MATH 201

Multivariable Calculus

Fall 2025, Session 1

昆山杜克大学
DUKE KUNSHAN UNIVERSITY

Class meeting time: Monday-Thursday 10:00 – 11:15 (China Standard Time) in AB 2103.
Recitation time: Monday 11:45 – 13:00 (China Standard Time) in AB 2103.
Academic credit: 4 DKU credits.
Course format: Lectures, Recitations.

Course Instructor

Instructor: Konstantinos Efstathiou, PhD.
Office: WDR 3107.
Office hours: Monday and Thursday 13:30-15:00 or by appointment.
Personal Zoom room: https://duke.zoom.us/my/k.efstathiou.
E-mail: k.efstathiou@dukekunshan.edu.cn.
Personal website: https://www.efstathiou.gr/.

Short bio: Professor Efstathiou studied physics all the way up to his PhD, focusing on the more mathematical aspects of physics, especially those related to dynamics and geometry. After his PhD, he worked in the Mathematics departments of the University of Groningen and the Xi' an Jiaotong Liverpool University. His research interests are mostly in the area of dynamical systems where the mathematical tools from multivariable calculus play an essential role in describing and understanding the geometry of the structures that appear in such systems. In this course he is looking forward to convey the essential unity, elegance, and applicability of the concepts in Multivariable Calculus and to demonstrate different techniques for dealing with problems involving many variables.

Teaching Assistants

Teaching Assistant: Wiam Benadder.
TA e-mail: wiam.benadder@dukekunshan.edu.cn.
Wiam Benadder is a junior year DKU student majoring in Data Science. She will be running the recitation sessions.

Teaching Assistant: Luyao Xu.
TA e-mail: luyao.xu@dukekunshan.edu.cn.
Luyao Xu is a sophomore year DKU student. He will be holding weekly drop-in office hours on Tuesday 19:00-20:00 in AB 1076 where he can be reached for course related questions. Moreover, he will be preparing homework sets under the guidance of Prof. Efstathiou,

Academic Resource Center Support

Peer Tutor: Phillip Zhu.
Tutor e-mail: phillip.zhu@dukekunshan.edu.cn.
Phillip Zhu is a sophomore year DKU student. As a peer tutor he will offer additional support for MATH 201. This tutoring service will be on a drop-in schedule on Fridays 13:00-14:00 in the Tutoring room in Library 2107. Appointments are also available outside of drop-in times, for mutually agreed-upon hours.

What is this course about?

In MATH 101 Introductory Calculus or in MATH 105 Calculus you have learned about single variable Calculus — the study of functions that depend on a single variable and whose output is a single number. This is the basis for large parts of modern Mathematics and its applications. However, it does not take long to realize that, despite all its intricacies, single variable calculus is not sufficient for describing many aspects of our world: planets and particles move along trajectories in three-dimensional space (or four-dimensional if you take the Theory of General Relativity into account); climate models describe the state of the atmosphere through quantities such as temperature, atmospheric pressure, and wind velocity — all of them functions of position (longitude, latitude, height) and time; wind velocity itself is not a single quantity but a vector — we need to know both how strong the wind is and what is its direction; neural networks, used in machine learning, are trained by minimizing cost functions that depend on millions of variables; in electromagnetism the electric and magnetic fields are described by vectors that depend on the position in three-dimensional space and time; volumes, surfaces, and curves in computer graphics and animation are represented using concepts from multivariable calculus; and, from a purely mathematical point of view, Multivariable Calculus is a subject that opens the door to almost all of modern mathematics — a beautiful topic with close connections to Geometry.

A very useful mathematical concept for working with many variables is vectors. In this course we consider vectors and the basic operations between them. Then we define vector functions that describe a curve in space and the motion of a particle along such a curve. After that we consider functions that depend on more than one variables (for simplicity, most of the discussion will be for two or three variables but the concepts can be generalized to any number of variables) and how to differentiate them, leading to the notions of partial derivatives, directional derivatives, and the gradient, and we use these to find minima and maxima of such functions. Then we take a look at how to compute integrals for functions that depend on two or three variables (double and triple integrals). We close the course with three fundamental results on integration (Green's Theorem, Stokes' Theorem, and the Divergence Theorem) that generalize to more than one dimensions the Fundamental Theorem of Calculus.

