Syllabus for

MAT 321—Calculus of Functions of Several Variables

4 Credit Hours

Spring 2006

I. COURSE DESCRIPTION

A course studying the calculus of several variables including graphs of functions in three dimensions, partial derivatives, directional derivatives, optimization, multiple integrals, and calculus of vectors.
Prerequisite: MAT 202.
Academic technology fee: $45.

This course is a study of the introductory concepts of several-variable calculus and is designed for students in engineering, economics, life science, mathematics, and physical science seeking basic skills and knowledge in those disciplines. First, the students are given a graphical introduction to functions of two variables. Vector geometry follows as the door to calculus of vector-valued functions. Partial differentiation and optimization of functions of several variables is also treated. Problems concerning (or solvable by) double and triple integrals are considered. Finally, Vector Calculus is studied.

II. COURSE GOALS

The course is designed to provide the students with a basic understanding of the differential and integral calculus of functions of several variables. This course and the preceding two calculus courses provide a thorough study of the foundations of calculus. Also, the students will use the computer to explore the concepts of calculus and to find solutions to the more difficult problems.

III. STUDENT LEARNING OUTCOMES FOR THIS COURSE

A. Unit Objectives

1. Functions of Several Variables

As a result of successfully completing this unit, the student will be able to do the following:

a. Apply several variable functions to real world situations.
b. Find the distance between two points in three-dimensional space and determine the equation of a sphere in the Cartesian coordinate system.
c. Sketch the level curves or surfaces for functions of several variables.
d. Describe surfaces parametrically in three-dimensional space and find the equation of a plane.
e. Describe and recognize graphs of functions of several variables in rectangular, cylindrical, and spherical coordinates.
f. Describe and recognize graphs of vector functions and space curves.
g. Consider limits of functions of several variables and determine the direction and concavity of a surface at a point *P* in the direction of a second point *Q*.
h. Compute the partial derivatives of functions of several variables.
i. Convert among spherical, cylindrical, and Cartesian coordinate systems.
j. Find the gradient and the directional derivative of a function.

2. Differentiable Functions of Several Variables

As a result of successfully completing this unit, the student will be able to do the

following:

a. Determine the differentiability of a function of several variables
b. Find equations of tangent planes for various surfaces and use tangent plane approximation.
c. Use and apply the chain rule for derivatives of functions of several variables.
d. Differentiate implicitly defined functions of several variables.
e. Find and classify critical points for functions of several variables.
f. Use the method of LaGrange Multipliers to optimize functions with constraints.
g. Find the velocity and acceleration of particles in three dimensions.
h. Find the arc length and curvature of a space curve.
i. Perform basic vector operations in two and three dimensions.

3. Multiple Integration

As a result of successfully completing this unit, the student will be able to do the following:

a. Find volumes of solids bounded by surfaces by evaluating double integrals.
b. Change the order of integration and compute double and triple integrals.
c. Compute the surface area of the graph of a function of several variables.
d. Compute double and triple integrals in cylindrical and spherical coordinates.
e. Use a change of variables and the Jacobian to evaluate double integrals over non-rectangular regions.

4. Vector Calculus.

As a result of successfully completing this unit, the student will be able to do the following:

a. Make some elementary analyses of certain vector fields.
b. Find potential functions for conservative vector fields.
c. Use a variety of methods to evaluate line integrals.
d. Use the Fundamental Theorem of Line Integrals and Green's theorem to compute line integrals.
e. Compute the divergence and curl of a vector function.
f. Use a variety of methods to evaluate surface integrals.
g. Use the Divergence Theorem and Stokes' Theorem to compute surface integrals.

5. Project.

As a result of successfully completing this unit, the student will be able to do the following:

a. Submit one project during the semester.
b. Choose from related projects contained in each chapter or from the some related projects that the instructor has.
c. Use the Computer Algebra System Maple © to make computations and generate graphs for the project.
d. Work on their assigned project in small groups of no more than three (individual work is permitted if preferred).
e. Write project report in the format of a term paper and hand it in at the appointed time (see the assignment schedule in this syllabus).

