To Whom it May Concern,

We are proposing a new Physics specialization in Astrophysics. This new specialization will require one course change (to the title) and the introduction of three new courses (two of which will be taught every second year). This proposal is part of our Strategic Plan efforts within the Physics group to make better use of our resources, better align our program with the Strategic Plan of the Faculty of Science and UOIT, and grow our program enrolment. In fitting with our overall plan, we have recently removed a specialization (Medical Physics) and are in the process of removing another (Forensic Physics).

Astrophysics is a very popular field of physics; we are frequently approached at UOIT recruitment events about an astrophysics option, and many universities in the area include it as an option for their physics students (for example, York, McMaster and Queen's all have Astrophysics specializations). Our specialization, however, will be unique -- and fit well within the Strategic Plan -- by focusing not just on the fundamentals of the subject, but also on the practical use of modern telescopes and instrumentation, including retrieval and analysis of real astronomical data collected from world-class telescopes. A second focus of the specialization is on computational astrophysics, allowing close connections with the Math and Computer Science groups at UOIT. We will make major use of UOIT's Mobile Program, and our graduates will be prepared not just for further academic studies at the graduate level, but also for a career as a technician in the field of astrophysics.

With such high demand for an astrophysics option, we expect enrolment within the Physics program to almost double with the introduction of this new specialization. At McMaster, for example, where the enrolment in Physics is similar to UOIT (comparing their Honours Physics option with our comprehensive Physics program), the Astrophysics option is almost on par with the Honours Physics option (it makes up 45% of the total enrolment). Given similar numbers at other universities, we think it is reasonable to expect major growth in the Physics program after introducing an Astrophysics specialization.

Finally, there would be major benefit to both comprehensive Physics students and Concurrent Education students, as well as all general Science students. Given the current small number of senior level physics courses, introducing new astrophysics courses gives the comprehensive program greater breadth and introduces students to different areas of physics. Furthermore, astronomy is a part of the grade nine curriculum in Ontario, making the new courses very appealing to Concurrent Education students. Our new course PHY 3900U Astronomy II will join Astronomy I as a possible Science elective for non-Physics students, increasing the (much needed) number of possible Science electives overall.

Thank you for your time,

Joseph MacMillan
Physics Lecturer, Faculty of Science

Rupinder Brar
Senior Physics Lecturer, Faculty of Science

Major Program Modification
New Physics Specialization – Astrophysics

Prepared by Joseph MacMillan and Rupinder Brar October 2012

1. Introduction

Physics is the science of nature. Force, motion, light, sound, electricity, magnetism, and the structure of matter all lay at the heart of natural sciences and technology. Students benefit from exposure to the cutting-edge research interests of faculty members in renewable energy, semiconductor devices, microelectronics, materials science, and computational physics. Students can choose follow the comprehensive program or choose to specialize in *Energy and the Environment* or *Forensic Physics*. The comprehensive program provides a broad coverage of fundamental topics in physics, and provides students with the flexibility to take elective courses in a different science discipline. The Energy and the Environment specialization is designed to meet the urgent demand for graduates with the knowledge and skills to address global issues of escalating energy consumption and declining resources. It emphasizes expertise in alternative and conventional energy and the scientific principles underlying the development of novel and economical means of generating and harvesting energy, while simultaneously minimizing their environmental impact. The Forensic Physics specialization is currently undergoing review due to low enrollment and poor program structure. The current plan is to cancel this specialization entirely.

Astrophysics is a popular topic of interest at the undergraduate level, as evidenced by frequent requests after astronomy or astrophysics from prospective students during recruitment events (e.g., the Ontario University Fair or UOIT Open Houses), as well as from the high enrollment in both general-level astronomy courses and science-specific courses currently offered by the Faculty of Science. We propose a new specialization, *Astrophysics*. With the Forensic Physics specialization likely being removed from the Physics program, adding this new specialization will keep the number of specializations within the program to two, and will continue to offer choice and flexibility to incoming and prospective physics students.

