

Multivariable Calculus

MAT 2228

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Prerequisites: Mastery of the material from MAT 1225 and 1226 (Calculus I and II) is essential. Some of the content from MAT 2401 (Linear Algebra) is also required. Some basic familiarity with Maple will also be expected.

Course Materials:

Textbook: *Calculus*, 5th edition, by James Stewart. See the attached schedule for details of the material to be covered. A variety of valuable supplements for the textbook are also available for purchase, including a student solutions manual and a study guide, but they are not required.

Computer Software: The class will meet in a computer classroom equipped with one PC for every two students. In this class, we will make substantial use of Maple, a computer algebraic system. Maple is available for use on computers in labs throughout the campus. You are also encouraged to purchase a copy of the software for use on your own computer since many homework assignments may require the use of the software. It will be available for purchase at a substantial discount for students using a discount code provided by your instructor. Most of your homework for the course will also be submitted online through WebAssign, so you will need to have access to a computer with an internet connection when working on homework. Please plan accordingly.

University and Departmental Mission: Seattle Pacific University seeks to be a premier Christian university fully committed to engaging the culture and changing the world by graduating people of competence and character, becoming people of wisdom, and modeling grace-filled community. The mathematics department at Seattle Pacific University seeks to provide excellent instruction to enable our students to be competent in the mathematics required for their chosen fields, and to share our expertise with the community through service and leadership. Hence, common goals for students in mathematics courses include 1) becoming competent in the topics covered in the course, 2) demonstrating skills and attitudes which contribute to professional, ethical behavior, 3) the ability to communicate mathematically, in both written and verbal form, and 4) learning to appreciate the beauty and utility of mathematics.

Course Objectives: This course provides an introduction to multivariable and vector calculus. The course covers vectors and analytic geometry in three dimensions, partial differentiation, multiple integration, and an introduction to line integrals. The primary aims of the course are to help students develop new problem solving and critical reasoning skills and to prepare them for further study in mathematics, the physical sciences, or engineering. By the end of the course, students should be able to

- recognize and sketch surfaces in three-dimensional space;
- recognize and apply the algebraic and geometric properties of vectors and vector functions in two and three dimensions;
- compute dot products and cross products and interpret their geometric meaning;
- compute derivatives and integrals of vector functions;
- compute partial derivatives of functions of several variables and explain their meaning;
- compute directional derivatives and gradients of scalar functions and explain their meaning;
- solve multiple variable maximum and minimum value problems;
- set up and evaluate double and triple integrals using a variety of coordinate systems;
- evaluate line integrals through scalar or vector fields and explain some physical interpretations of these integrals;
- apply Green's theorem;
- use Maple effectively to explore and solve problems;
- analyze and solve complex problems;
- write short proofs using the ideas and techniques listed above; and
- provide clear written explanations of the ideas behind key concepts from the course.

Students should also gain an increased appreciation of mathematics as part of the language of science and as a study in itself. Finally, I hope that you will have fun accomplishing all of these objectives, even if the material is difficult and the course takes a lot of time and effort.

Grading and Course Expectations

Exams: There will be two in-class midterms and a cumulative final exam. Use of computer software may be required as a part of the exams. Tentative dates for the exams are listed in the schedule at the end of this syllabus, *but the dates for the midterms are subject to change; actual dates for the exams will be announced in class about one week in advance.*

Most questions on the exams will be similar to exercises from the homework. You also may be expected to state some definitions, write some short proofs, and to provide written explanations of some key ideas of the course.

Homework: The only way to truly learn calculus is to work as many exercises as possible. There will be homework assignments given virtually every class period. There will be two types of homework assignments:

Online WebAssign Homework: Most of the basic computational exercises for the course will be submitted online using WebAssign. You can access WebAssign through SPU's Blackboard system. An online assignment will be due prior to the start of almost every class period during the quarter.

