Acknowledgement

UBC's Point Grey Campus is located on the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam) people. The land it is situated on has always been a place of learning for the Musqueam people, who for millennia have passed on in their culture, history, and traditions from one generation to the next on this site.

Course Information

Course Title	Course Code Number	Credit Value
Calculus III - Multivariable	Math 200	3

Textbook:

- CLP online textbook (`https://www.math.ubc.ca/~CLP/CLP3/`) by Profs. Feldman, Rechnitzer, and Yeager.
- See the Canvas page for additional references.

Prerequisites

One of MATH 101, MATH 103, MATH 105, MATH 121, SCIE 001.

Contact

Course Instructor	Contact Details	Office Location	Office Hours
Brian Freidin	<bfreidin [at] math [dot] ubc [dot] ca> or by Canvas messanger (expect a response within 1 business day	Canvas	Tuesday/Thursday 1-3pm or by appointment

Course Structure and Learning Outcomes

Multivariable calculus provides the language and tools to analyze the outcomes that depend on more than one parameter (which means, most situations in our world). It is important for anyone planning to use the scientific method in Chemistry and Life Sciences; the part that addresses integration is also essential for further development of probability theory, and applications to

Commerce and Economics. This course builds on single-variable calculus, and its natural follow-up courses are Math 317 (Vector Calculus), various courses on differential equations, or courses in Statistics/Probability. For some students, this is the last mathematics course (as it does teach sufficient mathematics background for many applications). Needless to say, this is also an essential part of the basis for Physics an Engineering, but Physics and Engineering students are advised to take MATH 253, which includes slightly more material.

Class time will be spent on a mix of lectures and interactive problem-solving. There will be ample (challenging) WeBWorK to help you practice technical skills and also develop understanding of the main concepts, and some written assignments to to practice your technical communication skills. You are strongly encouraged to be active on Piazza – asking questions and providing answers (and generally discussing mathematics with your friends) is an excellent way to learn!

Learning objectives

The main goal of the course is to enable you to recognize situations that require techniques from this course and to successfully apply those techniques. Some scenarios will need differentiation, while others will rely on integration. For example:

- Do you have an experiment where the outcome depends on some parameters? How will the result change if you fix all the parameters except one? How to find the parameters giving you optimal results? How to maximize the rate of change? How to find what combinations of parameters will keep the results constant? All these questions require differentiation of functions of several variables. By the end of the course you should be able to confidently reconginze questions of this kind, write down the functions responsible, and reduce the above questions to solving systems of equations (which then can be delegated to a computer).
- Are you interested in the total amount of snowfall over the North Shore? Or a total amount of light illuminating the solar panel? Or the joint distribution of two random variables that control particular stock prices? All of these questions require integration in more than one variable. By the end of the course you should be able to express questions of this kind in the form of finding an integral of a function of several variables.

In the first week of the course we will also discuss vectors, lines and planes in 3-dimensional space. You will find new appreciation for various problems of 3-dimensional geometry and for your linear algebra course (if you are taking one or took it recently).

Schedule of Topics

This is an approximate week-by-week outline of topics for the course. It may be updated as the course progresses.

- May 11-15: Three-dimensional coordinate systems, vectors, basic operations with vectors, length of a vector, unit vector in a specified direction, dot product, using dot product to find an angle between lines, cross product, using cross product to find a vector orthogonal to two given ones, cross product and area.

- May 19-22: Equations of lines and planes, equations for a line of intersection of two planes, finding distance from a point to a plane, cylinders and quadric surfaces, functions of several variables, domain and range, level curves and level surfaces.
- May 25-29: Limits and continuity for functions of two variables, partial derivatives, directional derivatives, differentials, higher-order partial derivatives, tangent planes and linear approximations, chain rule and implicit differentiation.
- June 1-5: Critical points, the second derivative test, absolute maximum and minimum values, Lagrange multipliers.
- June 8-12: Double integration (definition, area, integral of a function of two variables over a rectangle), Fubini theorem, double integrals over general regions, polar coordinates, center of mass.
- June 15-18: Triple integrals (definition, volume), triple integrals in cylindrical coordinates, triple integrals in spherical coordinates.