What background knowledge do I need before taking this course?

There is one prerequisite course:

- ☑ **MATH 101 Introductory Calculus** or **MATH 105 Calculus**.

Multivariable Calculus builds upon the concepts and techniques introduced in Calculus. In particular, you will need to know how to compute limits, how to determine if a function is continuous, what are derivatives and how to compute them, and what are definite integrals and how to compute them using different integration techniques such as substitution and integration by parts.

What will I learn in this course?

After successfully completing the course you will be able to:

1. Interpret real-world situations in terms of related Multivariable Calculus concepts.
2. Understand the concept of vectors, apply operations on vectors algebraically and geometrically, calculate the dot product and the cross product of vectors.
3. Develop analytical and computational skills required for working with lines, curves, planes, and surfaces in space.
4. Find limits, partial derivatives, directional derivatives, and the gradient of functions of several variables.
5. Understand the definitions of double integrals, triple integrals, line integrals, and surface integrals; recognize and implement appropriate techniques to evaluate them, and apply them to solve problems in mathematics, physical and social life sciences.
6. Apply the Fundamental Theorem of Line Integrals, Green's Theorem, Stokes' Theorem, and the Divergence Theorem, to simplify integration problems.

What will I do in this course?

During the **class meetings** I will review the main relevant ideas and, in some cases, delve into more technical aspects of the topic. **You are expected to have previewed the material for each lecture as contained in this syllabus.** The purpose of the lectures is to help you navigate the main ideas in the course and how they are related to each other. You are strongly encouraged to ask questions and discuss unclear points during lectures. During lectures there will also be activities such as problem-solving and poll-type questions.

The **assessment** of the learning objectives will be performed through a combination of homework assignments, exams (midterm and final), and an applied project.

There will be **7 homework assignments**. The purpose of the homework assignments is to make you actively think about the covered material and to assess your progress, providing also signs on how well the learning objectives are attained throughout the teaching session. The answers to the homework problems will be made available. Homework assignments will be graded based on completeness (whether you made a serious attempt to solve a problem), but not on correctness. It is your responsibility to check the correctness of your solutions, by comparing to the provided answers. In case of any doubts, feel free to contact me or the course TA(s). For the homework assignments (and also for the exams) I will be using **Gradescope**. You will need to scan your solutions to a PDF file and upload them to Gradescope.

The **midterm exams** and the **final exam** will assess the learning objectives for the corresponding parts of the course. Specifically, the first midterm exam will assess material from weeks 1-2, the second midterm exam from weeks 1-4, and the final exam from the whole course. All exams will be closed book.

Please **make ample use of office hours** and other opportunities to interact and ask questions (e.g., Canvas Discussions). **If the given office hours do not work for you, send me an e-mail or a message through Canvas to arrange an appointment.** My role is to guide and support your learning —do not hesitate to come to me or the course TA with your questions and comments.

How can I prepare for the class sessions to be successful?

To prepare for the course

- [x] Review the material from MATH 101 Introductory Calculus or MATH 105 Calculus concerning functions, derivatives, and integrals.
- [x] Install the Canvas smartphone app.
- [x] Install the Gradescope smartphone app. Read the instructions on using the Gradescope app to scan and submit an assignment.

To prepare for class meetings

- [x] Make sure that you have a thorough understanding of the material covered in previous class meetings and prepare a list of questions concerning aspects of the material that is still unclear. You can ask these questions during the following class meeting or during office hours.
- [x] Read carefully through the corresponding upcoming sections in the lecture notes (the lecture schedule is given later in this syllabus) and prepare questions to ask during the lectures. I will review this material in every lecture but may not go through every point in detail.

To prepare for the midterm and final exams

- [x] Review the solved problems from homework assignments and the problems solved in class. Make sure that you have mastered the problems. You can check this by being able to solve the problems without checking at all the given solutions.

What required texts, materials, and equipment will I need?

The course has the following required textbook which is freely available at the OpenStax website at https://openstax.org/details/books/calculus-volume-3.

Gilbert Strang, Edwin "Jed" Herman, *Calculus Volume 3*, OpenStax (2016).

