Physics & Astronomy Articulation Committee Meeting
May 5, 2017
Camosun College Lansdowne Campus, Victoria BC
Location: Wilna Thomas Cultural Center (WT 234)

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Nicole Arklie	Ministry of Education	Nicole.Arklie@gov.bc.ca

The meeting was called to order at 10:04am by Jennifer Kirkey, Chair.

1. **Introductions**

Chris Avis welcomed everyone to Camosun College and made a territorial acknowledgment: *Camosun College campuses are located on the traditional territories of the Lkwungen and W̱SÁNEĆ peoples. We acknowledge their welcome and graciousness to the students who seek knowledge here.*

Dominic Bergeron, Dean of Arts and Science, made a brief introduction and welcomed the committee to Camosun College. Jennifer Kirkey briefly covered meeting logistics.

Round Table of Introductions, all present introduced themselves and the institutions they were representing.

2. **Approval of the Agenda**

Takashi Sato motioned, Mark Laidlaw seconded. Motion carried, agenda approved.

3. **Approval of the May 2016 Minutes**

Dennis Lightfoot motioned to approve, Arnold Sikkema seconded. Motion carried, minutes approved.

4. Matters Arising from Minutes

Link to 2016 Minutes: http://www.bccat.ca/pubs/physics-and-astronomy-2016

5. Corrections/changes to Textbook Lists

Lists/Charts available at http://www.bccat.ca/articulation/arts/phys-astr

Presently there is an issue with the link and Jennifer Kirkey will correct this. (Action item)

6. BCCAT issues and information – Pending Requests in the Transfer Credit Evaluation System (TCES)

Bob Wood – System Liaison. He attends this meeting and presents information to BCCAT:

New curriculum is being developed for high school physics and the question is how that will integrate at the post-secondary level. New curriculum will be introduced in 2018. Committee members were provided a hand out that was included from BCCAT.

New courses/updated courses list provided to all members.
Discussion ensued around who University of Canada West (UCW). They are a private institution located in Vancouver. UCW is part of the BCCAT system and institutions should be processing transfer credit requests to and from them.

Barbara Frisken asked about resources for new Chairs. BCCAT website has information on articulation meetings for new Chairs. Jennifer Kirkey will add that link into agenda package so all new members are aware. (Action item)

7. BCCAT Update by Mike Winsemann (BCATT's Director of Information Technologies) and Dr. Robert (Bob) Wood (BCCAT System Liaison / Trinity Western University)

- Joint annual meeting is Nov 17th in Richmond Westin Wall Center – all Chairs invited that day.
- Currently accepting nominations for the BCCAT Transfer Awards.
- Rolling out new Transfer Credit Evaluation system. Will include new features, and can be used for more than just BC Articulations. Can be used nationally or internationally. Currently working with UVIC on a pilot project, and has potential to import and publish articulations. Whoever the institutional contact is will have access to this system.
- Education Planner BC application platform is being expanded and customized. Will include domestic and international students.
- Building a transcript exchange electronically. This includes high school and university/college transcripts. Trying to make application process much easier.
- Report coming out in June 2017 that looks at the issues of gender declaration on post-secondary information systems. While all members are philosophically on board, it is a matter of working towards something that works for technology and reporting reasons. They are looking at either dropping the question completely, or adding in more gender options.
- Report will also include the impact of post-secondary curriculum changes impact from high school curriculum changes.

8. Google group https://groups.google.com/forum/ - !forum/physastro-articulation

Contact Jennifer Kirkey regarding this group, she is the administrator. This is the main way that we communicate official documents so please make sure that the official representative is part of the group.

9. Confirmation of date/location of 2018 Meeting

Jennifer Kirkey has arranged for Douglas College to host the 2018 Articulation Meetings.

Engineering – Douglas College (New Westminster) Thursday May 3rd, 2018
Physics & Astronomy Articulation – Douglas College (New Westminster) Friday May 4th, 2018

BCAPT meeting – Douglas College (New Westminster) Saturday May 5th, 2018

Ryan Ransom from Okanagan College has offered to host Physics & Astronomy Articulation in 2019 and UBC-O will host the Engineering Articulation.

10. Roundtable reports/brief discussions of significant curriculum changes and associated issues (please see the full reports at the end of these minutes)

Alexander College

- Indian, Korean, and Chinese students make up the majority of Alexander College
- Algebra for Physics had low attendance which was cut
- Now offering grade 12 physics courses, starting in 2017 Winter

Camosun

- Revitalized courses to align with UVIC for one to one transferability
- 10% was knocked off final exam in PHYS-140 and 141 (from 50% to 40%) and 10% used on a lab exam. This was successful
- Demographic is changing – recruiting more International students. Higher rates of mental health issues/anxiety in Victoria students, probably due to higher rents in our area and students are having to work more than ever to support themselves.

Capilano

- New president at Capilano
- Algebra based physics course cut due to low enrolment
- Changing pre-requisites for calculus based physics
- Changing labs from 2 hours to 3 hours permanently, and at no cost to lecture hours

College of New Caledonia

- Offering 102 in both semesters
- Algebra based physics as low enrolment
- Also offering physics for medical radiography
- Civil Engineering program starting in Prince George with space for 90 students

College of the Rockies

- Slightly lower enrolment, generally lower in Winter vs. Fall
- No students registered in second year physics
- Offering gr 11 / 12 equivalency
- Still offering Astronomy – more interest from non-science students
- Wondering about purchasing a liquid nitrogen generator. Trevor is trying to justify the cost and is looking for feedback. Suggestions around sharing the use with the hospital to share the cost. Any further suggestions send to Trevor.

Columbia College

- Record high for enrolment, Physics enrolments stable
- Offering optics physics every semester now
- 2nd year E&M course hasn't been able to run yet
- Physics for non-science people – Tara would like suggestions for labs

Coquitlam College

- Continues to offer only 1st year physics
- Enrolment is good – still some challenges with calculus based physics

Douglas College

- Bigger than ever due to Engineering program
- Renovation was completed in September
- New Skytrain (Evergreen line) finally opened for Coquitlam campus access so there is hope that there will be more physics courses offered there.

Kwantlen

- Physics for Modern Technology - 3rd year has work term
- New online lab section piloted for PHYS 1100 (entry point for students who didn't take Physics 12). Only the lab section is offered online, lecture is on campus. Uses the IOLab Wireless Lab System offered for remote lab (North Island College also uses) this is signed out to students during the pilot run. These units cost approximately $100USD each. This hasn't increased cost of the course currently for the labs. Discussion about having this on the articulation agenda for next year. (Action item.)

Langara

- Most popular course is Physic 12 equivalent course
- Increase overall to international students – and international students make up the majority of enrolled students
- Unique challenges that are associated with international students (topic)

North Island College

- Fall semester always has higher enrolment than winter
- Space Science and Astronomy courses are being offered again after five years without, via ITV (video conference) in Port Alberni and Campbell River. Labs will be conducted via observation and some on each campus
- Actively recruiting for Dean of Arts, Science and Technology

Northern Lights College

- No physics courses being offered at this time

North West Community College

- Currently offers 4 courses
- New certificate in Physical science and Engineering Transfer
- PHYS 102 is offered via video conference, and Efran would like to discuss implications of video conference offered classes (offered to Prince Rupert via Terrace)

Okanagan College

- No major changes
- Offering 2nd year Astronomy courses which are open to Arts/Science/Business students as these do not have math pre-requisites
- Richard Christie is retiring this year

Selkirk

- No major changes

SFU

- Questions for Barb around the 'optional' textbook purchase for PHYS 140/141
- New labs from previous years have been implemented and are running smoothly since the changes
- Added some black box experiments (Colgate University) which have gone over well with Physics students as they are puzzle-like
- Sapling introduced about a year ago, experienced some issues. Other colleges have experienced technical issues in the marking portion – small glitches that had students doubting their answers

Thompson Rivers University

- No curriculum changes
- Enrolment in physics has seen a decline
- Local MLA, if elected, has promised more spaces for Engineering courses which should help

Trinity Western University

- Started using a new textbook – Principles & Practice of Physics by Eric Mazur. Went reasonably well according to the instructor. Some sequencing changes. Some viewpoints were 'picky', but will stick with it for another year

University of British Columbia - Okanagan

- First year enrolments are up, second year enrolments are down
- Calculus will be a co-requisite for all first-year Physics

University of British Columbia - Vancouver

- Stable enrolment
- Reconsider articulation agreements if you have a lab-less first year Physics course check to see if it will still articulate to UBC – PHYS 117
- 25-30% of graduate students came in as transfers

University of the Fraser Valley

- No major changes

University of Northern British Columbia

- Second year enrolment has gone up 78%
- Two years ago, they changed Astronomy acronym from PHYS to ASTR and saw a huge rise in enrolment
- Seeing a decline in Physics for Future Leaders (non-science Physics course)

University of Victoria

- PHYS 102 being split in 102A and 102B
- Introducing a new course: Computer Assisted Mathematics and Physics (being taught in Python) co-requisite of Vector Calculus and a programming pre-requisite
- Textbooks – Calculus Based: moving to a textbook written by UVIC faculty (Laidlaw and Keeler) will be sold for $40-$50 and will have an electronic edition as well.
  Tried out Moodle vs Mastering Physics and did not find any change in student homework completion, but Pearson stores student info in USA (which is against Canadian privacy legislation)

Vancouver Island University

- Global Issues in Science course funded by international department that is successful and hoping to expand

Vancouver Community College

- Physics in Music: will be split up into physics then application (music side)

- Similar issues with low calculus grades

Yukon College

- 13 Campuses across the Yukon with 1200 students
- Whitehorse campus PHYS-101 has 4 students PHYS-102 had 2 students, both calculus based courses
- First time at articulation

University of Alberta

- Does not get a dramatic number of BC students
- No separate report for Physics, but circulated the one that was written for Engineering

11. Changes to the Secondary School Science and Math Curriculum (Angie Calleberg and Nicole Arklie from the Ministry of Education presenting)

Information regarding these changes can be found at: https://curriculum.gov.bc.ca/sites/curriculum.gov.bc.ca/files/pdf/BC_Curriculum_Comparison_Guide.pdf

Presentation made by Angie Calleberg and Nicole Arklie, and information was distributed. The Ministry is looking for feedback from this by Fall 2017 (by early September) for implementation Fall 2018. Discussion around K-12 curriculum followed.

