CARLETON UNIVERSITY COMMITTEE ON
QUALITY ASSURANCE
Cyclical Review of the undergraduate programs
in Physics
Executive Summary and Final Assessment Report

This Executive Summary and Final Assessment Report of the cyclical review of Carleton's undergraduate programs in Physics are provided pursuant to the provincial Quality Assurance Framework and Carleton's Institutional Quality Assurance Process (IQAP).

EXECUTIVE SUMMARY

The undergraduate programs in Physics reside in the Department of Physics, a unit administered by the Faculty of Science.

As a consequence of the review, the programs were categorized by Carleton University's Senate Quality Assurance and Planning Committee (SQAPC) as being of good quality. (Carleton's IQAP 7.2.13-7.2.14).

The External Reviewers' report offered a very positive assessment of the programs. Within the context of this positive assessment, the report nonetheless made a number of recommendations for the continuing enhancement of the programs. These recommendations were productively addressed by the Chair of the Department of Physics, the Dean of the Faculty of Science in a response to the External Reviewers' report and Implementation on Plan that was submitted to SQAPC on October 27, 2022.

Physics

Unit Response to External Reviewers' Report & Implementation Plan

Programs Being Reviewed: Undergraduate Programs

Note: This document is forwarded to Senate, the Quality Council and posted on the Vice- Provost's external website.

Introduction & General Comments

Please include any general comments regarding the External Reviewers' Report.

The Physics Department was pleased to receive the Reviewers' very positive External Reviewers' report on April 26. We are committed to the continual improvement of our programs to enhance the student, staff, and faculty experience. This document contains both a response to the External Reviewers' Report and an Implementation Plan (Section B) which have been created in consultation with the Dean(s).

For each recommendation ***one*** of the following responses must be selected:

Agreed to unconditionally: used when the unit agrees to and is able to take action on the recommendation without further consultation with any other parties internal or external to the unit.

Agreed to **if additional resources permit:** used when the unit agrees with the recommendation, however action can only be taken if additional resources are made available. Units must describe the resources needed to implement the recommendation and provide an explanation demonstrating how they plan to obtain those resources. In these cases, discussions with the Deans will normally be required and therefore identified as an action item.

Agreed to in principle: used when the unit agrees with the recommendation, however action is dependent on something other than resources. Units must describe these dependencies and determine what actions, if any, will be taken.

Not agreed to: used when the unit does not agree with the recommendation and therefore will not be taking further action. A rationale must be provided to indicate why the unit does not agree (no action should be associated with this response).

Calendar Changes

If any of the action items you intend to implement will result in calendar changes, please describe what those changes will be. To submit a formal calendar change, please do so using the Courseleaf system.

Hiring

Where an action item requires additional hiring (faculty or staff) the owner should at minimum include the Dean of the faculty and member of the unit.

UNIT RESPONSE AND IMPLEMENTATION PLAN Programs Being Reviewed: Undergraduate Physics Prepared by (name/position/unit): Kevin Graham					
External Reviewer Recommendation & Categorization	**Unit Response (choose only one for each recommendation):** **1- Agreed to unconditionally** **2- Agreed to if additional resources permit (describe resources)** **3- Agreed to in principle** **4- Not agreed to** **Rationales are required for categories 2, 3 & 4**	**Action Item**	**Owner**	**Timeline**	**Will the action described require calendar changes? (Y or N)**
[Weakness] Systematically gather data on student outcomes. In reading the self-study we noticed that data on outcomes were largely absent, and in the virtual site visit we confirmed that data on outcomes is not available (apart from the NSSE survey and anecdotal reports). While this problem is not uncommon in Canadian physics programs, it impedes efforts to gauge quality and inform planning. For example, as the forefront of research changes and as the capabilities in demand by potential employers evolve, programs also need to evolve; data on outcomes is needed to inform this evolution. We recommend that the Department (or Faculty) institute better ways to track overall outcomes. It may be more efficient to implement this tracking at the Faculty of Science level. Among the approaches that could be considered are (1) improved tracking of alumni with regular surveys	*2* *We agree that having data on student outcomes would be useful for planning. Help from various university offices, such as University Advancement and the COOP office would be useful to collect this data.*	*At the Departmental level we propose to explore various options:* - *Conduct an exit survey for our graduates* - *Collect contact info of our graduates* - *Create a Linkedln account for the department, to connect with Alumni* - *Coordinate with the Faculty or the Advancement office to survey our Alumni.*	*Physics Department*	*2022-2023 academic year*	*N*