The Astrophysics specialization will focus more strongly on astronomy and astrophysics than our current course offering allows by providing both a strong base in the underlying physics of astronomy as well as knowledge of specific tools and techniques of astrophysics. The specialization will prepare graduates for both further academic studies in astronomy and astrophysics (e.g., at the Masters or Doctoral level)

as well as for a career as a technician in the field of astronomy. Furthermore, because of the strong physics component, any career options available to Physics Program graduates are equally open to students who have taken the Astrophysics specialization. Career options for a general UOIT Physics graduate include employment in consulting companies (in particular energy and environment), or government agencies (such as research labs or the Department of National Defence), and as a high school teacher (through the Concurrent or Consecutive Education program). Other post-graduate options include graduate studies in physics or a related field.

The introduction of this specialization will allow for major growth within the Physics program. When comparing UOIT to other universities in the area, McMaster is quite close in terms of sizes of the respective physics programs; enrollment numbers in the Physics program at UOIT is very similar to the current enrollment in the Honours Physics option at McMaster. However, McMaster also has an Astrophysics option, which almost doubles their enrollment (the Astrophysics option has about 45% of the total enrollment). There are similar numbers at other universities in the area, and it is expected that introducing the Astrophysics specialization here will allow us to almost double the enrollment in the Physics program.

Furthermore, this new specialization will provide balance and flexibility when placed side by side with the more industry and market focused specializations (e.g., the Energy and the Environment specialization). In fitting in with the Strategic Plan of UOIT, it will still, however, be application focused, with courses in modern astrophysics techniques and research methods. It will make heavy use of the laptop environment, and will prepare graduates for a future in astronomy and astrophysics.

With some emphasis on numerical modelling, the new course offerings will complement existing courses in Applied and Industrial Mathematics as well as Computational Science, and could provide a useful stream for students wishing to enter the Modelling and Computational Science graduate program at UOIT. Upper year physics courses in astrophysics topics will strengthen the breadth of physics courses that are currently offered and allow Physics Program students (not just those in the specialization) to gain a deeper understanding of different branches of physics.

2. Degree Requirements

a. Program Learning Outcomes

Graduates of the Astrophysics specialization are expected to meet the abilities of the current comprehensive Physics Program, while in addition gaining new knowledge and skills in the field of astronomy and astrophysics. In particular:

1. Depth and breadth of knowledge
    - Describe and explain the basic concepts and ideas in the field of astronomy, including modern telescopes, the solar system and extra solar planets, stars, galaxies, and the universe itself.
    - Demonstrate knowledge of astronomy, physics, mathematics, and computer science by solving problems in the field of astronomy and astrophysics.
2. Knowledge of Methodologies
    - Calculate the evolution of the solar system, stars, galaxies, and the universe using a broad range of modern techniques, including analytical and computational modelling.
    - Utilize knowledge and software to identify, retrieve, and analyse modern telescope data.
3. Application of Knowledge
    - Apply knowledge of astrophysics to conduct appropriate research in the field at the level of an undergraduate honours thesis.
4. Communication Skills
    - Discuss topics in astrophysics accurately and effectively, in both written and oral form, with members of academia as well as the general public.
5. Awareness of Limits of Knowledge
    - Some of the largest unsolved problems in physics are in the field of astrophysics (such as the theories of dark matter and dark energy). Students will recognize the limitations of the current state of knowledge in astrophysics, explain the motivations for new theories, and to be able to criticize them.
6. Autonomy and Professional Capacity
    - Student is expected to become an active member of multidisciplinary and multicultural teams and appreciate the importance of academic integrity, professional ethical conduct, and social responsibility.

b. Admission Requirements

All first year science programs, including Physics, share the same entrance requirements. The admission requirements are described specifically for Ontario secondary institutions; however these requirements also apply to students from out of province.

Current Ontario secondary school students must complete the Ontario Secondary School Diploma (OSSD) with a minimum overall average of 70 per cent on six 4U or 4M credits including English (ENG4U), advanced functions (MHF4U), and two of physics (SPH4U), chemistry (SCH4U), biology (SBI4U), or calculus and vectors (MCV4U). In addition, a combined minimum 70 per cent average in math and science courses is required.

