

<b>Faculty / Affiliated University College</b>	Science	
<b>Degrees Offered</b>	Master of Science (MSc) Doctor of Philosophy (PhD)	
<b>Date of Last Review</b>	2012-2013	
<b>Approved Fields</b>	<u>Physics</u> Condensed Matter Medical Physics Planetary Physics	<u>Astronomy</u> Astrophysics
<b>External Reviewers</b>	Dr. Gary Slater, Department of Physics, University of Ottawa	Dr. Stefi Baum, Faculty of Science, University of Manitoba
<b>Internal Reviewers</b>	Dr. Godwin Arku, Graduate Chair, Dept. of Geography & Environment	Abdelmoneim El Naggat, PhD candidate at the Civil and Environmental Engineering
<b>Date of Site Visit</b>	April 27, 28, 2023	
<b>Date Review Report Received</b>	June 30, 2023	
<b>Date Program/Faculty Response Received</b>	Program: Aug 23, 2023 Faculty: Aug 24, 2023	
<b>Evaluation</b>	Good Quality	
<b>Approval Dates</b>	SUPR-G: October 16, 2023 ACA: October 25, 2023 Senate: November 10, 2023	
<b>Year of Next Review</b>	2030-2031	
<b>Progress Report</b>	June 2026	

## **Overview of Western's Cyclical Review Assessment Reporting Process**

In accordance with Western's Institutional Quality Assurance Process (IQAP), the Final Assessment Report (FAR) provides a summary of the cyclical review, internal responses, and assessment and evaluation of the Physics and Astronomy Graduate Programs delivered by the Faculty of Science.

This FAR considers the following documents:

- the program's self-study brief;
- the external reviewers' report;
- the response from the Program; and
- the response from the Dean's Office, Faculty of Science.

This FAR identifies the strengths of the program and opportunities for program enhancement and improvement, and details the recommendations of the external reviewers – noting those recommendations to be prioritized for implementation.

The Implementation Plan details the recommendations from the FAR that have been selected for implementation, identifies who is responsible for approving and acting on the recommendations, specifies any action or follow-up that is required, and defines the timeline for completion.

The FAR (including Implementation Plan) is sent for approval through the Senate Graduate Program Review Committee (SUPR-G) and ACA, then for information to Senate and to the Ontario Universities' Council on Quality Assurance. Subsequently, it is publicly accessible on Western's IQAP website. The FAR is the only document from the graduate cyclical review process that is made public; all other documents are confidential to the Physics and Astronomy Graduate Programs, Faculty of Science, the School of Graduate & Postdoctoral Studies (SGPS), and SUPR-G.

## **Executive Summary**

The Physics Department at Western University was established in 1915, registering the first physics students in 1919. By 1939, both graduate and undergraduate Physics degree programs were offered. The astronomy graduate program at Western University was established in 1966 and was housed in a separate Department of Astronomy until 1996 when it was merged with the Department of Physics to create the current Department of Physics & Astronomy. Since the merger, the physics and astronomy graduate programs, while separate, have been governed in a coordinated and harmonized way.

The physics graduate program offers a thesis-based MSc degree and a thesis-based PhD degree in the approved fields of condensed matter, medical physics, and planetary

physics. In addition, a research project-based MSc degree has been offered since 2013. Total enrolment in 2022-23 was at 10 MSc and 15 PhD.

The Astronomy graduate program offers a thesis-based MSc degree and a thesis-based PhD degree in the approved field of astrophysics. In addition, a research project-based MSc degree (which is the most popular option) has been offered since 1995. Total enrolment in 2022-23 was at 14 MSc and 11 PhD.

The self-study was informed by a survey sent to faculty members and to current students and recent graduates. The results of both surveys were used as the basis for a full-day and half-day faculty retreat in May 2022. Written feedback from the graduate student survey was explicitly discussed, and a strengths-weaknesses-opportunities-threats (SWOT) analysis of each program was undertaken.

The external reviewers shared a positive assessment of the Physics and Astronomy Graduate Programs. They offer six recommendations with considerations for further enhancement.