What optional texts or resources might be helpful?

Other textbooks at similar level

There is a plethora of books discussing Calculus and Multivariable Calculus. Below are just two such books at the level of this course.

James Stewart, *Calculus: Early Transcendentals*, 8th Edition (2016).
Stewart's book is very similar to the OpenStax textbook and it is still being used as the required text for other MATH 201 sections. It is very detailed and contains several applications of the theory. Moreover, it contains a huge amount of additional questions that you can use to practice.

Susan Jane Colley, Vector Calculus, Pearson, 4th edition (2012).
Compared to the OpenStax textbook and to Stewart's book this is a more mathematically oriented book and it places somewhat less emphasis on applications.

Advanced texts

Michael Spivak, *Calculus on Manifolds*, Addison-Wesley (1965).
This is a nice little book to go through after you have completed the MATH 201 course if you are re-

ally interested to dive deeper into the Mathematics. It presents most of the concepts and results that we will discuss in MATH 201 from a more abstract and unified point of view. However, it lacks in motivation and presents no applications of the theory. The book's subtitle, "A Modern Approach to Classical Theorems of Advanced Calculus", refers to the Green's, Stokes', and Divergence Theorems, which are all special versions of a more general mathematical result stated by Élie Cartan in 1945 and known, rather confusingly, as the (Generalized) Stokes' Theorem.

Other resources

Kevin Houston, *How to Think Like a Mathematician*, Cambridge University Press (2009).
This is not a book about Multivariable Calculus but it contains useful advice to help you get more familiar with the world and culture of mathematics. In particular, Ch. 2 has useful advice about reading mathematics. This is an overall very useful book for all students of mathematics courses and I highly recommend it as a general resource even if you do not plan to later study Mathematics or related topics such as Data Science or Physics.

How will my grade be determined?

The grade will be determined through the following graded assessments:

- ☑ Homework assignments (10% of final grade; 7 homework assignments; 6 best will contribute to the grade).
- ☑ Midterm exam 1 (20% of final grade).
- ☑ Midterm exam 2 (20% of final grade).
- ☑ Final exam (50% of final grade).

Grading scale

The weighted score from the assessments above will be converted to a letter grade based on the following standard grading scale. Moreover, the final course grade will be F if one or more of the final exam score and midterm exam scores is below 40, or if there are more than 10 recorded absences from lectures.

Grade	Weighted score (s)	Grade	Weighted score (s)	Grade	Weighted score (s)	Grade	Weighted score (s)
A+	$98 \le s \le 100$	B+	$87 \le s < 90$	C+	$77 \le s < 80$	D+	$67 \le s < 70$
A	$93 \le s < 97$	B	$83 \le s < 87$	C	$73 \le s < 77$	D	$63 \le s < 67$
A-	$90 \le s < 93$	B-	$80 \le s < 83$	C-	$70 \le s < 73$	D-	$60 \le s < 63$
						F	$s < 60$

What are the course policies?

Attendance

Attendance of the class meetings (lectures) is mandatory and will be recorded. Attendance of the recitation sessions is optional but strongly recommended.

Your grade will not be penalized for up to 4 recorded absences from lectures. For each absence after the fourth one and for up to 10 absences your final course grade will be reduced by 5%. If there are more than

10 recorded absences then your grade will be F.

Communications

Almost all of the communications will be through **Canvas**. I will send announcements and documents through Canvas. Because of this, it will be useful that you install the Canvas app for students on your phone and turn on notifications.

If you have a question or discussion topic that you think could be relevant to the whole class then I would like to encourage you to ask it under Canvas Discussions so that everyone can participate. I would also like to encourage you to reply to questions if you know the answer. For questions that are only relevant to you I prefer e-mail. Note that I usually do not answer e-mails in the evenings and during the weekends except for urgent matters.

Generative AI

Generative AI such as ChatGPT and DeepSeek is a novel technology to which higher education is learning to adapt.