B. Objectives for Students in Teacher Preparation Programs.

The Teacher Preparation Program meets the competency-based requirements established by the Oklahoma Commission on Teacher Preparation. This course meets the following competencies: Subject Competencies (SC) 5,6,7,8, and 9.

SC5. Has a broad and deep knowledge of the concepts, principles, techniques, and reasoning methods of mathematics that is used to set curricular goals and shape teaching.

SC6. Understands significant connections among mathematical ideas and the applications of these ideas to problem solving in mathematics, in other disciplines, and in the world outside of school.

SC7. Has experiences with practical applications of mathematical ideas and is able to incorporate these in curricular and instructional decisions.

SC8. Is proficient in, at least, the mathematics content needed to teach the mathematics skills described in Oklahoma's core curriculum, from multiple perspectives. This includes, but is not limited to, a concrete and abstract understanding of number systems and number theory, geometry and measurement, statistics and probability, functions, algebra, discrete mathematics, and calculus necessary to effectively teach the mathematics skills addressed in the sixth through twelfth grade in the Oklahoma core curriculum. (The depth and breadth of knowledge should be much greater than for the Intermediate Mathematics certification.)

SC9. Is proficient in the use of a variety of instructional strategies to include, but is not limited to cooperative learning, use of concrete materials, use of technology (i.e., calculators and computers), and writing strategies to stimulate and facilitate student learning.

IV. TEXTBOOK

A. Required Textbook
Stewart, J. (1999). *Calculus: Early vectors, preliminary edition.* Pacific Grove, CA: Brooks/Cole.

B. Recommended Text/Material
Greenberg, M. D. (1998). *Advanced engineering mathematics, Second Edition*. Upper Saddle River, NJ: Prentice Hall.
Graphing calculator, Maple © Computer Algebra System.

V. POLICY AND PROCEDURES

A. University Policies and Procedures

1. Attendance at each class or laboratory is mandatory at Oral Roberts University. Excessive absences can reduce a student's grade or deny credit for the course.
2. Double cuts are assessed for absences immediately preceding or following holidays.
3. Students taking a late exam because of an unauthorized absence are charged a late exam fee.
4. Students and faculty at Oral Roberts University must adhere to all laws addressing the ethical use of others' materials, whether it is in the form of print, video, multimedia, or computer software. By submitting an assignment in any form, the student gives permission for the assignment to be checked for plagiarism, either by submitting the work for electronic verification or by other means.
5. Final exams cannot be given before their scheduled times. Students need to check the final exam schedule before planning return flights or other events at the

end of the semester.

6. Students are to be in compliance with University, school, and departmental policies regarding ePortfolio requirements. Students should consult the ePortfolio handbooks for requirements regarding general education and the students' majors.
   a. The penalty for not submitting electronically or for incorrectly submitting an ePortfolio artifact is a zero for that assignment.
   b. By submitting an assignment, the student gives permission for the assignment to be assessed electronically.

B. Department Policies and Procedures
1. Each Student who uses the computer is given access to the appropriate computer resources. These limited resources and privileges are given to allow students to perform course assignments. Abuse of these privileges will result in their curtailment. Students should note that the contents of computer directories are subject to review by instructors and the computer administrative staff.
2. A fee of $15.00 will be assessed for all late exams. This policy applies to all exams taken without notifying the professor prior to the regularly scheduled exam time, and to all exams taken late without an administrative excuse.

C. Course Policies and Procedures
1. Grading Procedures
   a. The standard grading scale will be used, A (90% - 100%), B (80% - 89%), C (70% - 79%), D (60% - 69%), F (0% - 59%). The composite score is determined by the following distribution:

four fifty-minute exams @ 120 points	480 points	(48%)
homework and quizzes	100 points	(10%)
computer labs	100 points	(10%)
written project	120 points	(12%)
one final exam	200 points	(20%)

   b. Points may be deducted for unexcused absences.
   c. The ePortfolio artifact is your Vector Calculus exam 4 that counts as 10% of the homework score and is therefore 1% of your course grade.
2. ePortfolio Requirements
   a. An ePortfolio artifact is required for this course. For specific requirements check the departments' ePortfolio handbook at http://www.oru.edu/eportfolio/CSCePHandbook/.
   b. Artifacts not submitted electronically or incorrectly submitted receive a zero for that assignment.