### **Strengths and Innovative Features Identified by the Programs**

- In alignment with Western's aim to address systematic issues of equity, diversity, and inclusion, and anti-racism and decolonization, the members of each program admissions committee will receive training in systematic and unconscious bias prior to the 2023 application season.
  - o Astronomy 9610 - Introduction to Modern Astrophysics, taken by all Astronomy MSc students, now includes a research project assigned to all students concerning marginalized researchers in astrophysics.
- Collaborative specializations in Planetary Astronomy and Space Exploration and in Scientific Computing, as well as the newly established Institute for Earth and Space Exploration (IESX).
- Students are supported in their professional development and career planning through the weekly "Physics and Astronomy Graduate Seminar".
- Programs are supported by strong administrative expertise and increased TA support (with the integration of Applied Mathematics).
- There is a very strong undergraduate research culture in Physics and Astronomy at Western and this translates into many students deciding to pursue graduate studies at Western and a strong student publication record.
- Renovated facilities include: (1) a fully equipped machine shop staffed by two highly skilled machinists, plus a student shop that can be used by faculty, staff, and students; (2) a woodshop, and (3) an electronics shop.
- Associated research facilities are impressive.
- Program success can be measured by graduates employed in a wide range of careers, including those in academia, industry, and government.

- The interdisciplinary nature of modern physics is also reflected in the many connections the physics program has with other Departments in Western's Faculty of Science, Faculty of Engineering and Schulich School of Medicine and Dentistry.
  - o Close connection with the Department of Medical Biophysics and its graduate program, as many medical physics faculty supervise students in the medical physics graduate program and vice-versa.
- \$2M+ was bequeathed to the department for the purpose of purchasing experimental equipment and supporting Canadian graduate students employed in research (Physics).

### **Concerns and Areas of Improvement Identified and Discussed by Each Program**

- There is need for 1) funding to support students' travel to conferences; 2) additional scholarships; 3) financial support to international students to ensure their success; 4) opportunities to enhance engagement among students and faculty.
- High international tuition and disparity in department level funding for domestic and international students.
- Offering the required variety and number of graduate courses has become a challenge due to expanded undergraduate teaching.
- Opportunity to implement a robust tracking system for our MSc and PhD students, post-graduation.
- Possibility of a new and unifying field of study in "Computational Physics", particularly given recent faculty hires and the new department members transferred from the former Applied Mathematics Department.

### **Review Process**

As part of the external review, the review committee, comprising two external reviewers, one internal reviewer and a graduate student reviewer, were provided with Volume I and II of the self-study briefs in advance of the scheduled review and then met virtually (due to pandemic restrictions) over two days with the:

- Vice-Provost of the School of Graduate & Postdoctoral Studies
- Associate Vice-Provost of the School of Graduate & Postdoctoral Studies
- Associate Vice-Provost, Academic Planning, Policy and Faculty
- Director, Academic Quality & Enhancement
- Associate Dean
- Department Chair
- Graduate Program Chair
- Associate University Librarian
- Graduate Program and Department Staff

- Program Faculty Members
- Graduate Students

Following the virtual site visit, the external reviewers submitted a comprehensive report of their findings which was sent to the Program and Dean for review and response. Formative documents, including Volumes I and II of the Self-Study, the External Report, and the Program and Decanal responses form the basis of this Final Assessment Report (FAR) of the Physics and Astronomy Graduate Programs. The FAR is collated and submitted to the SGPS and to SUPR-G by the Internal Reviewer with the support of the Office of Academic Quality and Enhancement.

### **Summative Assessment – External Reviewers’ Report**

External reviewers shared that *“these two graduate programs (Physics and Astronomy) are both strong and successful programs, with superb faculty in place to deliver the programs. They boast a unique set of interdisciplinary connections and centres that further strengthen the programs. The physical space and resources provided by all accounts support a strong environment for student and program success and the programs and student cohorts exhibit strong positive supportive and cohesive cultures.”*

### **Strengths of the Programs**

- Students and faculty benefit from a high interdisciplinary, interactive, and supportive environment. Students graduate with breadth, depth, and good communication skills and gain employment in varied areas and fields.
- The culture in the Department is extremely positive and the students were uniform in feeling accepted and supported, irrespective of their heritage and origins. The faculty and students (particularly in Astronomy) are very active in education and outreach activities with a diverse community beyond the university, encouraging a new generation of diverse scientists and communicators.
- Faculty members have strong research profiles and carry international reputations; expertise focused in a few fields allows for strong focus, research excellence, and productivity.
- Strong progression rates, excellent employment and career outcomes of the students tracked underscore the success of these two programs.
- The practice of not requiring students who excel in the Research Project option to write a thesis is an innovative approach that should be adopted by Canadian physics programs.
- A strong record of publications in appropriate journals for students completing research theses.
- The project-based masters appears to be very successful with students completing their degrees in a short period of time and going on either to further studies or to appropriate employment.