- ☑ Such tools may be used only if explicit permission has been given for specific purposes. If you are not sure whether using AI tools in a particular way is appropriate or acceptable, ask the instructor.
- ☑ In any situations in which such tools are used, you are obliged to cite fully any use of generative AI tools in the formulation of your work, including by preserving a record of the use of the tool as original source material.
- ☑ Remember that my goal as teacher is to help you learn how to generate your own ideas and communicate them clearly and effectively. Controlling the use of AI tools is not because AI tools are "bad"; instead it is because I want you to learn for yourself how to effectively communicate your own ideas.
- ☑ Use of these tools is governed by DKU's Academic Integrity Policy, and you must employ this technology in a way consistent with my expectations as described above. Failure to do that, will count as an instance of plagiarism.

Assignment deadlines

All homework assignments and the final version of the applied project written report should be handed-in by the announced deadline; late submissions will not be graded unless an extension has been requested at least 24 hours before the deadline and a convincing explanation has been provided. An extension will never be longer than 24 hours.

Discussion Guidelines

Civility is an essential ingredient for academic discourse. All communications for this course should be conducted constructively, civilly, and respectfully. Differences in beliefs, opinions, and approaches are to be expected. Please bring any communications you believe to be in violation of this class policy to the attention of your instructor. Active interaction with peers and your instructor is essential to success in this course, paying particular attention to the following:

- ☑ Be respectful of others and their opinions, valuing diversity in backgrounds, abilities, and experiences.

- ☑ Challenging the ideas held by others is an integral aspect of critical thinking and the academic process. Please word your responses carefully, and recognize that others are expected to challenge your ideas. A positive atmosphere of healthy debate is encouraged.
- ☑ Read your online discussion posts carefully before submitting them.

Academic Integrity

As a student, you should abide by the academic honesty standard of the Duke Kunshan University. Its Community Standard states: "Duke Kunshan University is a community comprised of individuals from diverse cultures and backgrounds. We are dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Members of this community commit to reflecting upon and upholding these principles in all academic and non-academic endeavors, and to protecting and promoting a culture of integrity and trust."

Academic Policy & Procedures

You are responsible for knowing and adhering to academic policy and procedures as published in University Bulletin and Student Handbook. Please note, an incident of behavioral infraction or academic dishonesty (cheating on a test, plagiarizing, etc.) will result in immediate action from me, in consultation with university administration (e.g., Dean of Undergraduate Studies, Student Conduct, Academic Advising). Please visit the Undergraduate Studies website for additional guidance related to academic policy and procedures.

Academic Disruptive Behavior and Community Standard

Please avoid all forms of disruptive behavior, including but not limited to: verbal or physical threats, repeated obscenities, unreasonable interference with class discussion, making/receiving personal phone calls, text messages or pages during class, excessive tardiness, leaving and entering class frequently without notice of illness or other extenuating circumstances, and persisting in disruptive personal conversations with other class members. Please turn off phones, pagers, etc. during class unless instructed otherwise. Laptop computers may be used only to take notes. If you choose not to adhere to these standards, I will take action in consultation with university administration (e.g., Dean of Undergraduate Studies, Student Conduct, Academic Advising).

Academic Accommodations

Duke Kunshan University makes reasonable academic accommodations for qualified students with disabilities. All undergraduate accommodations must be approved through the Student Accommodation Services. Students requesting accommodations for this course should forward their official accommodation letter to the instructor and ask to schedule a time to meet and discuss the implementation of their accommodation(s). It is the student's responsibility to meet, discuss, and provide an electronic copy of the Instructor Accommodation Letter to each instructor. Accommodations will not be granted retroactively. Accommodations for test, quiz, or exam taking must be arranged with the professor at least a week before the date of the quiz, test or exam, including finals.

What campus resources can help me during this course?

Academic Advising and Student Support

Please consult with me about appropriate course preparation and readiness strategies, as needed. Consult your academic advisors on course performance (i.e., poor grades) and academic decisions (e.g., course changes, incompletes, withdrawals) to ensure you stay on track with degree and graduation requirements. In addition to advisors, staff in the Academic Resource Center can provide recommendations on academic success strategies (e.g., tutoring, coaching, student learning preferences). Please visit the Office of Undergraduate Advising website for additional information related to academic advising and student support services.