No changes to the admission requirements will be made to accommodate the new proposed Astrophysics specialization.

c. Program Structure

The program map for the Astrophysics specialization is summarized in the table on the next page; note that green indicates new courses to be created for the Astrophysics specialization, black for required courses offered by other units, and red for required courses currently offered by Physics.

Also note that PHY 2900U is not a new course; it is currently offered as *The Science of Astronomy* and will require a change of name to *Astronomy I*.

Proposed calendar copy:

14.11.4.5 Physics – Astrophysics specialization

YEAR 1 – Regular program and Co-operative Education program

Semester 1 (15 credit hours)
BIOL 1011U Introductory Cell and Molecular Biology
CHEM 1010U Chemistry I
CSCI 1030U Introduction to Computer Science with C++
MATH 1000U Introductory Calculus+ or MATH 1010U Calculus I+
PHY 1010U Physics I+ or PHY 1030U Introductory Physics+

Semester 2 (15 credit hours)
BIOL 1021U Introduction to Organismal Biology and Ecology or CHEM 1020U Chemistry II
MATH 2050U Linear Algebra
MATH 1020U Calculus II
PHY 1020U Physics II
PHY 2900U Astronomy I

+All students who have completed Grade 12 Advanced Functions (MHF4U) and Calculus and Vectors (MCV4U) should take MATH 1010U and PHY 1010U. Students without one of these high school courses or equivalent are directed to take MATH 1000U and PHY 1030U.

YEAR 2 – Regular program

Semester 1 (15 credit hours)
CSCI 2000U Introduction to Mathematical Computation
MATH 2015U Calculus III
PHY 2030U Mechanics I
PHY 2060U Nuclear Physics and Relativity
STAT 2010U Statistics and Probability for Physical Science

Semester 2 (15 credit hours)
MATH 2060U Differential Equations
PHY 2010U Electricity and Magnetism I
PHY 2040U Mechanics II
PHY 2050U Thermodynamics and Heat Transfer
PHY 3900U Astronomy II

YEAR 3 – Regular program

Semester 1 (15 credit hours)
PHY 2020U Electricity and Magnetism II
PHY 3010U Statistical Mechanics I
PHY 3020U Quantum Mechanics I
PHY 3050U Waves and Optics
Elective**

Semester 2 (15 credit hours)
PHY 3040U Mathematical Physics
PHY 3060U Fluid Mechanics
PHY 4910U Techniques of Modern Astrophysics or PHY 4920U Cosmology
Elective** (MATH 2072U Computational Science I recommended)
Elective**

YEAR 4 – Regular program

Semester 1 (15 credit hours)
PHY 4020U Quantum Mechanics II
PHY 4410U Physics Thesis Project I*** or Senior Science elective***
Senior Physics elective**
Two electives**

Semester 2 (15 credit hours)
PHY 4420U Physics Thesis Project II*** or Senior Science elective***
PHY 4910U Techniques of Modern Astrophysics or PHY 4920U Cosmology
Senior Physics elective**
Elective** (CSCI 3010U Simulation and Modelling recommended)
Elective**

YEAR 2 – Co-operative Education program

Semester 1 (15 credit hours)
CSCI 2000U Introduction to Mathematical Computation
MATH 2015U Calculus III
PHY 2030U Mechanics I
PHY 2060U Nuclear Physics and Relativity
STAT 2010U Statistics and Probability for Physical Science

Semester 2 (15 credit hours)
MATH 2060U Differential Equations
PHY 2010U Electricity and Magnetism I
PHY 2040U Mechanics II
PHY 2050U Thermodynamics and Heat Transfer
PHY 3900U Astronomy II

Semester 3
SCCO 1000W Co-op Work Term I*

YEAR 3 – Co-operative Education program

Semester 1 (15 credit hours)
PHY 2020U Electricity and Magnetism II
PHY 3010U Statistical Mechanics I
PHY 3020U Quantum Mechanics I
PHY 3050U Waves and Optics
Elective**