Jennifer Kirkey: What feedback do we want to give to BCCAT formally as an Articulation Committee?
Motion on the floor to ask BCCAT to reinstate Provincial Exams.
Bradley Hughes asking for research and prior to voting on this. Motion was not carried to a vote.

Motion on the floor to instead request standardized summative assessment for post-secondary Physics entry. Discussion around pushing for Mathematics assessment rather than Physics assessment. More research needed on this motion as well. Motion was not carried to a vote.
Jennifer Kirkey encouraged the discussion to continue, communication around this can continue via Google group. (Action item)

12. BCcampus and Open Textbook Projects – How to make your own textbook using PressBooks and Beyond the Textbook with Open Pedagogy

BCcampus Open Education is supported by the British Columbia Ministry of Advanced Education and the Hewlett Foundation. Their mission is to make more open textbooks available at colleges and universities. https://open.bccampus.ca/ Open Textbooks are under an open copyright license and are free and legal to edit. The books are available in many formats. Once you've chosen a book you can legally edit and adapt the textbook as you see fit. It is highly recommended that you use PressBooks for editing and modifying. Easy to use and the equations are in LaTex. PressBooks is located in Montreal, therefore they comply with Canadian privacy laws. Be careful to use the BCcampus version as the regular PressBooks site has a file size limitation for free books. HTTPS://PRESSBOOKS.BCCAMPUS.CA
You can see Jennifer's catalog at https://pressbooks.bccampus.ca/catalog/kirkeyj

OpenStax is an organization based in the United States. They have a list of high-quality open textbooks in math, science, astronomy as well as some business and history. The books look and feel like a regular book from a big publisher. https://openstax.org/ has a list of textbooks available that have been edited and peer reviewed. OpenStax does not have associated homework software but something like Sapling can be applied. The textbooks hardcover will be about $50, electronic is about $15 soft cover about $35.OpenStax books are available for anyone to download. Free and legal to edit for you to edit. "Perfect Binding" through SFU is available for the printing of soft cover books. BCcampus uses SFU for all their printing.

Astronomy OpenStax is available now and Jennifer highly recommends it as she has used it the last two semesters in her astronomy for liberal arts course. Jennifer is working on importing it into PressBooks for easy editing. She will be making a Canadian content OpenStax Astronomy. All the equations created through LaTex.

There is grant money available for work like this from BCcampus and the Articulation Committee should consider coming up with a BC Textbook together.

13. Solar Eclipse: Monday, August 21st at approximately 10am
SolarFest: Madras, Oregon. For $150USD you can have a 5-day campsite. www.oregonsolarfest.com

Totality will occur in a band from Oregon to Carolina. About 60% coverage in Vancouver area. There will be lots of media interest around this event so consider holding an event at your institution.

14. Campus Tour

15. Adjournment

Physics and Astronomy Articulation May 5 2017

Reports and Contact Information

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Contact information for non-physics Chairs at the meeting

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Ministry of Education: Angie Calleberg Angie.Calleberg@gov.bc.ca

Ministry of Education: Nicole Arklie Nicole.arklie@gove.bc.ca

Physics representatives and their contact emails

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KPU- Kwantlen Polytechnic University	Takashi Sato	Takashi.Sato@kpu.ca
Langara College	Bradley Hughes	bhughes@langara.ca
North Island College	Dennis Lightfoot	Dennis.Lightfoot@nic.bc.ca
Northern Lights College	Glen Lainsbury, Dean	No physics courses being taught there now. glainsbury@nlc.bc.ca
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University of Alberta	Torrey Dance	torrey@ualberta.ca

Alexander College

Alexander College is a small private college that focuses primarily on foreign students who cannot get into the regular Provincial universities due to a lack of language and cultural skills. We have two campuses, one in Burnaby near Metrotown and the other in Downtown Vancouver opposite SFU Harbour Centre. We typically offer about 100 different courses with a combined enrollment of 1,600+ students.

Our general aim is to offer students a palette of first- and second-year courses along with intensive language training and small classes, where a large amount of personal attention is possible. The courses are designed to be at the academic standards of the corresponding introductory courses at SFU, UBC and UVic and, thus, to provide transferable credits to students who wish to gain entry to those institutions. We presently offer two-year "Associate" programs in Arts, Science, and Business, all of which include laboratory science requirements. We are in the process of developing a program of First-Year Engineering Transfer and are interested in implementing the *First-Year Engineering Curriculum for the BC Post-Secondary Sector* prepared by Brian Dick (Vancouver Island University) for our physics courses.

All Physics courses are offered at the Downtown campus limited to a class size of 20 students. Smaller classes allow students to more easily examine concepts in groups and share their results with the class. In addition, students are given the opportunity to work with concepts as they are being presented through active learning techniques and laboratory exercises.

Physics courses presently approved are:

Physics 100: Introduction to Physics (58 students over the last 3 terms) A one-semester preparatory course for students lacking physics background at the BC 12 level. (Text: Knight, Jones, and Field, *College Physics*) Note: Runs every semester; the past year ~45% of the students who registered in the course received A or B grades.

Physics 101-102: Physics for the Life Sciences I and II Two sequential one-semester algebra-based introductory physics courses for students concentrating in Biology and Chemistry. (Text: Giancoli, *Physics: Principles with Applications*) Note: Has not been offered since 2011.

Physics 141-142: Engineering Physics I and II

I: Mechanics and Modern Physics

II: Electricity and Magnetism, Optics

Two sequential one-semester calculus-based introductory physics courses designed for science and engineering students. (Text: Cummings, Laws, Reddish, and Cooney, *Understanding Physics*) Note: Was not offered last year.

Physics 151-152-153: Our 3-course Engineering sequence

151: Mechanics for Engineers (18 students over 1 term)

(Text: Hibbeler, *Engineering Mechanics: Static and Dynamics*)

152: Oscillations and Waves, Fluids, Heat, and Thermodynamics (31 students over 2 terms)

153: Electricity and Magnetism, Circuits, and Radiation (8 students over 1 term) (Text: *Knight, Physics for Scientists and Engineers*) Note: The past year, ~50% of the students registered in the course received A or B grades.

Physics 191: Introduction to Astronomy (18 students over 1 term) (Text: Backman, *ASTRO*) Note: The past year, ~33% of the students registered in the course received A or B grades.

BCIT – British Columbia Institute of Technology

The BCIT Physics Department has 11 full time faculty members, 3 technicians, and teaches around 1000 students in 17 different technologies.

This past term we offered a Grade 12 equivalency course through Part-Time Studies. There is demand for this as most of BCIT's engineering programs have increased their physics requirement to Physics 12.

James Brewer

Camosun College

In school of Arts & Science Studies at our Lansdowne campus, we offer college prep (access) PHYS 101 as well as first year courses: PHYS 104/105 (algebra based) and PHYS 140/141 (calculus-based) and enrollment in these courses has remained fairly steady over the past year. We are noticing increased interest in Physics 104 which is at an academic level comparable to Physics 12 and can be used as an entry requirement to college programs such as Medical Radiography and our 1st year Engineering Transfer. This fall we are also piloting a section of 101 delivered at a high school in the Western Communities in an effort to better serve students in this area of the Capital Region.

140 and 141 were run for the first time this year as a redesign of our previous calculus based courses to align with UVic's curriculum for their 110 and 111 courses. The initial offerings of both courses went fairly well, and we have introduced lab exams along with these courses. Most students seem to take the labs more seriously and come out from the course with a better set of lab skills for having done the lab exam. The major drawback is that the structure of our current exams puts a lot of demands on instructors at the tail end of term and requires two instructors to be present during each lab exam. We are also planning to switch from Young and Freedman's University Physics to Knight's Physics for Scientists and Engineers as the default textbook for these courses as we find the level of writing and coverage of material to be a better fit for the academic level of the courses.

Astronomy courses (ASTR 101/102) continue to attract students in large numbers and we have continued to maintain increased offerings with 3 sections per semester. The second-year courses at our Lansdowne Campus (PHYS 200, 210, 214 and 215) remain closed since 2010.

The department also offers "service" courses that are restricted to students in certain career programs. We offer MRAD 165, a Radiology Physics course at our Lansdowne Campus that is launching this Spring and PHYS 160 (Biomechanics) as a service course for PISE (Pacific Institute for Sport Excellence) at our Interurban Campus. Our remaining service courses are for various engineering programs offered at the Interurban campus and include engineering-restricted sections of

PHYS 101 and 104 as well as courses focussing on mechanics, electricity and magnetism (PHYS 157), 2nd year electricity and magnetism (PHYS 210), renewable energy (PHYS 272) and waves, optics and E&M (PHYS 295).