D. Other information
1. Class discussion is required for optimal learning. The student may be asked to put some problems or exercises on the board in class.
2. There are three types of activities—reading, text exercises, and computer laboratory. A daily assignment schedule is included in this syllabus. Each section of the text is to be read prior to the class discussion of that section. Exercises and problems must be turned in by the end of the day they are due in order to receive credit.
3. Reading mathematics is very different from reading a novel. Every word and equation is important. A pencil and paper should be kept handy when reading in order to fill in details that may not be written down explicitly. The answers to exercises are in the back of the text. The student should ask questions in class about the problems. Students should not be afraid to ask since there are others with the same question.

4. Some exercises are routine and mechanical, much like traditional homework in mathematics courses. Other exercises require more thought.
5. The computer laboratories are designed so students can explore the concepts that are covered in the text. The first few minutes of the lab period are used to introduce the laboratory exercise. Then the students will spend the rest of the time investigating calculus with Maple ©.
6. There are four exams as scheduled (see the daily assignment schedule) as well as a final exam. Each exam is similar to the exercises; the majority are similar to the problems that were assigned for homework. From time to time throughout the semester, there may be a quiz on the material covered recently in class. These quizzes may or may not be announced in advance.
7. Students should ask for help whenever they do not understand something or cannot solve problem. The instructor will try to be available as much as possible. **If the instructor's office hours are inconvenient, a student may call for help or make an appointment.**

VI. COURSE CALENDAR

Calculus III

Lesson	Section	Exercises	Laboratories
1	11.1: 3-D Coordinate Systems	5-37 odds	
2	11.2: Vectors & the Dot Prod. In 3-D	5-19 odd, 24, 26, 30, 32, 37-47 odds	
3	11.3: The Cross product	2, 5-21 odds	
4	11.4: Eqns. of Lines and	1, 5, 9, 13, 15, 17, 19,	Lab 1: Vectors

Lesson	Section	Exercises	Laboratories
	Planes	23, 29, 31	
5	11.4: Eqns. of Lines and Planes	35, 39, 43, 45, 47, 51, 56	
6	11.5: Quadric Surfaces	1-33 odds	
7	11.6: Vector Fns. & Space Cvs	1-13 odds	
8	11.6: Vector Fns. & Space Cvs	24, 28, 31, 36, 40, 43, 45, 57, 62	Lab 2: Vector Functions and Space Curves
9	11.7: Arc Length & Curvature	1, 3, 8, 12, 14, 15, 23, 24, 31, 33	
10	11.8: Motion in Space	1-23 odds; **EC**: 26, 28	
11	Review		
12	Test		
13	12.1: Fns. Of Sev. Variables	1, 5-29 odds	Lab 3: Level Curves
14	12.1: Fns. Of Sev. Variables	43-51 odds, 59-64	
15	12.2: Limits & Continuity	1-11 odds, 10, 16, 17, 22, 24, 25, 33, 36, 39	
16	12.3: Partial Derivatives	3, 7, 11, 15, 20, 24, 29, 33, 35, 39, 52, 56	
17	12.3: Partial Derivatives	57-77 odds, 92	
18	12.4: Tan. Planes & Lin. App.	1, 5, 11, 15, 19, 21, 23, 25, 29, 31	Lab 4: Partial Der., & Tan. Planes
19	12.5: The Chain Rule	1-19 odds	
20	12.5: The Chain Rule	23-37 odds	
21	12.6: Directional Derivatives	1, 5, 9, 13, 15, 17, 21, 23, 25, 27, 29, 31, 36, 40	
22	12.7: Max. & Min. Values	1-15 odds	
23	12.7: Max. & Min. Values	26, 28, 30, 32, 35-49 odds	
24	12.8: Lagrange Multipliers	1-15 odds, 20	Lab 5: Optimization
25	12.8: Lagrange Multipliers	25-39 odds	
26	Review		
27	Test		
28	13.1: Double Integrals over rectangles	1-9 odds, 14,16	
29	13.2: Iterated Integrals	1-31 odds, 36	Lab 6: Def. of Double Integrals
30	13.3: Double Integrals over General Regions	1-27 odds	
31	13.3: Dbl Intls over Gen. Reg.	33-47 odds	
32	13.4: Polar Coordinates	1, 5, 7, 11, 15, 17, 21, 23, 25, 29, 33, 35, 40, 43, 49, 53, 58	Lab 7: Polar Coordinates
33	13.5: Double Integrals in Polar Coordinates	3-27 odds **EC:** 30	
34	13.6: Apps of Double Integrals	1-9 odds 11-21 odds	
35	13.7: Surface Area	1-9 odds	
36	13.8: Triple Integrals	3-19 odds, 27-39 odds	Lab 8: Cylindrical & Spherical Coordinates
37	13.9: Cylindrical Coords.	1-11 odds, 35, 37, 45, 63	
38	13.9: Spherical Coords.	13-31 odds, 35, 39, 41, 43, 47, 51, 53, 55, 57, 65	