- Program curriculum is enhanced by: 1) the addition of the Academic Integrity Module; and 2) the ¼ courses that seem to be an attractive solution to the problem of offering enough graduate courses.

### **Prospective Improvements for the Program to Consider**

- Review whether differential outcomes exist for the thesis based and research project-based masters students upon graduation.
- While very thorough, it might be useful to compare the current format of the comprehensive exams to that found in other physics and astronomy programs across the country to see if it is the best approach to achieve your goals.
- Clarification is needed regarding the department's position on students switching to part-time to enable them to work while writing their thesis.
- Review the efficacy of the use of traditional assessment methods with the current revised Learning Outcomes (specifically about Awareness of Limits of Knowledge).
- Difficulty admitting and recruiting strong international students in the Masters program due to funding issues.
  - o Concern about future recruitment that might impact the diversity of the student body in negative ways.
- Prioritize addressing the issues of insufficient funding allocated to graduate students. (*embedded in external reviewer recommendation #4*)
  - o In some cases, it was shared that offer letters were unclear in terms of what funding they would receive and what expenses they would be responsible for.
- Low success rates for students winning external awards may be due to a lack of adequate support, advising, review for students when they apply for external funding, putting them at a disadvantage relative to students at other institutions where support is provided. (*embedded in external reviewer recommendation #5*)

While the areas of improvement noted in the first five bullet points were not explicitly expanded on as stand-alone recommendations by the external reviewers, several are embedded in the recommendations offered, as outlined in the section below. The points above remain suggestions for consideration by the Program.

## Summary of the Reviewers' Recommendations and Program/Faculty Responses

The following are the reviewers' recommendations in the order listed by the external reviewers. Recommendations requiring implementation have been marked with an asterisk (\*).

Reviewers' Recommendations	Program/Faculty Response
<p><b>Recommendation #1*: Teaching Assistantships</b></p> <p>The department should:</p> <ul style="list-style-type: none"> <li>A. have a training session each semester for TAs.</li> <li>B. establish clear guidelines for the use of TAs by professors.</li> <li>C. ensure equal utilization of TA resources.</li> </ul>	<p><b>Program:</b></p> <ul style="list-style-type: none"> <li>A. Introduction of a mandatory TA training session at the beginning of each semester for first-year students to review departmental expectations, effective teaching strategies, and address TAs concerns. CTL resources will be used to develop these TA training sessions, and TAs will be encouraged to enroll in pre-existing courses offered by the CTL.</li> <li>B. The existing TA guideline document (dated 2015) will be revised to more clearly outline best practices for professors when collaborating with TAs with focus on the following: 1) Clear communication of tasks and expectations; 2) Provision of grading rubrics or guidelines when TAs are assigned grading tasks; and 3) Regular check-ins to ensure clarity and provide support. This document will be shared with all faculty members and TAs to ensure a standardized approach.</li> <li>C. In an effort to foster an environment where TAs feel comfortable voicing concerns without fear, the department will 1) implement a mid-semester anonymous survey for TAs to provide feedback on their workload, faculty interactions, and any concerns they might have; 2) establish a position for a TA liaison (senior faculty or staff member) who will address immediate concerns and collect data from the mid-semester survey; 3) emphasize the importance of adhering to guidelines and ensuring equitable treatment of TAs at faculty meetings.</li> </ul> <p><b>Faculty:</b> The Associate Dean Graduate will help to connect the program with existing expertise on campus, such as TA training courses offered through CTL, and current guidelines regarding TA supervision that will help implement the Physics and Astronomy program-specific training for both TAs and supervisors.</p>
<p><b>Recommendation #2*: Orientation for new students</b></p> <p>The department should:</p> <ul style="list-style-type: none"> <li>A. host yearly orientation sessions to welcome and inform new graduate students, especially international students.</li> <li>B. provide senior</li> </ul>	<p><b>Program:</b></p> <ul style="list-style-type: none"> <li>A. To ensure a welcoming environment for new graduate students, from the next academic cycle: 1) a biannual orientation session will be organized at the beginning of each semester; 2) team-building exercises will be incorporated into the orientation session which will conclude with a social gathering. Additionally, students will be encouraged to attend events organized by Western International; 3) sessions will be dedicated to address the unique needs of international students.</li> <li>B. The department will launch a "Peer Mentorship Program." Senior graduate students and postdocs will be invited to volunteer as mentors and will be paired up with new students, preferably from similar research areas or backgrounds, to foster better understanding and support. Mentors 1) will be trained to ensure they are equipped to support their mentees effectively; 2) periodic check-ins will be scheduled between mentors, mentees, and a department representative to gather feedback and ensure the effectiveness of the mentorship relationship.</li> </ul>