The demographic of the college is gradually changing. Over the past few years, Camosun has made a major effort to recruit international students to the college. On the whole instructors find that these students have a better work ethic than domestic students but transfer credits are sometimes badly assessed with the result that some of these students are placed in courses that are too advanced. There is a continuing trend of domestic students seeming to be more and more ill-prepared for the rigours of a full college workload and suffering from more mental health problems. Anecdotally, it seems that this is due, to a large extent, to students having to work more than ever to afford to attend school as well decreasing standards in high school courses. Many students report heightened anxiety surrounding testing and faculty have been encouraged to find alternative means of evaluating students.

Bob Sedlock, a long-time faculty member, retired in December 2015. As a result of this, we have partially regularized our term faculty member, Stephanie LaForest, to part-time continuing status.

Chris Avis Chair of Physics & Astronomy

Enrollment Numbers 2016 Fall – 2017 Summer

Fall	**Winter**	**Summer**
ASTR 101 – 50	ASTR 101 – 32	PHYS 101 – 28
ASTR 102 – 28	ASTR 102 – 49	PHYS 104 – 28
		PHYS 105 – 22
PHYS 101 -120	PHYS 101 – 76	PHYS 141 – 10
PHYS 104 – 90	PHYS 104 -108	
PHYS 140 – 57	PHYS 105 – 53	
	PHYS 140 – 25	
PHYS 210 – 50	PHYS 141 – 38	
	PHYS 157 – 32	
	PHYS 160 – 33	
	PHYS 272 – 29	
	PHYS 295 – 39	

Capilano University

This year we offered: Introductory Physics (PHYS 104 x3), “calculus-based” (PHYS 114 x4, 115 x3), Physics for Engineers (PHYS 116 x2) and (PHYS 110 x1), our astronomy course ASTR (106 x2), and a service course for the Motion and Picture Arts (MOPA) faculty (SCIE 410: The Science of Sound and Light). Compared to 2015-2016 we are down one section of PHYS 111 and up one section of PHYS 115. The additional offering of PHYS 115 resulted from expansion in Engineering. The loss of PHYS 111 was due to low enrolment. The underlying cause of the PHYS 111 low enrolment is unknown.

For 2017-2018, we will be able to offer the same courses as 2016-2017 with an additional section of PHYS 114, and we will not be offering sections of PHYS 110 (or PHYS 111), or SCIE 410.

We have changed the length of our Phys 114 and Phys 115 labs from two contact hours per week to three contact hours per week. This change will likely be in place for Fall 2017. We will be seeking re-articulation for those two courses. Additionally, we have increased the pre-requisite requirements for PHYS 114 to a minimum B in Physics 12 (or equivalent), and this change will also be in place for Fall 2017.

Total enrollments for PHYS courses are down about 5% from the 2015-2016 academic year. Astronomy 106 has decreased in enrolment from 60 students per year to 55 per year. Total enrolment, including service courses, has remained nearly constant from 2015-2016 to 2016-2017.

CNC - College of New Caledonia

CNC offers calculus-based (PHYS 101/102, PHYS 204) and algebra-based physics courses (PHYS 105/106) to accommodate first year engineering transfer and general science transfer programs. Comparing to last year, we observed an increase in enrolment in calculus based-physics and a decrease in algebra-based physics.

PHYS 101 - Introductory Physics I - 52 students

PHYS 102 - Introductory Physics II - 29 students

PHYS 105 - General Physics I - 7 students

PHYS 106 - General Physics II - 6 students

PHYS 204 - Mechanics I Statics - 28 students

This year, algebra-based PHYS 105/106 courses were delivered only at the Prince George campus. Next year they will be offered via video conference, with the lectures broadcasted from Quesnel to Prince George and the labs delivered locally in Quesnel and Prince George. We are continuing delivery of calculus-based PHYS 101/102 in the off-semester pattern and delivery of PHYS 101 in intersession. This year we also started off-semester delivery of the mechanics course PHYS 204.

The Physics Department also offers two Medical Radiography physics courses, MRAD 113 and MRAD 245. In September 2016, the names of these courses were changed to PHYS 115 (Medical Radiography 1) and PHYS 225 (Medical Radiography 2), respectively. Also, the delivery pattern was modified and starting with 2016 cohort both courses are 15 weeks long comparing to the previous 15 weeks for MRAD 113 (term 1) and 20 weeks for MRAD 245 (term 5).

Barbara Rudecki Department of Physics & Applied Science

College of the Rockies – COTR

College of the Rockies

2017 Engineering Articulation Report

College of the Rockies continues to offer our first-year engineering transfer program (Engineering Certificate) with a block transfer available for students intending to enter UVic. Numbers have held steady with 15 students registered in our Intro to Engineering course in the fall semester (up from 12 in fall 2015), and 7 students registered in our spring semester Engineering Design course (down from 9 in spring 2016).

Starting in fall 2017, the scheduling of our engineering courses will undergo some changes:

Currently, our engineering students take ENGL 100 (English Composition) in the fall semester (Sept - Dec) and COMC 102 (Advanced Professional Communication) in the winter semester (Jan - Apr). They then take COMP 105 (Intro to C/C++) and APSC 123 (Engineering Design) in the spring semester (May - June).

Starting in fall 2017, COMP 105 will be offered in the fall semester and APSC 123 will be offered in the winter semester. ENGL 100 and COMC 102 will be offered in the spring semester, both as online courses.

Our hope is that these changes will give our students more freedom to work summer jobs (online courses can be done on their own time), and allow them to send preliminary transcripts that include all of their core engineering courses much sooner to receiving institutions, all while avoiding the increased workload that would result from trying to squeeze all courses into the fall and winter semesters alone.

Columbia College

2017 Physics & Astronomy Articulation Report May 5, 2016 - Camosun

Columbia College is completing our fourth year at our new campus and enrollment is at a record high for the college. Although the physics department has grown substantially over the past five years, over the past 2 or so, enrollment in physics has stabilized.

In 2016/17 Columbia College ran eight Physics courses, with six of them at the UT level and 2 at the secondary level:

- Physics 110 (Calculus based Newtonian Mechanics) 1- 15 1-15 1-6 1-13
- Physics 120 (Calculus based Electricity and Magnetism) 1-8 1-11 1-10
- Physics 130 (Calculus based Optics and Thermodynamics) 1-19 1-16
- Physics 118 (Engineering Mechanics) 1 – 5 1-4
- Physics 200 (Introduction to Modern Physics) 1-4 1-2
- Physics 205 (Thermal Physics)
- Physics 11 1-14
- Physics 12 1-14 1-27

The enrollment is fairly stable in our UT program. Throughout the 2016-2017 academic year, there has been a total of 4 sections of Physics 110 (approximately 15 students each), 3 sections of Physics 120 (approximately 10 students each), 2 section of Physics 130 (approximately 18 students each), and 2 sections of Physics 118 (only 4 and 5 students each time). This is one additional first year section than was offered in the previous year. Physics 200 has been offered two times, both as directed study courses due to low enrollment, and Physics 205 was not offered, but will be on the summer 2017 timetable. Typically Physics 200 and 205 are offered in alternating semesters.

Enrollment in Physics 11 is continuing to stay fairly low (14 students the last time it was offered), and the enrollment in Physics 12 has jumped substantially with 27 students enrolled last semester. Throughout the year, Physics 11 and 12 courses are offered in alternating semesters.

We have recently prepared a second-year Electromagnetics course that we hope to offer in the 2017-2018 academic year and are preparing a basic physics for non-science students to be articulated in Summer 2017.

Tara Todoruk

Columbia College
Vancouver, BC

Coquitlam College

There were no changes in Physics curriculum at Coquitlam College in the past year. We offer 1st year calculus-based Physics courses: Physics 101 (mechanics with an introduction to thermal Physics) and Physics 102 (electricity, magnetism and optics). Physics 101 is offered in the summer and the fall semesters, Physics 102 is offered only once a year in the spring semester. At present, there are no plans for the second-year courses.

The enrolment so far has been stable and good. As a rule, the classes of Physics 101 are full (100%), and the number of students enrolled in Physics 102 ranges from 16 – 20 (80 -100%). In the fall semester, the number of students frequently increases above the laboratory space limit (20) so that a second lab section has to be open (20 + 20 = 40 students).

Number of Students and Faculty

We are bigger than we ever have been, with three full time faculty and two contract sections this summer. It is a small expansion, though and has been due to our new Engineering program. In a typical academic year, we have about 120 students in our first-year life sciences stream, 80 students in our first-year calculus stream, 72 students take our physics up grading course, and 100 students take our Astronomy course for liberal arts majors. Our Coquitlam campus continues to have few classes with not as many students as we would like, but we have great hopes now that the Evergreen Skytrain line has finally arrived. We were calling it the "Nevergreen Line" for a reason. The first trains started running in December of 2016 but there was no noticeable increase in our students for the January semester.

New Engineering Essentials Program and New Lab Spaces

Our new Engineering Essentials program had its first cohort in the Fall of 2015 and the second cohort in the Fall of 2016. It offers either a certificate (1 year) or a diploma (2 year) credential. Of the 84 students who applied, 27 started the program in September. We have 7 registered in our Douglas credential this summer for our hands-on prototyping courses. Most went onto UBC or SFU after they finished the traditional eight months of academic courses.

Renovations to build the new lab space at the New Westminster Campus were complete in the middle of September 2016. We increased the physical foot print of the college by extending it out towards the sidewalk on Victoria Avenue. We had brand new physics lab as of September 2016 with the new engineering courses on mechanical fabrication, electronics prototyping, and embedded systems being run in the summer of 2017 in their new lab space.

