REPORT OF ACADEMIC STANDARDS COMMITTEE

Report #F2017–1; October 2017

In this report the Academic Standards Committee (ASC) brings to Senate its evaluation and recommendation on the following item:

- **MEDICAL PHYSICS – Major Curriculum Modification**

A. MEDICAL PHYSICS MAJOR CURRICULUM MODIFICATION

1. Introduction

The proposed major curriculum modification for the Bachelor of Science in Medical Physics (Honours) program at Ryerson University is a result of the Periodic Program Review (PPR) process completed in 2016. The proposed more versatile curriculum will give the students more options to enter graduate school programs and thus have access to a greater range of employment options. The accreditation of the graduate program in Biomedical Physics, now offered by the Department of Physics (launched in 2012), also requires the applicants to have a stronger Physics background. These issues call not only for an expansion and strengthening of fundamental Physics courses, but also for a restructuring of the Medical Physics curriculum with integrated mathematics-physics content and more professionally-related elective course options.

The proposed revised curriculum will: (1) improve the content and quality in the third year curriculum, (2) improve the application of mathematical knowledge to Medical Physics/Physics courses, (3) increase fundamental Physics topics, and (4) revise the co-op option in Medical Physics to allow more flexible work terms.

2. Comparison between the Proposed and the Current (2016/2017 Academic Year) Curricula

EXISTING CURRICULUM (2016/2017)	PROPOSED CURRICULUM	COMMENTS
Semester 1		
PCS 120 Physics I	PCS 120 Physics I	
MTH 131 Modern Mathematics I	MTH 131 Modern Mathematics I	
CHY 103 General Chemistry I	CHY 103 General Chemistry I	
BLG 143 Biology I	BLG 143 Biology I	
CPS 118 Intro Programming for Scientists	CPS 118 Intro Programming for Scientists	
SCI 180 Orientation	SCI 180 Orientation	
Semester 2		
BLG 144 Biology II	BLG 144 Biology II	
CHY 113 General Chemistry II	CHY 113 General Chemistry II	
MTH 231 Modern Mathematics II	MTH 231 Modern Mathematics II	
PCS130 Physics II	PCS130 Physics II	
LL LS (Liberal Studies Table A)	LL LS (Liberal Studies Table A)	
Semester 3		
MTH 330 Calculus and Geometry	MTH 330 Calculus and Geometry	
MTH 108 Linear Algebra	MTH 108 Linear Algebra	
MTH 380 Probabilities and Statistics I		Delete from the curriculum
PCS 229 Introduction to Medical Physics	PCS 229 Introduction to Medical Physics	
PCS 300 Modern Physics	PCS 300 Modern Physics	
	LL LS (Liberal Studies Table A)	Reposition from 4th semester of 2016/2017 curriculum semester

Semester 4		
	PCS 521 (Mathematical Physics) added new required course	Add as a new required course (to fill the identified gaps in mathematics content and to improve the synthesis of math knowledge and Physics content)
PCS 400 Quantum Physics I	PCS 400 Quantum Physics I	
PCS230 Photonics and Optical Devices	PCS 230 Photonics and Optical Devices	
PCS 227 Biophysics	PCS 227 Biophysics	
MTH 430 Dynamics Systems and Diff. Equations	MTH 430 Dynamic Systems and Differential Equations	
Lower Liberal (Liberal Studies Table A)		Reposition to Semester 3 to make space for the new required PCS 521 Mathematical Physics
Semester 5		
BLG 311 Cell Biology I	BLG 311 Cell Biology	
PCS 352 Nuclear Physics/Radiation Protection	PCS 352 Nuclear Physics/Radiation Protection	
MTH 501 Numerical Analysis		Delete from the curriculum
	PCS 622 Mathematical Methods in Medical Physics	Add as a new required course (to provide more Physics courses in the third year)
	PCS 623 Biostatistics	Add as a new required course (to cover the fundamental principles of Statistics applied to cases of direct interest to the program and research in Medical Physics)
BLG 701Anatomy	PR 1	Reposition to the PR list
Lower Liberal Studies Table A		Reposition to another semester to accommodate PCS623
Semester 6		
PCS 228 Electricity and Magnetism	PCS 228 Electricity and Magnetism	Add 1h per week of tutorials
PCS 335 Thermodynamics & Statistical Physics	PCS 335 Thermodynamics & Statistical Physics	
	PCS 405 Medical Imaging	Move from 7th to 6th semester (The repositioning to a lower semester will better prepare program students for the fourth year thesis projects with a topic in medical imaging)
Prof-Related: Two Table I courses		
	LL LS (Liberal Studies Table A)	Repositioned from another semester
Upper Liberal Studies Table B	PR 2 or UP LS 1/3 (Liberal Studies Table B)	In this term the curriculum provides a flexible course selection by allowing a student to select either one professionally-related elective course or an upper level Liberal Study course.
Semester 7		
PCS 040A Medical Physics Thesis	PCS 40A/B Medical Physics Thesis	
PCS 354 Radiation Biology	PCS 354 Radiation Biology	
PCS 405 Medical Imaging		Move from 7th to 6th semester (The repositioning to a lower semester will better prepare program students for the fourth year thesis projects with a topic in medical imaging)
Prof- Related: Two Table I courses		
	PR 2 or UL LS 1/3 (Liberal Studies Table B)	In this term the curriculum provides a flexible course selection by allowing a student to select either one professionally-