Semester 2
SCCO 2000W Co-op Work Term II*

Semester 3
SCCO 3000W Co-op Work Term III*

YEAR 4 – Co-operative Education program

Semester 1
SCCO 4000W Co-op Work Term IV*

Semester 2 (15 credit hours)
PHY 3040U Mathematical Physics
PHY 3060U Fluid Mechanics
PHY 4910U Techniques of Modern Astrophysics or PHY 4920U Cosmology
Elective** (MATH 2072U Computational Science I recommended)
Elective**

Semester 3
SCCO 5000W Co-op Work Term V*

YEAR 5 – Co-operative Education program

Semester 1 (15 credit hours)
PHY 4020U Quantum Mechanics II
PHY 4410U Physics Thesis Project I*** or Senior Science elective***
Senior Physics elective**
Two electives**

Semester 2 (15 credit hours)
PHY 4420U Physics Thesis Project II*** or Senior Science elective***
PHY 4910U Techniques of Modern Astrophysics or PHY 4920U Cosmology
Senior Physics elective**
Elective** (CSCI 3010U Simulation and Modelling recommended)
Elective**

Notes:

No more than 42 credit hours may be taken at the first-year level.

*This course is graded on a pass/fail basis.

****Electives and breadth requirements**
All students must complete 27 elective credit hours including two senior physics electives. Students not accepted to take PHY 4410U and PHY 4420U must take an additional two senior science electives for a total of 33 elective credit hours. At least 9 elective credit hours must be in science courses offered by the Faculty of Science including two senior physics electives. The additional two senior science electives, if taken in place of PHY 4410U and PHY 4420U, cannot be used to meet this requirement. In order to satisfy breadth requirements, no more than 6 elective credit hours may be in Physics (PHY) courses; at least 12 elective credit hours must be in courses outside the Faculty of Science.

*****Thesis Project or senior science courses**
Students in clear academic standing who have completed 90 credit hours of their program and six third-year required PHY courses may optionally apply to take a two-course sequence consisting of PHY 4410U and PHY 4420U (Physics Thesis Project I and II). Students not accepted to take the thesis courses must complete two additional senior science electives instead. A senior science elective is defined as any 3000- or 4000-level science course not specified in the program map, excluding SCIE and ENVS courses. A student meeting the above requirements who does not take PHY 4410U and PHY 4420U may optionally apply to take PHY 4430U (Directed Studies in Physics) as one of the required senior science electives. Opportunities for the Thesis Project and Directed Studies options are limited; students must apply through Science Advising by March 30 following completion of the first three years of the program.

Recommended senior science electives that students may choose to take include:

CSCI 3010U Simulation and Modelling
CSCI 3070U Analysis and Design of Algorithms
CSCI 3090U Scientific Visualization and Computer Graphics
MATH 3040U Optimization
MATH 3050U Mathematical Modelling
MATH 3060U Complex Analysis
MATH 3070U Algebraic Structures
MATH 4050U Partial Differential Equations
STAT 3010U Biostatistics
PHY 3030U Electronics
PHY 4010U Statistical Mechanics II
PHY 4030U Modern Physics
PHY 4050U Emerging Energy Systems
PHY 4040U Solar Energy and Photovoltaics
PHY 4080U Hydrogen-Based Energy Systems and Fuel Cells

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d. Program Content

Proposed new courses and course changes are provided using the New Course and Course Change templates; see the following pages.