All the equipment is in and running, except for the laser cutter. We will to looking to hire a lab instructor this summer.

Open Source Textbook & Free Resources

As part of our efforts to ease the financial burden on students and give more access for students, we have begun to use a large number of open source textbooks. We use the Open Stax College Physics textbook for PHYS1104 (Physics 11 equivalent) and PHYS1107 (first year algebra based Physics.) The textbook is offered free of charge for students to download as a PDF.

We have started to modify the textbook for our courses. PressBooks is the editing program chosen by BCcampus. It is easy to export the book into a variety of formats and most importantly, easy to modify so you can create your own version. The equations are the challenge, of course, as you have to use LaTex. We hired a student last summer to start the conversion, and will be hiring the same student again to convert the OpenStax Astronomy into a Canadian edition.

Open Stax has a calculus based University Physics book. We will not be using it this academic year. We are sticking with Halliday, Resnick and Walker. My colleagues have asked for one year without a new textbook.

I used the OpenStax Astronomy book for the last two semesters and I am happy with it.

The books are far from perfect, but I can attest to the fact that everyone having the same textbook makes the learning better. Student satisfaction and success has increased. If you want to read some of the scholarly research and learn more about the philosophy of open education I highly recommend a book that was recently published. It was edited by a Kwantlen Polytechnic University instructor, Rajiv Jhangiana. You can download the book for free at http://www.ubiquitypress.com/site/books/10.5334/bbc/i

KPU – Kwantlen Polytechnic University

Kwantlen Polytechnic University has campuses in Richmond, Surrey, Cloverdale and Langley and the Physics Department operates on three of them. At Langley Campus, PHYS 1400 & 1401 run as part of the long standing Environmental Protection Technology program. At Surrey and Richmond Campuses, we run our complement of first year courses in physics and engineering, as well as our various courses in astronomy for non-majors. In addition, Richmond Campus is home to the 2nd, 3rd and 4th year courses for the *B.Sc. Physics for Modern Technology*. In September 2016, we opened our new lab to support the upper level courses.

The *Physics for Modern Technology* degree is still undergoing its initial roll-out. One year from now, in May 2018, we expect to graduate our first cohort of students. Currently, in May 2017, these students are off campus on a work-term. The first year of this degree curriculum is a familiar mix of science courses but due to the very applied nature of this program, courses become specific for our degree from second year onwards. We see students transferring into our degree after (and during) first year fairly seamlessly but those arriving with some second and third year credits are seeing some glitches, as one normally would when changing majors mid-stream.

An online lab section of PHYS 1100 was offered on a pilot basis this winter, through the efforts of Jillian Lang and T. Sato. Students registered for the online lab section in conjunction with an on-campus "lecture" section. Students performed experiments using home kits built around the IOLab (http://www.iolab.science/) and remotely operated equipment of the Remote Web-based Science Lab (RWSL) located at North Island College. The experiments generally paralleled those in the on-campus lab sections. We are very pleased with the student outcomes, though no formal statistics are reported at this time due to the small sample size. We plan to continue with the pilot with a section in each of Fall 2017 and Winter 2018 semesters.
Submitted by Takashi Sato (for Jana Kolac)

Langara College

Langara College Physics and Astronomy
Articulation Report 2017

Submitted by Terry Coates: *tcoates@langara.ca*

We had extremely strong first-year enrolments in the 2016-2017 academic year. We ran 44 sections of physics and astronomy courses; 7 in summer 2016, 17 in fall 2016 and 20 in spring 2017. We still had waitlists for some of sections. We normally have 36 sections budgeted but were given the extra sections due to increases in International Education (IE) enrollment and expansion of the Engineering Transfer (ENGT) and Engineering Diploma (ENGD) programs. Starting in the new budget year we have been given 3 new permanent sections and could get more added in the future.

Except for the ASTR courses (and core course sections reserved for the ENGT/ENGD students) we have 50% of each section (approx. 15-16 spaces per section) held for IE students. As we get closer to the semester starting date any unfilled IE spaces are opened up to domestic students on the waitlist.

Astronomy Courses
We ran ASTR 1101/3310 (one half-section of 1101 (for Science students) and one-half section of 3310 (for Arts students)) in the fall with the similarly organized ASTR 1102/3311 course in the spring. Continuing the trend from previous years we are seeing a decline in enrolment for the 3310/3311 sections which may be due to the competition from a growing number of elective arts courses being offered at the college.

Introductory Courses
We ran 2 sections of PHYS 1114 (Grade 11 equivalent) in the fall and another 2 sections in the spring. Registration has held consistent in these courses although we are starting to have waitlists develop.

We ran 14 sections of PHYS 1118 (Grade 12 equivalent) which is our most popular course. We are seeing a huge increase in demand for this course as we have added multiple sections and still the waitlists are growing. This is primarily due to international students wanting to take the course. For this course we use the OpenStax College Physics textbook, which is free to all students.

1st-Year Courses
We ran 11 sections of PHYS 1125 (Physics I with Calculus) and 3 sections of PHYS 1101 (Physics I for Life Sciences). PHYS 1125 is very popular and we have had waitlists for this course. For 1125 we ran 5 sections in the fall and 4 sections in the spring as well as 2 sections in the summer. For 1101 we run one section every semester. We are seeing declining interest in this course and we rarely have waitlists for it.

We ran 5 sections of PHYS 1225 (Physics II with Calculus). We are getting increasing enrolment in the spring semester (3 sections) as we have expanded our ENGT/ENGD programs and those students take the course in the spring semester. Demand for the course is much lighter in the other semesters.

2nd-Year Courses
We ran our 2nd-Year physics program again this year. In the fall semester we had 18 students start in PHYS 2424 (Relativity and Quanta) and 12 students in PHYS 2309 (Intermediate Physics Lab I). In the spring semester we had 11 students in PHYS 2323 (Newtonian Mechanics) and 5 students in PHYS 2409 (Intermediate Physics Lab II).

Other Courses
We ran 3 sections of PHYS 1219 (Engineering Mechanics). We stopped offering it in the summer semester and added a section to the spring semester when the ENGT students have to take the course. The fall semester enrollment was quite low so we may switch to just running all sections in the spring semester.

General Notes:
Like many other institutions, the college has been expanding and diversifying its recruitment of international students and we are seeing a huge influx of students from India. A large portion of these students are interested in getting into STEM fields and as a result we are being allocated more physics sections to accommodate the increasing demand. There have been both positive and negative consequences to this increase in students.

Last August, our department (along with Chemistry, Biology, Nursing and some of Kinesiology and Computer Science) moved into the brand-new Science & Technology building. We have 3 dedicated lab rooms in the new department—two rooms for undergraduate courses and a dedicated Studio Physics Lab. All labs have multiple projectors, screens and whiteboards. Our offices have also moved into the new building. All of our labs/classrooms and offices are now on the same floor. We also have a viewing platform on the roof that we can use for setting up telescopes.

North Island College

NIC Physics Articulation Notes 2017

We have had no change in our physics offerings since last year. Our transfer courses in physics are:

- PHY 100/101 – Algebra based physics, for life sciences
- PHY 120/121 – Calculus based physics, for engineers, physicists, and most chemists
- PHY 141/170 – Engineering Mechanics (PHY 141 transfers to UVic Engineering, and PHY 170 transfers to UBC Engineering).

Enrollment in both streams of first year physics continue to be strong at our Courtenay Campus, and are modest but steady at Campbell River and Port Alberni campuses, where the courses are typically delivered by ITV (teleconference), with labs delivered face to face at each campus.

Our Space Science and Astronomy courses are going to be offered this year after a hiatus of about five-years. The course will be offered by ITV into our Port Alberni and Campbell River campuses, and will also be offered as dual credit to some high schools in our region.

Northern Lights College – no report as no physics courses are being taught there..

NWCC – North West Community College

Northwest Community College (NWCC) serves the rich and diverse communities and learners of BC's beautiful northwest region including Haida Gwaii and the Great Bear Rain Forest.

We continue to run one section of algebra based physics 101/102 at the Prince Rupert Campus and one section of calculus based physics 121/122 (advanced physics) and one section of physics 101/102 at the campus in Terrace. At the Terrace campus, the students for 101/102 and 121/122 share the same lab time. At both campuses, the class sizes are maxed out at 18 which is the maximum permitted in our lab. Both courses have 3 hours of lecture and 3 hours of lab each week for fourteen weeks and then one week for final exams in each term (Fall and Winter). Most of our advanced physics students continue in an engineering program at another institution.

Enrolment was a bit higher at both campuses, with 12 total in Terrace and 7 in Prince Rupert which is a slight increase from last year (12 and 4).

No significant change in curriculum, but we have used OpenStax textbooks this year for both courses.

Regan Sibbald
College Professor - Physics and Mathematics
NWCC Terrace
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Okanagan College

Okanagan College – 2017 Physics & Astronomy Articulation Report

Okanagan College has four campuses: Kelowna, Penticton, Vernon, and Salmon Arm. Kelowna is our largest campus, making up ~65% of Arts & Science students.