		related elective course or an upper level Liberal Study course.
	PR 3	
	UL (Liberal Studies Table B)	
Semester 8		
PCS 040 B Medical Physics Thesis	PCS 040 B Medical Physics Thesis	
MTH 820 Image Analysis		Reposition to the PR list (to accommodate the addition of required PCS407)
BLG 601 Physiology		Reposition to the PR list
	PCS407 Radiation Therapy	Reposition from the PR list to a required course
	PR 4	
	PR 5	
Two Liberal Studies Table B	UL LS (Liberal Studies Table B)	

3. Summary of the Proposed Curriculum Changes

The first and second semesters will remain the same, in common with the Biology, Chemistry and Undeclared Science Programs. MTH 380 (Probability and Statistics I) is to be deleted from the third semester required courses and replaced by the PCS 623 (Biostatistics) required course in the fifth semester. Biostatistics will cover the fundamental principles of Statistics (which were part of PCS 380), applied to cases of direct interest to the program and research in Medical Physics (Learning Outcome 1a, 2 and 3b) and thus essential for students' success in PCS 335 (Thermodynamic and Statistical Physics) as well as in PCS 40A/B (Medical Physics Thesis).

In the fourth semester, a new required course, PCS 521 (Mathematical Physics), will address (1) identified gaps in mathematics content (Learning Outcome 3b), such as differential equations, partial differential equations, complex variables, operators, etc., and (2) integrated mathematics-physics content, thus improving the synthesis of Physics content (Learning Outcome 2 and 6). In the fifth semester, the addition of two new courses, PCS 622 (Mathematical Methods in Medical Physics) and PCS 623 (Biostatistics) includes more Physics courses in the third year of the program. The Mathematical Methods in Medical Physics course will familiarize students with mathematical concepts required for image analysis and signal processing; this knowledge is required for their success in PCS 405 (Medical Diagnostic Techniques) and PCS 40A/B (Medical Physics Thesis).

In the sixth semester the repositioning of the Medical Diagnostic Imaging course to a lower semester will better prepare program students for the fourth year thesis projects with a topic in medical imaging. The addition of one professionally-related elective course will address one of the identified program challenges by increasing the number of professionally-related elective courses. In this semester the curriculum also provides a flexible course selection by allowing a student to select either one professionally-related elective course or an upper level Liberal Study course. These changes come at the expense of moving the currently required courses BLG 600 (semester 5) and BLG 700 (semester 6) to the professionally-related course list.

In the seventh semester a curriculum change is the conversion of PCS 407 (Radiation Therapy) from a professionally-related elective course to a required program course offered in the eighth semester. This course, at the core of the Medical Physics discipline, was a required course in the original Medical Physics curriculum. MTH 820 (Image Analysis) will also move from a required course to a professionally-related elective course, since the most relevant topics in this course will be included in the fifth semester course, PCS 623. This course repositioning will allow students interested in image analysis to expand their knowledge by electing MTH 820 as one of their professionally- related courses.

4. Course Calendar Descriptions for New Core (Required) Courses

PCS 521 - Mathematical Physics *(new required course)*: Introduction to complex variables and their role in physics. Taylor's formula, truncation error and round-off error. Nonlinear interpolation and curve fitting. Numerical integration. Ordinary differential equations, systems of linear differential equations. Differential equations of first and second order and their applications in physics. Numerical solutions of non-linear differential equations. All topics will be illustrated with physics examples including, but not limited to, such topics as damped oscillations, forced oscillations and resonance, motion with variable acceleration, motion in a viscous fluid. This course uses MATLAB as its programming language.