Additional information about WebAssign:

- ❑ You must have an internet connection to view and submit WebAssign homework assignments. However, if you wish to work offline, you can access the assignment online and print out the questions. You can then complete your work offline and return to a computer later to submit your answers.
- ❑ The questions on the assignments are generally taken from the textbook, but some aspects of each exercise may be randomized so that each student has a slightly different version of the question. The skills required to complete the exercise will be identical, but some numerical values involved will likely be different.
- ❑ As you work on the assignments, WebAssign will give you immediate feedback as to whether or not your answers are correct. For incorrect answers, you will be allowed to rework the exercise and submit a new answer. For most exercises, you will be allowed up to FIVE submissions for each part of each question. Only your last submission will count toward your actual grade for the assignment. As a result, it will be possible for most students to get perfect scores on most online assignments.
- ❑ To discourage random guessing, some questions (particularly multiple choice) will either not permit multiple submissions at all (so only your first submission will count) or will have a reduced number of submissions. Any such restrictions will be noted in the instructions for each assignment.
- ❑ WebAssign uses Maple to check answers, so it can recognize correct answers even if they are not written in the same form as the answer key. When submitting numerical answers, use exact answers whenever possible (for example, use $\sqrt{2}$ rather than a decimal approximation like 1.41, or use $1/3$ rather than 0.333). When it is necessary to submit decimal approximations, you should generally make sure that you submit at least 3 correct digits to make sure that you are within the error tolerance.
- ❑ Online assignments must be completed by 10:45 AM on the due date. Work submitted after that time will be worth NO credit. Note that the computer system will not be forgiving, even if it is 10:45:01, so do not wait until the last minute to complete your assignment.

Written Homework Assignments: In addition to the online assignments, a written assignment will be collected approximately once a week. These written assignments will consist of exercises which involve proofs, derivations, printouts from Maple, graphs, or written explanations which cannot easily be graded by an online system. Written assignments must be turned in at the beginning of class on the day it is due; *homework will not be accepted once class has started.* **Late written assignments will not be accepted for any reason** (but in the case of an excused absence the grade for an assignment may be dropped).

Your work must be neat and easily readable or you will receive NO credit. You must show all of your work – a correct answer with no justification will also be worth NO credit (particularly for odd numbered exercises with answers in the back of the book...). Not all written homework exercises will be graded. On a typical assignment, five representative exercises will be selected for grading and your grade for the assignment will be based on those five exercises only.

All assignments will be posted online; however, you are also responsible for all announcements made in class, whether or not they are posted on the web.

You are strongly encouraged to come to my office to ask me questions about the homework. You are also encouraged to work with other students on the homework. However, on written assignments, you must individually write up and turn in your own solutions. You are required to list on your paper all other individuals that you worked with or that assisted you in any way with the assignment – failure to do so will be considered cheating (since you are turning in someone else's work as your own).

Attendance: Attendance will not be taken, but if you expect to succeed in this course, it is essential that you come to class every day. Unless you have an acceptable excuse *and* make special arrangements with me *before* class begins, missing an exam or failing to turn in an assignment on time will result in a grade of zero. Late homework will not be accepted for any reason, but if you have an acceptable excuse and contact me before class, I will drop the homework score.

NOTE: Things such as oversleeping, lack of preparation, or sneezing twice are NOT acceptable excuses. Acceptable excuses include a death in your immediate family or a *severe* illness, and *you are responsible for providing me with documentation of your excuse.*

Course Grades: Course grades will be determined by a weighted average of your scores on the homework and the three exams. Your homework average will count for 30% of the overall course grade, and your two lowest homework scores will be dropped at the end of the quarter. The 2 midterms will each be worth 20% of the course grade, and the final exam will be worth 30%. Course grades will be based on the following scale:

	93-100%	A	90-92%	A-	
87-89%	B+	83-86%	B	80-82%	B-
77-79%	C+	73-76%	C	70-72%	C-
67-69%	D+	60-66%	D	Below 60%	E

A grade of I (incomplete) is only given for non-academic reasons such as a severe illness that prevents you from completing the course. You must have a passing grade on the material that you have completed in order to receive an incomplete.

Academic Dishonesty: Academic dishonesty includes copying another's work on an exam, preparing for an exam by using test questions from a stolen exam, bringing concealed answers to an exam, turning in another person's work as your own, committing plagiarism, assisting another student in cheating, or lying to the instructor. The *minimum* penalty for cheating or plagiarism in any form will be a zero for the assignment or exam in question. In addition, all students have an obligation to make efforts to prevent other students from cheating and to report incidents of cheating or plagiarism. Further details regarding SPU's academic dishonesty policies can be found online in the SPU Undergraduate Catalog. (<http://www.spu.edu/acad/UGCatalog/20089/GeneralInfo/policies.asp#2>).

