

Full Program Proposal

Bachelor of Science
Physics for Modern Technology Major

Department of Physics

Faculty of Science & Horticulture

Kwantlen Polytechnic University

June 2012

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Part 1 - Executive Summary

The Executive Summary must present, in a succinct manner, the purpose of the proposal and a summary of the key objectives and outcomes of the proposed degree program and must include the following information:

a) An overview of the organization's history, mission and academic goals

Founded as a community college for the South Fraser Region in 1981, subsequently granted university college status in 1995, and university status in 2008, Kwantlen Polytechnic University (KPU) has provided outstanding undergraduate education for more than twenty-five years. Undergraduate degrees have been offered at Kwantlen since 1996, along with a wide area of diplomas, associate degrees, certificates and citations in different fields of study. Designated Kwantlen Polytechnic University in 2008, the institution continues to prepare its students for successful careers as well as helping them develop the skills and critical awareness to be responsible citizens and community leaders. Today, Kwantlen serves approximately 17,500 students each year and is the fourth largest university in British Columbia.

Across its four main campuses in Cloverdale, Langley, Richmond and Surrey, Kwantlen takes up its role as B.C.'s polytechnic university by offering in excess of 130 programs spanning diverse educational areas: Trades, Vocational, Preparatory, Professional, and Academic. As a leader in innovative education, Kwantlen creates relevant and engaging programs that integrate a broad-based university education, community service opportunities, undergraduate and applied research experience, and essential skills practice. The learning culture at Kwantlen is learner-focused, academically rigorous, innovative, interdisciplinary and socially responsible.

Arising from its commitment to serve the Fraser Region, Kwantlen offers all learners, regardless of background and preparation, and from across the country and abroad, opportunities to achieve the highest standards of academic performance. Access and support services, multiple entry points, and bridging programs are examples of this commitment. Transition programs, international education, workplace experiences and continuing education are also part of Kwantlen's commitment to lifelong learning across a broad range of educational options.

Our university culture is based on critical inquiry, collegial debate, knowledge generation, freedom of expression, diversity, and environmental stewardship and sustainability.

See final mission & mandate document at: <http://www.kwantlen.ca/mission/mission-mandate.html#>.

b) *Proposed credential to be awarded, including the level and category of the degree and the specific discipline or field of study*

Bachelor of Science Major in Physics for Modern Technology

c) *Location*

The Physics for Modern Technology program will be offered on Kwantlen's Richmond campus.

d) *Faculty(ies) or school(s) offering the proposed new degree program*

The Department of Physics, Faculty of Science and Horticulture, will be offering the proposed Physics for Modern Technology degree.

e) *Anticipated program start date*

The anticipated start date of the program is September 2013 (Year 2 intake & Year 1 intake).

f) *Anticipated completion time in years or semesters*

Students engaged in full-time study will be able to complete the Physics for Modern Technology degree in four years or eight semesters.

g) *A summary of the proposed program*

Proposed is an applied degree in science and technology which works to advance KPU's polytechnic mandate in a very direct and simple way.

Although there is a handful of applied physics degrees across Canada, this degree is unique in our country. At its core is a curriculum that resembles what we see in many physics degrees, along with a general background in science. We then build on this core with courses that stress the applied nature of physics in the context of technology. The *B.Sc. Major in Physics for Modern Technology* will equip students to work in a wide variety of high technology careers.

In order to ensure program outcomes match the needs of the labour market, we have consulted extensively with local industry. The four broad areas that emerged, electronics, computer programming, process control and business, have been incorporated into the curriculum. A work-placement is also an integral part of the program.

Although Years 2, 3 and 4 are highly specialized, this degree curriculum is built on a Year 1 science curriculum that is broad based and familiar across B.C. Kwantlen offers multiple sections of most required courses across three semesters and two campuses. Students may work their way through the required Year 1 courses as the individual's preparation permits, facilitating access and flexibility. Adding to the flexibility is the fact that transferable courses are offered at institutions across B.C., making transfer to Kwantlen for Year 2 a seamless choice.

Upon graduation from this program, opportunities for further studies may include graduate work in physics or related fields and teacher preparation.

h) *Name, title, phone number and e-mail address of the institutional contact person in case more information is required.*

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Part 2 – Degree Content

Proposed is an applied degree in science and technology which works to **advance Kwantlen Polytechnic University’s polytechnic mandate** in a very direct and simple way.

In keeping with the description of *Our Profile* within the KPU vision statement, the Department of Physics seeks to offer a **well-rounded undergraduate education** through the *B.Sc. Major in Physics for Modern Technology*. At the same time, through **engagement with partners** that include industries, both local and multinational, and European institutions offering similar degrees, we have arrived at a curriculum that focuses on the **needs of the workforce** and prepares the graduate for a **successful and rewarding career**. These are key *Commitments* Kwantlen has made, and the resulting curriculum is a marked departure from traditional baccalaureate science curricula which implicitly prepare students primarily for further studies. Our degree maintains a strong focus on applied skills, and is underscored with a **work placement**.

Our *Vision Statement* tells us that “Innovative, transformative and ambitious, *Kwantlen Polytechnic University* will serve the needs of our region, of British Columbia, and beyond...” and, for reasons stated above, the *B.Sc. Major in Physics for Modern Technology* does exactly that. As part of **British Columbia’s polytechnic university**, the proposed program intends to draw students not only from the South-of-the-Fraser region, not only from across BC or Canada, but from all across the globe. Once established with such a profile, our degree will be a **Flagship Program** and a destination program for KPU.

At the core of the *B.Sc. Major in Physics for Modern Technology* is a curriculum that resembles what we see in many physics degrees, along with a general background in science. This degree is unique in Canada in that this core is built upon with courses that stress the applied nature of physics in the context of technology but it is not unique in that the academic rigour and the student’s commitment to hard work that are required are in line with science degrees found elsewhere and with other Kwantlen degrees. Although there is a handful of applied physics degrees across Canada, the *B.Sc. Major in Physics for Modern Technology* takes application to a whole new level as we aim to prepare students for entry into the workforce. The primary goal of our program is not one of preparing students for entry into graduate school. There are no other physics based degrees of this nature in British Columbia or elsewhere in Canada.

The *B.Sc. Major in Physics for Modern Technology* will equip students to work in a wide variety of high technology careers ranging from fuel cell development, particle accelerator operation, to technical sales. Additionally, p. 17 of the *Degree Proposal Review Report* (IAP) lists the following sectors where graduates can be expected to find employment working with scientific instrumentation: acoustics, alternative energy, astronomy and astrophysics, biomedical devices, business, cryogenics, finance, computer gaming,

geophysics, green energy, Information & Communications Technology (ICT), instrumentation, materials management, materials science, medical physics, meteorology, microelectronics, mining, nanotechnology, nuclear power and instrumentation, oil and gas, optics, optoelectronics, semiconductors, software development, teaching, and telecommunications/photonics.

In order to ensure program outcomes match the needs of the employers, we have consulted extensively with local industry over the past year or so (and those consultations are ongoing). [See *Program Consultation*.] Through this consultation process, four broad areas have emerged that are directly relevant to local industry: electronics, computer programming, process control, and business. Electronics and computing (along with math, physics, and chemistry) provide the basis on which an understanding of process control can be developed. Business skills are included because many instrumentation-related jobs in the Lower Mainland involve instrument sales. Also, business knowledge is important for anyone working in industry, whether in sales or in a technical position. Lack of business skills among technology graduates is a growing problem, and is underlined by the Information and Communications Technology Council (ICT Council or ICTC) in its *2011 – 2016 ICT Labour Market Outlook*¹, where it states that “the post-secondary system is graduating far too few individuals who combine ICT skills with an understanding of business processes.”

Because of the value we place on application of theory and development of practical skills, many of the applied Physics courses will have practical components infused across the course, rather than separating a lab component away from a lecture component. There will also be strong emphasis on written and oral communication including project reports and presentations in manners consistent with industrial workplaces as well as academic environments.

In addition to coursework that will support the employment outcomes, work-placement will be an integral part of the program. Important outcomes of the work placement will include: (i) students seeing the relevance of their studies to the workplace, (ii) students gaining valuable experience of the “real world” of employment, and (iii) students making contacts that will serve them well when they look for employment after graduation. We plan to schedule the work placement in Year 3 as a flexible semester (see Appendix A). For most students this will involve placement in industry. As an alternative to a single work placement, a complete co-op degree option is currently being explored. A *B.Sc. in Physics for Modern Technology, co-op option*, may offer competitive advantages to our graduates.

¹ Information and Communications Technology Council, *Outlook for Human Resources in the ICT Labour Market, 2011–2016*, http://www.ictc-ctic.ca/Outlook_2011/nat_sum_en.html

Although preparing students for further study is not a primary objective of this program, graduates will not be excluded from further study. Some excellent opportunities include the following:

Graduate Studies

This will be a new kind of bachelor's degree for Canada and there will be few, if any, domestic graduate programs tailored to accept our graduates but graduate admission is not precluded. As an example, communications with Prof. J. Steven Dodge (Graduate Chair, SFU Physics) suggest that a student may be admitted into a qualifying year during which specified undergraduate courses (mostly mainstream, theoretical courses that we don't include in our program as they are not as directly relevant to the areas of technology addressed in the program) would be made up.

Teacher Preparation

We believe graduates of our program will be exceptionally well prepared for entry into teacher preparation programs for secondary school science teaching. The program provides a combination of theoretical understanding at a level that appropriately exceeds that required in high schools and practical skills that supports the teacher's work. After the appropriate teacher-training, the more obvious areas of expertise include physics, math, electronics and information & communications technology.

The delivery model for the *B.Sc. Major in Physics for Modern Technology* detailed later in this proposal is based on a four year degree in which Year 1 has special features that sets it apart from Years 2, 3 and 4.

Year 1 will be called *Physics for Modern Technology – Foundation Year* and will be made available on an open admission, open registration basis. This flexibility is possible because Kwantlen offers multiple sections of most required courses across three semesters and two campuses. Adding to the flexibility is the fact that transferable courses run at institutions across B.C., making transfer to Kwantlen for Year 2 a seamless choice. Once admitted to the *Foundation Year*, students can identify with the *Physics for Modern Technology* program and receive guidance from program personnel. Students may work their way through the required Year 1 courses as the individual's preparation permits. Students who arrive at university missing key prerequisites have opportunities for upgrade during the *Foundation Year*.

Years 2, 3 and 4 of the *B.Sc. Major in Physics for Modern Technology* are more specialized and will be a selective entry, limited enrolment program.

Curriculum Design

a) *List the required courses, and indicate which courses are new/to be developed.*

[Note: For convenient reference, please see the recommended course grid, pp. 11 – 12.]

Within the General Framework for a Bachelor of Science at Kwantlen Polytechnic University² students completing the courses specified below will be granted the *B.Sc. Major in Physics for Modern Technology*.

[New courses are indicated with “new”.]

Physics courses:

- PHYS 1120 Physics for Physical & Applied Sciences I (4 credits, preferred)
or PHYS 1101 Physics for Life Sciences I (4 credits)
- PHYS 1220 Physics for Physical & Applied Sciences II (4 credits, preferred)
or PHYS 1102 Physics for Life Sciences II (4 credits)
- PHYS 1600^{new} Introduction to Modern Technology (3 credits)
- PHYS 2010^{new} Modern Physics (3 credits)
- PHYS 2030^{new} Classical Mechanics (3 credits)
- PHYS 2040^{new} Thermal Physics (3 credits)
- PHYS 2101^{new} Experimental Physics (W) (3 credits)
- PHYS 2420 Electricity and Magnetism (3 credits)
- PHYS 2600^{new} Digital Systems and Microcontrollers (3 credits)
- PHYS 2610^{new} Sensors and Actuators (3 credits)
- PHYS 3610^{new} Introduction to Control (3 credits)
- PHYS 3620^{new} Process Control (3 credits)
- PHYS 3700^{new} Signal and Image Processing (3 credits)
- PHYS 3710^{new} Applied Optics and Optoelectronics (3 credits)
- PHYS 3900^{new} Project in Physics & Technology (W) (3 credits)
- PHYS 3950^{new} Work Placement – Part I (3 credits)
- PHYS 3951^{new} Work Placement – Part II (3 credits)
- PHYS 4010^{new} Quantum and Solid State Physics (3 credits)
- PHYS 4600^{new} Programming for Instrumentation (3 credits)
- PHYS 4700^{new} Spectroscopic Instrumentation (3 credits)
- PHYS 4800^{new} Special Topics I (3 credits)
- PHYS 4801^{new} Special Topics II (3 credits)
- PHYS 4900^{new} Senior Project in Physics & Technology (W) (3 credits)

² General Framework for a Bachelor of Science at Kwantlen Polytechnic University
http://www.kwantlen.ca/_shared/assets/BSc_Framework_Added_June_201119530.pdf

Mathematics courses:

- MATH 1120 Differential Calculus (3 credits, preferred)
or MATH 1130 Calculus for Life Sciences I (3 credits)
- MATH 1220 Integral Calculus (3 credits)
or MATH 1230 Calculus for Life Sciences II (3 credits, preferred)
- MATH 2721 Complex Numbers and Linear Algebra (3 credits)
- MATH 2821^{new} Multivariate and Vector Calculus (3 credits)

Chemistry courses:

- CHEM 1110 The Structure of Matter (4 credits)
- CHEM 1210 Chemical Energetics and Dynamics (4 credits)
- CHEM 2315 Analytical Chemistry (4 credits)
- CHEM 4610^{new} Instrumental Analysis (4 credits)

Other science courses:

- BIOL 1110 Introductory Biology I (4 credits)

English course:

- ENGL 1100 Introduction to University Writing (W) (3 credits)

Business courses: [any two courses from the following list for 6 credits total]

- ACCT – any course other than 1130 and 1230
- BUQU – any course other than 1130 and 1230
- BUSI – any course other than 1204 and 1209
- MRKT – any course

In addition to the above required courses, a further 15 credits of breadth courses shall be taken. Up to six of these credits may be from the sciences.