(perhaps every five years) of their career paths and how well their educational programs prepared them, (2) regular interactions with employers of coop students concerning the preparation and capabilities of the students, (3) regular interactions with Major employment sectors of graduates concerning the same. The widespread use of social media such as LinkedIn may offer a cost-effective means of gathering these data.					
[Weakness] Provide common space for physics undergraduate study and cohort development. Since we were unable to tour the facilities in person, it was difficult for us to adequately assess the spaces available to the department for offices, labs, teaching, and help centres. However, the department clearly lacks dedicated space for interaction, study and cohort development for physics undergraduates. This kind of dedicated space can have a significant positive impact on student outcomes, and this need is pressing given the return of students and in-person instruction to campus. An open-plan space of adequate size (not small office) would be ideal for this purpose. Adequate space for graduate students is also essential, since a vibrant graduate program has highly beneficial impact on the undergraduate physics cohort. Insufficient graduate student space has a negative impact on undergraduate programs, as graduate students work as teaching assistants and frequently are work with undergraduate researchers as well.	*2* *We agree with the External Reviewers that having a physical space were undergraduate students can interact would be very useful to create a sense of community within the department. This has been a wish of the department for a number of years, unfortunately we could never secure an appropriate space due to a general lack of space at University and Faculty levels.*	- *We will continue to discuss with the Faculty to find an appropriate space*	*Physics Departmentt/Dean of Science*	*2022-2023*	*N*

[Concern] Support the observatory and astrophysics labs. The astrophysics stream shows clear growth. It needs solid support for the facilities (observatory and associated lab support) crucial for experiential learning. The hiring of a technical staff member or instructor with responsibilities for the observatory to support this area should be prioritized.	*2* *The observatory plays an important role for our Astrophysics stream and is used for popular outreach activities. In the past, activities related to the observatory were organized by a laboratory superintendent that since left the department. Currently, one of our graduate students plays this role. Having a staff member with responsibilities related to the observatory would provide a longer-term solution and would allow us to expand the activities of the observatory.*	- *The Department will look for opportunities to hire a staff member (for a current or new position) that has the required knowledge or experience to manage the operations of the observatory.*	*Physics Department/Dean of Science*	*2-3 years*	*N*
[Concern] Prior to pursuing a 15-credit degree program, articulate clearly its value. We were asked to comment on the idea of a 15-credit program in physics. At this stage the value of such a degree program has not been clearly articulated. It should *not* be defined as a fall-back option for students who are either unable to, or who decide they no longer wish to, complete an Honours or Major program. Before introducing such a program, a clear articulation of the likely or possible career paths of program graduates should be made, a realistic estimate of potential enrolments should be produced, and a process for following the career outcomes of these graduates should be envisioned. If such a program is implemented, the department will need to assure that adequate prerequisite requirements are in place so as to maintain the level of upper-division	*3* *The Department, working with the Dean's office and Provost's office, has developed a 15-credit program. This program can allow incoming students with specific career goals to have a shorter path to achieving them. For example, students planning to teach at a high school level can enter Teacher's College in Ontario with a 15-credit degree. As another example, students aiming at a science communications type of career could benefit from a flexible and shorter degree pathway.* *It is also true that the program could facilitate completion of degrees by students who might otherwise not realistically be capable of doing so.*	*- monitor enrolment and potential effects on resources and other programs*	*Physics Department*	*2023-2024*	*Y*

physics courses.	*The Dean's office has evaluated this aspect of the proposed program and has strongly encouraged its creation.* *Enrolment is not expected to be particularly significant for this program compared to other Physics programs and, as such, it is not expected to require any significant changes to resource allocations. Moreover, the quality and delivery of all existing courses for the 20-credit programs will not change. This will be emphasized to the Department and monitored.* *The Department values the feedback from the reviewers on this topic and, although creation of the 15-credit program will go forward, the concerns of the reviewers will be kept in mind and the effects (and effectiveness) of this program will be monitored carefully.*				
[Concern] Introduce computational training early and reinforce it throughout the program. We recommend that the department consider a more structured development of computational fluency in their students, as these skills are both essential in physics and broadly applicable outside of it. Such a structure would incorporate computational training in courses and labs early in the program and build these skills by threading computational components throughout the program. The implementation of this strategy may benefit from upgrading the	*2* *The Department is committed to developing the computational expertise of its students. It is clear that the computational skills of scientists and industry professionals alike are required to be at a higher level than ever before. The Department recognizes that its programs can benefit from a detailed review of the computational components and progression for undergraduate students. The Curriculum*	*- evaluate current computational content in existing courses* *- consider developing a new (likely 2nd year) dedicated computational course*	*Physics Department*	*2022-2023*	*Y*