PCS 622 -Mathematical Methods in Medical Physics *(new required course)*: Physics and Medical Physics applications of Dirac delta function, Fourier series and Fourier transforms. Laplace's equation solutions. Transport phenomena. Applications of partial differential equations and boundary value problems illustrated with solutions of wave and diffusion equations. This course uses MATLAB as its programming language.

PCS 623: Biostatistics *(new required course)***:** Introduction to experimental design, data presentation and statistics in biomedical sciences with a focus on application and interpretation. Fundamentals of probability including discrete and continuous models. Randomization and sample size. Foundations of statistical inference, hypothesis testing, p-value, confidence intervals, regression and correlation. Elementary non-parametric statistical methods. Presentation and communication of statistical data. Use of graphical and statistical software.

5. Changes to Professionally-Related (PR) Elective Courses

Depending on the relative proportion of core and professionally-related elective courses selected from the physics and mathematics courses as opposed to life sciences content, the curriculum changes proposed here will also suffice to prepare students for graduate work in other fields of physics or related areas, thereby maximizing the career options available upon graduation. Since the existing program curriculum has a low number of professionally-related elective courses, we suggest to increase the number of these electives from four to five. By selecting from the lists of suggested professionally-related courses, the students will be able to pursue further education and careers in (1) clinically-oriented Medical Physics, (2) Traditional Physics and (3) Computational Medical Physics.

The professionally-related (PR) elective table of Medical Physics will include the following courses:

- (PCS 624 (Electricity and Magnetism II) *(new course)*
- PCS 520 (Nanophysics) *(new course)*
- PCS 530 (Cellular Biophysics) *(new course)*
- PCS 358 Mechanics with Biomechanics *(revised PR course)*

- BLG 601 (Physiology) *(repositioned from required)*
- BLG 701 (Anatomy) *(repositioned from required)*
- CHY 142 Organic Chemistry I *(repositioned from required)*
- CPS 305 Data Structures *(addition to the PR list)*
- MTH 820 Image Analysis *(addition to the PR list)*
- CPS 109 Computer Science I *(addition to the PR list)*
- CPS 209 Computer Science II *(addition to the PR list)*

PCS 358 is an existing Physics course that will be modified to reinforce the fundamental knowledge of mechanics in the context of Medical Physics.

6. Calendar Descriptions of New or Revised Professionally-Related Courses

PCS 624 Electromagnetism II *(new course):* Solving Poisson and Laplace equations via method of images and separation of variables. Multipole expansion for electrostatics, electric dipoles, polarization in dielectrics. Magnetic vector potential. Multipole expansion in magnetostatics, magnetic dipoles, magnetization in matter, Maxwell's equations in matter. Boundary conditions. Poynting's Theorem. Electromagnetic waves in matter. Electromagnetic Radiation.

PCS 520 Nanophysics *(new course in this program, approved for the Biomedical Science Program):* Introductory course on nanotechnology and applications in biology and medicine. Physics at nano-scale of nano-particles and nano-devices. Fabrication and characterization of nanostructures. Magnetic and optical effects at nano-scale. Transport properties and nanotechnology.

PCS 530 Cellular Biophysics *(new course in this program, approved for the Biomedical Science Program)*: This course presents physical principles important to the operation of biological systems such as entropy, diffusion, cellular electricity, cellular motor forces, mechanical properties of the cell, and selected topics from radiation biophysics, biological switches, sensory physics, waves, self-organization, and biological complexity.

PCS358 – Mechanics with Biomechanics (revised): The physical significance of vector spaces and vector operations, coordinate transformations, matrix operations. Dynamics of particles and of rigid bodies. Center of mass. Kinematics and dynamics of rotational motion. Mechanical oscillations. Coupled oscillations. Hamilton's principle, Lagrangian and Hamiltonian dynamics.

7. Complete List of Professionally-Related Elective Courses

BCH 261 Biochemistry	CPS 209 Computer Science II	PCS 700 Quantum Physics II
BCH 361 Advanced Biochemistry I	CPS 305 Data Structures	PCS 724 Condensed Matter Physics/Materials
BLG 151 Microbiology I	CPS 844 Data Mining	PCS 624 Electricity and Magnetism II
BLG 251 Microbiology II	CPS 501 Bioinformatics	PCS 520 Nanophysics
BLG 400 Genetics	MTH 820 Image Analysis	PCS 530 Cellular Biophysics
BLG 600 or BLG 601 Physiology	OHS 319 Health Effects of Radiation	PCS 450 Directed Project I
BLG 700 or BLG 701 Anatomy	PCS 224 Solid State Physics	PCS 550 Directed Project II
BLG 856 Immunology	PCS 350 Modeling in Medical Physics	CMN 600 Science, Communication and Society
CHY 142 Organic Chemistry I	PCS 358 Mechanics with Biomechanics	
CHY 242 Organic Chemistry II	PCS 406 Radiation Protection/Health Physics	
CPS 109 Computer Science I	PCS 407 Radiation Therapy	