A quick look at enrollments:
▪ Science numbers were up significantly this year compared to last year (+13%), with campus breakdowns as follows: Kelowna (+14%), Penticton (+11%), Vernon (+2%), and Salmon Arm (+18%).
▪ Arts numbers were up slightly this year (+2%), with campus breakdowns as follows: Kelowna (–7%), Penticton (+20%), Vernon (+12%), and Salmon Arm (+4%).
▪ First-year Physics numbers were up 10% overall. Our calculus-based courses (OC PHYS 111/121) were up 52%, while our algebra-based courses (OC PHYS 112/122) were down 10%. In Kelowna, our calculus-based section was at 95% capacity in the fall semester (34 students, 36 available seats), while our algebra-based sections were at 90% capacity (65 students, 72 available seats). Attrition between the first and second semester was not a major problem (<20% across all campuses).
▪ We offered three second-year Physics courses on our Kelowna campus again this year: Modern Physics (OC PHYS 200), with 4 students compared to last year's 5; Thermodynamics (OC PHYS 215), with 15 students compared to last year's 11; and Statics & Dynamics (OC PHYS 202), with 5 students compared to last year's 10. The Thermodynamics course is part of the ELEN and CIEN "Bridge" programs into UBC-O Engineering. The Statics & Dynamics course is part of the Engineering stream in Applied Science.
▪ First-year Astronomy numbers were up 25% overall. Our Astronomy courses (OC ASTR 11X/12X) draw both Arts and Science students.
▪ We offered two second-year Astronomy courses on our Kelowna campus again this year: Astrobiology (OC ASTR 220), with 14 students compared to last year's 9; and History of Cosmology (OC ASTR 230), with 25 students compared to last year's 11. These courses draw Arts, Science, and Business students.

A quick look at applications:
▪ Applications in Science are up 7% for Fall 2017 compared to Fall 2016 (for the same April 5 reporting date), with campus breakdowns as follows: Kelowna (0%), Vernon (+40%), Penticton (+7%), and Salmon Arm (–5%).
▪ Applications in Arts are up 4% for Fall 2017 compared to Fall 2016, with campus breakdowns as follows: Kelowna (+2%), Vernon (+28%), Penticton (–5%), and Salmon Arm (–16%).

Activities that enhance student learning:
▪ Our department participates in the CAP Lecture Series and the AAS-sponsored Harlow Shapley Lecture Series. The speakers usually visit one or more classrooms and give one or more formal presentations. This winter our CAP speaker was Kris Poduska from Memorial University of Newfoundland. This coming fall our Harlow Shapley speaker will be Sondra Springmann from the University of Arizona. We also had the pleasure this past fall of hosting three presentations by Jaymie Matthews from UBC-V.
▪ Our department conducts tours each semester of the Dominion Radio Astrophysical Observatory (DRAO). Each tour draws 20-30 students from across our four campuses.

News related to student success:
▪ One of our 2nd-year physics students has been awarded a summer internship in Germany as part of the Research Internships in Science & Engineering (RISE) program. She will be working in with Florian Römer at the University of Duisburg-Essen on the magnetism of thin film nanostructures.

Selkirk College

Physics and Astronomy Articulation Report

May 2017

Selkirk College continues to offer the same physics courses in 2016-2017 as in the previous several years. Our physics courses serve students in the first year engineering transfer program, the rural pre-medicine program, as well as students enrolled in general arts and science. No major changes occurred to the physics courses in 2016-2017.

The courses offered include:

- PHYS 102/103 – Algebra-based.
- PHYS 104/105 – Calculus-based.
- PHYS 200 - Principles of Mechanics, for engineers.
- Astronomy 102, for arts students, not offered since 2013.

Textbooks remain the same for the past four years:

- *Physics* (9th ed.) by Cutnell & Johnson, for 102/103.
- *Fundamentals of Physics* (10th ed.) by Walker et al., for 104/105.

Enrollment in physics courses at the Castlegar campus increased by 20% compared to last year. We ran a full engineering program for the second year in a row. We expect a similar enrollment for the upcoming year.

SFU – Simon Fraser University

SFU Departmental Report 2017

There have been no major curriculum changes in the past year.

The textbooks for introductory streams remain the same. Tests of OpenStax College Physics were satisfactory; there were some problems with content, but everybody appreciates the fact that it is free. We are now learning how to adapt a BC College text. We had some problems with Sapling, the on-line homework system that was chosen, because the level of problems was a bit difficult for PHYS 100. But we have been given access to highschool-level problems, which we will incorporate.

First-year Textbook Summary:

Physics 100 (physics 12): OpenStax College Physics
Physics 101/102 (life sciences): Giancoli - Physics: Principles with applications
Physics 120/121 (calculus): SmartPhysics + Tipler (optional)
Physics 125/126 (enriched): Halliday, Resnick and Krane
Physics 140/141 (studio, calculus): SmartPhysics + Tipler (optional)

The complete textbook list is attached as a separate page.

Enrolment is steady for the introductory courses. Last year, we reported that enrolment in 200- and 300-level courses was up 20-40% in the last several years. Enrolment has held steady, with slightly better numbers again this year.

Barbara Frisken, Undergraduate Chair, Dept. of Physics, SFU

TRU – Thompson Rivers University

THOMPSON RIVERS UNIVERSITY

Department of Physical Sciences, Faculty of Science

Articulation Report, Camosun College, Friday May 5, 2017

ENROLMENTS FOR 2016-2017 (# of students after stable enrolment date)

Fall Semester

ASTR 1140 – The Solar System	63
EPHY 1150 – Physics for Engineers 1	57
PHYS 1010 – Physics for Future Leaders	32
PHYS 1100 – Fundamentals of Physics 1	99
PHYS 1150 – Mechanics and Waves	28
PHYS 1510 – Applied Physics 1	23
PHYS 1580 – Physics for Respiratory Therapists	48
PHYS 2000 – Relativity and Quanta	10
PHYS 2150 – Circuit Analysis*	15
PHYS 3080 – Optics	7
PHYS 3250 – Advanced Electromagnetism	6
PHYS 3400 – Principles and Applications of Quantum Mechanics 1	7

Winter Semester

ASTR 1150 – Stars and Galaxies	57
EPHY 1250 – Physics for Engineers 2	50
EPHY 1700 –Engineering Mechanics	47
EPHY 1990 – Introduction to Engineering Measurements	52
PHYS 1200 – Fundamentals of Physics 2	74
PHYS 1250 – Thermodynamics, Electricity and Magnetism	16
PHYS 1610 – Applied Physics 2	23
PHYS 2200 – Mechanics	7
PHYS 2250 – Intermediate Electromagnetism*	13
PHYS 3100 – Digital Electronics*	12
PHYS 4140 – Radioactivity & Nuclear Physics	6
PHYS 4400 – Principles and Applications of Quantum Mechanics 2	4
PHYS 4500 – Advanced Physics Laboratory	4

**Courses are also part of the second-year engineering transfer program*

ENROLMENTS continued

Summer Semester

ASTR 1140 – S16	43
ASTR 1150 – S16	26
ASTR 1140 – S17 registration ongoing, numbers as of April 12	36
ASTR 1150 – S17 registration ongoing, numbers as of April 12	30

TEXTS

- ASTR 1140/1150 – *The Solar System*, Seeds & Backman (8th or 9th eds.)
- PHYS 1100/1200 – *OpenStax* College Physics and *College Physics*, Serway & Vuille (10th ed.)
- PHYS/EPHY 1150/1250 – *Physics for Scientists & Engineers*, Serway & Jewett (9th ed.)

Open textbooks are being considered as replacements for published textbooks in all of the introductory physics courses.

BACHELOR OF SCIENCE – PHYSICS MAJOR DEGREE

The number of physics faculty has increased to eight. We have a three-year limited term contract position supporting the release granted to the department co-chair and the B.Sc. advisor. Three students received their degrees last June. We are expecting two to receive their degrees this year.

There were no changes to the physics program curriculum in the past year. As part of a campus-wide initiative, the program learning outcomes were formally articulated. These learning outcomes are expected to influence the direction of plans and development within the department.

PHYSICS PROGRAM LEARNING OUTCOMES

Students completing a Physics degree shall be able to:

1. Apply the fundamental principles of physics in the areas of: classical mechanics, electromagnetism, special relativity, optics, fluids, nuclear physics, material science, quantum mechanics, and thermodynamics, as well digital and analog electronics.
2. Utilize mathematical tools such as differential, integral and vector calculus, elementary probability and statistics, differential equations, linear algebra, Fourier and Laplace transforms to solve physical problems.
3. Use computer tools for the measurement, analysis and modelling of physical phenomena.
4. Employ traditional experimental techniques and modern measurement technology.
5. Undertake independent research and learning using the methods of scientific inquiry.
6. Present well-organized, logical and scientifically sound oral and written reports.
7. Recognize career paths and opportunities open to students majoring in physics.

TWU – Trinity Western University

Physics at Trinity Western University

Report for the BC Articulation Committee Meeting
5 May 2017

by Dr. Arnold E. Sikkema
Professor of Physics
Chair of the Mathematical Sciences Department
Trinity Western University

- TWU Physics mainly serves our B.Sc. programmes in Biology and Chemistry, as well as our pre-engineering options.
- Physics is part of our Department of Mathematical Sciences, which includes math, computing science, physics, pre-engineering.
- Enrolment in our first-year calculus-based physics sequence (with lab) was a little below normal for the fall (50) & spring (33), with 4 & *x* failing (the value of *x* TBD). We started to use Mazur's new book *Principles & Practice of Physics*, and have continued to use *MasteringPhysics* for these courses.
- All our other courses are offered on an alternate year basis, to allow students to complete a minor or concentration, with zero to three graduating per year with these options (two this year).
- Enrolments in 2016-17 were:
  - 111: Fundamentals of Physics I: 50
  - 112: Fundamentals of Physics II: 33
  - 230: Electricity & Magnetism (with lab): 3
  - 310: Topics in Modern Physics: 3
  - 341: Advanced Physical Chemistry (with lab, and cross-listed with Chemistry): 3
- Courses planned for Fall 2017 are:
  - 111: Fundamentals of Physics I
  - 215: Stellar & Galactic Astronomy
  - 360: Optics (with lab)
- Courses planned for Spring 2017 are:
  - 112: Fundamentals of Physics II
  - 220: Mechanics
  - 240: Physical Chemistry (with lab, and cross-listed with Chemistry)
- Since our new university-wide "core curriculum" (effective for incoming students in Fall 2017) requires a course with "quantitative & computational inquiry" instead of a second science course (which had been permitted to be a non-lab course), the future of our two conceptual non-lab courses targeted to non-science students — namely 210 (Conceptual Modern Physics) and 215 (Stellar and Galactic Astronomy) — is in doubt.