Courses designated with “(W)” are intended to satisfy the writing intensive requirement stipulated in the B.Sc. Framework.

b) *In an appendix, list the courses along with their calendar description and prerequisites.*

Please see Appendix A.

A recommended course grid for full time students entering at Year 1 is shown below.

Recommended course grid for *B.Sc. Major in Physics for Modern Technology*

For full time students entering at Year 1

Semester 1	Semester 2	Semester 3	Semester 4
PHYS 1120 or 1101 Mechanics, oscillations, waves. (existing course)	PHYS 1220 or 1102 Optics, electricity, magnetism. (existing course)	PHYS 2420 Electricity and Magnetism. (existing course)	PHYS 2600 Electronics with Digital Systems and Microcontrollers (W)
MATH 1120 or 1130 Differential Calculus (existing course)	MATH 1220 or 1230 Integral Calculus (existing course)	PHYS 2010 Modern Physics Intro to quantum physics; intro to solid state physics	PHYS 2610 Sensors and Actuators Also transducers.
PHYS 1600 Intro. Modern Technology Including applications in analog electronics, digital systems and microcontrollers	BIOL 1110 Introductory Biology (existing course)	PHYS 2101 Experimental Physics (W) Analog and digital electronics; statistics; data analysis; data acquisition; technical writing.	PHYS 2030 Classical Mechanics Vibrations, waves, fluid mechanics Variant of PHYS 2330
CHEM 1110 The structure of matter (existing course)	CHEM 1210 Chemical Energetics and Dynamics (existing course)	MATH 2721 Complex variables, linear algebra, etc.	MATH 2821 Multivariate and vector calculus
English 1100 (B, W) (existing course)	Arts elective (B) (existing course)	Arts elective(B) (existing course)	PHYS 2040 Thermal Physics Heat flow, thermodynamics & applications

Semester 5	Semester 6*	Semester 7	Semester 8
PHYS 3900 (W) Project in Physics and Technology	PHYS 3700 Signal and Image Processing Signal-to-noise, noise reduction, Fourier analysis, FFTs, filters.	CHEM 4610 Instrumental Analysis Atomic & molecular spec, mass spec, GC-MS, HPLC, electrochemistry.	PHYS 4900 (W) Senior Project
PHYS 3610 Intro to Control On-off control, PID concepts, PLCs, valves & motors	PHYS 3620 Process Control PIDs, modeling, stability, feedforward control, industrial case studies.	PHYS 4600 Programming for Instrumentation e.g. LabVIEW, Matlab, VB	PHYS 4010 Quantum / Solid State Physics Basic QM, crystallography, energy bands, semiconductors, photoelectron spectroscopy, electron microscopy and scanning probe microscopy.
CHEM 2315 Analytical Chemistry (existing course)	PHYS 3710 Applied Optics and Optoelectronics Wave optics, lasers and LEDs, optical detectors and devices, fibre optics.	Breadth (B) (existing course)	PHYS 4700 Spectroscopic Instrumentation UV/Visible, IR, microwave, THz, NMR, Mass spec.
Business I (existing course)	PHYS 3950 & 3951 Work Placement (March to August)	Breadth (Science OK) (B) (existing course)	Breadth (Science OK) (B) (existing course)
PHYS 4800 Special Topics I		PHYS 4801 Special Topics II	Business II (existing course)

Notes:

B: satisfies breadth requirement

W: writing intensive

*Semester 6 includes a work placement. The remainder of courses will be taken in compressed mode, January to February, in order to make the period from March through August available for work placement. The exact starting date will be determined in consultation with the placement sponsor.

Program Delivery

a) *Explain the learning methodology/methodologies to be used.*

The *B.Sc. Major in Physics for Modern Technology* is a four year degree in which Year 1 has special features that sets it apart from Years 2, 3 and 4.

Year 1 will be called *Physics for Modern Technology – Foundation Year* and will be made available on an open admission, open registration basis to the University. This flexibility is possible because Kwantlen offers multiple sections of most required courses across three semesters and two campuses. Adding to the flexibility is the fact that transferable courses run at institutions across B.C., making transfer to Kwantlen for Year 2 a seamless choice.

Once admitted to the *Foundation Year*, students can identify with the *Physics for Modern Technology* program and receive guidance from program personnel. Students may work their way through the required Year 1 courses as the individual's preparation permits. Students who arrive at university missing prerequisites have opportunities for upgrade during the *Foundation Year*.

Years 2, 3 and 4 of the *B.Sc. Major in Physics for Modern Technology* are more specialized and will be a selective entry, limited enrolment (20 students) program. Students will need to progress through the required courses in the prescribed timetables due to the practicalities of scheduling. Most program courses will have specific and sequential prerequisites and run only one section every year (or every two years), such that students will be required to keep to the recommended schedules. (See Appendix A for a recommended course grid).

The program structure is aimed primarily for full time studies after Year 1 but will also allow half time studies for students following the recommended course grid. First year science courses are generally offered at KPU's Richmond and Surrey campuses, some in the evenings. Because of the requirement for a lab facility, all program specific courses will be located at one campus. These will include the majority of courses in Years 2, 3 and 4.

Our courses will utilize a range of delivery methods. Most year one courses will be delivered in a traditional lecture/lab format. Many of the new, applied Physics courses will have practical components infused across the course, rather than separating a lab component away from a lecture component. Such infusion and seamless transitions between course components are in part made possible by KPU's small classes and our

program size limit of 20 students. The project based courses will require students to spend significant time working within our laboratory.

We will explore remote delivery (e.g. videoconferencing) of courses in order to access highly qualified instructors outside of our local area. Such courses may be shared with partner institutions overseas. Because of the necessary ties to the laboratories, we envision that many of our courses cannot be offered online to students who are not on campus. However, we do plan to offer a selection of courses on compressed, intensive schedules. In so doing, we hope to make courses accessible to industry professionals both as students and as instructors, the latter when they have exceptional and unique qualifications for specific courses.

A work placement is an integral part of this degree. We plan to schedule it in Year 3 as a flexible semester. For most students this will involve placement in industry, where the student applies the skills acquired in an industrial setting and learns further from the experience. As an alternative to a single work placement, a complete co-op degree option is currently being explored. A *B.Sc. in Physics for Modern Technology, co-op option*, may offer competitive advantages to our graduates.

Admission Requirements

a) *Describe the admission requirements for this program.*

Admission into Year 1: *Physics for Modern Technology – Foundation Year*

[Year 1 is open admission, open registration]

A student applying for Year 1, the Foundation Year, need only meet the general university admission requirements.

Students who arrive at university missing prerequisites have opportunities for upgrade during the *Foundation Year*.

Admission into Year 2: *B.Sc. Major in Physics for Modern Technology*

[Year 2 and beyond are selective entry, limited enrollment]

In order to be admitted, an applicant must have completed 30 university level credits including:

- PHYS 1220 or PHYS 1102
- MATH 1230 or MATH 1220
- ENGL 1100

A grade no less than C in each course applied towards this 30 credit count will be required.

Applicants for Year 2 admission need not have studied Year 1 within the *Physics for Modern Technology – Foundation Year*, or within Kwantlen at all, as we recognize that there are many ways to satisfy these requirements. Students wishing to transfer in from another BC institution will find entry into Year 2 relatively seamless due to the close articulation of first year science courses across B.C. Students need only complete the equivalent courses that are transferable to Kwantlen.

Special Note: Laddering from Certificate of Engineering

Applicants who have completed Kwantlen's Certificate of Engineering will find substantial overlap in coursework with Year 1 of this degree and may wish to seek admission into Year 2. The Department of Physics wishes to facilitate a smooth transition for applicants in this position by fully recognizing the work previously completed.

The required courses for the Certificate of Engineering are:

- APSC 1124, 1151, 1299
- CHEM 1154
- CPSC 1103
- ENGL 1100
- MATH 1120, 1152, 1220
- PHYS 1120, 1170, 1220
- Complementary Studies elective

for a total of 40 credits.

Students who have successfully completed all of these courses will receive advanced standing into year two of the *B.Sc. Major in Physics for Modern Technology*. Earned credits in the Certificate of Engineering will apply towards graduation requirements of the *B.Sc. Major in Physics for Modern Technology* as follows: (40 credits):

- CHEM 1110, 1210
- ENGL 1100
- MATH 1120, 1220, 2721
- PHYS 1120, 1600, 1220
- Nine Breadth credits

Entry beyond Year 2

Applicants will need to meet the Year 2 admission requirements (above) and any additional credits or advanced standing will be assessed on an individual basis.

Faculty

a) *List the faculty and their areas of specialization.*

Regular faculty

Fergal Callaghan:	Experimental condensed matter physics
J. Michael Coombes:	Solid state physics theory specializing in superconductivity, polymer physics, computer applications, programming, and data acquisition.
Jana Kolac:	Physics, mathematics and astronomy education
Tom McMath:	Radiation spectrometers, optical properties, thick film circuits & transformer design
Don Mathewson:	Biophysics, modeling, physics education
Takashi Sato:	Observational astronomy, modeling, astronomy education.

Non-regular faculty

Michael Poon:	Engineering physics, fusion reactor materials, solid oxide fuel cells
Tyron Tsui:	Particle astrophysics, photomultiplier tube response models, image and signal processing and pattern recognition in images

b) *In an appendix, provide the list of faculty along with a brief curriculum vitae for each.*

Please see Appendix C.

Program Resources

a) *Describe the resources that will be required to mount this program including:*

There are two primary resource needs required to mount this program: personnel and laboratory facilities.

Because the Department of Physics is currently a small department with only six full time faculty, we will require some additional personnel if only to cover the 20 new courses currently not on offer. They could be phased in as we implement each additional year of the degree.

These new faculty hires represent opportunities to address another issue. With the current complement of faculty, the Physics Department has the expertise to develop

and teach the overwhelming majority of the proposed new courses. The exceptions are in the areas of process control and optoelectronics. The new hires can be targeted in these areas, as well as for general qualifications desired in all faculty members.

A laboratory space is required by the *Physics for Modern Technology* students for their coursework, including the project courses in Years 3 and 4. This lab will be a classic physics lab with electronic instrumentation, such as an oscilloscope at each student station. One distinguishing feature of this lab is that it will require electrical supplies above and beyond those normally located in rooms on campus both in terms of variety (high voltage, high current, three phase) and quantity (ample number of regular 120V, 15A circuits). Luckily, the Department of Physics has such a lab on the Richmond campus which is currently being used in ways that are less electrically intensive. However, alternate space will need to be established as a lighter duty lab for the courses that will be displaced from our existing lab. A minor electrical upgrade may be required to ensure there are at least ten 15A circuits. This new space can also be shared with Year 2 courses.

In the laboratories, we will require that each student station be equipped with a basic complement of electronic instruments. While there is no rigid definition of what a “basic complement” consists of, it will include such items as an oscilloscope, multimeters, a DC power supply and a function generator. We currently estimate a budget of \$5000 per station, and each student in Years 2, 3, and 4 will require a set.