computational teaching lab and from the selection of one main computing platform to ensure a minimum competency level. There may be scope for collaborating with other Science departments in this effort, e.g., having a software development position at the Faculty level to support integration of computational tools in undergraduate (and graduate) education.	*Committee will carry out this exercise with the goal of ensuring that appropriate levels of computational training are being provided at each stage of an undergraduate student's program. The Committee will evaluate the possibility of enhancing the computational elements in existing courses and also the possible creation of a new, computational focused course at the 2nd year level.* *One challenge often encountered when wanting to incorporate more significant computational elements into a course is the need for expert support in developing the hardware and/or software tools required. Having access to dedicated support person could obviate this difficulty.*				
[Concern] Regularly assess the mathematical and computational preparedness of incoming students. An ongoing concern for all university educational programs that require a strong foundation in mathematics is the preparation of incoming high school graduates. The general trend has been toward lower mathematical competency, on average, for incoming students. Mathematical competency is critical for the attainment of a physics degree. Thus the adequacy of the mathematical, computational, and statistical education provided as part of the Major and Honours degrees becomes increasingly important. It is well understood that lack of adequate mathematical and computational capability can create a barrier to	*2* *The mathematical preparedness of incoming students has been a concern of the department for some time. Some resources exist to better prepare students for University level mathematics or help current students who struggle with math. For example, the Science Student Success Centre offers mentoring and the Peer Assisted Study Sessions allow students to attend weekly workshop and office hours. Finally, each summer there is a program called Math Matters that helps incoming students get up to speed on math topics they will need in their*	- *Work with course instructors to make sure important math topics are taught in some depth in physics courses.* - *Explore the possibility of establishing our own preparation course, inspired by the Math matters program (Chem Matters and Comp Matters also exist).* - *Explore the possibility of giving a placement test to incoming students to identify weaknesses*	*Physics Department*	*2022-2023*	*N*

success in STEM fields. Helping students translate understanding from one field (e.g., mathematics) to application in another (e.g., solving of physics problems) is universally acknowledged to be a very difficult problem that can only be addressed by repeated exposure and by building capacity in students through application. We recommend that the department regularly assess the mathematical and computational capacity of incoming students (is there a non-binding mathematics placement test conducted for incoming students, or on a regular basis?) and design an approach that assures adequate mathematical and statistical understanding in students as they progress through the program, so they do not enter a course unprepared. We encourage the opening of well coordinated combined physics/math/computation help centres where students can go for regular assistance with problem solving, the building of their understanding and its application to complex topics.	*degree. This is a program that we always advertise this program to our incoming class.* *The Department could also explore the possibility of developing new resources tailored to physics students.*				
[Concern] Create a long-term plan for laboratory upgrades and renovations The laboratory staff are to be congratulated on their dedication and flexibility in responding to the restrictions imposed by public health authorities on in-person learning. Our virtual tour of the laboratories showed clean, well organized spaces with a 'vintage' look. This is not necessarily a negative, but we recommend that a long-term plan for equipment upgrades and laboratory renovations be put in place to ensure	*1* *We agree that it is essential to keep the laboratories functional and up to date with current technology and ideally relevant to future employment.* *Every year, as part of the budget submission to the Dean, the Scientific Officer prepares a list of laboratory equipment that need to be upgraded or replaced. The list classifies the different elements according to the urgency in replacing them. We will keep working with the Scientific*	- *Based on the budget submission, create a long-range plan of laboratory upgrades and renewal.*	*Physics Department*	*2022-2023*	*N*