Table 1: Astrophysics Specialization Program Map

Year 1, Semester 1	BIOL 1011U Introductory Cell and Molecular Biology	CHEM 1010U Chemistry I	CSCI 1030U Introduction to Computer Science with C++	MATH 1000U Introductory Calculus or MATH 1010U Calculus I	PHY 1010U Physics I or PHY 1030U Introductory Physics
Year 1, Semester 2	BIOL 1021U Introduction to Organismal Biology and Ecology or CHEM 1020U Chemistry II	MATH 1020U Calculus II	MATH 2050U Linear Algebra	PHY 1020U Physics II	**PHY 2900U Astronomy I**
Year 2, Semester 1	CSCI 2000U Introduction to Mathematical Computation	MATH 2015U Calculus III	STAT 2010U Statistics and Probability for Physical Science	PHY 2030U Mechanics I	PHY 2060U Nuclear Physics and Relativity
Year 2, Semester 2	MATH 2060U Differential Equations	PHY 2010U Electricity and Magnetism I	PHY 2040U Mechanics II	PHY 2050U Thermodynamics and Heat Transfer	**PHY 3900U Astronomy II**
Year 3, Semester 1	PHY 2020U Electricity and Magnetism II	PHY 3010U Statistical Mechanics I	PHY 3020U Quantum Mechanics I	PHY 3050U Waves and Optics	Elective
Year 3, Semester 2	**PHY 4910U Techniques of Modern Astrophysics or PHY 4920U Cosmology**	PHY 3040U Mathematical Physics	PHY 3060U Fluid Mechanics	Elective (MATH 2072U Computational Science I recommended)	Elective
Year 4, Semester 1	PHY 4020U Quantum Mechanics II	PHY 4410U Physics Thesis Project or Senior Science elective	Senior Physics Elective	Elective	Elective
Year 4, Semester 2	PHY 4420U Physics Thesis Project II or Senior Science elective	**PHY 4910U Techniques of Modern Astrophysics or PHY 4920U Cosmology**	Senior Physics Elective	Elective (CSCI 3010U Simulation and Modelling recommended)	Elective

COURSE CHANGE TEMPLATE

For new courses see New Course Template

Faculty: Science	
Course number: PHY 2900U	**Current course title:** The Science of Astronomy
__X_ Core __X_ Elective	

COURSE CHANGES (check all that apply)

X	Course title		Credit weighting
X	Course description		Contact hours
	Course number	X	Prerequisites
	Course design		Co-requisites
	Learning outcomes		Cross-listings
	Mode of delivery		Credit restrictions
	Teaching and assessment methods		Credit exclusions

REASON FOR CHANGE AND WAYS IN WHICH IT MAINTAINS/ENHANCES COURSE OBJECTIVES

The course title is being changed to reflect the addition of a second astronomy course intended for science students. This one will be named Astronomy I and the follow up will be named Astronomy II (PHY 3900U).
The course description is being changed to reflect that which was originally accepted by the faulty of Science curriculum committee when PHY 2900U was originally proposed. Somehow an earlier draft of the course description ended up in the calendar. Minor corrections have also been made to reflect the fact that this course will not just be an elective for some students.
The prerequisite is being changed to better reflect the physics content in the course and so that students can take it in their first year.

CHANGE TO CALENDAR ENTRY

Current	**Proposed**
The Science of Astronomy This introductory course on the Astronomy of the Solar System is specifically designed for students who have a science background from any discipline. In this course students will begin by gaining an understanding of the basics of astronomy, our place in the Universe, and the development of the discipline from ancient astronomy to modern technology. Students will then begin a detailed exploration of the solar	**Astronomy I** An introduction to the origin, evolution and structure of the solar system and its constituents, as well as extra-solar planets. At the same time, the course develops a basic observational, theoretical and quantitative understanding of the science of astronomy. This course is appropriate for all students with some science background. 3 cr, 3 lec. Prerequisite: PHY 1010U or PHY 1030U. Credit restrictions: SCIE 1900U, SCIE 1920U.

system gaining an understanding of its constituents, origin, and evolution as a whole. 3 cr, 3 lec. Prerequisite: PHY 1020U or PHY 1040U. Credit restrictions: SCIE 1900U, SCIE 1920U.	