Each student station will also require a computer as part of, and in order to operate, the instrumentation. We propose simply to have each incoming second year student build her own computer from supplied parts and install the operating system(s) as part of the learning exercise, and to be used for the duration of the program. This approach has the advantage that the student can take figurative ownership of the equipment. It also reduces cost compared to purchasing, maintaining and upgrading the computers commercially or by Kwantlen staff. Outside of our labs, the program faculty, staff and students have adequate access to computers in offices, computer labs, and libraries to facilitate their work and study.

In addition to the standard bench instruments, the program will require capital investments in such areas as process control, optics and spectroscopic equipment. These are detailed in the Program Concept Proposal and other reference documents available upon request.

For existing Year 1 courses in the *Physics for Modern Technology* degree, Kwantlen has excellent laboratory facilities for Biology, Chemistry and Physics at two campuses which can continue to be used, with the exception of the relocation mentioned above.

Library Impact Assessments (See Appendix D) have been conducted for the new B.Sc. Major in Physics for Modern Technology program to establish budgetary and purchasing priorities that will be met in order to support new courses in development.

- b) Provide the intended implementation schedule for the new program and evidence of the appropriateness of the schedule, given the timing of the proposal and readiness of the institution to offer the program.*

Thus far in the development of this degree, we have engaged in consultation with industry and academic stakeholders and received advice from overseas colleagues and Kwantlen's own internal personnel (see Program Consultation). The Program Concept Proposal has been approved by Senate and Board of Governors.

Our schedule for implementation is shown below. With the exception of one course (PHYS 1600, which can be taken in Fall of Year 2), all Year 1 courses as shown in the recommended course grid are already running regularly and so that we can plan to offer Year 2 at the earliest opportunity (Fall 2013). Meanwhile, PHYS 1600 is planned for offer in Spring 2013, independently of the degree implementation. (Should the degree not be implemented, the students will have taken a very excellent science elective and potential students will be advised accordingly.)

The capital investments and a phase-in of new faculty hires will need to be incorporated into the University budget for 2013/2014 and onwards.

Implementation Schedule (proposed)

Summer 2012 Full Program Proposal presented to Faculty, SSCC and Senate
Full Program Proposal presented to Ministry
Development continues for new Year 1 & 2 courses

Fall 2012 Student recruitment efforts begin

Spring 2013 PHYS 1600 runs for the first time

Summer 2013 New course development begins for Year 3 courses

Fall 2013 Year 2 intake begins
Year 1 intake begins

Summer 2014 New course development begins for Year 4 courses

Fall 2014	Years 3, 2 and 1 are running
Fall 2015	Years 4, 3, 2 and 1 are running
Spring 2016	First graduates at convocation

Program Consultation

- a) *Provide a list and brief explanation of the nature of the consultations that have occurred in the development of the degree program.*

Both internal and external consultations have been an integral part of the development of this degree program proposal from the outset.

Internal Consultations

Kwantlen personnel

- Department of Physics faculty and staff members
- Department of Biology (in particular Greg Harris and Jane Hobson)
- Department of Chemistry (in particular Jennifer Au and Patrick Duffy)
- Department of Mathematics (in particular Jan Verster, John Inglis, Avtar Sadhra and Allyson Rozell)
- Department of Environmental Protection Technology (Paul Richard)
- David Wiens, Associate Dean, School of Business
- Ron Maggiore, Associate Vice President, Strategic Enrollment Management
- Kathleen Bigsby, Director, Institutional Analysis and Planning
- Melike Kinik, Manager, Strategic Research, Institutional Analysis and Planning
- Shawn Erickson, Director, Centre for Co-operative Education and Career Services
- Lyn Benn, Director, Student Development and Success
- Zena Mitchell, Director, Admissions and Records
- Josh Mitchell, Director, Student Engagement
- Julia Denker, Director, Student and Financial Awards Services
- Warren Stokes, Director, Registration and Student Information Systems
- Paula Hannas, Manager of User Support, IET

Kwantlen students

In November 2011, we surveyed the students in our PHYS 1120 (Physics for Physical and Applied Science I) course on both the Richmond and Surrey campuses. The results were encouraging. The responses to two of the questions stand out. In response to “After having read the background on the previous page, please rate your interest in the

proposed degree,” 49 out of 67 students rated their interest as “high” or “very high”. In response to “If we offered this degree at Kwantlen, would you enroll in it?”, 28 out of 67 answered with a “yes” or a “strong yes”.

External Consultations

Local Industry

Given that a major goal of this program is that graduates will be employable in industry, consultation with local employers was considered paramount to informing the development of the program. In fact, consultation with industry is still ongoing.

The purpose of consulting with local industry is to find out (a) if graduates of such a program would be employable, and (b) what sort of program content would be useful.

The following is a list of those who have been consulted so far:

- Dr. Paul Beattie, Manager MEA Development and Research & Development, Ballard Power Systems
- Dr. Frank Haran, Senior Engineering Manager (Sensor Development), Honeywell Process Solutions
- Dr. Harold Zwick, Engineering Manager, Research & Development, MacDonald, Dettwiler and Associates (MDA) Ltd
- Darryn George, Application Engineering Manager, Norpac Controls
- Mike Rotzien, President of the BC branch of the International Society of Automation (ISA), and Senior Technologist at Autopro Automation Consultants Ltd
- Jeff Remple, PLC & Motion Control Product Manager
- Dr. Vighen Pacradouni, Senior Engineer (Measurements and Testing), Powertech Labs
- Valer Eugen Demian, Technical Services Manager, Analytic Systems
- Janet Pel, Human Resources, ALS Environmental and Mineral Labs

Letters of Support and emails from many of the above can be found in Appendix B.

Local educational and research institutions

Consultation with SFU centred around prospects for graduates of our program to pursue graduate studies at SFU. We visited BCIT to view their instrumentation labs and discuss teaching issues. We also obtained feedback from TRIUMF, which is a large local physics research facility that is affiliated with several Canadian universities. Consultations involved the following people:

- Ian Ross, Instructor, School of Energy, BCIT
- Prof. J. Steven Dodge, Graduate Chair, Department of Physics, SFU
- Dr. Oliver Stelzer-Chilton, TRIUMF Student Program, TRIUMF

Email correspondence from Prof. Dodge can be found in Appendix B.

International educational institutions

Several post-secondary institutions in Ireland offer degree programs similar to the one outlined in this proposal. In order to learn more about what they do, and to strengthen ties, we visited those institutions in May 2011. Although we met with many faculty and staff members during the visit, our primary contacts at those institutions are:

- Dr. Joe O'Mahony, Lecturer and Researcher, Waterford Institute of Technology
- Dr. Liam McDonnell, Head of Department of Applied Physics and Instrumentation, Cork Institute of Technology
- Dr. Gareth Roe, Lecturer, Department of Physical and Life Sciences, Galway-Mayo Institute of Technology

Relevant email correspondence can be found in Appendix B.

Professional Associations

Fergal Callaghan of Kwantlen Department of Physics became a member of the International Society of Automation (ISA) as well as its local BC branch. This has resulted in useful consultations with branch president Mike Rotzien, as well as the opportunity to widen industry contacts through attending events and seminars organized by the branch.

In addition, Callaghan has accepted an invitation from the ISA's Education Division to be a campus representative. This will enable our students, faculty and staff to avail more fully of opportunities provided by the ISA (e.g. awards, conferences, workshops, publications etc.).

b) Attach all written comments, both positive and negative from:

Please see Appendix B.

Appendix A

Program Course Descriptions

Semester 1

PHYS 1101 - Physics for Life Sciences I (existing) [4 credits]

Students will study work, energy, power, efficiency, and heat; kinematics and dynamics of rotation; fluids; oscillations, waves, and sound. Students will study relevant examples and applications of each course topic in the areas of medical and life sciences. Students will participate in laboratory activities that emphasize data collection and analysis.

Prerequisites: PHYS 1100 or Principles of Physics 12 (with a P)

Co-requisites: MATH 1120 or 1130 or 1140

PHYS 1120 - Physics for Physical and Applied Sciences I (existing) [4 credits]

Students will learn about statics, dynamics, oscillations, mechanical waves and sound. They will use computers extensively in the lab for data collection and analysis.

Prerequisites: PHYS 1100 or Principles of Physics 12 (with a C)

Co-requisites: MATH 1120 or 1130

PHYS 1600 - Introduction to Modern Technology (new) [3 credits]

Students will learn to work with microcontroller chips which are at the heart of many modern technological devices. Students will program a microcontroller to develop a device (e.g. a calculator or a simple robot) to function as intended. Students will learn the basics of the C programming language as well as skills such as simple circuit design, data acquisition, digital input and output (DIO), analog-to-digital conversion (ADC), pulse width modulation (PWM), and timing. Students, working in pairs or small groups, will complete a number of small projects aimed at finding solutions to specified problems. Students will also complete a larger group project and make an oral presentation on their solution.

Prerequisites: PHYS 1100 or Principles of Physics 12 (with a C)

CHEM 1110 - The Structure of Matter (existing) [4 credits]

Students will study the modern view of atomic structure, nuclear chemistry, theories of bonding and molecular structure, organic chemistry (properties and reactions of the major functional groups and isomerism) after a brief review of stoichiometry, gases and the treatment of experimental data. Students will also perform experiments in the laboratory.

Prerequisites: (CHEM 1105 or [Chemistry 12 with a C+]) and (MATQ 1093 or MATH 1093 or 1117 or ABEM 0011 or 0082 or MATP 1011 or PSPM 1082 or [Pre-calculus 12 with a C] or [Pre-calculus 12 with a P plus Mathematics Placement Test] or [Principles of Mathematics 12 with a C] or [Principles of Mathematics 12 with a P plus Placement Test])

Co-requisites: MATH 1112 or (MATH 1111 and 1113) is strongly recommended

ENGL 1100 - Introduction to University Writing (existing) [3 credits]

Students will learn to apply principles of rhetoric and critical analysis in response to selected readings, which will include examples of scholarly writing and academic argument. They will develop their writing skills through exploratory writing, academic argument, and critical analyses of material from a variety of contexts.

Prerequisites: English 12 (B) or English 12 First Peoples (B) or ENGQ 1099 or ABEE 0091 or ENGP 1091 or ABEE 0092 or ABEE 0097 or ENGP 1097 or Kwantlen English Placement Test or an LPI Essay score of 30 – Level 5 or (ELST 0381 (B) and 0383 (B)) or IELTS 6.5 with no band less than 6.0 or iBT 86 with no sub score less than 20 or (TOEFL 570 with TWE 5.5)

MATH 1120 - Differential Calculus (existing) [3 credits]

Students will learn to differentiate algebraic and elementary transcendental functions and to apply these skills to graphing, maxima and minima, related rates, and rectilinear motion. They will be introduced to parametric curves and their differential calculus.

Prerequisites: MATH 1112 or Pre-calculus 12 with a B; or Principles of Mathematics 12 with a B; or Pre-calculus 12 with a C plus Mathematics Placement Test; or Principles of Mathematics 12 with a C plus Mathematics Placement Test

MATH 1130 - Calculus for Life Sciences I (existing) [3 credits]

Students will study differential calculus and its applications to biological sciences. In particular, they will study limits and differentiation of algebraic and elementary transcendental functions, with applications to graphing, optimization, and growth and decay.

Prerequisites: MATH 1112 or Pre-calculus 12 with a C+; or Principles of Mathematics 12 with a C+; or Pre-calculus 12 with a C plus Mathematics Placement Test; or Principles of Mathematics 12 with a C plus Mathematics Placement Test

Semester 2

PHYS 1102 - Physics for Life Sciences II (existing) [4 credits]

Students will learn about optics and optical instruments; electrostatic forces and fields; magnetic forces and fields; electromagnetic induction; electric circuits; atomic structure, nuclear physics and radioactivity. Students will study relevant examples and applications of each course topic in the areas of medical and life sciences. Students will participate in laboratory activities that will emphasize data collection and analysis.

Prerequisites: PHYS 1101 or PHYS 1120

Co-requisites: MATH 1220 or 1230 or 1240

PHYS 1220 - Physics for Physical and Applied Sciences II (existing) [4 credits]

Students will learn about optics, modern physics, electricity and magnetism. They will use computers extensively in the lab for data collection and analysis.

Prerequisites: PHYS 1120 or 1101

Co-requisites: MATH 1220 or 1230

BIOL 1110 - Introductory Biology I (existing) [4 credits]

Students will study the diversity of life on Earth, the classification of organisms, and the interactions of organisms with their environments. They will examine the structure and function of body systems in a variety of organisms.

Prerequisites: none

CHEM 1210 - Chemical Energetics and Dynamics (existing) [4 credits]

Students will learn about topics including liquids, solids and solutions, a review of redox reactions, electrochemistry, the laws of thermodynamics, equilibrium, acids and bases, ionic equilibria, and chemical kinetics. They will also perform experiments in the laboratory.