UBC – O University of British Columbia – Okanagan

During the past academic year, first-year Physics enrolments have increased somewhat from 2015-16. In the fall term, combined enrolments in the algebra- and calculus-based streams amounted to 632 (vs 526 last year), and in the spring term the combined total was 493 (vs 482 last year). The attrition between first and second term, however, has increased considerably from last year, without an obvious explanation. There were 95 enrolments in first-year Astronomy, all in the first term as the 2nd-term offering was cancelled for logistical reasons.

Second- and upper-year enrolments in Physics have dipped in comparison to 2015-16. Second-year class sizes ranged from 8 to 66, averaging to 29 (versus 34 last year). Upper-level class sizes ranged from 10 to 29, averaging to 19 (versus 25 last year). The number of students graduating in Physics this year is level with last year, with 24 in total (8 in Honours, 14 in the Major, none in the Minor, and 2 in the Combined Math/Physics Major.

There were no curriculum changes taking effect this past year in our undergraduate program. However, final Senate approval has been obtained for a reorganization of the first-year Physics courses, which will take effect in the upcoming academic year. The algebra-calculus dichotomy is being eliminated. Two streams of first-year Physics will be run, as before, but henceforth they will be distinguished by orientation toward life sciences or physical sciences, rather than according to mathematical level. Calculus will now be a corequisite for both streams, and either stream may now serve indifferently as a prerequisite for further Physics courses. The imposition of a Calculus corequisite on the life-science-oriented courses is not expected to cause much disruption in students' programs, as the vast majority of first-year students are taking Calculus concurrently with their Physics in any case. In the past, the algebra-based course included a weekly tutorial hour that the calculus-based course did not. In the future, enrolment in the tutorial will be required not according to which course the students are taking, but rather according to their high-school Physics

background. (Students who completed Physics 12 will be exempt from the tutorial, and others required to take it.) It is expected that the total enrolment in tutorials, and thus the cost of providing them, will be about the same as before the change.

Our new postgraduate program in Medical Physics has begun operating in 2016-17, with two students enrolled in its inaugural year. A significant number of our undergraduate students have made inquiries about this program, and have chosen to take the Medical Physics courses we offer at the undergraduate level. We feel this program is generating interest among students in Physics generally, and has or will have a positive effect on undergraduate enrolments.

Murray Neuman

Assoc. Prof., Physics, UBC Okanagan

UBC – V University of British Columbia – Vancouver

Tom Mattison mattison@physics.ubc.ca

There are currently 94 students in Physics or Astronomy degree programs in 4th year (or above), compared to 92 (2016), 69 (2015), 93 (2014), 93 (2013), and 79 (2012). They are: 36 majors physics or astronomy, 17 honours biophysics, 16 combined-honours physics, 10 honours physics or astronomy, and 15 combined-major physics & computer science.

There are 56 students who have applied to graduate this year, compared to 59 (2016), 46 (2015), 70 (2014), 57 (2013), and 49 (2012). We also graduate about 50 students in engineering-physics each year.

It is difficult to extract the average time students spend getting a degree from the registration system. If half of the students graduate in 4 years and the other half in 5 years, the number of 4th year and above students would be 50% greater than the number graduating each year, which is about what we observe on average.

PHYS 101 enrollment was 1416, compared to 1353 last year and 1671 (in 2015, before PHYS 117 was created). The vast majority of these are life-science students. We also have about 800 engineering students in PHYS 170, 157, 158, and the lab course 159 each year.

The enriched PHYS 107 enrollment was 98 this year, vs 95 (2016), and 99 (2015). PHYS 108 enrollment was 94 this year, vs 83 (2016), and 77 (2015).

PHYS 117 enrollment was 291, up from 229 last year. PHYS 118 enrollment was 379, compared to 427 (2016) and 532 (as PHYS 102 in 2015). This fall-off is in large part due to the Coordinated Science Program no longer including a second term of physics. PHYS 119 enrollment was 236, compared to 228 last year.

An early measure of potential degree students is the second-year lab course PHYS 219, which is required for both majors and honours in both physics and astronomy, and is taken by very few other students. Enrollment this year was 101, compared to 131 (2016), 92 (2015), 99 (2014), and 76 (2013).

Enrollment in ASTR 310 for Arts students was 110 compared to 143 (2016), 97 (2015), 106 (2014), 184 (2013). Enrollment in ASTR 311 was 70 compared to 61 (2016), 55 (2015), 97 (2014), 146 (2013). We had 81 additional students in the distance-education version of ASTR 311, compared to 32 last year.

Previously, we had created a new classical mechanics course PHYS 117 (with no lab component), and split PHYS 102 (E&M with a lab component) into PHYS 118 (lecture) and PHYS 119 (lab).

This year we made PHYS 216 into a true intermediate mechanics course, and it is now required for all physics & astronomy degrees. We have also removed PHYS 101 as a sufficient pre-requisite for PHYS 216, so either PHYS 117 or PHYS 107 (enriched classical mechanics) is required for PHYS 216.

You may wish to change your articulation agreements with UBC-Vancouver due to these curriculum changes.

If your courses have lab components, they probably transfer as PHYS 101 or PHYS 102 at present. PHYS 102 is still a valid pre-requisite, and PHYS 101 is still a valid pre-requisite for anything except PHYS 216, so for non-physics-degree students that would be OK. But you may wish to change the articulation for a mechanics course with a lab component to UBC PHYS 117+119. This would be work for both physics-degree and non-physics-degree students.

If you offer a mechanics course that does not have a lab component, it probably transfers as PHYS 1st rather than PHYS 101, which is not very useful to students. But it could now transfer as PHYS 117, which would be useful. If you offer an E&M course that does not have a lab component, it probably transfers as PHYS 1st rather than PHYS 102, which is not very useful to students. But it could now transfer as PHYS 118, which would be useful.

If you have a stand-alone physics lab course, you should change the articulation agreement so it transfers as PHYS 119.

UFV – University of the Fraser Valley

University of the Fraser Valley Articulation Report - May 2017

- UFV currently offers Honours, Major, and Minor degrees in Physics, and also a diploma in Engineering Physics (Mechatronics). The Diploma program is still relatively new, as we had our first graduating class last year (2016). We have a faulty of 5 permanent lecturers, and two permanent lab instructors. This past year we were allotted two Limited Term Appointments (LTA) which covered lecture sections, while another 5 sessionals covered both lab and lecture sections. Although we are in need of at least one new hire, we have not been granted the funding to post for a new position. Instead, we have been given another two LTA's for next year.
- Our first year algebra based Physics textbook used was the free *Openstax College Physics,* while our calculus based textbook used was *University Physics with Modern Physics Technology Update w/Mastering Physics* by Young and Freedman.
- Our first year calculus numbers are down from 360 last year to 309 this year, while our algebra based numbers went from 100 to 126. Our Astronomy numbers are steady at 72 (the maximum for the number of sections put on), while we have given back the ABE courses to the Faculty of Access and Continuing Education along with the rest of the Sciences (as of Summer last year). Our second year and above were fairly constant at 76 (down from 88) and 130 (up from 125) respectively, while our Diploma numbers are down significantly from 109 to 47 this year. As a result, our overall enrolments are down this year by about 12% - 933 compared to a record high last year of 1056. Enrolment numbers are down across the institution, and a partial explanation seems to be the demographics are in a down swing for the usual age group.
- Although our Diploma has seen a dramatic drop in enrolments (mostly due to promised international students who did not materialize, as well as a lack of advertising on behalf of the University), of the 9 graduates last year, all but one has found fulltime employment in their field. So there is a demand for the skills they are learning, we just need to make a more concerted effort to make students aware of the program.
- As part of the Diploma program, we have been working closely with the BC Cancer Agency in Abbotsford on projects related to medical imaging and radiation therapy (student participate as part of their capstone project course). This is a relationship we see continuing into the future, as it is mutually beneficial to both UFV and BC Cancer.
- To help recruit new students for our programs, we have two Work-Study student positions for the next year to help us reach out to local schools.
- This year we expect to have 8 Major graduates, 3 Minor graduates, and 14 Diploma graduates. This is comparable to last year, where we had 14 Majors, 1 Honours, 1 Minor, and 9 Diploma graduates.
- Physics along with both Biology and Chemistry are currently undergoing renovations on our labs/classrooms this summer on the Abbotsford campus. The renovations are a bit more extensive in Biology and Chemistry, while Physics is primarily getting the millwork replaced.
- Physics is also undergoing a Program Review this year as part of the regular 5 year review process now in effect at UFV (this will be our second since UFV became a university in 2008).
- The Faulty of Arts is making some significant changes to their degrees as of this Fall. Of interest to Science, they are removing their Science Lab requirement, and replacing it with a Science Literacy requirement. As a result, we expect that our first year Astronomy numbers may be affected, as that course is primarily put on for students in Arts and Business requiring a lab science for graduation. In addition, Arts will be requiring all students to take 4 courses (one each year) which will focus on preparing and creating a portfolio for graduation. Science has a subcommittee looking at something similar, but that is in its very early stages and has not yet made its way to Faculty Council for feedback.