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

APPROVAL DATES

Date of submission	
Curriculum Committee approval	
Faculty Council approval	

NEW COURSE TEMPLATE

For changes to existing courses see Course Change Template

Faculty: Science		
Course title: Astronomy II		
Course number: PHY 3900U	**Cross-listings:**	**__X_ Core _X___ Elective**
Credit weight: 3	**Contact hours:** __3__ Lecture _____ Lab _____ Tutorial _____ Other	

CALENDAR DESCRIPTION

An exploration of the universe beyond our solar system using an observational, theoretical, and quantitative approach. Topics covered include stars, the interstellar medium, stellar remnants including black holes and supernovae, the Milky Way, astrobiology, external galaxies and clusters of galaxies, along with a brief introduction to cosmology and the history of the universe. This course is intended as an elective for all science and engineering students who have taken at least one Astronomy course and is a core course for the Astrophysics specialization.

Prerequisites	PHY 2900U
Co-requisites	N/A
Credit restrictions	N/A
Credit exemptions	N/A
Grading scheme	**[x] letter grade ☐ pass/fail**

LEARNING OUTCOMES

1. Understand constituents of the universe including stars, the interstellar medium, stellar remnants (e.g., supernovae, neutron stars, black holes), the Milky Way, and external galaxies. Describe the fundamentals of astrobiology, cosmology and the history of the universe.

2. Ability to comprehend the latest results in astronomy.

3. Apply scientific principles to interpret and examine astronomical observational evidence of extra-solar phenomena.

4. Synthesize and demonstrate broad big-picture knowledge of Astronomy. Prepare some students for more advanced courses in the Astrophysics specialization.

DELIVERY MODE

(check all that may apply) [x] face-to-face ☐ hybrid ☐ online

TEACHING AND ASSESSMENT METHODS

Teaching methods include standard lecturing, demonstrations, and guidance of group work. Assessment methods include assignments, quizzes, a midterm examination, and a final examination.

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

APPROVAL DATES

Date of submission	
Curriculum Committee approval	
Faculty Council approval	

NEW COURSE TEMPLATE

For changes to existing courses see Course Change Template

Faculty: Science		
Course title: Techniques of Modern Astrophysics		
Course number: PHY 4910U	**Cross-listings:**	**__X_ Core ____ Elective**
Credit weight: 3	**Contact hours:** __3__ Lecture _____ Lab _____ Tutorial _____ Other	

CALENDAR DESCRIPTION

An examination of a variety of modern techniques in the field of astrophysics. The first part of the course covers instrumentation of modern telescopes, data mining, reduction, and analysis in the radio, infrared, optical, and high energy parts of the spectrum. The second part of the course focuses on computational astrophysics, and includes N-body methods, grid-based hydrodynamics, and techniques for radiative transfer problems. Modern research software will be used extensively throughout the course; students will also be expected to develop their own.

Prerequisites	PHY 2030U, PHY 3900U, CSCI 2000U
Co-requisites	N/A
Credit restrictions	N/A
Credit exemptions	N/A
Grading scheme	**[x] letter grade ☐ pass/fail**

LEARNING OUTCOMES

1. Utilize the major tools of modern observational astronomy, in important parts of the spectrum.
2. Access, reduce and analyze astronomical surveys and data using some of the major software currently employed in the astronomy community.
3. Apply computational analysis to the field of astrophysics, in particular N-body algorithms and standard hydrodynamics techniques.
4. Develop simple software and utilize publicly available code to solve astrophysical problems.

DELIVERY MODE

(check all that may apply) [x] face-to-face ☐ hybrid ☐ online

TEACHING AND ASSESSMENT METHODS

Teaching methods include standard lecturing, demonstrations, and guidance of group work. Assessment methods include assignments, quizzes and tests, and a major project.

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

APPROVAL DATES

Date of submission	
Curriculum Committee approval	
Faculty Council approval	

NEW COURSE TEMPLATE

For changes to existing courses see Course Change Template

Faculty: Science		
Course title: Cosmology		
Course number: PHY 4920U	**Cross-listings:**	**__X_ Core ____ Elective**
Credit weight: 3	**Contact hours:** __3__ Lecture _____ Lab _____ Tutorial _____ Other	

CALENDAR DESCRIPTION

This course offers an examination of the universe as a whole, from the big bang to the current epoch. After a brief overview of how we observe the universe, the equations describing the evolution of the universe are studied in detail. Topics covered include the Robertson-Walker metric, the cosmological constant, dark matter, dark energy, and the cosmic microwave background.