Prerequisites: CHEM 1110 and ([MATH 1112 or higher level] or [Principles of Mathematics 12 with a B] or [Pre-calculus 12 with a B])

MATH 1220 - Integral Calculus (existing) [3 credits]

Students will learn to integrate algebraic and elementary transcendental functions and to apply these skills to appropriate problems. In addition, they will learn the fundamental theorem of calculus, the integral calculus of parametric curves, Taylor polynomials, sequences and series and simple differential equations.

Prerequisites: MATH 1120 or MATH 1130 with C + or better or MATH 1140 with a B- or better

MATH 1230 - Calculus for Life Sciences II (existing) [3 credits]

Students will study integral calculus and its applications to biological sciences. In particular, they will study the indefinite and definite integral, functions of several variables, differential equations, and probability theory, with applications to biological problems.

Prerequisites: MATH 1140 with a C+ or better or MATH 1120 or MATH 1130

Semester 3

PHYS 2420 - Electricity and Magnetism (existing) [3 credits]

Students will learn the principles of electricity and magnetism at an intermediate level. Topics covered are: electrostatic forces and fields, electric potential, capacitance and dielectrics, magnetic fields, magnetic properties of materials, and introduction to semi-conductor devices and Maxwell's equations.

Prerequisites: (PHYS 1220 or 1102) & (MATH 1220 or MATH 1230)

Corequisites: MATH 2321 or MATH 2721 or MATH 1152

PHYS 2010 - Modern Physics (new) [3 credits]

Students will study the basic postulates and results of the Special Theory of Relativity and Quantum Mechanics. They will review the experimental evidence for quantization. They will use the Schrodinger equation to obtain wavefunctions for a variety of situations, including the Hydrogen atom. They will also be introduced to solid state physics with an emphasis on electronic devices.

Prerequisites: (PHYS 1102 or PHYS 1220) & (MATH 1220 or MATH 1230)

PHYS 2101 - Experimental Physics (Writing Intensive. new) [3 credits]

Students will learn how physical and statistical principles are applied in designing experiments and analyzing their results. They will learn the electronic skills necessary to work in a modern physics laboratory. Students will perform experiments in basic analogue and digital electronics, learn the use of standard electronic instrumentation, and use the computer for data analysis, which will involve statistical analysis as appropriate. Report writing and presentation will be integral parts of the experience.

Prerequisites: (PHYS 1102 or PHYS 1220) & (MATH 1220 or MATH 1230)

MATH 2721 - Linear Algebra and Complex Numbers [3 credits]

Students will use row reduction to solve systems of linear equations. They will study the algorithms for matrix multiplication, inversion and transposition. For matrices up to size 3x3, they will take determinants, find eigenvalues and eigenvectors, and diagonalize. They will apply these skills to practical problems such as quadratic forms and coupled harmonic oscillators. They will study the geometry of Euclidean space including dot and cross products. They will study the arithmetic of complex numbers, exponentials and logarithms of complex numbers, and the complex plane. They will use complex numbers to solve a variety of applied problems in physics and engineering, such as the damped harmonic oscillator. Students will use a Computer Algebra System to solve problems in matrix algebra.

Prerequisites: MATH 1220 or MATH 1230

Semester 4

PHYS 2030 - Classical Mechanics (new) [3 credits]

Students will study intermediate topics in Classical Mechanics that rely heavily on Mathematical skills developed in introductory calculus courses. Topics include time, position and velocity dependent forces, damped and forced vibrations, inertial and non-inertial frames of reference, the Kepler problem, general plane motion and fluid mechanics. Students will extend the concepts learned in PHYS 1120.

Prerequisites: PHYS 1120 or (PHYS 1101 with a B), (MATH 2721 or MATH1152)

Corequisites: MATH 2821

PHYS 2600 - Electronics with Microcontrollers (Writing Intensive. new) [3 credits]

Students will learn about direct current (DC) and alternating current (AC) circuits. Students will work with microcontrollers and C language in a lab setting to learn skills such as circuit design, data acquisition, digital input and output (DIO), analog-to-digital conversion (ADC), and timing. Working in pairs or small groups, students will complete several labs and one project aimed at finding solutions to specified problems. Students will apply programming and debugging skills to make a device perform as intended. Report writing and presentation will be integral parts of the experience.

Prerequisites: PHYS 1220, (PHYS 1600 or APSC 1299) & MATH 1220

PHYS 2610 - Sensors and Actuators (new) [3 credits]

Students will be introduced to components of measurement systems using a variety of sensors, with emphasis on the practical use of associated signal measurement equipment. Students will also learn the theory of operation of sensors, actuators and transducers and use these components to build working systems.

Prerequisite: PHYS 2101

Corequisite: MATH 2821

PHYS 2040 - Thermal Physics (new) [3 credits]

Students will learn about the thermal properties of matter, and mechanisms of heat transfer. They will study heat engines and refrigeration, phase changes, and the laws of thermodynamics. They will also study environmental applications of thermal physics and applications in green energy technology.

Prerequisites: (PHYS 1102 or PHYS 1220) & (MATH 1220 or MATH 1230)

MATH 2821 - Multivariate and Vector Calculus (new) [3 credits]

Students will study the principles of multivariate and vector calculus. They will study surfaces, partial derivatives, gradients, and multiple integrals in polar, cylindrical, and spherical co-ordinate systems. They will also study derivatives of vector valued functions, differential operators, line integrals and Green's theorem, surface integrals including divergence and Stokes' theorems, conservative fields, and potentials. Applications will be emphasized.

Prerequisites: (MATH 1220 or 1230) and (MATH 2721 or MATH 1152)

Semester 5

PHYS 3610 - Introduction to Control (new) [3 credits]

Students will learn the basics of control systems, including on-off control, proportional-integral-derivative (PID) control and tuning; correction elements such as hydraulic and pneumatic systems, control valves, and motors; ladder logic and programmable logic controllers. Students will apply their knowledge to basic control systems in the laboratory.

Prerequisites: PHYS 2101, 2600, 2420, 2610 & (MATH 2821 or MATH 3322)

PHYS 3900 - Project in Physics and Technology (Writing Intensive, new) [3 credits]

Students will work as part of a team on a pre-determined project in the area of physics and/or instrumentation. With appropriate guidance, students will write their work into a formal report or paper and present it three times during the semester, thus developing their presentation and communication skills.

Prerequisites: PHYS 2101, 2600, 2420, 2610 & (MATH 2821 or MATH 3322)

PHYS 4800 - Special Topic I (new) [3 credits]

Students will examine a selected topic in physics, instrumentation or technology. They will examine the theoretical basis and their applications. Students will examine and evaluate recent developments in the specific field and identify future directions for development.

Note: the area of study will be established in advance by the department.

Prerequisites: 18 credits of 2000 level PHYS courses.

CHEM 2315 - Analytical Chemistry (existing) [4 credits]

Students will learn the fundamental concepts of analytical chemistry. They will study quantitative analysis of aqueous solutions and solid samples, experimental design and data analysis, as well as spectroscopic and chromatographic methods. Students will engage in extensive laboratory work and practical applications.

Prerequisites: CHEM 1210

Semester 6

PHYS 3620 - Process Control (new) [3 credits]

Students will learn about piping and instrumentation diagrams, modeling control systems, transfer functions, response of first and second-order systems, frequency response, stability and feedforward control. Students will analyse industrial case studies. Practical work will involve simulations as well as laboratory models of industrial processes.

Prerequisites: PHYS 3610

PHYS 3700 - Signal and Image Processing (new) [3 credits]

Students will learn about the noise characteristics of components, sensors, and systems, as well as signal recovery techniques. They will also learn about the acquisition, processing and analysis of images for scientific and industrial applications. Students will apply signal and/or image processing techniques through practical work. Statistical analysis will be applied throughout, both for theory and for analysis.

Prerequisites: PHYS 2420 & 2610

PHYS 3710 - Applied Optics and Optoelectronics (new) [3 credits]

Students will study advanced wave optics, and will learn about optical sources such as lasers and light emitting diodes (LEDs). They will also study optical detectors (e.g. charge-coupled devices) and fibre optics. Students will apply optical techniques through laboratory work.

Prerequisites: PHYS 2101, 2600, 2420, 2610 & (MATH 2721 or MATH 1152)

PHYS 3950 - Work placement – Part I (new) [3 credits]

Students will apply their previous learning to a “real world” situation during a work experience term with supervision from Physics faculty. Students will prepare proposals of work to be performed as well as interim reports midway through the placement.

Prerequisites: approval by work placement committee

PHYS 3951 - Work placement – Part II (new) [3 credits]

Continuing from Work Placement- Part I, students will apply their previous learning to a “real world” situation during a work experience term with supervision from Physics faculty. Students will prepare final reports at the conclusion of the placement.

Prerequisites: approval by work placement committee

Semester 7

PHYS 4600 - Programming for Instrumentation (new) [3 credits]

Students will learn programming languages that have been chosen based on current industry practices and apply them in instrumentation. Specific languages may include Visual Basic and MATLAB, and LabVIEW. Applications will include experimental data acquisition, processing and analysis, as well as active control of instrumentation.

Prerequisites: PHYS 3610 & 3700

PHYS 4801 - Special Topics II (new) [3 credits]

Students will examine a selected topic in physics, instrumentation or technology. They will examine the theoretical basis and their applications. Students will examine and evaluate recent developments in the specific field and identify future directions for development.

Note: the area of study will be established in advance by the department.

Prerequisites: 18 credits of 2000 level PHYS courses.

CHEM 4610 - Instrumental Analysis (new) [4 credits]

Students will learn the main spectroscopic and chromatographic techniques that are in widespread use today. Students will perform a limited selection of laboratory assignments to amplify theoretical concepts. Students will study the principles of signal generation by chemical species, and detailed descriptions of the components of instruments. Students will discuss the importance of optimization at all stages of an analysis, from sampling and sample preparation to signal detection and data analysis.

Prerequisites: CHEM 2315

Semester 8

PHYS 4010 - Quantum and Solid State Physics (new) [3 credits]

Students will learn about the underpinnings of quantum mechanics. Students will further apply these concepts in their development of understandings in crystallography, energy bands, and semiconductors, as well as experimental techniques such as electron microscopy, scanning probe microscopy, and photoelectron spectroscopy.

Prerequisites: PHYS 2010 & (MATH 2821 or MATH 3322)

PHYS 4700 - Spectroscopic Instrumentation (new) [3 credits]

Students will study the instrumentation behind techniques such as visible, ultraviolet, infrared, terahertz, and microwave spectroscopy, nuclear magnetic resonance and mass spectrometry. Students will acquire practical experience of some of these systems in the laboratory.

Prerequisites: PHYS 3710 & CHEM 4610

PHYS 4900 - Senior Project (Writing Intensive - new) [3 credits]

Students will work on a semester long project that will ideally have a connection with a specific industry. Students will prepare written documentation of their project and present the results orally.

Prerequisites: PHYS 3900 & 4600

Appendix B

Program Consultations

Letters of Support from Local Industry

Letters of Support from the following supporters are included:

- Dr Christopher Guzy June 7, 2011
Vice President and Chief Technology Officer
Ballard Power Systems, Burnaby, B.C., Canada
(N.B. This letter refers to the program by its earlier proposed title³.)

- Dr Frank Haran Oct 11, 2011
Senior Engineering Manager
Honeywell Process Controls
North Vancouver, B.C., Canada

- Dr Harold Zwick Nov 07, 2011
Engineering Manager
MDA Systems Ltd.
Richmond, B.C., Canada
(N.B. This letter refers to the program by its earlier proposed title³.)

- Darryn George, P.Eng. Jan 24, 2012
Application Engineering Manager
NORPAC Controls Ltd.
Burnaby, B.C., Canada

³ The previous working title of the program was “B.Sc. Major: Applied Physics and Instrumentation”. We had intended that the word “instrumentation” would signify a study of the principles and operation of scientific and industrial instruments in general. However, during the process of consulting with local industry, and with other educational institutions, we discovered that the word “instrumentation” can mean different (and specific) things to different people, depending on their background. We recently visited Waterford Institute of Technology (WIT) in Ireland, where the physics department has launched a new degree this semester. The content and aims of their degree are very similar to those of our proposed degree. After much consultation with stakeholders, WIT decided to call their degree “Physics for Modern technology”. We feel that this title better encapsulates the ethos and content of our proposed program. In addition it is less open to misinterpretation. We stress that the change in working title has not in any way affected the proposed content of the program.