Office Hours: My office hours will be announced in class during the first week of class. They will also be posted on the course web pages and outside my office door. You are strongly encouraged to drop by my office to ask questions, discuss problems, and just to get to know me better. If you are unable to meet with me during my scheduled office hours, I am available at other times by appointment. I also maintain an "open door" policy – any time that my office door is open, you are welcome to drop in to talk to me, even if it is not during my scheduled office hours. *Please note that I also work as the statistician for a research lab at the University of Washington, so I am not available at all on campus on Tuesdays and Thursdays. Please plan accordingly.*

Additional Notes:

Calculators: Calculators will be permitted on all exams. Any basic scientific calculator or a graphing calculator such as the TI-81, TI-82, TI-83, or TI-85 will be allowed. However, calculators which are capable of symbolic manipulation (such as the TI-89 or TI-92) are *NOT* permitted. If you have any doubt as to whether or not your calculator is acceptable, please ask me as soon as possible.

E-mail: All SPU students have an SPU e-mail address. I will make use of these SPU e-mail addresses to send information to all members of the class, so you should check your e-mail regularly. If you do not use your SPU e-mail account, there is a utility available through Banner to set up your SPU e-mail account to forward messages to some other e-mail address. I strongly recommend doing this so that you do not miss any important messages.

Please note that while it can be a great tool for quick communication, *e-mail is rarely a good substitute for face-to-face conversations and is very poorly suited for answering mathematical questions.* When you come to my office to ask me questions, I engage you in a discussion about the problem, ask questions about what ideas you have for approaching the problem, explore various possible approaches (and what goes wrong with some of them), etc. In the process, I can usually find out precisely where your difficulties lie and help you to learn how to get past them. Such a conversation is impossible by e-mail. Furthermore, typing and e-mailing mathematical symbols is very time consuming, and the resulting equations in the e-mail often come out garbled (or even completely missing).

Students with Disabilities: Students with disabilities need to contact Disabled Student Services in the Center for Learning to request academic accommodations. Disabled Student Services sends letters out to all your professors indicating the appropriate accommodations for the classroom based on your disability. Once you

have done this, you should also make an appointment to meet with me as soon as possible to discuss the details of how we will implement the accommodations in this course.

Emergency Procedure: Please note the emergency procedures posted in the classroom and note all emergency exits. In case of an emergency (fire, earthquake, hazardous material spillage, bomb threat, etc.), the class will evacuate the building and gather in the Alumni Center parking lot outside Otto Miller Hall. Please try to stay together so that we can check that everyone has made it safely out of the building.

Modifications to the course requirements (such as the addition of quizzes) can be made at any time. It is your responsibility to know all course requirements as described here or announced in class.

Tentative Class Schedule

The table below provides a listing of topics that I plan to cover from the text. The exact dates on which we cover material will almost certainly vary somewhat from this list. Also, topics may be added to or removed from this list at any time.

Date	Section
March 30	13.1 Three-dimensional Coordinate Systems 13.2 Vectors
April 1	13.3 The Dot Product
April 3	Maple lab: vector operations, graphing surfaces & curves in 3-d
April 6	13.4 The Cross Product
April 8	13.5 Equations of Lines and Planes
April 10	14.1 Vector Functions and Space Curves
April 13	14.2 Derivatives and Integrals of Vector Functions
April 15	14.3 Arc Length and Curvature
April 17	14.4 Motion in Space: Velocity and Acceleration
April 20	Review 15.1-15.3 Functions of Several Variables
April 22	Review
April 24	Exam 1
April 27	15.4 Tangent Planes
April 29	15.5 The Chain Rule
May 1	15.6 Directional Derivatives and the Gradient
May 4	15.7 Maximum and Minimum Values
May 6	17.1 Vector Fields
May 8	17.2 Line Integrals
May 11	More on line integrals
May 13	17.3 The Fundamental Theorem for Line Integrals
May 15	Review 16.1 through 16.4: Double Integrals
May 18	17.4 Green's Theorem
May 20	Review
May 22	Exam 2
May 25	No Class – Memorial Day
May 27	17.5 Curl and Divergence
May 29	16.7 Triple Integrals
June 1	16.8 Triple Integrals in Spherical and Cylindrical Coordinates
June 3	More on Triple Integrals
June 5	Review/Wrap-up
June 9	Final Exam 10:30-12:30

“The chief aim of all investigations of the external world should be to discover the rational order and harmony which has been imposed on it by God and which He revealed to us in the language of mathematics.”

Johannes Kepler (1571-1630)