8. Curriculum Advising

It is anticipated that the students will require guidance when choosing the courses that will enable them to follow the different educational and career paths, although all will graduate with a BSc degree in Medical Physics. In choosing the relevant professional electives, students will be advised by the Program Director and the departmental office as follows:

1. Students wishing to apply for the **clinically-accredited graduate programs in Medical Physics** are advised to choose as many courses as possible from the following list of professionally-related courses:

PCS 406 Radiation Protection/Health Physics	PCS 530 Cellular Biophysics
PCS 700 Quantum Physics II	PCS 450 Directed Project I
PCS 724 Condensed Matter Physics/Materials	PCS 550 Directed Project II
PCS 624 Electricity and Magnetism II	BLG 600 or BLG 601 Physiology
PCS 520 Nanophysics	BLG 700 or BLG 701 Anatomy

2. Students wishing to pursue a professional or academic career in **Physics** are advised to choose their electives from the following list of professionally-related courses:

PCS 224 Solid State Physics	PCS 450 Directed Project I
PCS 700 Quantum Physics II	PCS 550 Directed Project II
PCS 724 Condensed Matter Physics/Materials	PCS 358 Mechanics with Biomechanics
PCS 624 Electricity and Magnetism II	

3. Students wishing to obtain solid **computational skills** are advised to choose from the following list of professionally- related courses:

CPS 109 Computer Science I	CPS 305 Data Structures
CPS 209 Computer Science II	CPS 844 Data Mining
CPS 393 Introduction to C and UNIX	CPS 501 Bioinformatics
PCS 350 Modeling in Medical Physics	

9. Proposed Changes to the Co-Op Medical Physics Option

Students must successfully complete a minimum of four work terms in order to graduate from the co-op program. In order to have greater flexibility, we propose three different options for the sequence of academic and work terms for a co-op student in Medical Physics. The revised co-op sequence will allow more flexible work terms, thus making our students more attractive and relevant to potential employers.

Option 1: Proposed Sequence of Co-Op Work Terms in Medical Physics

Term	Year 1	Year 2	Year 3	Year 4	Year 5
Fall	Semester 1	Semester 3	Semester 5	WKT 605	Semester 7
Winter	Semester 2	Semester 4	WKT 505	Semester 6	Semester 8
Summer	Free term	WKT 405	WKT 506	WKT 606	Graduation

Option 2: Proposed Sequence of Co-Op Work Terms in Medical Physics

Term	Year 1	Year 2	Year 3	Year 4	Year 5
Fall	Semester 1	Semester 3	Semester 5	WKT 506	Semester 7
Winter	Semester 2	Semester 4	Semester 6	WKT 605	Semester 8
Summer	Free term	WKT 405	WKT 505	WKT 606	Graduation

Option 3: Proposed Sequence of Co-Op Work Terms in Medical Physics

Term	Year 1	Year 2	Year 3	Year 4	Year 5
Fall	Semester 1	Semester 3	Semester 5	Semester 7	WKT 606
Winter	Semester 2	Semester 4	Semester 6	WKT 506	Semester 8
Summer	Free term	WKT 405	WKT 505	WKT 605	Graduation

Students selecting Option 3 will not be able to complete their fourth-year thesis course (PCS 40A/B) which would be replaced by two professionally-related electives: PCS450 (Directed Project I) and PCS550 (Directed Project II). However, Option 3 will not change the students' learning outcomes in the program, because the PCS 40A/B Medical Physics Thesis course will be replaced by two Directed Project courses. PCS 450 and PCS550 courses are professionally related electives that are project-based and have strong research component similar to PCS 40A/B. Taken together, they will provide a research experience comparable to that of the thesis course. Since the replacement of PCS40A/B requires the consent of the Program Director, the students will be directed to take PCS 450 and PCS 550 as a replacement of PCS 40A/B. Moreover, in many cases the work terms of the co-op program already provide the students with research experience, because of the nature of co-op placements in our Program (research positions in hospitals, university, or technology companies). We expect that the number of the affected co-op students will be small, if any, as it involves only one co-op option. In the Option 3, the students would take PCS450 in semester 7 and PCS550 in the semester 8.