Ballard Power Systems

9000 Glenlyon Parkway
Burnaby, BC V5J 5J8
Canada

Tel: 604-454-0900
Fax: 604-412-4700
www.ballard.com

June 7, 2011

Fergal Callaghan, Ph.D.
Department of Physics
Kwantlen Polytechnic University

Dear Professor Callaghan,

We have conducted a review of the course proposal and outline for the new degree entitled "Applied Physics and Instrumentation" that you would like to offer at Kwantlen Polytechnic University.

It appears to cover a broad range of subject matter that is directly applicable in the development of fuel cells and fuel cell systems. From a research perspective, we are obviously interested in candidates with a good grounding in fundamental science. In addition, our research and development groups routinely use analytical tools to conduct material/component characterization as part of our technology and product development efforts. The development of fuel cell stacks and implementation into fuel cell systems requires an understanding of thermodynamics as well as effective interfacing with electrical systems and the monitoring of overall system performance. The suggested modules on "Green Energy Technology" and "Sales and Marketing" are excellent additions from the perspective of developing well-rounded candidates. One area that might be of value to include is a module on electrochemistry since this is obviously key to fuel cells. It also has applications in batteries, electrolyzers, and some solar applications.

Ballard has a number of employment opportunities that arise from time to time. These include co-op work terms. Students who are taking the "Applied Physics and Instrumentation" course may be good candidates for those types of opportunities.

In summary, we feel that the course outline as described offers significant benefits to potential student in terms of future career development options in the green technology sector.

Sincerely,

A handwritten signature in black ink, appearing to read "CG", is written over a light blue horizontal line.

Dr. Christopher Guzy
Vice President and
Chief Technology Officer

CG/bm

Commercial Confidential

.....

Frank Haran, PhD
Senior Engineering manager
Honeywell Process Controls
500 Brooksbank Avenue
North Vancouver, BC Canada V7J 3S4
Phone: (604) 980-3421
Direct: (604) 982-3575
Fax: (604) 980-0120
Email: frank.haran@honeywell.com

Honeywell ASCa Inc.

10/11/2011 5:45:00 PM

Dr Fergal Callaghan
Department of Physics
Kwantlen Polytechnic University
British Columbia
Canada

Dear Fergal:

I have reviewed your proposal for a new degree course in "Physics for Modern Technology" at Kwantlen Polytechnic University. As an employee of a company that is at the forefront of industrial and commercial instrumentation and control I confirm the need for personnel educated in the physics of measurement technologies and how they are applied in a real commercial environment. I have reviewed your course outline and can confirm that it covers many of the relevant areas required to produce people with the relevant skills for employment at Honeywell.



Frank Haran, PhD, MBA
Senior Engineering Manager



November 07, 2011

Dr Fergal Callaghan,
Department of Physics,
Kwantlen Polytechnic University,
8771 Lansdowne Road,
Richmond V6X 3V8

Dear Dr Callaghan,

I have reviewed with interest, your proposed Instrumentation and Applied Physics program for Kwantlen Polytechnic University. It seems to me that this is an important contribution to enable the training of a new generation of technically well rounded graduates for our future industrial, public sector as well as academic market. I am unaware of a similar offering and expect you will attract an interesting group of students to this program.

I therefore endorse your proposal and wish you success in launching the new program.

Yours truly

A handwritten signature in blue ink, appearing to read "Harold Zwick", is written over a faint, larger version of the same signature.

Harold Zwick, PhD
Engineering Manager
Research and Development
MDA Systems Ltd



NORPAC Controls Ltd.
P: 604.422.3700
F: 604.422.3788
7300 Vinton St.
Burnaby BC
Canada V5A 4X5

24 January 2012

Department of Physics
Kwantlen Polytechnic University
BC, Canada

Attention: Fergal Callaghan, Ph.D.

Subject: B.Sc. Major: Physics for Modern Technology

Dear Fergal,

Further to the information you have provided with respect to the above proposed Degree Program at Kwantlen Polytechnical University, I am pleased to offer the support of NORPAC Controls with respect to this unique and differentiated degree offering within British Columbia. The curriculum appears thorough, detailed and ambitious as are the technical requirements of Modern Technology.

I feel that employers in the Industrial Process Control sector such our ourselves and many of our clients, including major BC Engineering Consultants, Process Plants and OEM's, would be interested in future graduates of this program to strengthen their organisations.

Regards,

Darryn George, P.Eng.
Application Engineering Manager
NORPAC, a division of Spartan Controls



www.norpaccontrols.com



Email Comments on Proposal from Local Industry

Dr. Vighen Pacradouni, Senior Engineer (Measurements and Testing), Powertech Labs.

RE: Potential Kwantlen physics/instrumentation degree

Vighen Pacradouni [vighen@vighen.com]

Sent: February-02-11 12:01 AM

To: Fergal Callaghan

Hi Fergal,

With regards to the curriculum my comments are the following:

- a course or portion thereof should cover fluid dynamics (it could be in the class mechanics)
- a course or portion thereof should cover heat flow (it might be in the thermal physics course)
- a course or portion thereof should cover Labview or a similar instrumentation package beyond just a programming course (this may be implicit but should be made explicit); Labview seems to be the one dominant in industry
- the Forensic Analysis is particularly appealing to Powertech as we do quite a bit of that
- a course in Project Management would be useful or it could be combined with the Sales and Marketing course as this is what a lot of the engineers/scientists and senior techs work involves; writing appealing proposals to clients and then often managing other people's work as well as one's own to complete on time and on budget.

Powertech does hire coop students but it varies from year to year based on need, particular skills, and management philosophy. As for graduates of such a degree, they would face stiff competition from engineering graduates. Currently the technicians seem to have A.Sc.T degrees, the scientists (physicists and chemists generally) MSc and PhD's and most of the other professionals are B.Eng P.Eng engineers. Although not usually legally required the P. Eng. stamp on the reports we send out to clients seems to be appreciated. It is more likely however that graduates from the program would be hired into the technical and senior technical positions.

I hope that's helpful.

Vighen.

Notes in response to Dr Pacradouni's comments:

We have included Fluid Mechanics in our Classical Mechanics course.

Heat flow will be covered in our Thermal Physics course.

Students will gain experience of using LabVIEW during the program.

Courses such as marketing are among the recommend a list of two business courses students must choose.

Jeff Remple, PLC & Motion Control Product Manager, _____

RE: Potential Kwantlen physics/instrumentation degree

Jeff Remple [jeff.remples@_____.ca]

Sent: January-19-11 8:34 PM

To: Fergal Callaghan

Hi Fergal,

Yes I remember our conversation regarding the new program. _____ has never hired co-op students before so I'm not sure if they'd be willing to do it. That decision would have to come from the Automation Manager (my boss). If you want, I can give you his contact info... just let me know if that's something you want to explore.

I looked over the proposed course listing. I like a couple of the applied courses. Since I'm in a technical automation sales position with _____, the ones that stood out for me were:

Actuators and Sensors - We sell many sensing products and being that I'm the motion control product manager I could see value in the actuators if the course covers mechanical actuators such as ball screws, roller screw actuators, belt actuators etc. We don't sell many of these products but knowledge on them is valuable because we often couple our servo motors to them and need to size speed/torque/inertia accordingly.

Opto Electronics - My last job at _____ would be related to this course. I used to make scanners for lumber mills (by the way, they might be interested in a co-op student). We also sell a few sensor products here at _____ that probably have related technology.

Modeling and Design - While not really used here at _____, I find it interesting and all our Automation engineers / customers use some form of Solidworks, Orcad, or other modeling program... I think this is a good idea for a course. We didn't have this as a dedicated course in Btech at BCIT but I would have taken it if it was offered.

Green Energy Technology - Sounds interesting. I've quoted some parts to a solarpanel company and we work with BCHydro on powersmart savings so this would be a good idea.

Sales & Marketing - Probably the best course to be applied at working at _____ since we are in sales, not engineering. I'm currently thinking of taking a few sales courses.

The other applied courses on your list weren't as relevant for here but maybe elsewhere. If I were going to add any courses, I'd add an Automation specific course on programming PLC's, Drives, and HMI's. Perhaps one course for each because those can each be a large topic. Btech at BCIT doesn't offer this. They have it in the Automation program diploma at BCIT (which I didn't take, I took Telecom) but not in the Btech program I took. I asked them to add these however they decided to focus more on the controls (feedback, signal, controls courses) which were also good but definitely not as relevant to my job. Being in a technical sales position, I find I'm often missing some core hand-on automation experience having gone straight out of school to _____ for one year before starting with _____. We do get to go on _____ training for a couple weeks out of the year however not the kind of foundation that would be found from taking a full set of courses at school.

I hope this feedback can help you out. If you ever want to chat more, feel free to email or give me a call.

Cheers,

Jeff Remple, B.Tech.
PLC & Motion Control Product Manager

Notes in response to Mr. Remple's comments:

We plan to cover PLCs in our Introduction to Control course.

Courses such as selling and marketing are among the recommend a list of two business courses students must choose.

Valer Eugen Demian, Technical Services Manager, Analytical Systems.

RE: Potential Kwantlen physics/instrumentation degree
Eugen Demian [eugend@analyticalsystems.com]
Sent: February-15-11 11:28 AM
To: Fergal Callaghan

Dear Fergal,

Thank you for your message! I took the time to read it together with the attached document and my first reactions are as follows:

1. Analytic Systems (ASW) is looking for people specialized in power electronics and less into physics/chemistry, or sensors and actuators.
2. Computer programming could be of interest to write code for intelligent power electronics units.
3. Our company has developed over the years a very close relationship with SFU in general and its mechatronics program in particular. The reason is very simple: such program combines the knowledge of electronics with mechanical basics.
4. The accelerated growth of the company in recent years has created the need to offer Coop terms to mostly senior students (3rd and 4th year) rather than junior ones (1st and 2nd year).

My background is mechanical engineering, so all I can say about power electronics is that it is a very particular field where a good specialist is extremely valuable; such specialists are what we are interested in first and foremost.

In my opinion an instrumentation degree is more suitable for scientific research and/ or bodies in charge

with certification of any kind (CSA, UL, EU, etc).

Please let me know if you wish to follow up with more discussions and information.

Kind regards,
Eugen D.

Valer Eugen Demian
Technical Services Manager
8128 River Way, Delta, BC V4G 1K5

Notes in response to Mr Demian's initial comments:

Computer Programming will be an important part of our program.

Although students will gain a solid grounding in electronics in our program, power electronics will likely not be a specialization.

The program will not have much of a mechanical slant, which Mr Demian suggests is important for employment at Analytic Systems.

RE: Potential Kwantlen physics/instrumentation degree
Eugen Demian [eugend@analyticsystems.com]
Sent: May-09-12 9:27 AM
To: Fergal Callaghan

Good morning Fergal,

Thanks for sending me the material! All looks extremely interesting and well put together. If I was not very convinced something like this is needed, now I have completely changed my mind.

We have our own lab and testing equipment here at Analytic Systems; however the problem is (and has been) to find someone comfortable enough to take the lead and be in charge of it. This has been happening for years now and after we have tried several solutions. We offered the opportunity to technicians, engineers, etc. I guess a graduate of your proposed program could fill the void with ease and be an extremely valuable asset!

One small observation: my name is spelled with "e" as a second letter = DEMIAN. I know it is easy to spell it differently (it happened even in my country of origin), so it is no biggie as long as we fix it.

Kind regards,
Eugen D.

Valer Eugen Demian
Technical Services Manager

Notes in response to Mr Demian's recent comments:

We are very happy that Mr Demian now sees the proposed program as being beneficial to the work being carried out at Analytic Systems.

Janet Pel, Human Resources, ALS Environmental and Mineral Labs.

RE: Potential new Kwantlen degree
Janet Pel [Janet.Pel@ALSGlobal.com]
Sent: February-10-11 12:01 PM
To: Fergal Callaghan

Hello Fergal,
I had a look at the course map and felt that this was a good program. Chemistry was sufficient.

Just a couple of comments:

Our current model for hiring is to put new grads into entry level positions which do not usually involve instrumentation. They develop their basic lab skills and become familiar with our systems and they can apply internally for promotion and opportunity to work on the more sophisticated instrumentation.

To promote someone to a higher level there would need to be a corresponding amount of supporting chemistry - possibly industrial chemistry, certainly analytical, solid training in organic chem..

Our staff not only run instrumentation but are expected to learn the sample preparation to ready the material for instrumental analysis. For ICPMS, as an example, we analyze water, soil, plant and animal tissue, air, waste water and sludges for trace metals. These various matrices need to be digested/prepared to make the metals available. Matching standards need to be made. Similarly for GCMS - samples need to be extracted, cleaned up and prepared for analysis. It is not enough to us that they are familiar with the instrumentation. By the time they are running a complicated instrument they have to also know the types of samples, preparation and problems that can arise.