Writing and Language Studio

For additional help with academic writing—and more generally with language learning—you are welcome to make an appointment with the Writing and Language Studio (WLS). You can register for an account, make an appointment, and learn more about WLS services, policies, and events on the WLS website. You can also find writing and language learning resources on the Writing & Language Studio Sakai site.

IT Support

If you are experiencing technical difficulties, please contact IT:

- China-based faculty / staff / students 400-816-7100, (+86) 0512-3665-7100
- US-based faculty/staff/students (+1) 919-660-1810
- International-based faculty/staff/students can use either telephone option (recommend using tools like Skype calling)
- Live Chat: https://oit.duke.edu/help
- Email: service-desk@dukekunshan.edu.cn

What is the expected course schedule?

The schedule below is provisional and the specific details may be adjusted throughout the course. Section numbers refer to the corresponding OpenStax section.

Week 1

Class meeting 1-1: Course overview. Syllabus review. Rectangular, polar, cylindrical, and spherical coordinates (§1.3, part of §2.2, §2.7).

Recitation 1: Calculus review. Coordinate systems. Gradescope demonstration.

Class meeting 1-2: Parametric curves (§1.1, §1.2).

Class meeting 1-3: Vectors (§2.1, §2.2).

Class meeting 1-4: Dot product (§2.3).

Week 2

Deadline Homework 1 (Monday, 10:00)

Class meeting 2-1: Cross product (§2.4).

Recitation 2: Problems from class meetings 1-2 to 2-1.

Class meeting 2-2: Lines, planes, and quadric surfaces (§2.5, §2.6).

Class meeting 2-3: Vector-valued functions and space curves (§3.1, §3.2).

Class meeting 2-4: Arc length, curvature, and more about space curves (§3.3, §3.4).

Week 3

Deadline Homework 2 (Monday, 10:00)

Class meeting 3-1: Functions of several variables, limits and continuity (§4.1, §4.2).

Recitation 3: Problems from class meetings 2-2 to 3-1.

Class meeting 3-2: **Midterm Exam 1.** This closed book, in-class exam covers all material from weeks 1-2. The exam duration is 75 minutes.

Class meeting 3-3: Partial derivatives, tangent planes, and linear approximations (§4.3, §4.4).

Class meeting 3-4: Chain rule (§4.5).

Week 4

Deadline Homework 3 (Monday, 10:00)

Class meeting 4-1: Directional derivatives and the gradient (§4.6).

Recitation 4: Problems from class meetings 3-3 to 4-1.

Class meeting 4-2: Maxima / Minima problems and Lagrange multipliers (§4.7, §4.8).

Class meeting 4-3: Double integrals over rectangular regions (§5.1).

Class meeting 4-4: Double integrals over general regions, and in polar coordinates (§5.2, §5.3).

Week 5

Deadline Homework 4 (Monday, 10:00)

Class meeting 5-1: Triple Integrals (§5.4).

Recitation 5: Problems from class meetings 4-2 to 5-1.

Class meeting 5-2: **Midterm Exam 2.** This closed book, in-class exam covers all material from weeks 1-4. The exam duration is 75 minutes.

Class meeting 5-3: Triple integrals in cylindrical and spherical coordinates (§5.5).

Class meeting 5-4: Change of variables in multiple integrals (§5.7).

Week 6

Deadline Homework 5 (Monday, 10:00)

Class meeting 6-1: Vector Fields (§6.1).

Recitation 6: Problems from class meetings 5-3 to 6-1.

Class meeting 6-2: Line Integrals (§6.2).

Class meeting 6-3: Conservative Vector Fields (§6.3).

Class meeting 6-4: Green's Theorem (§6.4).

Week 7

Deadline Homework 6 (Monday, 10:00)

Class meeting 7-1: Divergence and Curl (§6.5).

Recitation 7: Problems from class meetings 6-2 to 7-1.

Class meeting 7-2: Surface integrals (§6.6).

Class meeting 7-3: Stokes' Theorem and the Divergence Theorem (§6.7, §6.8).

Class meeting 7-4: Review. Problems from class meetings 7-2 to 7-4.

Deadline Homework 7 (Sunday, October 12, 20:00)

Exam Week

Final Exam The final exam takes place October 14, 2025, 15:30–18:30 in AB 2103.