UNBC – University of Northern British Columbia

University of Northern British Columbia Physics Department

2017 Articulation Report

UNBC offers a full physics program, and no major curriculum changes were made during 2016/2017.

Enrolment

	2015-2016	2016-2017	% change
Physics 115 (physics 12)	61	68	+11
Physics 110/111 (calculus-based)	149	131	-12
Physics 100/101 (algebra-based)	156	172	+10
ASTR 120/121 (Astronomy)	32	39	+22
Physics 150 (Physics for Future Leaders)	26	10	-62
Second-Year (four-course total)	18	32	+78

Textbooks

	2015-2016	2016-2017
Physics 115 (physics 12)	*Physics*, Cutnell and Johnson	College Physics: OpenStax
Physics 110/111 (calculus-based)	*Physics for Scientists and Engineers*, Serway and Jewett	*Physics for Scientists and Engineers*, Serway and Jewett
Physics 100/101 (algebra-based)	*College Physics*, Serway and Vuille	*College Physics*, Serway and Vuille
ASTR 120/121 (Astronomy)	*Astronomy Today*, Chaisson and McMillan	*Astronomy Today*, Chaisson and McMillan
Physics 150 (Physics for Future Leaders)	*Physics and Technology for Future Presidents*, Muller	*Physics and Technology for Future Presidents*, Muller

After the academic year 2014/15, the astronomy course's subject designation was changed from PHYS to ASTR, and enrolment went from 9 in 2014/15 to 32 and 39 in 2015/16 and 2016/17.

In 2016/17, OpenStax was used for the first time in the physics 12 equivalency course

George Jones
Department of Physics
University of Northern British Columbia

UVIC – University of Victoria

UVic 1st and 2nd year PHYS and ASTR articulation report, April 2017

1st year PHYS:

There were no significant changes in our offerings this past year.
Our calculus-based survey offerings have stable enrolment, but continuing decline in the enrolment of in courses aimed at students continuing in Physics. This might be due to lab requirements.

- Effective September 2017 we will split PHYS 102 into PHYS 102A and 102B. There are no plans for a significant change in content or scheduling. The pairs of courses in the transfer guide system that went to PHYS 102 will now, together, go to PHYS 102A and 102B.
- Effective September 2017 we will no longer be using Mastering Physics for assignments in PHYS 110 and 111. We will be using UVic's Moodle-based platform instead.
- Effective September 2017 we will change the textbook for PHYS 110 to one written from scratch by UVic faculty. We are working on a similar text for PHYS 111 and hope to have it ready prior to the 2019/2020 academic year.

Courses offered:
PHYS 102 (two-term course) – An algebra-based survey of physics.
Normally offered Sept-April. *Being split into PHYS 102A and 102B.*
Primary Audience: Biology students
Text: Serway (algebra based, latest edition)
Enrolment: Initially around 500.
Final enrolment: 2017: 410 ('16: 413, '15: 446, '14: 399, '13: 436)
Topics: Mechanics and energetics, oscillatory and wave motion, fluids, thermodynamics, electricity and magnetism, optics, modern physics

PHYS 110 (first term) and 111 (second term) – A calculus-based survey of physics
PHYS 110 offered Fall (Sept) and Spring (Jan)
PHYS 111 offered Spring (Jan) and Summer (May)

Primary Audience: Natural Science and Engineering students
Text: UVic custom edition Young & Freedman with locally-written supplements.
Enrolment: Initial (fall) enrolment peaks at 750-800
Final enrolment PHYS 110:
Fall 2016: 599 (’15: 606, ’14: 609, ’13: 566)
Spring 2017: 162 (’16: 154, ’15 159, ’14: 134)
Final enrolment PHYS 111:
Spring 2017: 448 (’16: 460, ’15: 473, ’14: 435)
Summer 2017: 81 (’16: 84, ’15: 87, ’14: 73)
Topics: As for 102, with limited content on fluids and electromagnetism
110 – Mechanics, conservation laws, electric and magnetic forces
111 – Thermodynamics, oscillatory and wave motion, optics, modern physics

PHYS 120 (first term) and 130 (second term) – Physics for Physicists and Astronomers

Normally offered Fall (120) and Spring (130)
Primary Audience: Prospective major/honours students
Text: Young and Freedman – University Physics with Modern Physics (latest edition)
Enrollment: Initially peaks at 120-140
Final enrolment 120: 2016: 74 (’15: 88, ‘14: 104, ‘13: 106, ‘12: 116)
Final enrolment 130: 2017: 50 (’16: 58, ’15: 68, ‘14: 72, ‘13: 66)
Topics: As for 102 omitting Electricity and Magnetism and Thermodynamics
120 – mechanics and special relativity
130 – rotational motion, oscillatory motion, waves, modern physics

2nd year PHYS:

The University of Victoria offers six second year Physics courses, four of which are common to all our undergraduate programs. These have had fairly stable enrollment for the past years.
Three significant changes are coming to our programs effective fall 2017:

- Electronics course repurposed as lab techniques course and renumbered PHYS 229 (PHYS 214). The calendar description of the redesigned course is: *Principals and techniques of experiment design and measurement, systematic and statistical uncertainties, data acquisition, analysis and the dissemination of knowledge. Laboratory experiments focus on the use of electronics, instrumentation, and optical systems fundamental to experimental physics.*
- Thermodynamics is moved to 3rd year and renumbered as PHYS 317 (from 217)
- New 2nd year course numbered PHYS 248 offered in partnership with MATH. The course title is *Computer Assisted Mathematics and Physics.* The calendar description is *Use of a high-level computer language for mathematical and scientific experimentation, simulation, and calculation. Programming of mathematics using available functions and routines and also writing short programs for symbolic and numerical computations, visualization, graphical output, and data management. The goal is to become competent with a high-level mathematics language and to practice programming in such a language. Emphasis on hands-on coding for experimentation in a variety of mathematical and physical contexts.* This course will be required in all programs.

Courses offered:

PHYS 210 (also EOS 210) – Geophysics

Normally offered in the fall.

Primary Audience: PHYS/EOS combined program students

Text: Selections from several books, including Lillie – Whole Earth Geophysics

Enrolment: About 60 (20 as PHYS, 40 as EOS).

PHYS 214 – Laboratory Electronics

Normally offered in the fall. *Being replaced by PHYS 229 in September.*

Primary Audience: PHYS and ASTR major and honours students

Text: Horowitz and Hill – Art of Electronics

Enrolment: 2016: 63 (’15: 51, ‘14: 54, ‘13: 46, ‘12: 46, ‘11: 41)

PHYS 215 – Introductory Quantum Physics

Normally offered in the spring and summer.

Primary Audience: PHYS and ASTR major and honours students

Text: Varies depending on instructor, usually Thornton and Rex

Enrolment-Spring: 2017: 42, (’16: 46, ‘15: 35, ‘14: 32, ‘13: 48, ‘12: 44)

Enrolment-Summer: 2017: 12 (’16: 13, ‘15: 10, ‘14: 17, ‘13: 9, ‘12: 19)

PHYS 216 – Introductory Electricity and Magnetism

Normally offered in the fall.

Primary Audience: PHYS and ASTR major and honours students, and Engineers

Text: Excerpts from Young and Freedman – we are looking for a better text.

Enrolment: 2016: 64 (’15: 67, ’14: 53, ‘13: 54, ‘12: 61, ‘11: 53)

PHYS 217 – Introductory Thermodynamics

Normally offered in the spring. *Moving to 3rd year effective 2017/18.*

Primary Audience: PHYS and ASTR major and honours students

Text: Carter

Enrolment-Spring: 2017: 42, (’16: 37, ‘15: 36, ‘14: 27, ‘13: 46, ‘12: 34)

PHYS 248 – Computer Programming in Math and Physics

Normally offered in the spring. Offered as a “trial” in 2015 and 2016.

Required in MATH effective 2016/17 year.

Required in PHYS effective 2017/18 year.

Primary Audience: PHYS, ASTR, and MATH major and honours students

Text: None standardized

Enrolment-Spring: 2017: 27, (’16: 10, ’15: 7)

1st year ASTR:

The University of Victoria offers three 1st year Astronomy courses, two intended for non-majors and one that is the first course in our ASTR progression.
The number of sections of ASTR 101 and 102 offered has changed in response to the recent retirement of a long-serving staff member.

Courses offered:

ASTR 101 and 102 – Astronomy for non-specialists (101-Solar System, 102-Cosmology/Stars)

Primary Audience: General interest
Text: Varies depending on instructor
Enrolment: About 180-200/term in ASTR 101; About 80-100/term in ASTR 102. Summer offering about 60-80.

ASTR 150 – Concepts in Astronomy

Primary Audience: Astronomy major/honours students
Text: Varies depending on instructor
Normally offered in the spring.
Enrollment: 2017: 61 ('16: 72, '15: 83, '14: 67, '13: 55, '12: 45)

2nd year ASTR:

The University of Victoria offers three second-year Astronomy courses, one intended for general interest, and two that form part of our ASTR program. ASTR 201 is a recently developed course.

Courses offered:

ASTR 201 – Search for Life in the Universe

Primary Audience: General interest
Text: Readings
Enrolment: 40-50.
Normally offered in the fall.