I see this degree as being more applied than just a chemistry or physics degree. It could be very useful but for us needs the supporting knowledge of how to get the samples to the instrument, prepare standards and the necessary qc to support the data.

Give me a call if you would like to chat.

Thanks,
janet

Janet Pel, CHRP
HUMAN RESOURCES BUSINESS PARTNER
ALS I Group

Address
8081 Lougheed Hwy
Burnaby, BC V5A 1W9

Notes in response to Ms. Pel's comments:

At the time of corresponding with Ms. Pel, we had planned to have more chemistry in the program. However, since then we have removed two of the chemistry courses (Organic Chemistry, and Spectroscopic Techniques in Organic Chemistry). Therefore our proposal may not be as relevant to her company's work as it was at that time.

Email Comments on Proposal from Local Educational Institutions

Prof. J. Steven Dodge, Graduate Chair, Department of Physics, SFU.

Re:
From: J. Steven Dodge [jsdodge@sfu.ca]
Sent: June-27-11 12:44 AM
To: Fergal Callaghan

Hi Fergal,

The proposal looks interesting, and I'll be curious to learn how successful it becomes. For admission to graduate school at SFU, we like to see something like the equivalent to our fourth year courses in the foundational areas of E&M, QM, and StatPhys. If a student is lacking one of these then we usually ask them to take the undergrad course before taking the introductory grad course on the same topic. We also prefer that a student has had a smattering of advanced special topics courses, as well as some analytical mechanics. Your course map suggests that students that completed your proposed program would have a broad exposure to experimental methods in condensed matter, but would lack advanced course work in the foundations. If a student were to apply from such a program with strong recommendation letters, we could elect to admit the student on a qualifying or conditional basis for one year, requiring a set of advanced undergraduate coursework during that year. We do this fairly regularly, maybe not every year but certainly once every couple of years, and in many instances these students have worked out well.

I hope this is enough for you to go on: basically, it wouldn't be impossible for a student with such a degree to enter graduate school at SFU, but the likelihood of success in admission would depend on many details that are not in the proposal. I recommend that you take a look at our own undergraduate curriculum for guidance, e.g., <http://www.physics.sfu.ca/assets/teaching/ugrad/Physmajorhonours.pdf>. I think our honours undergraduate students are very well prepared for graduate school and most of our introductory graduate courses are implicitly based on an undergraduate degree like what we offer.

Cheers,

Steve

Note in response to Prof. Dodge's comments:

Although qualifying for entry into graduate school is not a primary goal of our program, we are happy that students may be able to do so by completing a qualifying year.

Email Comments on Proposal from International Educational Institutions

Dr. Joe O'Mahony, Lecturer and Researcher, School of Engineering, Waterford Institute of Technology.

Proposed Degree
Joseph O'Mahony [jomahony@wit.ie]
Sent: February-21-11 1:38 PM
To: Fergal Callaghan

Hi Fergs,

Sorry about not getting back to you sooner, I've been kept quite busy of late with school work, we've just finished a HEA research review and I'm now busy trying to put together an EU consortium on Solar PV research.

By the looks of it you have quite a good course plan for your new degree, it probably would be wise to concentrate on the key strengths that you have available and to avoid duplicating what other nearby universities offer. I would advise going down the route of interacting more closely with industry, even simple modules like LabView can be a deal clincher when seeking employment with large multinationals. Have you any plans to develop an R&D arm to support research informed learning?

As I am on mid term this week, if you forward you contact number and an appropriate time (Irish Time) to contact you, I can give you a ring to discuss.

Best Regards,

Joe.

Dr. Joe O'Mahony
Lecturer Electronic Engineering
School of Engineering
Waterford Institute of Technology
Waterford
Rep. Ireland

**Dr. Liam McDonnell, Head of Department of Applied Physics and Instrumentation, Cork
Institute of Technology.**

Your proposed degree

Liam McDonnell [Liam.McDonnell@cit.ie]

Sent: January-24-11 6:49 AM

To: Fergal Callaghan

Attachments: CR365 rev 1.pdf (152 KB) ; cr001.pdf (987 KB) ; cr360.pdf (1 MB) ; BEST Programme
Submission ~1.doc (951 KB)

Hello Fergal,

Happy New Year to you and your colleagues.

Thank you very much for your two emails. My apologies for not acknowledging the first one but I have been buried in start-up issues for the next semester.

FYI, our international office contact is margaret.mulderigg@cit.ie

Just to bring you up to date with our current full-time programmes, I attach the course leaflets and summarise same:

CR001 BSc in Applied Physics and Instrumentation

3 yr full-time Level 7 programme with one year full-time add-on Level 8 programme with the award of BSc Honours in Applied Physics and Instrumentation

During the add-on honours year, students can opt for Applied Physics modules or Instrument Engineering modules and also request a relevant project.

CR360 BSc Honours in Instrument Engineering

4 yr full-time Level 8 programme that is essentially the same as the instrument engineering route through CR001 plus instrument engineering option in add-on honours year. Established in September 2009 to target students seeking an "engineering" rather than a "science" degree.

CR365 BSc Honours in Environmental Science and Sustainable Technology

4 yr full-time Level 8 programme started in September 2010. New programme concept based on physical sciences with sustainability management. I have attached the programme document as this may be of interest to you.

Levels 7 (Ordinary Degree) and 8 (Honours Degree) relate to the Irish National Qualifications Framework (<http://www.nfq.ie/nfq/en/>) established by the Irish National Qualifications Authority (<http://www.nqai.ie/index.html>). Level 9 is MSc and Level 10 is PhD.

I have read your proposal for your new degree and understand the context that you are adopting. You can see from the above summary and the recent evolution of CR365 that we have been serving two markets; firstly the minority market of applied physics and the majority market of instrument engineering. At our last programmatic review in 2005 the final year differentiation between these two types of graduate was greater than it is now. We had to cut back somewhat on the differentiation when we subsequently modularised and semesterised our programmes and dealt with financial cutbacks. Nevertheless, we still have this differentiation. We have started preparing the next programmatic review but are not likely to depart from this duality except that students selecting instrument engineering in year 4 will get the BSc Honours in Instrument Engineering.

Instrumentation, measurement and control, etc. programmes have typically been located within the engineering domain, often as off-shoots of electronic engineering. I have always been of the view that (as the Institute of Physics in London used to say "physics is at the heart of everything" whilst "instrumentation makes it happen", the latter being a byeline that we will be using in our new web-site and promotional material. CIT has been unusual in positioning instrumentation within a science department, with others such as GMIT following our lead (one of my ex-researchers Gareth Roe is there and I can put you in contact). Due to the major concentration of pharmachem companies in the Cork region CIT's instrumentation programme is biased towards process industries whereas GMIT's programme is more general. Given the existence of process automation programmes in another institution (BCIT) it would make sense for your new programme to as broad as possible and encompass both scientific and industrial instrumentation without becoming process instrumentation/process automation specific (yes the latter is very expensive). At the end of the day, your market research of employment opportunities will guide you.

Whilst we will not have the current picture on employment until surveys are completed later this semester, you may be interested in the historic data as to the employment sector of our Applied Physics and Instrumentation graduates:

Computing 15%

Electronics 8%

R&D 5%

Non-discipline 11% (includes students on gap year, about 56%)

Pharma-chem 18%

Engineering Services 37% (this sector includes system integrators and services process industries including pharmachem)

I reckon that the bias towards Pharma-chem/Engineering Services will have increased since this survey.

I note that you want to cater for sales and marketing careers. This is a good idea. We get Erasmus students from France who are on a programme designed for this marketplace and I can put you in touch with them. As the content is still at an early stage, I will limit my comments here. You are quite correct

that you will need employer feedback before finalising this. The latter will determine the sectors that you will be supporting such as medical devices, health-care, IT, photonics, etc.

What I would stress though is the importance of a systems approach to instrumentation from an early stage. I have found that "scientific" students are comfortable with black-box approaches whereas "engineering" students can be uncomfortable as they want to know what's in the box!, so it will depend on the "type" of students you recruit. Here, I find that students at second level have sorted themselves into categories based, to some extent, on their personalities/intelligences/skills as scientists, engineers, business, art, etc. even though they do not specialise to any significant sense at school.

I hope this is of some help. If I have any further thoughts I will get back to you.

I certainly hope that we can work together on this.

Best regards,

Liam

Head
Department of Applied Physics and Instrumentation
Cork Institute of Technology
Cork
Ireland

RE: degree proposal
Liam McDonnell [Liam.McDonnell@cit.ie]
Sent: November-14-11 7:05 AM
To: Fergal Callaghan
Importance: High

Hello Fergal,

Many thanks for the information on your proposal. Well done on getting things this far. It reads very well and is properly placed based on the overall analysis of the situation in BC.

I do hope that it progresses to fruition and I wish you the best of luck in each step.

Regards,

Liam

Dr Liam McDonnell CPhys FInstP
Head of Department of Applied Physics & Instrumentation

Cork Institute of Technology
Rossa Avenue
Cork
Ireland

Dr. Claire Keary, Lecturer, Department of Computing, Maths and Physics, Waterford Institute of Technology.

Re: degree proposal
Claire Keary [CKEARY@wit.ie]
Sent: November-22-11 5:24 AM
To: Fergal Callaghan; Catherine Walsh [CWALSH@wit.ie]; Mícheál Ó hEigeartaigh [moheigeartaigh@wit.ie]
Cc: Takashi Sato

Hi Fergal,

I've taken a look at your proposal and would like to compliment you and your colleagues on its content. It is very comprehensive and you have excellent supporting documentation.

The suite of modules that comprise this course look very interesting. As expected for this type of course, it is quite resource-intensive; in the current (recessionary) climate in Ireland we would have difficulty getting a commitment for such an investment on any physics-based course but, as you have identified, this investment will be required over a phased basis making this more attractive. It is interesting to note that your students will build their own pc; this will certainly enhance their learning experience.

I wish you all the best with your proposal and hope that it will be approved by your Science Division's curriculum committee.

Best regards,
Claire.

Appendix C

Faculty Curriculum Vitae

Fergal Callaghan

Department of Physics, Kwantlen Polytechnic University fergal.callaghan@kwantlen.ca

Education:

- **August 2006 – April 2007**
 - *Certificate Program in University Teaching and Learning*, Simon Fraser University.
- **1995 – 1999**
 - *PhD*, School of Mathematics and Physics, Queen's University, Belfast.
- **1992 – 1995**
 - *BSc (Hons.) Physics with Astrophysics*, Queen's University, Belfast.

Teaching Experience

- **August 2007 – present**
 - *Faculty*, Department of Physics, Kwantlen Polytechnic University.
- **September – August 2007**
 - *Sessional Instructor*, Department of Physics, Simon Fraser University.
- **2001 – 2003**
 - *Tutor*, School of Physics and Astronomy, University of Nottingham.

Postdoctoral Research Experience

- **April 2003 – August 2006**
 - *Postdoctoral Fellow*, Department of Physics, Simon Fraser University.
- **October 1999 – March 2003**
 - *Postdoctoral Research Associate*, School of Physics and Astronomy, University of Nottingham.

Professional Memberships

- Member of the American Physical Society.
- Member of the International Society of Automation.
- Member of the American Association of Physics Teachers.
- Member of the British Columbia Association of Physics Teachers.
- Granted title of Chartered Physicist (CPhys) by the Institute of Physics (UK).

Other Professional Activities

- Between 2007 and 2010 I was a referee for the journals Physical Review Letters and Physical Review B.