- June 22-26: Final Exam

Learning Activities and Assessments of Learning

Course mark will be based on WeBWorK (10%), ComPAIR assignments (10%), 2 in-term quizzes (20% each), and the final exam (40%). The final exam will cover material from the entire course.

WeBWorK and Piazza

The main goal of WeBWorK is to help you learn the material. You are strongly encouraged to work in groups on the more difficult problems, but then complete your individualized problems yourself. Do post questions and answers about WeBWorK (and other parts of the course) on Piazza, but when posting the answers, refrain from solving the problem completely, instead, point out relevant ideas from the course.

ComPAIR

You will have the opportunity to write solutions to some exercises and evaluate your peers' solutions. You should practice writing complete and understandable solutions, as technical communication is an important skill. You will give feedback to your classmates on the correctness of their mathematics as well as the clarity of their explanations.

Gateway Quizes

There will be two in-term quizes hosted on WeBWorK, the dates of which will be announced at the start of the term. These assignments differ from traditional WeBWorK assignments in a few ways. Each quiz is timed, so you will only have a fixed amount of time to work once you begin. You will not recieve feedback from WeBWorK as you go, you will only see your grade when you complete the assessment. You will have an opportunity to retake the quiz on the following day with new randomized problems.

Concessions

There will be no make-up quizzes, and no late homework accepted. Students with concessions

(e.g. for illness or family emergencies) will have the weight of a quizz transferred to the other quiz and the final exam; the weight of a WeBWorK or ComPAIR assignment will be transferred to the other assignments. You can receive **one** concession during the term, by submitting the Concession request form (it can be downloaded at: `https://www.math.ubc.ca/Ugrad/ugradForm/`) to your instructor. Further concessions or missed final exams need to be discussed with the Academic Advisors of your Faculty. There cannot be any exception to this university-wide policy.

Final Exam Requirements

For a full description of the final exam regulations, see the UBC Calendar page on Student Conduct during Examinations (`http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3%2C41%2C90%2C0`). The same regulations apply for the in-class quizzes.

Scaling

Term marks may be scaled. No scaling will be decided upon until all assessments are marked. Because WeBWorK homeworks historically have very high averages, the quizzes and final might be written to have slightly lower averages. Average marks for assessments are not always shared with students. If you are unhappy with your mark, rather than comparing it to your classmates, consult with your instructor about ways to improve your studying.

Learning Materials

All course materials are available online and are free.

- The course website is hosted on Canvas. Lectures will happen over CollaborateUltra, linked on the Canvas site. There will be links to the textbook, suplementary references, and all other learning materials.
- Wolfram Alpha: www.wolframalpha.com
  This is a wonderfull tool for plotting graphs of functions of two variables, for example. If you want to visualize, for example, the surface $x^2 + xy - y^2 + 3z = 0$, just type in "plot (x^2+xy-y^2+3z=0)". A note about WeBWorK and Wolfram Alpha: there will be many problems in WeBWorK which require thinking and which Wolfram Alpha cannot do; for the more mechanical ones that it can do, if you just use the software and copy the answers, it detracts from your learning. You might get a few extra points for the WeBWorK problem, but you'll certainly lose much more on the exam for not having that skill. So use this great software to your advantage (to help you visualize the objects we study, and to learn), not to your disadvantage (to cheat on WeBWorK). However, it is reasonable to use Wolfram Alpha to check your computations or to complete the last step of tedious WeBWorK problems.
- Math Learning Center drop-in tutoring may be available over Canvas: see the schedule at `https://www.math.ubc.ca/~MLC/` for more information.

University Policies

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious observances. UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions. Details of the policies and how to access support are available on the UBC Senate website (`https://senate.ubc.ca/policies-resources-support-student-success`).

Learning Analytics

This course will be using the following learning technologies: Canvas, Piazza, WeBWorK, ComPAIR. Many of these tools capture data about your activity and provide information that can be used to improve the quality of teaching and learning. In this course, I plan to use analytics data to:

- View overall class progress
- Track your progress in order to provide you with personalized feedback
- Review statistics on course content being accessed to support improvements in the course
- Track participation in discussion forums
- Assess your participation in the course

Copyright

Lectures will be recorded for use in-term by registered students only.