<p>graduate students opportunities to mentor new graduate students.</p>	<p><b>Faculty:</b> The department's plans for program-specific graduate orientation and mentorship programs are thorough and will enhance the experience of their graduate students. The ADG can connect the program with other programs on campus that have implemented similar orientation and mentorship programs. Similarly, the Dean's Office can help connect the program with Western International for advice on supporting their new international students.</p>
<p><b>Recommendation #3*: Career</b> The program should explore:</p> <ul style="list-style-type: none"> <li>A. the establishment of internships in industry, NGOs, and govt/public organizations for domestic and international students.</li> <li>B. incorporating an internship component into the degree requirements for international students through a professional one-year masters program.</li> <li>C. explicitly including MyGradSkills and OwnYourFuture resources in the curriculum.</li> </ul>	<p><b>Program:</b></p> <ul style="list-style-type: none"> <li>A. The Program 1) has begun to evaluate the need for a dedicated "Internship and Career Opportunities" desk which would collaborate with industry, NGOs, government organizations, and programs such as MITACs to curate internship opportunities specifically tailored to students; 2) develop strategies in collaboration with the Science Internship Program; 3) workshops organized each semester to inform students of internships, application processes, and CV building; and 4) dedicated sessions to ensure that international students are well-informed about the requirements and opportunities available to them.</li> <li>B. The grad-affairs committee will investigate the feasibility and structure of a one-year professional master's program which will emphasize hands-on experiences and may culminate in a capstone project or internship. Discussions were initiated with Medical Biophysics to promote a 2-year physics+CAMPEP program. The program is exploring potential funding opportunities and partnerships that can be fostered through the introduction of such a program.</li> <li>C. Incorporate OwnYourFuture into the Curriculum and organize biannual workshops or webinars in collaboration with OwnYourFuture representatives to highlight the significance and benefits of these resources.</li> </ul> <p><b>Faculty:</b></p> <ul style="list-style-type: none"> <li>A. The Career Services unit at the Dean's office already has a team of staff that helps students and programs prepare for work experience and to find placements for internship positions. This team can work with the Physics and Astronomy Department to explore options and pathways to incorporate internship and industry experiences into their program.</li> <li>B. The ADG will assist the program in exploring the feasibility of offering a one-year professional MSc program.</li> </ul>
<p><b>Recommendation #4*: Student Funding</b> The department should:</p> <ul style="list-style-type: none"> <li>A. clarify and communicate to all incoming students, total funding allocated.</li> <li>B. increase funding allocated to graduate</li> </ul>	<p><b>Program:</b></p> <ul style="list-style-type: none"> <li>A. Review current funding mechanisms to simplify and clarify the process for students; include complete funding model on a dedicated section on the departmental website. At the start of each academic year, students will receive detailed instructions on accessing their personalized funding statements via Mercury.</li> <li>B. Conduct a comparative study with other U15 universities to understand the benchmark for student funding. Consider revising the minimum contribution from faculty grants to support graduate students; and, explore additional funding opportunities. Continue to explore opportunities for utilizing the funding received from the Hunt bequest.</li> <li>C. Organize annual information sessions addressing application processes and eligibility criteria of various external scholarships. Faculty will be encouraged and incentivized to review students' research statements and applications, offering their expertise and feedback.</li> </ul>