Publications

- *Penetration depth, multiband superconductivity, and absence of muon-induced perturbation in superconducting $\text{PrOs}_4\text{Sb}_{12}$* , Lei Shu, D.E. Maclaughlin, W.P. Beyermann, R.H. Heffner, G.D. Morris, O.O. Bernal, F.D. Callaghan, J.E. Sonier, W.M. Yuhasz, N.A. Frederick, and M.B. Maple, *Physical Review B* **79**, 174511 (2009).
- *Hole-doping dependence of the magnetic penetration depth and vortex core size in $\text{YBa}_2\text{Cu}_3\text{O}_y$: Evidence for stripe correlations near 1/8 hole doping*, J.E. Sonier, S.A. Sabok-Sayr, F.D. Callaghan, C.V. Kaiser, V. Pacradouni, J.H. Brewer, S.L. Stubbs, W.N. Hardy, D.A. Bonn, R. Liang, and W.A. Atkinson, *Physical Review B* **76**, 134518 (2007).
- *Spin-glass state of individual magnetic vortices in $\text{YBa}_2\text{Cu}_3\text{O}_y$ and $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ below the metal-to-insulator crossover*, J.E. Sonier, F.D. Callaghan, Yoichi Ando, R.F. Kiefl, J.H. Brewer, C.V. Kaiser, V. Pacradouni, S.A. Sabok-Sayr, X.F. Sun, S. Komiya, W.N. Hardy, D.A. Bonn, and R. Liang, *Physical Review B* **76**, 064522 (2007).
- *Muon spin rotation measurements of the vortex state in vanadium: A comparative analysis using iterative and analytical solutions of the Ginzburg-Landau equations*, M. Laulajainen, F.D. Callaghan, C.V. Kaiser, and J.E. Sonier, *Physical Review B* **74**, 054511 (2006).
- *A New Basic Motif in Cyanometallate Coordination Polymers: Structure and Magnetic Behavior of $M(\mu\text{-OH}_2)_2[\text{Au}(\text{CN})_2]_2$ ($M=\text{Cu}, \text{Ni}$)*, J. Lefebvre, F. Callaghan, M.J. Katz, J.E. Sonier, D.B. Leznoff, *Chemistry - A European Journal* **26**, 6719 (2006).
- *Coexistence of magnetism and superconductivity in ultraclean underdoped $\text{YBa}_2\text{Cu}_3\text{O}_{6.37}$* , R.I. Miller, R.F. Kiefl, J.H. Brewer, F.D. Callaghan, J.E. Sonier, R. Liang, D.A. Bonn and W. Hardy, *Physical Review B* **73**, 144509 (2006).
- *Field dependence of the vortex core size in a multiband superconductor*, F.D. Callaghan, M. Laulajainen, C.V. Kaiser, and J.E. Sonier, *Physical Review Letters*, **95**, 197001 (2005).
- *Variable temperature magnetic force microscopy with piezoelectric quartz tuning forks as probes optimized using Q-control*, **F.D. Callaghan**, X. Yu, and C.J. Mellor, *Applied Physics Letters*, **87**, 214106 (2005).
- *Shrinking magnetic vortices in V_3Si due to delocalized quasiparticle core states: confirmation of the microscopic theory for interacting vortices*, J.E. Sonier, **F.D. Callaghan**, R.I. Miller, E. Boaknin, L. Taillefer, R.F. Kiefl, J.H. Brewer, K.F. Poon, and J.D. Brewer, *Physical Review Letters* **93**, 017002 (2004).
- *The micro-magnetic structures of Mn^+ ion-implanted GaSb*, F. Zhang, N.F. Chen, Z. Liu, C. Chai, S. Yang, J. Yang, J. Wu, L. Lin, **F.D. Callaghan**, T. Li, C.T. Foxon, and C.A. Bates, *Japanese Journal of Applied Physics (Part 1)* **42**, 3389 (2003).
- *Dynamic force microscopy in superfluid helium*, **F.D. Callaghan**, X. Yu, and C.J. Mellor, *Applied Physics Letters* **81**, 916 (2002).

J. Michael Coombes

EDUCATION

1987 Ph.D., Theoretical Solid State Physics, McMaster University, Hamilton, Ontario

Thesis Title: *Some Aspects of the Strong-Coupling Theory of Superconductivity*

1983 M.Sc., Theoretical Solid State Physics, McMaster University, Hamilton, Ontario

Thesis Title: *Energy Dependence in the BCS Interaction Potential $V(\varepsilon, \varepsilon')$*

1981 B.Sc. (Hon) Physics and Mathematics, Memorial University of Newfoundland

Thesis Title: *A Determination of the Mean Square Anisotropy of Superconductors*

EMPLOYMENT

1993 Instructor, Department of Physics, Kwantlen Polytechnic University.

- Taught a variety of introductory, first-year, and second-year Physics and Applied Science courses.

1987 Postdoctoral Research Fellow, Department of Physics, Memorial university of Newfoundland.

- Modelled physical properties of co-polymer solids.

AWARDS

2004 NISOD Excellence Award.

1985-1986 McMaster University Graduate Fellowship

1981-1985 Natural Sciences and Engineering Research Council (NSERC) Graduate Scholarship

1981-1985 McMaster University Lyman Hooker Scholarship

1981	NSERC Summer Student Research Scholarship
1979	Memorial University of Newfoundland Faculty Association Scholarship
1977	Women's Association Scholarship
1976	Student of the Year, Brother Rice High School, St. John's NL
1976	Grade XI Newfoundland Provincial Government Scholarship
1975	Grade X Newfoundland Provincial Government Scholarship

MEMBERSHIPS

A longtime member of the executive of the BC section of the American Association of Physics Teachers and have held posts such as President and Treasurer.

PUBLICATIONS

1. J.M. Coombes and J.P. Carbotte, "On the Thermodynamics of Superconducting PB under High Pressure", Solid State Comm., **54**, 871 (1985).
2. J.M. Coombes and J.P. Carbotte, "Some Thermodynamic and Optical Properties of NbN", Solid State Comm., **58**, 657 (1986).
3. J.M. Coombes and J.P. Carbotte, "Dependence of $2\Delta_0/k_B T_c$ on the Shape of the Electron-Phonon Spectral Density", Jour. of Low Temp. Phys., **63**, 431 (1986).
4. J.M. Coombes and J.P. Carbotte, "Jump in Current at the Gap Voltage in a Superconducting Junction", Phys. Rev. **B**, **34**, 4622 (1986).
5. F. Marsiglio, J.M. Coombes and J.P. Carbotte, "On the Toxen Relation for the Energy Gap". Phys. Rev. **B**, **35**, 3219 (1987).
6. J.M. Coombes and J.P. Carbotte, "Functional Derivatives of the Current Jump at the Superconducting Gap", Phys. Rev. **B**, **35**, 6643 (1987).
7. J.M. Coombes and J.P. Carbotte, "Dependence of Superconducting Thermodynamic Ratios on the Shape of the Electron-Phonon Spectral Density", Phys. Rev. **B**, **38**, 8697 (1988).

Jana Kolac

Education:

Masters of Science in Physics - Charles University, Prague, Czechoslovakia
Thesis: Spectroscopy of comets

Career Summary:

2000 – present	Kwantlen Polytechnic University, Physics & Astronomy Instructor
1999	British Columbia Institute of Technology
1995 – 1998	Capilano College
1994 -- 1997	Douglas College
1992	Columbia College
1991	British Columbia Institute of Technology
1991	North Vancouver School Board
1990	Vancouver Community College – King Edward Campus
1989 – 1999	Douglas College
1977 – 1987	Publishing House, Prague, Czechoslovakia
	Editor: Editing contents of physics textbooks for high school and university levels.
	Senior High School, Melnik, Czechoslovakia
	Teacher: Teaching an advanced academic program in mathematics and physics

Memberships:

Astronomical Society of the Pacific
British Columbia Association of Physics Teachers

Donald J. Mathewson

don.mathewson@kwantlen.ca

Education: DEC: John Abbott College 1983 Awards in Math, Computer Science
BSc: McGill University 1987; Honours Math; Honours Physics
Gold Medal in Physical Science
MSc: UBC 1990; Physics (thesis: Mathematical Models of Immunity)
BEd: UBC 1990; Secondary Math, Physics

Work Experience:

2000-present: Instructor: Kwantlen Polytechnic University, Physics Department.
Teaching: Preparatory and U1 Physics, Environmental Physics, U2/3 Biophysics.
Department Chair 2007-2011. Rewrote several courses to include Interactive/Engagement strategies and modern probeware; one example is the *Physics 1100 Lab Manual*. Developed new Life Science Physics Courses for First and Third year students. Wrote *Environmental Physics*, a textbook for physics-of-energy courses.

1990-2000: Teacher: Steveston Senior Secondary, BC School District #38 (Richmond).
Teaching: Senior Physics, Math, Science and Technology (STS), Advanced
Placement Physics. Staff Professional Development (PD) chair for 2 years. Wrote resource book: *Activity Based Physics Instruction*, lab manual: *Physics 12 Lab Manual*,
and textbook: *Physics 12 Student Workbook*. These books are in use at many schools across BC.

Other Relevant Experience:

2006 to present: Founder, Organizer- Kwantlen Science Challenge
(www.kwantlen.ca/sciencechallenge). A Kwantlen sponsored competitive science event for BC High School students. It draws 400 students each year to compete in lab science events.

1993- present: Member BC Association of Physics Teachers (www.bcapt.ca).
Two terms as Vice-president and two terms as President. Helped organize three PD conferences annually for BC Physics/Science teachers. Presented workshops in 1996, 1997, 2006, 2007. Co-founder of bi-annual BCAPT/TRIUMF BC Science Teachers Day.

1987-present: Member Canadian Association of Physicists. Member of executive for 1994-5 (Director of Affiliate Members). In 1998, 2003, 2004, 2009, 2010 presented at annual CAP congress. In 2005 co-organized the CAP Congress' One-Day Teacher Conference. In 1987 organized annual national student (CUPC) conference.

1999, 2004, 2006, 2008: Physics workshops at BC Science Teachers bi-annual Catalyst Convention

2005, 2007, 2009, 2010: Physics workshops for School District #38 PD day and School District #36

Publications:

Activity Based Physics Instruction, Donald J. Mathewson, 1996
Physics 12 Student Workbook, Donald J. Mathewson, 2002
Physics 1100 Lab Manual, Donald J. Mathewson, 2005
Environmental Physics, Donald J. Mathewson, 2011

Curriculum Vitae: Takashi Sato, Ph.D.

Dept. of Physics & Applied Science
Kwantlen Polytechnic University

EDUCATION

- | | |
|------|---|
| 1986 | B.Sc. (Hons.) Physics and Astronomy
University of British Columbia |
| 1988 | M.Sc., with specialization in observational optical astronomy.
Dept. of Geophysics & Astronomy
University of British Columbia
Thesis Topic: "Deep CCD Photometry in the Globular Cluster M12." |
| 1995 | Ph.D., with specialization in observational millimetre and submillimetre radio and
infrared astronomy and numerical modelling.
Dept. of Physics
University of British Columbia
Thesis Topic: "Line and Continuum Studies of some Star Forming Regions." |

ACADEMIC APPOINTMENTS

- | | |
|----------------|--|
| 1996 – present | Faculty
Dept. of Physics and Applied Science
Kwantlen Polytechnic University (Kwantlen University College) |
| 2002 – 2003 | Sessional Lecturer
Dept. of Physics and Astronomy, University of British Columbia |
| 1997 | Faculty
Academic and Career Preparation, Kwantlen University College |

MEMBERSHIPS

- Canadian Astronomical Society
- Astronomical Society of the Pacific
- British Columbia Association of Physics Teachers
- SPIE - the international society of optics and photonics
- American Astronomical Society

SELECTED PUBLICATIONS

- Sato, T., Richer, H. B., & Fahlman, G. G. (1989). Deep CCD Photometry in Globular Clusters VIII. M12. *Astronomical Journal*, 98, 1335.
- McCutcheon, W. H., Sato T., Matthews, H. E., Kuiper, T. B. H., & Sutton, E.C. (1990). Comparison of Two Star Formation Regions in NGC 6334. *Bulletin of the American Astronomical Society*, 22, 1299.
- McCutcheon, W.H., Dewdney, P.E., Purton, C.R., & Sato T. (1991). Protstellar Candidates in a Sample of Bright Far-Infrared IRAS Sources. *Astronomical Journal*, 101, 1435.
- McCutcheon, W.H., Sato, T., Matthews, H.E., Kuiper, T.B.H., & Sutton, E.C. (1991). Comparison of Two Star-formation Regions in NGC 6334. *Journal of the Royal Astronomical Society of Canada*, 85, 192.
- McCutcheon, W.H., Sato, T., Purton, C.R., Matthews, H.E., & Dewdney, P.E. (1995). Millimeter and Submillimeter Wavelength Continuum Observations of Massive Young Stellar Objects. *Astronomical Journal*, 110, 1762.
- McCutcheon, W.H., Kuiper, T.B.H, Matthews, H.E., White, G.J., Sandell, G., Sutton, E., & Sato, T. (1998). The Multiple Star Forming Complex NGC 6334: Line and Continuum. *Journal of the Royal Astronomical Society of Canada*, 92, 25.
- McCutcheon, W.H., Sandell, G., Matthews, H.E., Kuiper, T.B.H. Sutton, E.C., Danchi, W.C. & Sato, T. (2000). Star Formation in NGC 6334 I and I(N). *Monthly Notices of the Royal Astronomical Society*, 316, 152.
- Sato, T. (2005). Imaging the Moon: Observation and Analysis. *Cosmos in the Classroom 2004: A Hands-on Symposium on Teaching Introductory Astronomy*, A. Fraknoi and W. Waller, Eds.
- Sato, T. (2008). Man on the Moon?, Paper presented at *Catalyst (BC Science Teachers Association)*, Kelowna, BC, Canada
-