ASTR 250 – Introductory Astrophysics

Primary Audience: ASTR major/honours students
Text: Freedman and Kaufman - Universe
Enrolment: 2016: 24 ('15: 33, '14: 24, '13: 30, '12: 21, '11: 20)
Normally offered in the fall.

ASTR 255 – Planetary Science

Primary Audience: ASTR major/honours students
Text: Varies depending on instructor
Enrollment: 2017: 15, ('16: 11, '15: 10, '14: 11, '13: 16, '12: 10)
Normally offered in the spring.

VIU - Vancouver Island University

Vancouver Island University
report to the
Physics Articulation Meeting (05-May/17)

1. Student numbers were stable in our 1st year: Life sciences courses (P111/P112) numbered 86/57 this year* and 83/56 last year. Calculus-based courses (P121/P122) numbered 71/54 this year and 76/51 last year.

   *Enrolment in Nov/2014 (PHYS 111/121) and Mar/2015 (PHYS 112/122)

2. Astronomy continues to run two 1st year (solar system, stars & galaxies) & two 3rd year (cosmology, history). While the 3rd year courses remain well subscribed, the first-year enrolment feel considerably resulting in a noticeable decline in overall numbers this past year (this year 90; last year 115). It is unclear why the lab-based astronomy courses have shown such a large single year decrease; we are looking into scheduling, content, workload and competing electives as possibilities.

   Extended periods of poor weather this year severely limited outdoor observing sessions. As we have found that such sessions are a favourite for many students, the limited viewing opportunities this year may also have played a role in the decline in class size. We have continued to explore a mix of traditional visual observing and electronically assisted (near real-time camera based) viewing. The two types of viewing greatly complement each other, but moving to running two (dedicated) telescopes would eliminate delays due to changeover time and make better use of (limited) observing time.

   Solar scope (H-alpha) and a white-light solar prism refractor viewing of the sun has continued to be a hit; there are plans to mount these scopes on a tracking mount to improve viewing time and to allow for easier public outreach. The mount could also be used to run a second (or third!) scope at night, allowing us to expand our electronically assisted viewing sessions.

3. PHYS 216 (Introduction to Electromagnetism) was run for the second year, but numbers were low. As a result, the Dean decided not to offer it in 2017/18.

4. The annual Extreme Science show (benefiting the charity LED Africa) continues to be popular with 1400 attendees (mostly K-12 students) over five sessions. The total number of attendees during the last decade or so has been almost 12 000.

VCC – Vancouver Community College

Vancouver Community College Articulation Report

"Physics and Astronomy" held at UVIC, May 5, 2017

Prepared by Dr. Aydan Bekirov (abekirov@vcc.ca)

Vancouver Community College offers a First-Year University Transfer Engineering program. Students gain transfer credits towards the second year of SFU Engineering science degree programs via assured or competitive admission. Also, transfer to the second year UBC Engineering program by competitive admission.

The program was launched in 2015 and 58 students have registered to date. Students can start during any semester and all credits must be obtained within sixteen months from the start of their first semester. In addition, for at least two of the semesters at VCC, students would need to meet a minimum course load of 12 credits, and an overall average GPA of 2.75. We anticipate first-year graduates by the end of the summer 2017 semester.

We offered two sections of the first half of our calculus-based 1st year physics (PHYS 1100) in fall 2016 and two sections of PHYS 1200 in the winter - spring of 2016/17.

In the summer 2017, we will be offering Mechanics 1 (PHYS 1170). In the fall of 2017 VCC will continue with one or two sections of PHYS 1100 and will be adding one new section of Astronomy I.

Yukon College – no report as of this time

University of Alberta

Torrey Dance will be attending our Physics articulation this year.

University of Alberta Faculty of Engineering

Contacts: Dr. Tim Joseph, Associate Dean Co-op and Student Services
Torrey Dance, Strategic Advisor to the Associate Dean Co-op and Student Services

The Faculty of Engineering at the University of Alberta is home to approximately 4600 undergraduate students and offers 35 different Engineering programs in various disciplines and routes (traditional or co-op), as well as with various options (i.e. Biomedical, Nanotechnology, Environmental, etc.). The first-year class is composed of roughly 1050 students, and students "qualify" for second year disciplines depending on how well they do in the first year.

The Faculty of Engineering participates in the Alberta Council on Admissions and Transfer (ACAT) and accepts students from transfer programs around the province including:

- Macewan University (Edmonton, AB)
- Red Deer College (Red Deer, AB)
- Grande Prairie Regional College (Grande Prairie, AB)
- Medicine Hat College (Medicine Hat, AB)
- Keyano College (Fort McMurray, AB)
- Lethbridge University (Lethbridge, AB)

The standard first year course load offered at both the University of Alberta and at the transfer colleges is 37.5 units of graded engineering coursework. In order to successfully transfer from these programs, students must achieve a 2.5 GPA during the fall/winter terms, attempt at least 30.0 units of coursework in the fall/winter and transfer 30.0 units of coursework in the fall/winter/spring (a grade of C- or higher is required for a course to be considered transferable). Meeting

the admission requirements set out at the beginning of the academic year guarantees admission into the faculty, but does not guarantee a student their chosen discipline.

The Faculty of Engineering currently accepts applications from students at other institutions and from other faculties at the University of Alberta. Admission through this route is competitive and GPA requirements may change year-to-year. For students applying to the 2017/2018 year, the competitive GPA is at least a 3.0 on 8 or more courses in the most recent fall/winter.

First Year Engineering – University of Alberta

Term 1

CHEM 103 - Introductory University Chemistry I

★ 4.3 (fi 6) (either term, 3-1s-3/2) Atoms and molecules, states of matter, chemistry of the elements. Prerequisite: Chemistry 30, or equivalent.

ENGG 100 - Orientation to the Engineering Profession I

★ 1 (fi 3) (first term, 1-0-0) An introduction to the Faculty of Engineering and the engineering profession: the engineering disciplines; study skills; cooperative education; work opportunities; engineering and society including elements of ethics, equity, concepts of sustainable development and environmental stewardship, public and worker safety and health considerations including the context of the Alberta Occupational Health and Safety Act.

ENGG 130 - Engineering Mechanics

★ 4 (fi 8) (either term, 3-0-2) Equilibrium of planar systems. Analysis of statically determinate trusses and frames. Friction. Centroids and centres of gravity. Forces and moments in beams. Second moments of area. Corequisite: MATH 100.

MATH 100 - Calculus I

★ 3.5 (fi 6) (either term, 3-0-1) Review of numbers, inequalities, functions, analytic geometry; limits, continuity; derivatives and applications, Taylor polynomials; log, exp, and inverse trig functions. Integration, fundamental theorem of calculus substitution, trapezoidal and Simpson's rules. Prerequisites: Pure Mathematics 30 or Mathematics 30-1 or equivalent, and Mathematics 31.

PHYS 130 - Wave Motion, Optics, and Sound

★ 3.8 (fi 6) (either term, 3-0-3/2) Geometrical optics, optical instruments, oscillations, waves, sound, interference, diffraction. Prerequisites: Mathematics 30-1, Mathematics 31, Physics 30. Corequisite: MATH 100 or 113 or 114 or 117 or 134 or 144 or equivalent.

Complementary Studies Elective (3-0-0)

★ 3 Chosen from an approved list:
http://calendar.ualberta.ca/preview_program.php?catoid=20&poid=18784

Term 2

CHEM 105 - Introductory University Chemistry II

★ 3.8 (fi 6) (either term, 3-0-3/2) Rates of reactions, thermodynamics and equilibrium, electrochemistry, modern applications of chemistry. Prerequisite: CHEM 103.

ENCMP 100 - Computer Programming for Engineers

★ 3.8 (fi 8) (either term, 3-0-1.5) Fundamentals of computer programming with emphasis on solving engineering problems. Structure and syntax of computer programs, variables, data types, data structures, control structures, functions, input/output operations, debugging, software development process.

ENGG 101 - Orientation to the Engineering Profession II

★ 1 (fi 3) (second term, 1-0-0) An introduction to the engineering profession and its challenges: the engineering disciplines, career fields; professional responsibilities of the engineer including elements of ethics, equity, concepts of sustainable development and environmental stewardship, public and worker safety and health considerations including the context of the Alberta Occupational Health and Safety Act.

EN PH 131 - Mechanics

★ 4.3 (fi 6) (either term, 3-1s-3/2) Kinematics and dynamics of particles; gravitation; work and energy; linear momentum; angular momentum; systems of particles; introduction to dynamics of rigid bodies. Prerequisites: MATH 100 or 117, and ENGG 130. Corequisite: MATH 101 or 118.

MATH 101 - Calculus II

★ 3.5 (fi 6) (either term, 3-0-1) Area between curves, techniques of integration. Applications of integration to planar areas and lengths, volumes and masses. First order ordinary differential equations: separable, linear, direction fields, Euler's method, applications. Infinite series, power series, Taylor expansions with remainder terms. Polar coordinates. Rectangular, spherical and cylindrical coordinates in 3-dimensional space. Parametric curves in the plane and space: graphing, arc length, curvature; normal binormal, tangent plane in 3-dimensional space. Volumes and surface areas of rotation. Prerequisite: MATH 100.

MATH 102 - Applied Linear Algebra

★ 3.5 (fi 6) (either term, 3-0-1) Vectors and matrices, solution of linear equations, equations of lines and planes, determinants, matrix algebra, orthogonality and applications (Gram-Schmidt), eigenvalues and eigenvectors and applications, complex numbers.