Lesson	Section	Exercises	Laboratories
39	13.10: Triple Integrals in Cyl. & Spherical Coordinates	1-11 odds, 15-21 odds, 29, 33, 35, **EC**: 38	
40	13.11: Change of Variables	1-9 odds	Lab 9: Vector Fields
41	13.11: Change of Variables	11-21 odds; **EC**: 24	
42	14.1: Vector Fields	1-23 odds	
43	Review		
44	Test		
45	14.2: Line Integrals	1-19 odds	
46	14.2: Line Integrals	27, 30, 36, 38	Lab 10: TBA
47	14.3: The Fundamental Theorem of Line Integrals	1-21 odds, 28	
48	14.4: Green's Theorem	1-21 odds; **EC**: 24, 26	**PROJECT DUE**
49	14.5: Divergence	1-11 odds (b only), 28, 36	
50	14.5: Curl	1-33 odds; **EC**: 44	
51	14.6: Parametric Surfaces and Their Area	1-25 odds	
52	14.6: Surface Integrals	1-13 odds	
53	14.7: Surface Integrals	15-23 odds	
54	14.8: Stokes' Theorem	1-15 odds	
55	14.9: The Divergence Theorem	1-13 odds	
56	Review		
57	Test		
58	Review		
59	Review		
60	Review		

Course Inventory for ORU's Student Learning Outcomes

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This course contributes to the ORU student learning outcomes as indicated below:
Significant Contribution – Addresses the outcome directly and includes targeted assessment.
Moderate Contribution – Addresses the outcome directly or indirectly and includes some assessment.
Minimal Contribution – Addresses the outcome indirectly and includes little or no assessment.
No Contribution – Does not address the outcome.

The Student Learning Glossary at http://ir.oru.edu/doc/glossary.pdf defines each outcome and each of the proficiencies/capacities.

OUTCOMES & Proficiencies/Capacities	Significant Contribution	Moderate Contribution	Minimal Contribution	No Contribution
1	**Outcome #1 – Spiritually Alive** Proficiencies/Capacities				
1A	Biblical knowledge			X	
1B	Sensitivity to the Holy Spirit			X	
1C	Evangelistic capability			X	
1D	Ethical behavior		X		
2	**Outcome #2 – Intellectually Alert** Proficiencies/Capacities				
2A	Critical thinking	X			
2B	Information literacy			X	
2C	Global & historical perspectives			X	
2D	Aesthetic appreciation			X	
2E	Intellectual creativity		X		
3	**Outcome #3 – Physically Disciplined** Proficiencies/Capacities				
3A	Healthy lifestyle				X
3B	Physically disciplined lifestyle				X
4	**Outcome #4 – Socially Adept** Proficiencies/Capacities				
4A	Communication skills			X	
4B	Interpersonal skills			X	
4C	Appreciation of cultural & linguistic differences			X	
4D	Responsible citizenship			X	
4E	Leadership capacity			X	