<p>students from advisors' grants. C. support graduate students throughout their scholarship application process.</p>	<ul style="list-style-type: none"> <li>▪ Collaborate with the university's central research organization and set up mock review sessions during which students present their proposals and receive feedback.</li> </ul> <p><b>Faculty:</b> The Dean's office 1) supports the programs initiatives to provide more clarity to students regarding their funding package; 2) encourages the program to use the Mercury software to convey annual funding packages to students (rather than posting the funding term by term).</p> <p>The Dean's office recognizes the financial strain that students living in London currently face. In 2022-2023, the minimum graduate stipends in Physics and Astronomy were the highest in all programs in Science. The program and faculty in Physics and Astronomy have been and continue to be very sensitive to the issue of student funding. The Dean supports the program's initiatives to: 1) review the possible support from faculty grants, 2) seek additional funding opportunities, and 3) increase scholarship success through coaching.</p>
<p><b>Recommendation #5*: Student Recruitment</b> The department should:</p> <ul style="list-style-type: none"> <li>A. review admission benchmarks to enhance recruitment.</li> <li>B. Reassess the decision to not allow direct entry into the doctoral program.</li> </ul>	<p><b>Program:</b></p> <ul style="list-style-type: none"> <li>A. Organize departmental meetings (with faculty and graduate students) to define recruitment goals. A clear recruitment strategy will be documented, highlighting the program's approach to selecting candidates and methods of achieving a balance between quality and inclusivity.</li> <li>B. The grad affairs committee will review the current restrictions on accelerated and direct entry into the doctoral program which will include a comparative study of peer institutions that allow such entry pathways to understand the advantages, challenges, and outcomes. Based on the findings, the program will draft a proposal to introduce flexible entry pathways, ensuring that the mechanisms are in place to support students who might take these routes, ensuring their success and integration.</li> </ul> <p><b>Faculty:</b> The Dean's office supports the program's proposed plan.</p>
<p><b>Recommendation #6*: Course work (including the PhD comprehensive exam)</b> The department should:</p> <ul style="list-style-type: none"> <li>A. monitor the level and content of the quarter courses and ensure that they meet the learning outcomes and are appropriately sized.</li> <li>B. ensure that the 9610 classes achieve their objective.</li> </ul>	<p><b>Program:</b></p> <ul style="list-style-type: none"> <li>A. Initiate periodic reviews of all quarter courses, focusing on their content, intensity, and alignment with learning outcomes. Faculty members teaching quarter courses will be encouraged to have mid-course feedback sessions with students to gauge their perspective on course intensity and pacing.</li> <li>B. The grad affairs committee will review the curriculum and structure of the 9610 classes. This committee will closely analyze student feedback, exam outcomes, and teaching methods to identify areas of improvement. A comparative analysis will be conducted on comprehensive exam outcomes, distinguishing between students who have a strong background in the field and those who might not. This will allow the program to measure the effectiveness of the 9610 classes and make necessary adjustments.</li> </ul> <p><b>Faculty:</b> The Dean's office supports the program's proposed plans.</p>

## Implementation Plan

The Implementation Plan provides a summary of the recommendations that require action and/or follow-up. In each case, the Graduate Program Chair, in consultation with the SGPS and the Dean of the Faculty is responsible for enacting and monitoring the actions noted in Implementation Plan.