Prerequisites	PHY 2030U, MATH 2060U
Co-requisites	N/A
Credit restrictions	N/A
Credit exemptions	N/A
Grading scheme	**[x] letter grade ☐ pass/fail**

LEARNING OUTCOMES

1. Demonstrate an understanding of the universe as a dynamic system.
2. Develop the Robertson-Walker metric using both Newtonian physics and general relativity.
3. Derive the Friedmann differential equations which govern the evolution of the universe, and explore their solutions using a combination of analytical and numerical techniques.
4. Evaluate observational evidence for the big bang, dark matter, and dark energy.

DELIVERY MODE

(check all that may apply) [x] face-to-face ☐ hybrid ☐ online

TEACHING AND ASSESSMENT METHODS

Teaching methods include standard lecturing, demonstrations, and guidance of group work. Assessment methods include assignments, quizzes, a midterm examination, and a final examination.

CONSULTATION AND FINANCIAL IMPLICATIONS, WHERE APPROPRIATE

APPROVAL DATES

Date of submission	
Curriculum Committee approval	
Faculty Council approval	

3. Resource Requirements

a. Faculty Members

Core faculty associated with this new specialization include all current Physics core faculty: Anatoli Chrebtii, Franco Gaspari, and Isaac Tamblyn. In addition, new specialized courses will be taught by Rupinder Brar (Senior Lecturer) and Joseph MacMillan (Lecturer). Both Dr. Brar and Dr. MacMillan have extensive knowledge of and expertise in the field of astronomy and astrophysics and currently conduct research in that field with undergraduate thesis students.

No new core faculty hires are required.

b. Additional Academic and Non-Academic Human Resources

With the introduction of two new required courses (per year), it is likely that part-time faculty (Sessional Instructors) will be required to teach core Physics courses currently taught by Drs. Brar and MacMillan.

Depending on class sizes, it is possible that marking support may be requested.

There are no other required resources; in particular, teaching assistants will not be required for the new courses.

c. Physical Resource Requirements

Classroom space for one new course in Winter 2015 and two new courses (total) in Winter 2016 and subsequent years will be required. Note that enrollment is expected to be less than 80 students in each course, low enough for utilization of the smaller classrooms on campus.

4. Business Plan

a. Statement of Funding Requirements

The current enrollment of PHY 2900U (offered in Winter 2013) is 76 students. Enrollment at this level is likely to continue or rise slightly. The new course PHY 3900U Astronomy II can serve as a Science elective as well as a core course for students in the Astrophysics specialization; as such we expect similarly high enrollment, with a likely range from 40-70 students. Enrollment in PHY 4910U Techniques of Modern Astrophysics and PHY 4920U Cosmology will likely be smaller due to the increased prerequisites and more narrow focus, although PHY 4920U Cosmology will serve as a Senior Physics Elective for all Physics majors.

Assuming a start date of Fall 2013 for the new specialization, the first new course (PHY 3900U Astronomy II) will be taught in Winter 2015 and subsequent Winter terms thereafter. The projected cost of this course is the cost of hiring one Sessional Instructor ($7000) to fill a course normally taught by Dr. Brar or Dr. MacMillan.

The second new course (PHY 4910U Techniques of Modern Astrophysics) will be taught in Winter 2016 and every second year thereafter. The third new course (PHY 4920U Cosmology) will be taught in Winter 2017 and every second year thereafter. The cost for both of these courses is the cost of hiring one Sessional Instructor ($7000) to fill a course normally taught by Dr. Brar or Dr. MacMillan.

Note that, should the Physics group receive one new core faculty hire before Winter 2015 (with a normal teaching load of four courses), they could serve as a replacement for the above proposed Sessional Instructors, lowering the overall cost of the new specialization.

b. Statements of Resource Availability

To follow.