Physics
Update on Unit Response to External Reviewers' Report & Action Plan Programs Being Reviewed: Undergraduate Programs
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Note: This document is made available for public posting on the Vice- Provost's website.

***** Denotes items that SQAPC would like the unit to pay particular attention to based on their past review of the original action item.**

External Reviewer Recommendation	Original Action Item and Unit response	Owner & Timeline	Progress Update DATE	Have calendar changes been initiated or completed (Not applicable/Yes/No), if Yes, when
[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 (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	**2. Agreed to if additional resources permit** *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 LinkedIn 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*	*- the Department has carried out an analysis of historical grade distributions for all courses. Analysis will continue with particular focus on courses with higher than average F/W rates or with significant year-to-year variations in grade distributions* *- the Department has gathered information from alumni to evaluate outcomes in terms of career paths post graduation. This information continues to be challenging to gather and additional efforts will be made in this area.* *- the Department has started to engage with Companies in the context of new programs and potential co-op partners.* *- a number of courses have instituted student surveys w.r.t. particular course outcomes. The Department will explore the usefulness of creating program level surveys as well.*	

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. Agreed to if additional resources permit** *We will continue to discuss with the Faculty to find an appropriate space*	Physics Department/Dean of Science/ 2022-2023	*- the Department continues to work with the Dean's Office to identify space. Unfortunately, space is limited and no space has been allocated as of yet.*	
[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. Agreed to if additional resources permit** *-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*	*- two graduate students have been assigned to support observatory operation. To facilitate knowledge transfer for longer-term operation, an operations manual is being developed* *- the Scientific Officer in the teaching labs has had responsibility for delivering the lab components of the astrophysics program and has incorporated use of the observatory. Unfortunately, this position has discontinued owing to a VRIP* *- the Department has requested the addition of a staff member dedicated (at least 50%) to the*	

			observatory efforts, but unfortunately this hasn't been approved	
[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 physics courses.	**3. Agreed to in principle** *- monitor enrolment and potential effects on resources and other programs*	*Physics Department/ 2023-2024*	*- this program currently has 18 students enrolled in it over all years of study.* *- additional efforts will be made to advertise the program and delineate its purposes clearly. The program does include a balance between students who enrolled directly in this program vs students that transferred to it (primarily from Engineering)* *- note that no special courses are required for students in this program and hence no additional resources are required to operate it.*	*Yes, completed.*
[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 computational teaching lab and from the selection of one main computing platform to ensure a minimum competency level. There may be scope for	**2. Agreed to if additional resources permit** *- evaluate current computational content in existing courses* *- consider developing a new (likely 2nd year) dedicated computational course*	*Physics Department/2022-2023*	*-the Department has created PHYS 2801: Calenar Description - "Computational Methods in Physics"* Introduction to omputational methods in physics. Software platforms and programming languages. Data formats and structures, histograms, and data visualization. Probability distributions, fitting/parameter estimation, function minimization. Interpretation and treatment of uncertainties. Introduction to machine learning and classification.	*Yes, completed.*

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.				
[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 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.	**1- Agreed to unconditionally** *Based on the budget submission, create a long-range plan of laboratory upgrades and renewal.*	*Physics Department/ 2022-2023*	*- working with the Associate Dean, the Math Department, and the Science Student Success Centre, a survey has been created that incoming 1st-year students are asked to complete. The survey presents a set of math problems on topics students are expected to already understand. This survey acts as a self-assessment for students and to remind them of the required math skills for our 1st-year courses. A second survey/test is available that allows students to solve a comprehensive set of problems to test their skills/knowledge. Although the surveys are not mandatory, students who complete them have been given 1% bonus grade in some 1st-year courses as incentive.* *At the conclusion of the surveys, students are directed to a set of modules under a Brightspace module 'MATH4U'. Lectures and tests are available on each of the math subjects relevant to 1st-year courses. This provides an excellent place for students to prepare and practice their math skills/knowledge.* *- in our 1st-year physics course, an additional survey is provided to evaluate student math skills specific to this course. Some supplementary training, particular in calculus, might be provided in the early lectures.* *- the Department has delivered tutorial lectures to 1st-year students to help guide them towards better study/learning approaches and this includes some math skills content*	

			- the Department also runs a drop-in centre where students can interact with TAs to solve problems including applications of math tools to problem solving	
[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 that students gain experience during their education with environments and instrumentation similar to what they will use in post-graduation employment or graduate research.	-	*Physics Department/2022-2023*	*- the Department has continued to replace/upgrade teaching laboratory equipment with significant computer and hardware upgrades* *- unfortunately, the University Budget currently is experiencing challenges and the planned laboratory renovations and upgrades are on hold*	
[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	**2. Agreed to if additional resources permit** - Explore possibilities for new partnerships to enhance capabilities for offering astrophysics specific honours projects	*Physics Department/2022-2023*	*- as indicated above, unfortunately the current budget will not provide for a dedicated staff member to be allocated to the observatory and for providing astrophysics honours project support. As the financial situation develops, this will be revisited.* *- unfortunately, in addition, the Department Scientific Officer (lab supervisor) who had provided some support has retired and will not be replaced at present* *- efforts continue to be made to search for useful partnerships outside of Carleton.* *- it should be noted that a number of research groups are providing honours projects relevant to our astrophysics students*	

strategy of the department. The department should consider these points in their updated strategic plan.				
[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. Agreed to unconditionally** - Work on the new departmental long-range plan will begin in the Fall of 2022.	*Physics Department/ 2022-2023*	*- meetings were organized by the Department Executive working with the Office of Quality Initiatives (OQI). Separate meetings were held with the Staff, Faculty, Students, and Research Staff. Feedback was collated and distributed to the Department. The next steps will follow in September 2025. Note that a separate set of documentation related to Departmental plans was created in conjunction with the provincially mandated review of the university. This document/information will also be used to inform the new Department LRP.*	
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[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. Agreed to in principle** - *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*	*- the Department has chosen to focus more efforts on exploring/developing new undergraduate and graduate programs.* *- discussions will continue to be held to evaluate the effectiveness of the Major programs to ensure the programs are best serving the students in them.* *- it was decided to not allow Major program students into the honours project courses. This decision will be reevaluated regularly.*	
[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	**1. Agreed to unconditionally** - *Update the long-range plan.*	*Physics Department/2022-2023*	*- as indicated above, the LRP is currently being updated and the faculty hiring plan is a key part of this. Owing to the current financial situation at Carleton, opportunities to hire new faculty are limited. None-the-less, the Department continues to work with the Faculty of Science and University Administration to pursue opportunities to bring new world-class researchers and academics to Carleton.*	

lecturers to reduce the dependence on contract instructors and provide enhanced quality and continuity.			*- the Department has engaged in LRP related discussions on whether, if opportunities arise, new faculty members could be added in new areas to add breadth to the Department* *- unfortunately, the teaching professor in the Department has retired and, owing to the financial situation, it is unlikely that this position will be replaced.*	
[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 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	1. **Agreed to unconditionally** - *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*	*- all main physics courses for physics program students are held in-person. Some lecturers continue to post online materials including recorded lectures, but in general it was found that this needs to be done in a limited way to avoid inadvertently discouraging in-class participation.* *- the only courses that have online options are two astronomy course electives and two physics course electives. Although there are challenges with online delivery, the department has found that, for these 'interest' courses, the benefits of online outweigh the difficulties.*	

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 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	**2. Agreed to if additional resources permit** - *We will try to increase awareness of these grants within the department.*	*Physics Department/2022-2023*	*- the Department regularly distributes information regarding such programs and will continue to encourage Department members to take advantage of these opportunities.*	

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.				