Prioritized Recommendations	Proposed Action and Follow-up	Responsibility	Timeline
<p><b>Recommendation #1: Teaching Assistantships</b> The department should:</p> <ul style="list-style-type: none"> <li>A. have a training session each semester for TAs</li> <li>B. establish clear guidelines for TAs</li> <li>C. ensure equal utilization TA resources</li> </ul>	<ul style="list-style-type: none"> <li>- Introduce a mandatory TA training session for first-year students.</li> <li>- Revise the existing TA guideline document.</li> <li>- Implement a mid-semester anonymous survey to get feedback from TAs.</li> <li>- Establish a TA liaison position.</li> <li>- Underscore the importance of adhering to guidelines and ensuring equitable treatment of TAs at faculty meetings.</li> </ul>	<ul style="list-style-type: none"> <li>• Graduate Chair</li> <li>• Graduate Committee</li> <li>• Associate Dean, Graduate</li> </ul>	By September 2024
<p><b>Recommendation #2: Orientation for new students</b> The department should:</p> <ul style="list-style-type: none"> <li>A. host yearly orientation sessions to welcome and inform new graduate students, especially international students.</li> <li>B. provide senior graduate students opportunities to mentor new graduate students.</li> </ul>	<ul style="list-style-type: none"> <li>- Introduce an orientation session scheduled at the beginning of each semester.</li> <li>- Launch a <i>Peer Mentorship Program</i> with senior graduate students and postdocs as mentors to be paired with new students.</li> <li>- Train and conduct periodic check-ins between mentors and mentees.</li> <li>- Connect with Western International for advice on supporting their new international students.</li> </ul>	<ul style="list-style-type: none"> <li>• Graduate Chair</li> <li>• Associate Dean, Graduate</li> </ul>	By September 2024
<p><b>Recommendation #3: Career</b> The program should explore:</p> <ul style="list-style-type: none"> <li>A. the establishment of internships in industry, NGOs, and govt/public organizations for domestic and international students.</li> <li>B. incorporating internship component into the degree requirements for international students through a professional one-year masters program.</li> <li>C. explicitly including MyGradSkills and</li> </ul>	<ul style="list-style-type: none"> <li>- Evaluate the need for a dedicated "Internship and Career Opportunities" desk.</li> <li>- Develop strategies in collaboration with the Science Internship Program.</li> <li>- Organize scholarship/internship information workshops, with dedicated sessions for international students each semester.</li> <li>- Investigate the feasibility and structure of a one-year professional master's program.</li> <li>- Incorporate OwnYourFuture into the Curriculum and</li> </ul>	<ul style="list-style-type: none"> <li>• Graduate Chair</li> <li>• Graduate Affairs Committee</li> <li>• Associate Dean, Graduate</li> </ul>	By June 2025

OwnYourFuture Resources in the curriculum.	biannual workshops/webinars. - Career Services unit within the Dean's office to support the program's exploration of internships.		
<b>Recommendation #4: Student Funding</b> The department should: A. clarify and communicate to all incoming students, total funding allocated. B. increase funding allocated to graduate students from advisors' grants. C. support graduate students' throughout their scholarship application process	<ul style="list-style-type: none"> <li>- Simplify and upload complete funding model on the departmental website.</li> <li>- Provide students instructions on how to access their personalized funding statements via Mercury.</li> <li>- Conduct a comparative study with other U15 universities to understand the benchmark for student funding.</li> <li>- Faculty to review students' research statements and applications, offering relevant feedback.</li> <li>- Collaborate with the university's central research organization to run mock review sessions prior to students' submission.</li>   <li>- Review the minimum contribution from faculty grants to support graduate students; and, explore additional funding opportunities.</li> <li>- Continue to explore opportunities for utilizing the funding received from the Hunt bequest.</li> </ul>	<ul style="list-style-type: none"> <li>• Graduate Chair</li> <li>• Graduate Affairs Committee</li> <li>• Associate Dean, Graduate</li> </ul>	By January 2024  By September 2024         By June 2025
<b>Recommendation #5: Student Recruitment</b> The department should: A. review admission benchmarks to enhance recruitment. B. Reassess the decision to not allow direct entry into the doctoral program.	<ul style="list-style-type: none"> <li>- Organize departmental meetings (with faculty and graduate students) to define recruitment goals.</li> <li>- Develop a recruitment strategy to address candidate selection.</li> <li>- Review the current restrictions on accelerated and direct entry into the doctoral program.</li>   <li>- Potentially draft a proposal to introduce flexible entry pathways, highlighting mechanisms to support students who might take these routes, ensuring their success and integration.</li> </ul>	<ul style="list-style-type: none"> <li>• Graduate Chair</li> <li>• Graduate Affairs Committee</li> </ul>	By December 2024         By June 2025
<b>Recommendation #6: Course work</b> The department should: A. monitor the level and content of the quarter courses and ensure that they meet the learning outcomes and are appropriately sized. B. ensure that the 9610 classes achieve their objective.	<ul style="list-style-type: none"> <li>- Initiate periodic and mid-course reviews of all quarter courses.</li> <li>- Review the curriculum and structure of the 9610 classes.</li> </ul>	<ul style="list-style-type: none"> <li>• Graduate Chair</li> <li>• Graduate Affairs Committee</li> </ul>	By September 2024