Michael Poon, PhD

Education

- | | |
|------|--|
| 2004 | Ph.D. in Fusion Reactor Materials
Institute for Aerospace Studies, University of Toronto |
| 1998 | M.A.Sc. in Fusion Reactor Materials
Institute for Aerospace Studies, University of Toronto |
| 1996 | B.A.Sc. in Engineering Physics (MECH option)
University of British Columbia |

Research Experience

- | | |
|-------------|---|
| 2006 – 2009 | Post Doctorate Fellow
University of British Columbia, Department of Mechanical Engineering
Advisor: Dr. O. Kesler
<u>Project:</u> <i>Investigation of the use of pore formers in plasma-sprayed nickel-oxide/yttria-stabilized-zirconia anodes for solid-oxide fuel cells</i> |
| 2006 | Post Doctorate Fellow
University of Toronto, Institute for Aerospace Studies
Advisor: Prof. A.A. Haasz
<u>Project:</u> <i>Modelling thermal desorption of deuterium from tungsten, based on experimental thermal desorption data and secondary-ion mass spectrometry.</i> |

Teaching Experience

- | | |
|----------------|--|
| 2009 – present | Physics Instructor , Kwantlen Polytechnic University
Department of Physics and Applied Science |
| 2008 – 2010 | Physics Lab Instructor , Kwantlen Polytechnic University
Department of Physics and Applied Science |

Refereed Publications

(**bold** indicates principal author; underline indicates contributing author)

- Michael Poon**, Olivera Kesler. *"The influence of pore formers on the microstructure of plasma sprayed NiO-YSZ anodes"*, J. Power Sources 210 (2012) 204.
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Education:

Doctor of Philosophy, Astrophysics, University of British Columbia, 2009

Masters of Science, Astronomy, University of British Columbia, 2002

Bachelors of Science, Astronomy, University of British Columbia, 2000

Research Experience:

Doctoral Student, Department of Physics and Astronomy, University of British Columbia
Advisor: Dr. Chris Waltham

Thesis: Through-Going Muons at the Sudbury Neutrino Observatory

- Neutrino oscillation parameters
- Event reconstruction, data processing and extraction
- Pattern recognition, image processing and smoothing, edge detection
- Photomultiplier tube hit timing response model

Masters Student, Department of Physics and Astronomy, University of British Columbia
Advisors: Dr. Stephane Courteau and Dr. Paul Hickson

Thesis: Galaxy Classification in the UBC/NASA Multi-Narrowband Survey

- Galaxy identification
- Image processing, smoothing filters

Teaching:

April 2010 – Present

Laboratory Demonstrator, Langara College, Vancouver, BC

January 2010 – Present

Instructor, Langara College, Vancouver, BC

May 2009 – Present

Instructor, Kwantlen Polytechnic University, Surrey, BC

Conferences and Workshops:

December 2009

Instructional Skills Workshop. Langara College.

June 2006

Neutrino 2006. Santa Fe, NM

Poster presentation: Muons and Atmospheric Neutrinos at SNO

June 2005

Canadian Association of Physicists Congress. Vancouver, BC

Poster Presentation: Pattern Recognition Techniques for Analyzing Muons at SNO

February 2005

Western Regional Nuclear and Particle Physics Conference. Banff, BC

Oral Presentation: Looking for SNO Cones

Selected Publications:

1. **R. Abruzzio et. al.**, Calibration of Muon Reconstruction Algorithms Using an External Muon Tracking System at the Sudbury Neutrino Observatory, Nucl. Instr. Meth. A648, 92, 2011
2. **The SNO Collaboration**, Measurement of the Cosmic Ray and Neutrino-Induced Muon Flux at the Sudbury Neutrino Observatory, Phys. Rev. D, 80, 012001, 2009
3. **The SNO Collaboration**, An Independent Measurement of the Total Active ^8B Solar Neutrino Flux Using an Array of ^3He Proportional Counters at the Sudbury Neutrino Observatory, Phys. Rev. Lett. 101, 111301, 2008
4. **The SNO Collaboration**, Determination of the ν_e and Total ^8B Solar Neutrino Fluxes with the Sudbury Neutrino Observatory Phase I Data Set, Phys. Rev. C 75 045502, 2007
5. **The SNO Collaboration**, A Search for Neutrinos from the Solar hep Reaction and the Diffuse Supernova Neutrino Background with the Sudbury Neutrino Observatory, ApJ 653, 1545, 2006
6. **The SNO Collaboration**, A Search for Periodicities in the ^8B Solar Neutrino Flux measured by the Sudbury Neutrino Observatory, Phys. Rev. D 72, 052010, 2005
7. **The SNO Collaboration**, Electron Energy Spectra, Fluxes, and Day-Night Asymmetries of ^8B Solar Neutrinos from the 391-Day Salt Phase SNO Data Set, Phys. Rev. C 72, 055502, 2005

Appendix D

Library Impact Assessment

Name of Program

Library Impact Assessment

for New and Revised Programs

December 2, 2011

**Kwantlen Library Impact Assessment Process for
New and Revised Programs**

ASSESSMENT POLICY

1. Library impact assessments will be completed for new degree, diploma, certificate, or citation programs, and for major program revisions.
2. Requests for a library impact assessment are to be directed to the Senate Standing committee on curriculum (SSCC) liaison librarian.
3. The development of library impact assessments for programs is based on a consultative model. The SSCC liaison librarian will review proposals and consult with both proposing faculty and with appropriate librarians. In the case of revised programs, the SSCC liaison librarian will make a decision on whether the revised content requires a library impact assessment.
4. Timelines for completion of the Library Impact Assessment are:
 - New Programs:** Developers must allow a minimum of 3 weeks for the completion of a new program library impact assessment.
 - Revised Programs:** Developers must allow a minimum of 2 weeks for the completion of a revised program library impact assessment.
5. Completed library impacts assessments will be signed by the SSCC liaison librarian and the university librarian and sent to the program developer. A copy of the assessment summary (Part B only) must be appended to the program concept and sent to the Senate office after the program and developer has reviewed and signed the assessment. Assessments will be sent electronically to the Senate office and will be followed by signed paper copies.
6. The library impact assessment will normally include projected and retrospective monograph and periodical costs based on average costs for materials in the subject area, collection needs of the program or course, average price increases in the subject area as well as the strength or weakness of the existing collection. Audio-visual purchase costs will be included where appropriate. Projected enrolments will be included in the cost calculations where multiple sections or multiple campus enrolments are indicated or in cases where most resources will be provided by interlibrary loan.
7. Specialized or subject-specific databases not already held by the library will be costed against the number of 300- and 400- level courses in the subject area. Upper-level field courses, co-ops, and practicums will be deducted from the total number of subject area 300- and 400- level courses.

Library Resources Impact Assessment New Program Proposal or Revision

Name of Program:

B.Sc. Major: Physics for Modern Technology

Is this a Revision of an Existing Program?Yes ☐ No ☒**Name(s) of Program Developer(s):**

Fergal Callaghan

Graham Rankin

Takashi Sato

Key Online Databases (periodical indexes/abstracts):

Name	Held by KPU Library?	If no, estimate annual cost to provide:
PhysicsNetbase	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	\$2500
Sub Total		\$2500

Comments:

From astrophysics to quantum physics, materials science to optoelectronics, this collection of e-books offers both fundamental theories as well as contemporary investigations of time, matter, and space. Also includes many volumes from the world-renowned Institute of Physics Publishers

Key Periodicals (core titles in the subject area):		
Name	Held by KPU Library?	If no, estimate annual cost to provide:
Various*	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	\$3000
Sub Total		\$3000
Comments: * Titles would be selected depending on which databases were added. Acquisitions for the serials collection would be selected in consultation with faculty. We also investigate the feasibility of subscribing to the specific journals indicated on the bibliography sections of the new course outlines.		

Key Reference Titles:		
Name	Held by KPU Library?	If no, estimate annual cost to provide:
Encyclopedia of Physical Science (electronic)	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	\$244
Concise Handbook of Mathematics, Physics, and Engineering Sciences (electronic)	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	\$119
Illustrated Encyclopedia of Applied and Engineering Physics	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	\$149
Sub Total		\$512.00
Comments:		

Monographs:	
Number of titles held by Kwantlen in this subject area:	344
Number of titles published annually in this subject area:	800-900
Average number of titles purchased annually:	30
Average cost per volume of titles in this subject area:	\$125
Is the collection current?	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
Data/Comments on the currency/comprehensiveness of the monograph collection in this subject area:	
~135 or 40% are published later than 2000	
Sub Total	
0	
Comments:	
Physics currently has a yearly operating budget of \$2,000. The subject selector for Physics, Colleen van de Voort, submits that up to ½ of this could be used to develop the collection for these degrees. To begin with, she estimates that amount should be sufficient.	

Key Audio Visual Materials:	
Number of titles held by Kwantlen in this subject area:	200
Number of titles published annually in this subject area:	30
Average number of titles purchased annually:	5
Average cost per volume of titles in this subject area:	\$250
Is the collection current?	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
Data/Comments on the currency/comprehensiveness of the monograph collection in this subject area:	
The video collection is adequate for the present course offerings in Physics. However the proposed new course offerings for a Major, Minor and B.Sc. in Physics require the additional purchase of DVDs especially in the area of electricity, magnetism, quantum mechanics, optics, optoelectronics, thermal physics and solid state physics. Further, out-dated Physics related VHS need to be replaced with more current DVDs or streamed videos.	
Sub Total	
\$5000	

Summary Statement:

Overall the Library will continue to work on developing a good core collection of physics material and improving the currency of the collection. Specifically we will focus on acquiring more higher level material and appropriate material related to the new degree courses.

The collections of the 3 institutes that were visited in preparation for drafting the degree proposal will serve as a resource for some of the collection development related to the new degrees:

Cork Institute of Technology: 377 titles with a Physics subject heading, overall an old collection

Galway-Mayo Institute of Technology: 446 titles with a Physics subject heading

Waterford Institute of Technology: 540 titles with a Physics subject heading

Previous Collection Development:

The current collection has been developed to meet the needs of students enrolled in existing undergraduate courses.

Future Collection Needs:

With some additions, the research needs of first and second year students enrolled in this program should for the most part be adequately met by our current print collections developed for Physics. We plan on expansion in our upper level materials. Also, if faculty is actively conducting their own research, and need specific or extensive materials, the Library is prepared to accommodate these requirements.

Collection Development Obstacles:**Funding:**

It is recommended that funding for library resources be continued and increased in order to build an excellent, academic, polytechnic library collection, appropriate to a university offering academic degrees.

Time:

Expanding the library collection and acquiring new online research databases will take place over a period of time. It is important that the Library continue to be involved in the planning and development of new degrees and programs in order that sufficient preparation time is available for the planning and building of new library collections.

Total Estimated Start up Costs (one time):

n/a

Total Estimated Annual Costs (on-going):

\$11012

Assessment Prepared by:



Elaine Samwald, SSCC Liaison Librarian

02 December 2011

Date

Assessment Reviewed by:



Cathy MacDonald, University Librarian

December 6, 2011

Date

Kwantlen Polytechnic University
Library Impact Assessment
Support for Program Proposal/Revision

Name of Program**Date**

B.Sc. Major: Physics for Modern Technology

02 December 2011

The Library supports the development and implementation of the proposed B.Sc. Major: Physics for Modern Technology. We feel that with some strategic collection growth the impact on Library resources and services should be very manageable.

This Library Impact Assessment has been based on the most current information available but it is possible that, as course outlines and specific curriculum are developed; further resources may need to be allocated in support of this program. The Library will continue to work with the Physics department to ensure that the resources and services remain current and effective.

Summary of Start-up and Subsequent Costs:

Reference Materials	\$512
Videos	\$5000
Periodicals	\$3000
Databases and Indexes	\$2500
Monographs	n/a
TOTAL	\$11012

Assessment Prepared by:


Elaine Samwald, SSCC Liaison Librarian

02 December 2011

Date

Assessment Reviewed by:


Cathy MacDonald, University Librarian

Date

Please attach this section only to the program concept.

Part B

I support this collection assessment: Yes ☐ No ☐*

Program Developer:

Name/Title

Date

**Please provide reasons for non-support of assessment*