10. Additional Resources

If an additional faculty member is not hired before 2021/2022, the proposed curriculum will be delivered by the existing full time RFA members with the expertise to teach these upper-level physics and medical physics courses. This will come on the expense of changing their teaching assignments from the multiple large (250 – 400 students) first year physics courses to the new courses, while CUPE I instructors will be hired for the first year physics courses. This approach to the teaching assignments will negatively impact the departmental budget and we trust it will not be the case. The Dean has supported this need by requesting a new faculty positions in support of the presented curriculum changes and the Department of Physics. All other resources are in place to support the proposed curriculum changes.

11. Program Balance

As of 2014/2015 (before the PPR related revisions), the program was composed of 41 courses: 33 core (required) one-semester courses, 2 professionally-related electives and 6 liberal arts electives. The required

courses accounted for 80% of the entire program. Once all the proposed changes are implemented, the number of professional electives will increase to a total of 5, while the number of core courses will decrease to 30 (73% of the entire curriculum), thus providing more choices to the students in crafting the curriculum that better suits their career aspirations.

12. Summary of Implications for External Recognition and/or Professional Accreditation
While the Program itself does not require professional accreditation, the proposed changes will make our graduates better candidates for CAPMEP-accredited graduate programs (including our own graduate program in Biomedical Physics), for regular graduate programs and for professional schools.

13. Effect upon the Undergraduate Degree Level Expectations (UDLES)
The proposed changes are aligned with the UDLES. The program learning outcomes 1, 2, 3, 4, 6 and 7 address the requirements "*Depth and Breadth of Knowledge*" (UDLE 1) and "*Critical Evaluation of Qualitative and Quantitative Information*" (UDLE 3); program learning outcomes 1, 2 and 4 address "*Understanding/Application of the Inquiry Method in the Student's Primary Area of Study*" (UDLE 2); program learning outcomes 4, 5, 6 and 7 address the requirement "*Communication Skills*" (UDLE 4); program learning outcomes 1, 2 and 3 address the requisite "*Awareness of Limits of Knowledge*" (UDLE 5); in general, all program learning outcomes and, in particular, program learning outcome 8 address the requirement of "*Autonomy and Professional Capacity*" (UDLE 6).

14. Revised Program Learning Outcomes (revised wording)
Graduates of Medical Physics will be able to:
Learning Outcome 1: Solve problems through the application of fundamental concepts and theories in core areas of physics including:

1a. Mechanics
1b. Optics
1c. Thermodynamics and Statistical Mechanics
1d. Classical Electricity and Magnetism
1e. Modern/Quantum Physics
1f. Nuclear Physics.

Learning Outcome 2: Solve problems through the application of fundamental concepts and theories in core areas of medical physics including:

2a. Radiation Therapy
2b. Medical Imaging
2c. Nuclear Medicine Physics
2d. Health Physics.

Learning Outcome 3a: Describe, discuss and apply foundational concepts in Biology and Chemistry as supporting disciplines of Medical Physics; particularly in Biology (*Cell structure and function, metabolism, anatomy and physiology, ecology, genetics, immunology),* and in Chemistry (*Chemical equilibrium, thermochemistry, structure of inorganic and organic materials, chemical reactions)*.
Learning Outcome 3b: Solve problems using a range of mathematical skills including Calculus, Vector Calculus, Differential Calculus, Statistics to Medical Physics questions.
Learning Outcome 3c: Apply computing and programming principles and skills in order to develop models and to solve Physics and Medical Physics problems.
Learning Outcome 4: Apply the methodology of scientific inquiry in the areas of problem solving, analytical and critical thinking, logical reasoning and experimental techniques.
Learning Outcome 5: Communicate scientific arguments and analyses clearly and concisely, to the general public, to government and within the scientific community itself both

5a. orally, and in
5b. written form.

Learning Outcome 6: Apply critical thinking and analytical skills to interpret and synthesize knowledge

from areas including Physics, Mathematics, Biology and Computer Science.
Learning Outcome 7: Discuss and communicate the implications of Medical Physics in society in order to make sound judgments on issues in health care where Medical Physics plays a role.
Learning Outcome 8: Work with autonomy, confidence and perseverance; demonstrate accountability, ethical and professional integrity, time management.

15. Other Programs Affected by Proposed Changes
The proposed curriculum changes do not affect other programs since no physics courses are going to be discontinued. Nevertheless, letters of support have been received from the Chairs of Mathematics, Chemistry and Biology, Computer Science and Electrical Engineering - teaching departments affected by these modifications.

Recommendation

- Having satisfied itself of the merit of this proposal, ASC recommends: *That Senate approve the Medical Physics Major Curriculum Modification*

Respectfully Submitted,

Marcia Moshé

Marcia Moshé, Chair for the Committee

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