that students gain experience during their education with environments and instrumentation similar to what they will use in post-graduation employment or graduate research.	*Officer to make this plan more detailed and longer term.*				
[Opportunity] Provide more administrative support for faculty research Faculty time is an essential and limited commodity. With the increase in funded research, it becomes critical to increase the administrative support for faculty research; otherwise all faculty activities suffer. This administrative support would also benefit the undergraduate program directly by facilitating the pursuit of both internal and external funds to support UG student research.	*2* *The combination of Departmental, University, and research administrative loads on faculty members often restricts contributions in other areas. For example, decisions on whether to take on undergraduate students (and graduate students) for research, participation in university committees, course creation and development, generating funding applications etc are directly affected by considerations of administrative loads. Additional administrative support, particularly towards research, would directly enhance the Department's ability to deliver and enhance undergraduate programs and research efforts. An additional administrative position could help, for example, in managing travel, expenses and HQP salaries for group with large, multi-PI grants, help with organization of conferences and workshop, help with communication (website, social media) and help with the administration of the CAMPEP medical physics program.*	- *Explore with the Dean of Science the possibility of adding an administrative position for the department.*	*Physics Department/Dean of Science*	*2022-2023*	*N*

[Opportunity] Update the departmental strategic plan. We understand that it has been some time since the last strategic planning exercise took place. The updated plan should account for changed realities, internal and external.	*1* *We agree, this is overdue.*	- *Work on the new departmental long-range plan will begin in the Fall of 2022.*	*Physics Department*	*2022-2023*	*N*
[Opportunity] Support teaching and Honours project supervision in the astrophysics stream. The department needs to ensure that the teaching and research project supervision for this growing stream are adequately resourced. This could be accomplished through the hiring of one or two tenure-stream faculty in astrophysics and/or the active affiliation of astrophysicists and astronomers from NRC or other colleges or universities. This is vital to assure that research underpins the undergraduate educational strength for this stream as it does for the other streams offered by the department. It is very possible to hire tenure-stream faculty in astronomy and astrophysics whose research has strong connections (computation, modelling, statistical analysis, imaging, instrumentation) to particle physics and medical physics, so hiring in this area need not be a strong deviation from the current strategy of the department. The department should consider these points in their updated strategic plan.	*2* *The astrophysics stream program has become one of the most popular undergraduate programs in the Physics Department. A key requirement for all Physics honours programs is a 1.0 credit honours project normally completed during the 4th year of a student's program.* *In the past, the Department was able to provide astronomy and cosmology specific projects to undergraduate students. This was, in part, coupled to the operation of the observatory facility. Unfortunately, the key employee contributing to this chose to move on from Carleton and no current personnel have the expertise to take up this role. In addition, former links to scientists outside of Carleton who provided astrophysics-related projects have been lost (in part owing to the pandemic).* *The Department continues to explore opportunities for partnerships with outside institutions but would greatly benefit from in-house expertise to support the astrophysics program.*	- Explore possibilities for new partnerships to enhance capabilities for offering astrophysics specific honours projects	*Physics Department*	*2022-2023*	*N*

[Opportunity] Build and brand the Major programs around recognizable goals that are distinct from those of the Honours programs. The Honours programs have a well articulated goal and purpose, and outcomes are tracked through the success of students entering graduate programs and their subsequent graduate degree attainment. As noted above the Honours program at Carleton is strong, and by these metrics, achieving its intended purpose. The Major programs should address the needs of students who do not necessarily want to pursue graduate degrees in physics. They can serve a clear need by offering flexibility (which is constrained in the highly prescriptive Honours programs) to allow students to craft more personanlized educational paths. For example, some students may want a greater emphasis on computation and statistics, others may want more emphasis in policy and communication, etc. The opportunity (not requirement) for Major students to participate in capstone research projects in their final education year should be considered, as the department has the research faculty capacity for this.	*3* *We agree with the External Reviewers that offering flexibilities is desirable, and in fact the Major program does offer a lot of flexibility in term of optional courses. We also agree in principle that allowing students in the Major program with a good GPA access to honours projects could be beneficial, but the ability to do so is limited by the number of projects available.*	*.* - *The curriculum committee will examine the possibility of offering to students in the Major program with good GPA the possibility of doing an honours project. The committee will need to determine whether the offering of projects by faculty members is sufficient to allow this option.*	*Physics Department*	*2022-2023*	*N*

