The Faculty’s Plan lists these research areas and also lists subfields for each. Those that are relevant to our Department are: 1) Marine Sciences (physical oceanography, oceanographic modelling, ocean acoustics, ocean data visualisation, ocean sensor and visualisation); 2) Natural Resources and Energy (alternative energy sources); 3) Mathematical and Computational Sciences (complex systems and their simulation, geophysical modeling, ocean and atmosphere modeling); 4) Biomedical Sciences and Health (antimicrobial properties, biological molecule structure and function, drug discovery); and 5) Materials Science (magnetic and electronic materials, nanomaterials, optical and electrically-responsive materials). We emphasize that these areas and subfields are taken directly from the Faculty’s Strategic Plan. Our proposed future faculty hires fall under categories 1) Marine Science and 5) Materials Science.

Public Engagement and Outreach Activities

Outreach activities enhance the scientific knowledge of the general public and are very important to the Department of Physics and Physical Oceanography. They allow us to promote science, physics in particular, and hopefully attract new students to our physics programs. Events in which the Department participates are Science Literacy Week (September, includes talks hosted within Department and events in the mall), Let's Talk Science tours (winter midterm break), Junior High Minicourse (late April), Science Fair tours (May), Science Rendezvous (May), Shad Valley (midsummer), Engineering Summer Camps (once a week in July and August). Public attendance has been increasing recently, and the Department should ensure that sufficient resources and staffing levels are made available for such activities. These events involve active participation from faculty, staff and students.

Our planned activities include engagement with local industry, especially research-oriented companies which employ physicists, in order to give students exposure to commercial innovation and to increase career opportunities for physics graduates.

Infrastructure

Our Department identifies improved and increased space for experimental physics research as a prerequisite for fulfilling our strategic research goals. Our future space requirements are compatible with the redevelopment of the Chemistry-Physics building, addressed in the University's Multi-Year Infrastructure Plan.

APPENDIX C

The origins of this document and our consultative process

A Strategic Planning Committee was set up in April 2016 with a mandate from faculty in the Department of Physics and Physical Oceanography. The timeline was:

- April - Dec 2016 – consultation within the Department.
- March 2017 – initial draft sent to Head for comment.
- May 2017 – revised draft sent circulated to Faculty.
- June 2017 – discussion at faculty meeting.
- June 2017 – minor editing.
- Fall 2017 – discussions at faculty meetings and major editing.

Members of this committee involved in executing the mandate:

- James Munroe (Chair, 2016)
- Ivan Saika-Voivod (Chair, 2017)
- Stephanie Curnoe
- Kris Poduska
- Anand Yethiraj
- Len Zedel