[Opportunity] Create or update a faculty hiring plan. The focus on hiring in particle physics and medical physics has served the department well, allowing it to maintain national and international prominence in these areas. However, there may be scope for providing some breadth and responding to student interest in a related area, as mentioned elsewhere in the report. Consideration should also be given to hiring full-time lecturers to reduce the dependence on contract instructors and provide enhanced quality and continuity.	*1* *We agree that maintaining an up-to-date hiring plan is necessary. Historically this has been a major focus of the departmental long-range plan and we intend to include one in the next iteration.*	- *Update the long-range plan.*	*Physics Department*	*2022-2023*	*N*
[Opportunity] Consider carefully the benefits, costs and compromises associated with hybrid learning formats. Like many universities, there is limited experience available at Carleton to date with return to in-person learning and the pros and cons of hybrid formats of education. We heard from both faculty and students a desire to return to in-person format. We share this viewpoint, which recognizes the importance of in-person interactions and collaborative problem-solving for the learning of complex mathematical and physical concepts. In-person interaction can also be vital for the learning of guided experimental techniques on dedicated equipment. We also heard about equity concerns, such as the desire to accommodate students for whom travel to campus imposes significant difficulties. The lessons from the massive experiment with remote learning remain unclear, at Carleton and elsewhere. In all likelihood, hybrid learning may play a role in some, but not all, courses and programs going	*1* *We agree that remote teaching is probably here to stay, and that the department will need to adapt its offering to the new reality. In the next academic year, one lecture section for our Fall and Winter service courses will be online as well as our general interest astronomy courses (which always had a remote component).*	- *The curriculum committee will monitor and assess the outcome of our online offering and adjust it based on this assessment, the pedagogical requirements of our programs and the needs of our students.*	*Physics Department*	*2023-2024*	*N*

forward. We recommend careful consideration and enunciation of goals and desired outcomes, and the measurement thereof, recognizing that all solutions require compromises. For instance, it may be possible to offer hybrid learning but doing so may require significant extra expenditure of time and energy to ensure that those learning in person and online have equivalent educational experiences and acquire the same level of understanding, without reducing standards. It may turn out that it is not possible to ensure that those choosing the online approach to a hybrid class will attain the same level of understanding; in that case a decision will have to be made about which way to proceed. The Department or University may find hybrid learning so important that, although it requires more time and energy to do it well, it is worth it. This means, in the absence of additional resources, that something else would need to be given up. Our recommendation is simply to think clearly about the situation and possibilities, to measure outcomes (one approach to this is to give an anonymized, annual year-end knowledge test to students with rewards for participation that is used only for assessing pedagogical outcomes) and to choose carefully the path forward.					
[Opportunity] Create and/or make use of internal grant programs. The most important commodity for departments and faculty is their time. Time is needed to improve pedagogical approaches, to consider curriculum evolution, to develop outcome-monitoring plans and follow through on them, to apply for and receive	*2* *Various internal grants exist at the University level. For example, the Teaching Development Grant can support Faculty, Instructors or contract instructors that want, for example, to implement new teaching strategy, re-design assessment*	- *We will try to increase awareness of these grants within the department.*	*Physics Department*	*2022-2023*	*N*

funding for undergraduate research and for Major external research funds. We recommend that the Faculty and the University institute, if they do not have them, internal grant programs that allow faculty members to apply for substantial multi-year internal grants for pedagogical improvement, and that Physics take advantage of such opportunities as they arise. For example, the faculty responsible for first year physics courses might apply for a grant to study and evolve the approach to mathematics and computational education for first year students from varying backgrounds and consider how best to bring students to a common fluency in their understanding of physics concepts and mathematical capacity. A group of faculty at the second year level might consider the pros and cons of separating second-year laboratories from lecture classes. Another group of faculty might consider the role of hybrid classes, and conduct experiments with approaches and assessments to determine how best to proceed in the in-person environment in ways which retain the best of what we learned during the COVID-19 online experiment. The grants need to be of a sufficient size to provide some teaching release to allow faculty to invest the needed time and effort in new pedagogy development.	*strategies or develop new teaching and learning resources.* *Another example is the Carleton University Experiential Learning Fund that can help to increase experiential learning opportunities.* *Most of these awards are however insufficient to allow reduced teaching load.*				